Employment Protection – Structural Policy, Economic Resilience, and Inequality

Thesis submitted in partial fulfilment
of the requirements for the degree of
"DOCTOR OF PHILOSOPHY"

by

Tomer Ifergane

Submitted to the Senate of Ben-Gurion University

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April 29th, 2021
Be'er Sheva

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Approved by the advisor ____________
Approved by the Dean of the Kreitman School of Advanced Graduate Studies ____________

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This work was carried out under the supervision of Dr. Nadav Ben Zeev,
in the Department of Economics,
Faculty of the Humanities and Social Sciences

Research-Student's Affidavit when Submitting the Doctoral Thesis for Judgment

I Tomer Ifergane, whose signature appears below, hereby declare that:

I have written this Thesis by myself, except for the help and guidance offered by my Thesis Advisors.

The scientific materials included in this Thesis are products of my own research, culled from the period during which I was a research student.

Date: 25.11.2021 Student's name: Tomer Ifergane Signature: תומר

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Abstract

This thesis examines the macroeconomic implications of employment protection legislation. I focus on the role of termination costs and termination notice and analyse their significance in macroeconomic transmission and as an insurance device. The thesis consists of three chapters. First, I use cross-country panel data for 21 OECD economies containing measures of the strictness of employment protection, labour market activity, and national accounts to examine the role employment protection measures play in the transmission of macroeconomic shocks. Using an identified risk premium shock and utilising the local projections method to estimate impulse responses, I show that strictness of employment protection amplifies the shock's effect on output, leading to a more severe recession. The data points toward misallocation as the mechanism that drives these results. In the second chapter, I construct a model of how employment protection measures may affect cyclical transmission via their ability to enhance misallocation following an adverse shock. I show this by using a new aggregation result that links between firing restrictions and the dynamic path of misallocation. A calibrated version of the model accounts for a sizeable portion of the observed effect. Additionally, the model yields a sufficient statistic that can be used to quantify this channel in future works. In the last chapter, I focus on termination notice as a distinct form of employment protection. I show the pros and cons of the policy using two analytical partial equilibrium results. I also construct and calibrate a general equilibrium model in which termination notice and unemployment insurance are used both as an insurance device in an environment featuring frictional labour markets, incomplete asset markets, and moral hazard. The model is then calibrated to match Israeli data and to compute optimal policies. I show that termination notice may be welfare improving when employed harmoniously with other policy tools. The work presented here shows the power of employment protection measures to affect the macroeconomic environment. The insights gained from this research are particularly relevant for the global effort to recover from the COVID-19 recession.

Keywords: Employment protection, Firing restrictions, Termination notice, Labour market institutions, Labour market regulation, Business cycles, Misallocation, Search and matching, Unemployment insurance, Incomplete markets
JEL: E02, E24, E32, E60, J08, J65, J64

General Introduction

Employment protection legislation (henceforth employment protection or EPL) is an umbrella term for a class of policy devices that govern employment relationships through a legal mandate. These policies are a salient feature of most developed market economies, which, in some cases, had been in place for nearly a century. In the early 1990s employment protection was a topic of focus in the policy debate, which led to employment protection measures being relaxed in many European economies to boost economic growth. Albeit the pervasive nature of these policy devices, a significant part of their macroeconomic implications are understudied and, as a result, are absent from the policy debate. This thesis aims to discuss several of these gaps in the literature and shed light on the consequences, intended or otherwise, of this class of policy devices.

To put these policies in some political context, the idea of employment protection stems from the creation of labour as a social class with unemployment as a key risk to household income. In a frictional labour market, employment is associated with rents. When a large portion of the population is employed and has the political power to push for policies that would secure their rents from employment, they would strive to do so (Saint-Paul, 2000). In the early 20th century, legislative measures such as mandated severance pay, termination notice, and the introduction of the concept of wrongful termination into the legal framework (Schwenning, 1932) were introduced in many countries. These laws limit the freedom of contract as they reflect the view that not all employment contracts are valid even if agreed upon by the two parties. Effectively, these policies institutionalise a departure from the doctrine of 'at-will employment', whereby workers can be hired and fired at will without limit other than those of mutual consent on the employment contract's continuation by the contracting parties (Summers, 2000).

From the macroeconomic perspective, EPL acts as an adjustment cost for labour and an insurance device for households. As an adjustment cost, EPL can affect aggregate output and the distribution and allocation of firms and jobs across the economy. It would imply different speed of labour re-allocation, it would derive, to some extent, the size distribution of firms and would manifest itself into the entry and exit decisions. On the household's side, if one were to depart from the representative agent paradigm, EPL has implications for the income and wealth distributions via the incentive to save and insure oneself. As such, the potential of EPL to drive macroeconomic outcomes is staggering.

This thesis tackles three questions concerning the macroeconomic impact of employment protection. The first chapter explores the contribution of EPL to act as an amplifier of macroeconomic shocks. Using panel data for 21 OECD countries from 1985-2013, I show that stricter forms of employment protection make countries more prone to prolonged recessions and to exhibit a stronger decline in real output following the impact of a common adverse shock. In the second chapter, I construct a theoretical model that showcases the mechanism by which EPL fosters increased labour misallocation during business cycles, thus leading to more severe recessions. Quantitatively, the modelled channel can account for a significant portion of the empirical differences observed in the data.[1] The last chapter narrows the discussion from EPL at large to the practice of a legislated termination notice. The chapter examines the costs and benefits of using termination notice as a means of providing insurance to households. Using a general equilibrium model featuring incomplete markets, search and matching, and moral hazard, I illustrate the potential implications of termination notice and discuss its optimal use.

To conclude this introduction, the findings laid out in this thesis shed light on the effects of employment protection on the macroeconomic environment and have implications for central and timely policy issues such as the labour markets' recovery post-COVID-19; the design of optimal insurance systems; the cost of the business cycle; and the redistributive effects of labour market regulation.

[1] These two chapters have already been accepted for publication in *Review of Economic Dynamics* under the title 'Firing Restrictions and Economic Resilience: Protect and Survive?'.

Chapter 1

Firing Restrictions and Macroeconomic Transmission

1.1 Introduction

How do firing restrictions affect the transmission of macroeconomic shocks? Employment protection legislation (EPL) in general, and firing restrictions in particular, is a widely used class of policy devices in developed market economies. Most of the policy debate regarding EPL circles around two main issues: its effects on long-term macroeconomic performance on the one hand and its significance for microeconomic outcomes in the labour market on the other. However, the use of such a policy device in times of economic adversity may alter the impact of macroeconomic shocks, influence their transmission mechanisms, and affect recovery. Thus, this chapter aims to explore the potential link between EPL in the form of firing restrictions on individual contracts and economic resilience or the inherent amplification of a macroeconomic shock.

The global financial crisis in 2008 had a considerable effect on developed market economies which vary substantially concerning their labour market policies. Such global shifts in credit conditions allow me to conduct a quasi-natural experiment utilizing shocks to risk premia and their propagation in economies that exhibit varying degrees of strictness of firing restrictions. I carry out this analysis by estimating state-dependent impulse response functions of real activity and labour market activity measures to an identified financial shock. My empirical strategy relies on the local projections method of Jordà (2005) adapted to a panel setting, and inference is based on Driscoll and Kraay (1998) standard errors, which control for temporal and cross-sectional correlation in the error term.

The main results can be summarized as follows. Strict firing restrictions are associated with a reduced initial effect of the shock on the labour market, leading to a smaller and slower rise in unemployment, a smaller drop in employment, and more stability in labour-force participation. However, circa a year and a half from the cycle's beginning, exact timing depends on the specification of choice, economies under a stricter regime of firing restrictions experience a stronger and more persistent decline in real output. The drop in output is in the opposite direction of the effect on employment and too fast and sizeable to be accounted for by a differential decline in capital stock. Taken together, these lead me to suspect that the driving force behind this difference is a drop in total factor productivity (TFP) when firing restrictions are stricter. Such a drop is present in the data and is statistically significant. I further demonstrate that this sequence of differential responses in the labour market, real output, and TFP is statistically significant and robust to various choices of specification, measure, and sample.

Related Literature. This chapter is most closely related to the literature on labour market institutions and their interaction with macroeconomic shocks. The seminal work of Blanchard and Wolfers (2000) describes how changes in European unemployment data can be explained by the interactions of the institutional factors in the labour market with various shocks. In addition to the long-term changes in unemployment, institutional factors have been linked to macroeconomic volatilities e.g., Gnocchi et al. (2015a) and Rumler and Scharler (2011). More specifically, Nunziata (2003) had studied the interaction between EPL and the business cycle and demonstrated empirically and theoretically that strictness of EPL lowers the output elasticity of employment. Along this line, Duval and Vogel (2008) illustrate how strict EPL leads to greater persistence in business cycle dynamics using output gap to identify cycles. The mechanism suggested by theory to explain this link between cyclical adjustment and EPL is that strict EPL should slowdown turnover dynamics and make the re-adjustment process in response to a shock longer as in Bentolila and Bertola (1990) and Garibaldi (1998). The work of Messina and Vallanti (2007) supports this claim using firm-level data, indicating that strictness of EPL dampens the response of job destruction to the cycle, thus leading to less counter-criticality in job destruction.

This chapter is also related to the literature which emerged after the Great Recession that aimed to understand how different advanced economies have responded to what was generally considered as a global shock. Just following the Great Recession Ohanian (2010) examined how Europe and the United States experienced this shock using business cycle accounting. Ohanian's analysis points to the fact that in Europe the drop in the productivity deviation was more pronounced, while the United States had experienced little change in the productivity deviation but did experience a sizeable drop in the labour deviation relative to that which was present in Europe. Ohanian notes that this may be due to European firing restrictions which may have led to labour hoarding and lower measured productivity. This insight, which is revisited in Ohanian and Raffo (2012), is another motivation for the present work as it demonstrates in detail how this may be the case and to what extent is this channel present. The relevance of labour market rigidities to the propagation of international business cycles is also discussed in the work of Perri and Quadrini (2018) who show that when a variation in the adjustment costs of the labour input between the United States and the G6 countries is accounted for, their model is able to provide a better match for the response patterns from the Great Recession.

Contribution. This chapter contributes to the empirical literature by conducting a comprehensive investigation of the link between firing restrictions, and the transmission of credit supply shocks to several outcome measures, such as real output, privet consumption, investment, capacity utilization, TFP, unemployment, employment to population ratio, and labour-force participation. My empirical strategy differs from the aforementioned works due to the use of an identified shock and higher data frequencies to estimate state-dependent, non-linear, impulse response functions using local projections to observe the effect of firing restrictions on the shock's transmission channel rather than exploring their effects on moments or long-term trends. The transmission channel documented here can be attributed to the effect of firing restrictions on turnover, which, combined with a business cycle, results in a slower reallocation of labour. This slower reallocation leads to increasing levels of labour misallocation. Thus, stricter firing restrictions hinder recovery in terms of TFP and real output. In doing so, this chapter also contributes to the literature on the cleansing and sullying effect of the business cycle by demonstrating empirically an EPL-induced transmission channel that is consistent with cyclical misallocation of labour.[1]

[1]Chapter 2 further explores this idea by using a search and matching model to suggest a proper quantification of this channel.

1.2 Methods

1.2.1 Defining and Measuring Firing Restrictions

Measurement of EPL. EPL is an umbrella term for several policy devices. There are several indices that measure EPL's strictness based on the specific policies included in the index, their coverage, and their implications.[2] These indices measure policies that govern different employment contracts, i.e., fixed-term employment contracts or regular employment contracts. In the case of regular employment contracts, employment protection mainly consists of firing restrictions. For temporary workers, EPL is chiefly a hiring restriction that limits the formation of fixed-term contracts. These indices also distinguish between policies by the type of dismissals covered by the legal provisions, i.e., individual dismissals versus collective ones. EPL indices employ a measurement strategy of 'hierarchy of hierarchies', meaning that they are aggregates of several scales that rank the strictness of the legislation (e.g., from 0 to 6 as in the OECD indices). These scales are aggregated according to predetermined weights to form a final index.[3]

Metric of Choice. In this chapter I am interested in restrictions on firing regular employees or the protection of regular employees. With this focus in mind, I chose as my measure of strictness of firing restrictions the OECD index 'strictness of employment protection - individual dismissals (regular contracts)' (EPR V1). This index encompasses the definition of wrongful termination, the procedure of terminating an individual employee, severance pay and notice due, and the legal recourse available to a wrongfully terminated worker.[4,5] The data for this index runs annually from 1985 to 2013.

[2] A more comprehensive discussion of EPL measurements, coverage, and definitions can be found in Boeri and van Ours (2013).

[3] A critique of this measurement method and its limitations can be found in Myant and Brandhuber (2016).

[4] See Table 1 for a detailed break down of the index to its components and the data that composes each component.

[5] A roughly equivalent EPL index is also available annually for 1960-2004 in a database created by Nickell (2006). However, the index displayed there for the years 1960 to 1985 is a backward extension of the OECD index created by assuming that its rate of change over time is the same as the change in another index which uses data taken from Blanchard and Wolfers (2000) and from Lazear (1990). From 1985 onward, the index given by Nickell (2006) is the same as the OECD's index. For the sake of consistency, and since the OECD index is available for twenty eight consecutive years for most of the sample, I chose to rely on the OECD's index instead of utilizing a mixed measurement methodology.

Although I focus on firing restrictions and protection from individual dismissals, other forms of employment protection and other labour market institutions are also present. Taking this into consideration, I use data on other forms of employment protection and labour market institutions in the robustness analysis in Section 1.5.

Using EPL Indecies. EPL indices are composed of several scores which are ordered variables. The final index can take non-integer values, as can the individual components, but that does not change the fact that the components themselves are a ranking system of ordinal variables. This point emphasises the importance of using an identification that allows for variation in an ordered variable and not a continuous one. I choose to use dummy variables to identify policy regimes rather than take the index's levels. This order-preserving identification approach avoids manipulations to the ranking scale that can occur when using a continuous interaction of a variable with the index. Specifically, one could conceive an order-preserving non-linear transformation of the EPL components that would reflect the same order of ranking but would change the results of a continuous-interaction-based regression analysis, thus altering the conclusions based on the transformation of choice. Nevertheless, the EPL index has largely been treated as if it were a continuous variable. Noteworthy examples of this simplification can be found in Blanchard and Wolfers (2000), Messina and Vallanti (2007), Nunziata (2003), and Duval and Vogel (2008). The only methodological exceptions, to the best of my knowledge, are studies that consider only the cardinal elements of EPL such as months of notice and months of payment offered as severance pay and ignore the regulatory environment, as in Lazear (1990), or studies that focus on correlations and utilize the Spearman correlation coefficient as in Gnocchi et al. (2015b).

1.2.2 Outcome Measures

To examine the implications of firing restrictions for macroeconomic resilience, I have created a panel containing the following variables:[6] Labour market variables such as unemployment, employment to population ratio, and labour force participation rates, national accounts data (all in real terms) including output,[7] consumption, investment, government expenditure, im-

[6] For further details and information on the data used in this chapter, see Appendix A.

[7] Output and not output per-capita is used for two reasons: First, to be consistent with the other national accounts data that are available only without such normalizations; and second, due to data availability. Using output yields 2,068 quarterly observations while using output per-capita yields only 1,774 such observations for the same countries and time-frame. In Section 1.5.1, I show that the results are robust to using this

ports, and exports; TFP; capacity utilization; total hours worked; hours worked per worker; our shock variable, a measure of excess bond premium (EBP), which will be discussed shortly; and the EPL index. I use data from 21 OECD economies for the period between 1985 to 2013.[8] The choice of sample, both along the country dimension and the time dimension, arises from the availability of the EPL index.[9] All dependent variables are taken from the OECD's database.[10]

1.2.3 Shock Variable

In the analysis that follows, I use the EBP (excess bond premium) measure from Gilchrist and Zakrajšek (2012), as the shock variable. The authors use micro-level data to construct a credit spread index which they decompose into a component that captures firm-specific information on expected defaults and a residual component that they term the excess bond premium. To the best of my knowledge, there is no financial shock variable that has been calculated specifically for every one of the economies included in the analysis. That said, the increasingly global nature of the world economy means that EBP can be interpreted as a global shock variable within the framework of this analysis, especially given that I limit the scope to include only developed market economies.

1.2.4 Empirical Strategy

I follow the class of specifications that use the local projection method from Jordà (2005) to estimate impulse response functions. The estimated specification is adapted to a state-dependent setting as the one employed in Auerbach and Gorodnichenko (2012a), Owyang et al. (2013), Ramey and Zubairy (2017), and Tenreyro and Thwaites (2016). The major advantage of this strategy is that it allows for state-dependent non-linear effects in a straightforward manner while maintaining a simple estimation by regression techniques. Moreover, it is more robust to misspecification than a non-linear VAR. Additionally, the strategy can be used to analyze data of differing measurement frequencies as one is not required to estimate

choice of measure.

[8] Quarterly data frequency is used for all variables except unemployment for which monthly data is available and for TFP and hours worked, which are available only at an annual frequency; all data which are available for quarterly or monthly frequencies are seasonally adjusted.

[9] In the UK the OECD's EPL index is available for 2014, and therefore I use data from this year as well for the UK.

[10] All OECD data were retrieved from http://stats.oecd.org/; for exact details see Appendix A.

a multi-variate system in a joint fashion. Joint estimation here will require interpolation or temporal aggregation to achieve a panel of the same frequency. Additionally, estimating a multi-variate system of this type requires the omission of many data points due to a missing values.

Definition of Policy States. In defining the state, or the policy regime used, I wish to group observations in a way that allows for sufficient differentiation between the groups and in a manner that can describe broadly the policy regime; too many groups will limit sample sizes severely, while too few will not enable differentiation. To allow for sufficient differentiation, I use the following groups: first, the lower quartile of EPL index's distribution as an indicator of being under a regime of lax firing restrictions; second, the upper quartile of the EPL index's distribution as an indicator of being under a regime of strict firing restrictions; and third, the rest of the observations (i.e., the interquartile range of the EPL index's distribution) as an indicator of being in an intermediate regime. This kind of grouping allows me to identify differential effects across strict, intermediate, and lax policy regimes, where the interest lies mainly in looking at the difference between the strict and lax groups given that this gap reasonably captures a sufficiently large differentiation between policy regimes for picking up any true effects in the data. While these policy regime dummies are time-varying, it is important to note that the EPL index exhibits little temporal variation, as opposed to relatively large cross-sectional variance, resulting in relative stability of policy regimes over long horizons.[11]

As in Auerbach and Gorodnichenko (2012a), I make use of the Jordà (2005) local projections method within a fixed-effects panel model, where inference is based on Driscoll and Kraay (1998) standard errors that allow arbitrary correlations of the error term across countries and time. In particular, I estimate impulse responses to the credit supply shock by projecting a variable of interest on its own lags and contemporaneous and lagged values of the EBP variable from Gilchrist and Zakrajšek (2012), while allowing the estimates to vary according to the policy state in a particular country and time.

The following equation demonstrates the class of the state-dependent models I estimate

[11]The relatively low temporal variance of EPL and labour market institutions is also noted in Lazear (1990) and Gnocchi et al. (2015a).

using y as an example of a dependent variable:[12]

$$\begin{aligned} \ln y_{i,t+h} - \ln y_{i,t-1} = A_{i,t-4}[\alpha^h_{A,i} + \beta^h_A EBP_t + \Theta^h_A(L)EBP_{t-1} + \Gamma^h_A(L)\Delta \ln y_{i,t-1}] \\ +B_{i,t-4}[\alpha^h_{B,i} + \beta^h_B EBP_t + \Theta^h_B(L)EBP_{t-1} + \Gamma^h_B(L)\Delta \ln y_{i,t-1}] \\ +C_{i,t-4}[\alpha^h_{C,i} + \beta^h_C EBP_t + \Theta^h_C(L)EBP_{t-1} + \Gamma^h_C(L)\Delta \ln y_{i,t-1}] + \epsilon^h_{i,t+h}, \end{aligned} \tag{1.1}$$

where i and t index countries and time; α_i is the country fixed effect; $\Theta(L)$ and $\Gamma(L)$ are lag polynomials; β^h gives the response of the outcome variable at horizon h to a credit supply shock at time t; $\epsilon^h_{i,t+h}$ is the residual; and, importantly, all the coefficients vary according to the policy state of EPL which is represented by the state dummies $A_{i,t-4}$, $B_{i,t-4}$, and $C_{i,t-4}$ that take the value of one when the policy regime is lax, intermediate, or strict. The estimated impulse responses to the credit supply shock for the three states at horizon h are simply β^h_A, β^h_B, and β^h_C, respectively.[13]

Lags of y and EBP are included in the regression to remove any predictable movements in EBP. This facilitates identifying the response to an unanticipated EBP shock, which is the object of interest in this estimation. I assign the value of the order of lag polynomials $\Theta(L)$ and $\Gamma(L)$ to 8, i.e., I allow for 8 lags of the log-first-difference of the outcome variable and EBP in the regression.[14] I assume a relatively large number of lags because of the construction of the EPL variable which is based on annual data. Since the EPL variable was converted from annual to quarterly frequency by assuming identical values within the year, it is necessary to include it in the regression with at least four lags to avoid correlation of the error term with the policy dummy. This, in turn, requires that more than four lags of output and EBP be included in the regression to purge the state dummies of any potentially endogenous sources.

The EBP credit supply shock is normalized so that it has a zero mean and unit variance. Note that a separate regression is estimated for each horizon. I estimate a total of 21 regressions for each quarterly variable and collect the impulse responses from each estimated regression, allowing me to examine of the state-dependent effects of credit supply shocks for

[12] To correctly adapt a state-dependent model for panel data, one must refer to a form of normalized changes in variables for these changes to be commensurable between countries. For this purpose, one may use a dependent variable of the form $\ln y_{i,t+h} - \ln y_{i,t-1}$ which represents the log-cumulative-difference in our variable of interest from the baseline level prior to the shock until horizon h.

[13] The notation $A_{i,t-4}$, represents a one year lag of the dummy as most of the analysis is done using quarterly data. When using other data frequencies, I use a one year lag for the same dummy variables.

[14] When using other data frequencies, I use two years of lagged values, for consistency.

five years following the shock.

This form of state-dependence is slightly different from the conventional one (see, e.g., Ramey and Zubairy (2017)), which usually uses a binary state variable. Specifically, it adapts the strategy of Ramey and Zubairy (2017) to allow for an ordered ranking system by breaking down the raw EPL index into three different ordered EPL regimes. If the strictness of firing restrictions indeed causes a change in the response of a certain variable, then one would expect to see that its responses to the shock across policy regimes will maintain an ordered pattern, i.e., $\beta_A^h > \beta_B^h > \beta_C^h$ or $\beta_A h < \beta_B^h < \beta_C^h$. Note that this strategy does not assume anything that would guarantee such an order unless the order is present in the data, unlike the results that would have been obtained from a continuous interaction exercise. In Section 1.5.1 I conduct a robustness analysis of the results to the choice of cut-off values for the policy regime dummies to ensure that the results are not driven by the choice of cut-off values.

1.3 Results

I estimate the state-dependent specification described in Equation (1.1) for output, consumption, investment, government expenditure, imports, exports, the real wage, the stock of vacancies, employment to population ratio, labour-force participation, and unemployment. The estimation results are presented in Figures 1 and 2, where the responses of economies with strict firing restrictions are shown in blue, for those with lax restrictions in red, and those in the intermediate regime in black.

Regardless of the policy state, the credit supply shock causes the expected dynamics, i.e., an increase in unemployment and a decrease in real activity measures (most importantly, a decrease in real output, consumption, and investment). My interest lies in the differences of responses across the policy regimes whose statistical significance is indicated by the shaded areas in Figures 1 and 2.

1.3.1 Labour Market Outcomes

The first form of differential response to arise between the policy regimes is in the labour market and it is presented in Figure 1. Having a lax regime of firing restrictions produces an immediate increase in unemployment and a decrease in employment while having a strict regime generates no significant change in unemployment until a year after the shock and no statistically significant decrease in employment at all horizons. This pattern also agrees with the claim in the literature that job-destruction is less counter-cyclical under a strict EPL regime, thus making overall employment less responsive.[15] Notably, the labour markets with lax firing restrictions manage to recover back to steady state significantly faster than in the stricter ones, with the unemployment rate and vacancies responses during the later phase of the cycle being significantly higher and lower, respectively, in the strict EPL state relative to the lax one.

A difference observed across policy states from which the theoretical literature usually abstracts is that labour-force participation is adversely affected by the shock when firing restrictions are lax, while being in the strict EPL state produces no such effect. The effect on participation could be interpreted as being driven by the relatively higher value of the job-seeker from a future match with an employer, anticipating a longer employment duration which lowers discouragement from costly search activities.

1.3.2 National Accounts

The second form of differential response is the response of real activity measures presented in Figure 2. One year after the shock, one can observe that real output starts to decline more where firing restrictions are strict compared to the lax policy regime. This gap in output steadily widens, starting to be significantly different from zero from the 7th quarter onwards and translating to a relative cumulative output loss of 0.75% after two years, 1.31% after three years, 2.18% after four years, and a peak 2.40% after five years.[16] Later, in Section 1.5.1, I will demonstrate that this response pattern is robust to cut-off values' selection, lag order selection, and alternative sample and output measure choices.

Other measures of real activity do not exhibit any statistically significant differential response pattern until at least two years after the shock. Consumption starts to decline in a significantly differential fashion from the 9th quarter onwards, and or investment, a significant differential decline occurs from the 11th quarter onwards. Imports fall differentially from the 10th quarter onwards quarters whereas exports begin to decline differentially after five quarters, but only until the 7th quarter and then again after 12 quarters up to the 15th quarter (and at somewhat lower confidence levels relative to the other variables, with

[15] See Bentolila and Bertola (1990), Garibaldi (1998), and Nunziata (2003).

[16] All results are presented for a five-year horizon. However, to test that this effect does not in further in magnitude, I estimate the corresponding difference after six years to be 1.55% using the same methods explained above.

p-values always exceeding 5%). These differential responses all occur in the same direction as that of output's response, i.e., being in a strict EPL state generates a stronger decline in all these real activity measures relative to being in the lax EPL state. It is noteworthy that these differential responses all occur in the absence of any persistent significant changes in the real wage in all EPL regimes with similarly weak responses of government expenditures.

Linking the results from Figure 2 to those from Figure 1, we can observe that the initially stronger decline in employment from the latter figure occurs under the lax policy regime while the following stronger drop in output occurs under the strict one, with no differential response in employment taking place after the first two years. Moreover, the differential response of investment would not be able to account for any significant diminution in the capital stock available for production until at least three years after the shock (i.e., the decline in output precedes the drop in capital stock and not vice versa), and even then the differences are not strong enough to explain the differential output response by themselves.[17] In other words, the difference in output response across the policy regimes is too large to be explained solely by changes in factor inputs at any point in time, giving rise to what at first glance seems like a contradiction. A relative decline in output is present, whereas inputs are the same.

Furthermore, given the response patterns for investment, it is more likely that this difference in capital stock response arises from the earlier differential decline in overall real activity. Viewing the employment to population ratio as a measure of the labour input in production, leads one to conclude that there is no differential response in labour after the first two years, meaning that something else must be driving these response patterns in output. With this discrepancy in mind, I now turn to an investigation into the potential root causes of output's differential response.

1.3.3 A Closer Examination of the Supply Side.

Since the form and magnitude of the differential output responses cannot stem from the differences in investment or from the changes in the employment to population ratio, I turn now to examine the behaviour of inputs in the aggregate production function. The analysis that follows is driven by the following considerations: First, do I accurately account for the

[17] To illustrate, if one were to assume a 10% annual depreciation rate of capital stock, and use the exact cumulative changes in investment from Figure 2, assuming that both policy regimes begin from the same level of steady-state capital stock, the differences between the capital stock in the strict and lax policy regimes would be less than 0.1% for the first three years of the cycle, 0.54% for the fourth year and 1.07% for the fifth one.

labour input? And second, am I taking into account all the relevant parts of the aggregate production function that could explain the differential responses in output across EPL states?

To allow for better measurement of labour input, I use data on actual hours worked. Despite the longer annual frequency of this series, it still has the potential to better measure true variation in input quantity than using the number of employed persons. Also, if one were to consider a more general production function, then output will be determined by raw input quantities, the degree to which they are utilized, and the TFP level. With these two considerations in mind, I estimate the impulse responses of total hours worked and TFP, at an annual frequency, as well as those of capacity utilization at a quarterly frequency, again conditioning on the initial policy regime using the same estimation given in Equation (1.1).[18]

The results of this exercise are shown in Figure 3. Most striking is that TFP declines where strict firing restrictions are present. However, under a lax regime of firing restrictions, TFP is not affected by the shock in any statistically significant way. This difference in TFP responses is sizeable, peaking at 0.79% after three years and is statistically significant.

A smaller initial decline in hours worked under the lax policy regime is statistically significant only for the first year after the shock. This finding is in line with the employment to population ratio response and agrees with the interpretation that labour input in production declines immediately after an adverse shock when firing restrictions are lax but responds more sluggishly when restrictions are strict.

Capacity utilization, which can be thought of as a proxy for factor utilization, behaves in a significantly different manner that can at least in part also account for the differential output response. Overall, across all three policy states, one can see that the beginning of the cycle is associated with decreased capacity utilization. However, the persistence of the decline in utilization varies according to the initial policy regime. After 10 quarters, one may observe a diverging recovery pattern that is statistically significant from about 3.5 years after the shock onwards, with the associated response difference peaking at 1.71% after 17 quarters. These results are in accordance with the recovery of hours worked during the same time frame.

To conclude this section, it is worthwhile to recapitulate briefly the overall empirical pattern. The credit supply shock, as one would expect, reduces employment and output. The decline in employment and the increase its unemployment is faster when firing restrictions are lax. Additionally, around a year and a half into the cycle, there is no difference in employment across the different policy regimes. Around the same period, output begins

[18] Detailed description of the data series can be found in Appendix A.

to decline more where strict firing restrictions are in effect. This drop persists throughout the cycle and leads to a more severe recession in the stricter policy group. During the first few years of the cycle, TFP declines when strict firing restrictions are imposed but remains relatively unaffected when such restrictions are lax. The decline in TFP does not seem to originate from a differential response of capacity utilization. In Section 1.5, I explore the robustness of this response pattern an show that it is indeed robust and merits a serious consideration. The differential output decline and the robustness thereof turn out to be the central empirical finding of this chapter.

1.4 Discussion

1.4.1 Structural Interpretation

The results from Figures 1 to 3 indicate that the smaller, immediate decline in effective inputs under a stricter regime of firing restrictions is followed by a decline in TFP, which, in turn, leads to the stronger drop in real output. This amplification mechanism further enhances the business cycle's strength, contributes to its persistence, and leads to a slower recovery of the economy as a whole. Importantly, since the TFP measure used here is not adjusted for factor utilization changes and the differential drop in utilization takes place only after the drop in TFP occurs, I infer that a potentially important channel for explaining TFP's differential decline lies in increased factor misallocation when firing restrictions are more strict.[19] Specifically, the results indicate that a factor-misallocation-induced TFP decline can explain the stronger output decline in the first three years after the shock. In contrast, the subsequent two-year differential output fall seems to be mostly driven by a corresponding differential drop in factor utilization.

The transmission channel observed, by which firing restrictions on regular workers affect output's recovery from a financial shock via a misallocation-induced-drop in TFP, requires a connection between TFP and firing restrictions. From the perspective of a search and matching model, firing restrictions can be considered as firing taxes. If separation is endogenous, e.g. as in the model of Mortensen and Pissarides (1994) or the textbook model in chapter

[19] Underlying this factor-misallocation based interoperation is the assumption that the level of pure technology is unaffected by credit supply shocks, as is normally assumed in the literature (see, e.g., Buera et al. (2011), Pratap and Urrutia (2012), Petrosky-Nadeau (2013), Khan and Thomas (2013), Buera and Moll (2015), Buera et al. (2015), Gopinath et al. (2017), Buera and Shin (2017), and Manaresi and Pierri (2017)).

2 of Pissarides (2000), then a tax on separation should lower the reservation productivity level, i.e. the lowest match quality realization that would result in a continuation of the employment relationship. Lagos (2006) makes a clear connection between EPL and TFP by using a search and matching model with endogenous separation, adding hiring and firing taxes and using a Pareto distribution for match quality which results in an aggregate Cobb-Douglas production function with endogenous TFP, with the level of TFP being exactly proportional to the reservation productivity level. Lagos proves that increasing firing taxes in this setting would result in a steady state with lower TFP.[20] Importantly, Lagos' model features a non-degenerate distribution of marginal products of labour across jobs or firms[21] which connects the result in Lagos (2006) to the concept of misallocation as conceptualized in the empirical works of Restuccia and Rogerson (2008) and Hsieh and Klenow (2009).

This link between EPL and steady-state TFP in mind, can help one to understand the effect of an adverse shock. Through the lens of a search and matching model, the occurrence of the shock is analogous to a transitory decline in the marginal product of labour via the decline in the quantity of its complementary input, namely, capital. Firing will occur quickly when it is cheap and includes no procedural delays. However, when firing is expansive and time-consuming, worker turn-over will be more sluggish and occur less often. The result is a smaller increase in job destruction and a smaller incentive to create jobs since there are fewer job-seekers, which further increases labour misallocation. If this increase in misallocation occurs, then it would follow that faster turn-over and re-allocation of misallocated labour would benefit aggregate welfare. Therefore, if the economy is capable of faster re-allocation of its labour input, its TFP level would recover faster to steady-state levels. This slightly differs from the mechanism depicted in Lagos (2006) since Lagos considers the steady-state levels of TFP and not to their dynamic responses. I argue that given this connection between EPL and TFP via misallocation of labour, a faster labour re-allocation can better remedy any additional misallocation introduced by the shock.

1.4.2 EPL and Slower Turn-Over

A key claim underlying my interpretation that the firing restrictions amplification channel stems from misallocation is the association of EPL with slower labour turn-over. This claim finds wide support in the literature on EPL, for a summary of the research which links EPL to slower job flows see Skedinger (2010). In what follows, I further illustrate this point

[20]See Proposition 2 in Lagos (2006).

[21]In this class of models one firm is one job and vice versa.

within the context of the policy regimes I thus far discussed. Since flow data is not as readily available as employment and unemployment data I utilize decomposed flow hazards from the work of Elsby et al. (2013). They combine OECD data and additional surveys and compile a data series of job-finding rates and separation rates at an annual frequency for 17 of the 21 countries in my sample for varying time frames until 2009.[22] Given the partial nature of this data, it is not included it in the main analysis but rather utilized within the same empirical framework of the rest of the chapter. This facilitates a correspondence between my work which utilizes data on stocks and the literature which discusses job flows.

The data from Elsby et al. (2013) agrees with the literature claiming that EPL strictness is associated with slower flows. Using a simple regression of the job-finding rate and the separation rate as dependent variables and the three policy dummies as independent variables, indicates that job flows in and out of employment are significantly slower as firing restrictions become more strict. These results are presented in Table 2. Importantly, the order of magnitude is such that hazard rates in the lax group are nearly three times as large as those in the strict one and almost twice as large as those in the intermediate group. Without regard to the policy regime in question, the response of the logged hazard rates to the shock depicted in Figure 4 is in line with the overall dynamics of the macroeconomic environment documented before. The job-finding rate decreases in response to the shock and the separation rate increases albeit these responses are mostly not statistically significant other than at the first year horizon for the job-finding rate. The weaker statistical significance of these response is not surprising as the aftermath of the strongest realizations of the shock (i.e., those taking place in 2008) is mostly absent from the sample and that the data is at a low frequency. Hence, this estimation is probably suffering from a lack of statistical power. However, the response's direction agrees with the overall dynamics described in Section 1.3.

When conditioning on the initial policy state, the response of the job-finding rate across the policy regimes is very much in line with the results regarding vacancies. Namely, job-finding decreases in a statistically significant fashion when firing restrictions are lax but not when the restrictions are strict. This supports the conclusion that the increase in unemployment documented in Figure 1 is due, at least in part, to an increase in separations. Additionally, when firing restrictions are lax separations increase in a statistically significant manner for the first two years following the shock. Under the strict policy regime, separations increase in a statistically significant fashion only three years following the shock's impact. This increase is larger than that in the lax regime and is roughly consistent with

[22] For additional detail see Appendix A.

the ending of the TFP differential between the policy regimes which agrees with the labour misallocation interpretation of the results.

In linking between EPL and misallocation, it is worthwhile to note several examples from the literature that support this line of reasoning. A theoretical example of this connection can be found in Garibaldi (1998) who concludes, based on a stochastic search model, that firing restrictions reduce labour re-allocation and slow turnover. More recent empirical evidence linking EPL and factor misallocation, in general, lend support to this claim. Caballero et al. (2013) find that stricter EPL, especially with respect to dismissal regulations, is linked to a lower speed of adjustment to shocks, which lowers productivity growth, a process which they connect to Schumpeter's idea of 'creative destruction'. Using a difference in differences estimation and industry-level data, Bassanini et al. (2009) show that EPL strictness is associated with a lower productivity growth rate and that this effect is due to the binding limitation on termination, which may lead to a lower change in aggregate productivity unless the market is extremely centred around industries for which terminations are not the primary source of turnover. Petrin and Sivadasan (2013) find from plant-level evidence in Chile's manufacturing industry that there is reason to believe that changes in severance pay are responsible for an increase in the gap between the value of the employees' marginal product and their wage. This gap measures allocation inefficiency, which means that the introduction of stricter termination regulations in Chile may have induced an increase in factor misallocation. The work of Lashitew (2016) provides further support to this claim by using plant-level data that shows a link between EPL strictness and factor-misallocation-induced productivity losses.

To sum up, my results show that the strictness of firing restrictions slows labour market dynamics. The impact of an adverse shock induces a certain need for re-allocation to bring the economy to full productive capacity given the new aggregate conditions. Firing restrictions act as a buffer that limits this necessary adjustment process and induce a level of labour misallocation that lowers aggregate productivity and hinders output's recovery. Still, strictness of firing restrictions need not be the cause of this misallocation but merely the reason for the persistence thereof for this amplification channel to manifest.

1.5 Robustness

This section examines the robustness of my main result, the differential response pattern of output, alongside the differential increase in unemployment, the drop of employment and the differential TFP decline. First, I analyse the robustness of the responses across policy states to various alterations of my baseline specification: cut-off value selection for defining the policy states, continuous interaction instead of a dummy based approach, lag order selection, and choices of output measure and samples. Second, I examine the main result's interpretation, i.e., the misallocation amplification channel of firing restrictions by testing if determining the policy regimes according to other labour market institutions results in a similar pattern of response.

1.5.1 Alternative Specifications and Samples

Cut-off Values. The empirical strategy described in Section 1.2.4 hinges upon the initial state of an ordered variable. Any strategy of this kind would be potentially sensitive by design to the choice of cut-off values. To assure that the results do not arise from a specific choice of cut-off values, but indeed from a change in the intensity of the policy variable, I repeat the estimation described by Equation (1.1) for unemployment, employment to population ratio, output, and TFP with the only difference being that I now use different percentile values for the state dummies. Specifically, I assign the state of strict EPL to the top 15, 25, 35, and 45 percentile values of the EPL index's distribution and the corresponding bottom percentile values to the state of lax firing restrictions, where the remaining residual percentile range continues to cover the intermediate EPL state. Note that as the cut-off value increases, the number of observations assigned to the intermediate EPL state decreases while the number of observation assigned to the two extreme states of the distribution increases.

The results from this exercise for unemployment, employment to population ratio, output, and TFP are shown in Figure 5. For comparison purposes, notice that the baseline estimation results are obtained using the 25th percentile and the 75th percentile as cut-off values for the lax and strict EPL regimes. Those baseline results are presented in the second row Figure 5. The results from Figure 5 indicate that the differential response pattern of all the main variables is robust to cut-off value selection as all cut-off values examined exhibit a significantly stronger output fall taking place under the strict EPL regime with the same employment and unemployment dynamics, accompanied by a similar differential TFP drop. Moreover, for every cut-off value of choice except the 45th percentile value, the response magnitude is ordered according to the initial state of EPL strictness with the responses of output and TFP growing in magnitude along with the increase in the EPL state with similar ordering in the opposite direction for the labour market responses. The 45th percentile value has the smallest intermediate group. Therefore, it is expected that the intermediate EPL state's responses would behave more erratically and exhibit lower statistical significance using this cut-off value than the other ones, as is indeed the case.

Continuous Interaction. As discussed in Section 1.2.4, EPL is an ordered variable. The use of a discretization into regimes based upon degrees of exposure of the economy to EPL is my approach for including this variable as a policy state in the regressions. However, the literature on state-dependent impulse responses sometimes utilizes a smooth transition function or a probabilistic rather than a deterministic state assignment. The key works which have pushed for this methodological approach are Auerbach and Gorodnichenko (2012b), and Auerbach and Gorodnichenko (2013) which use a smooth transition to account for being in a recessionary or an expansionary stage of the business cycle. I now conduct a robustness test to the dummy-based regressions compatible with this line of research. In what follows, I describe briefly the challenges involved, illustrate the specifics of the chosen specification, and show that the results are robust to such specification.

To use such an approach in my set-up is challenging and requires some modification because of two differences between the work here documented and that of Auerbach and Gorodnichenko (2012b). First, the main source of variation in EPL is along the spatial dimension and not the temporal one. EPL data exhibits no cyclical behaviour and varies little over time, so a regime-switching approach is not the correct way to go for each country in this panel as regimes are unlikely to switch. Second, the regimes in Auerbach and Gorodnichenko (2012b) are binary, so while this is certainly the right conceptualization in their set-up, for my design, this is not the case. It does not seem plausible to me that the three regime dummies represent the only three possible policy regimes. Rather, I consider them as an approximation of many ordered states that describe the degree to which firing restrictions are costly and limiting for the firm. I use only three states to reduce the problem's dimensions and allow for a parsimonious estimation given the available data. With these differences in mind, I suggest the following specification that follows from the methodology in Iacoviello and Navarro (2018):

$$\begin{aligned} \ln y_{i,t+h} - \ln y_{i,t-1} = \alpha_i^h + \beta_{50th}^h EBP_t + \Theta_{50th}^h(L) EBP_{t-1} + \Gamma_{50th}^h(L)\Delta \ln y_{i,t-1} \\ + \gamma_{t-4}^{EPL}\left[\beta^h EBP_t + \Theta^h(L) EBP_{t-1} + \Gamma^h(L)\Delta \ln y_{i,t-1}\right] + \epsilon_{i,t+h}^h, \end{aligned} \tag{1.2}$$

where $y_{i,t}$ is again an outcome variable y, in country i, at time t, h denotes the horizon of estimation, and EBP is the shock variable. The exposure to EPL is encapsulated in the γ^{EPL} variable. As in Iacoviello and Navarro (2018), I treat the EPL index as an exposure variable that is normalized to have mean zero and unit variance. I then proceed by applying the logistic transformation to the normalized variable which results in $d = \frac{e^{EPL}}{1+e^{EPL}}$. The resulting variable d is an order-preserving transformation of the basic measure of the strictness of EPL. Finally, I compute $\gamma^{EPL} = \frac{d-d(50th)}{d(75th)-d(50)}$, which has several appealing features. First, $d(50th)$ is the value of d for the EPL's median level. Thus, at the median γ^{EPL} is zero and the response to a one standard deviation shock of EBP at horizon h is given by β^h_{50th}. As such, the total response to a one standard deviation shock in EBP is given by $\beta^h_{50th} + \gamma^{EPL}_{t-4}\beta^h$. Second, γ^{EPL} normalizes the distance between the 75th to the 50th percentile to unity. This yields that the sum of the coefficients $\beta^h_{50th} + \beta^h$ is the impulse response at the 75th percentile.[23] This approach results in a straightforward interpretation of the coefficients, which one would not normally obtain from a specification that is based upon a continuous interaction with an ordered variable. The logistic transformation maintains the probabilistic characteristics of the method of Auerbach and Gorodnichenko (2012b), but in a form that is more suitable to this non-binary set-up.

The results of this estimation procedure are given in Figure 6. These results are very similar in signs and significance to the baseline results. Output drops more strongly when EPL is more strict, unemployment rises slower, but employment does not respond differentially after the first year. Importantly, here, as in the baseline, TFP drops in a more pronounced fashion when EPL is strict. Overall, this set of results is very much in line with the baseline estimation and supports the robustness of my findings.

Lag Order Selection. To avoid endogeneity problems, use of a lagged value of the state dummies is necessary. Due to the assumption that EPL does not change within the same year, I therefore, include at least more than one year of lagged values in each estimation. Since the specific choice of lag order may influence the results, I test their robustness to choosing a smaller lag order than in the baseline of $L = 8$ for quarterly data frequencies and $L = 24$ for monthly ones resulting in more parsimonious model specifications. Figures 7 and 8 present the impulse responses of output, employment to population ratio, and unemployment to an adverse credit supply shock for different lag orders alongside the baseline results.

[23] As in the baseline specification, the term γ^{EPL}_{t-4} relates to the values of EPL at a one year lag. The subscript $t-4$ is for quarterly frequency data. When annual or monthly data is used, the lag is chosen to the value that corresponds to one year.

This exercise does not meaningfully change the differential response patterns' magnitude, duration, or statistical significance and lends further support to the result' robustness.

Alternative Measure of Output. As mentioned earlier, I use output instead of output per-capita to be consistent with the components of output in the baseline estimation and due to the sizeable difference in sample sizes between the two series. Figure 9 presents the results from estimating impulse response functions using Equation (1.1) and uses output per-capita instead of real output as an outcome measure. These results show that the differential response pattern is robust to using this choice of output measure. The ordered response magnitude and the statistical significance are similar across the different cut-off values.

Excluding the Global Financial Crisis Period and the U.S. The choice of EBP as a shock variable is based on its large realizations in the 2008-2009 financial crisis period as these facilitate identification. However, one could question if this method does not merely capture the implications of this particular crisis, with its unique characteristics and implications for the European markets (most of which have rather strict EPL levels), thus limiting the ability to draw from it reliable policy implications.

To test if these results are indeed sensitive to the exclusion of the global financial crisis, I repeat the estimation while excluding all observations from 2008:Q1 onwards from the sample. It should be born in mind that this exclusion may reduce the significance of any result because more than 20% of the original sample is excluded. Moreover, these same 20% also consist of the large adverse credit supply shock realizations associated with the global financial crisis of 2008-2009.

Additionally, the global crisis began in the U.S., which may have caused its economy to respond differently from the rest of the world. This is not due to its labour market policy but because it had been the shocks' origin. Thus, I test if the inclusion of the U.S. in the original sample affects the results by estimating the specification from Equation (1.1) using a sample that excludes it.

The results of the above two tests are presented in Figure 10. We can see that the differential response patterns are rather similar and statistically significant for these two tests, thus lending support to the robustness of the results. The findings that may be viewed as exceptions are the response of TFP without the U.S. which is slightly less statistically significant, and the response of employment to population ratio without the periods of the financial crisis, which display a somewhat erratic pattern for the strict policy groups. These two findings do not contradict the differential response pattern but rather are weakly consistent with it.

1.5.2 Other Forms of Employment Protection and Institutional Factors

My interest in firing restrictions stems from their potential cyclical implications, which I believe are understudied and somewhat missing from the policy debate. Unfortunately for any empirical analysis of labour market institutions, institutional factors are not assigned randomly to different countries and other institutions may affect business cycle dynamics and confound my findings. Examples of such institutional factors may be found in the work of Botero et al. (2004) which explores the cultural and legal origins of the regulation of labour across countries, and the work of Blanchard and Tirole (2008), which discusses the connection between EPL in the form of firing taxes and unemployment insurance, and in subsection 1.2.1 which explores the forms of employment protection.

Other institutional factors act as state variables potentially affecting the shock's transmission. My baseline specification for the quarterly frequency data using one state variable requires fixed-effects for each regime-country pair, eight lagged values of the outcome variable and the shock, and the contemporaneous shock, which amounts to 51 coefficients and up to 63 fixed effects.[24] Adding another state variable to this analysis as a control will require the estimation of several hundred coefficients which will severely lower the statistical power and limit interpretation. Instead of controlling for these variables directly, I carry out a similar estimation of impulse responses as described in detail in Section 1.2.4 but, this time, I change the institutional factor used as a state variable. Doing this allows me to look for other institutional factors which produce similar differential response patterns to those observed for the EPL index. Such factors would suggest a similar amplification channel for the shock and warrant concern that the baseline results may be partly picking up an amplification role of an institutional factor other than firing restrictions. Conversely, not finding such similar response patterns would materially alleviate this concern.

With this aim in mind, I add to the panel institutional data on temporary employment protection, employment protection from collective dismissals, union density, collective bar-

[24] This number is the upper limit of the fixed effects - 21 countries across three possible regimes. In actuality, the number is closer to half of this, depending on the specification. This is because institutional factors do not exhibit much temporal variation, so that transitions within the same country are rare.

gaining coverage, and net replacement rates for the relevant countries and time frames.[25] I then estimate the state-dependent specification given by Equation (1.1) for different cut-off values. This is a replication of the results presented in Figure 5 using an alternative state variable. Results for this estimation are shown in Figures 11 through 15 for the state-dependent responses of unemployment, employment to population ratio, real output, and TFP.

Other Forms of Employment Protection. Protection of temporary employment (EPT) measures seem to hinder the response of unemployment to the shock at the beginning of the cycle (Figure 11). This is probably due to the fact that the more restrictive hiring such temporary workers is, the more difficult it is to adjust employment along this margin during a cycle. This conjecture is in line with the results for the employment to population ratio at the lower cut-off values. However, the strength of this pattern declines as the cut-off values increase, so much so that for the 35th percentile and 45th percentile cut-off values, there is no statistically significant differential response pattern in employment. In terms of output, a differential response pattern can be observed that is inconsistent across the different cut-off values and smaller than that observed for EPL. Importantly, the response of output occurs without any differential response in TFP. Taken together, these responses indicate that the effect of EPT on business cycle dynamics is different from that of EPL, leading to the conclusion that differences in EPT do not confound the results regarding EPL.

Using protection from collective dismissals (EPC) as a state variable in the analysis results in little to no differential response pattern between the policy regimes in terms of labour market implication of the shock on impact (Figure 12). There is only a small statistically significant difference between the lax and strict policy regimes without the ordered pattern of responses, suggesting that EPC may not be the driving force behind the observed response difference across the policy regimes. There is also a differential output response pattern that is not ordered by policy strictness and is smaller in magnitude than EPL and without the differential drop in TFP. Hence, all in all, the results from Figure 12 lead to the conclusion that the EPL-based results are unlikely to be driven by an EPC-induced amplification mechanism.

Other Labour Market Institutions. First, using union density as a state variable (Figure 13) results in a differential response pattern in unemployment, the statistical significance

[25] See Appendix A for detailed descriptions of the data series used.

of which decreases in the cut-off value, without a differential response in employment to population ratio. Output and TFP respond differentially to the shock. However, the real output responses and TFP responses are not ordered by union density, and their duration is shorter than those obtained for EPL.

Second, if one looks at collective bargaining coverage (Figure 14), an interesting pattern can be observed. There is a differential impact TFP drop that grows in strength as collective bargaining agreements become more prevalent. Furthermore, the persistence of those responses and their statistical significance declines with the increase in cut-off values. There is, however, a differential response in recovery that is unlike that of the baseline results, i.e., a differentially faster recovery of real output, employment, and unemployment without a differential response of employment or unemployment on impact. This suggests that the less prevalent are the collective bargaining arrangements, the faster the economy can adjust to the shock's impact. The strength of the differential recovery in output is smaller than that in the baseline results using EPL. The contributing factors to the differential output decline seem different altogether, pointing towards an interesting find but not to a threat to the interpretation of the findings in Section 1.3 as stemming from differences in EPL.

Last, although there is complementarity between the generosity of unemployment benefits and EPL, the former does not seem to generate the same cyclical implication as the latter. Using net replacement rates as a state (Figure 15) results in no statistically significant differential response patterns that survive across alternative cut-off values and suggest a coherent contribution to the dynamic responses and little ordering in responses.

Although the exercises carried out in this subsection point towards interesting effects of other labour market institutions for cyclical dynamics, the results do not indicate a single institutional factor that may confound the main results regarding EPL's amplifying effect on the shock's transmission.

To conclude, although the exercises carried out in this subsection point towards interesting effects of other labour market institutions for cyclical dynamics, the results do not point towards a single institutional factor which may confound our results regarding EPL's amplifying effect on the shock's transmission via a slower reallocation of the labour input which results in lower aggregate TFP and slower recovery in real output.

1.6 Conclusion

This chapter examined the relationship between firing restrictions and economic resilience using a state-dependent local projection-based empirical strategy within a panel fixed-effects setting. The findings indicate that the strictness of firing restrictions has the capacity to act as an amplifier to macroeconomic shocks. While diminishing the drop in employment following an adverse credit supply shock, firing restrictions severely hinders the recovery of real output to pre-shock levels. This sizeable and robust relative decline in real activity seems to arise from an input-misallocation-induced TFP decline that is present when firing restrictions are strict and is absent when they are lax. Strict firing restrictions facilitate a stronger increase in misallocation due to their effect on job flows, resulting in a slower turnover and slower re-allocation of labour.

These conclusions should be understood and interpreted only in the context of business cycle transmission and in business cycle frequencies. In the long run, EPL, although heavily persistent, is endogenous and may have a bearing on the first-order moments of the economy like aggregate employment, output, and TFP. The empirical strategy used in this chapter relies on lagged values of the policies to minimize any endogenous response, but in the very long run, this will not be sufficient.

From a policy-making standpoint, the results indicate that relaxing firing restrictions for terminating regular employees may allow a faster recovery of real output during times of recessions. To the best of my knowledge, to date, the use of pro-cyclical or counter-cyclical EPL as a policy instrument had not been examined. The findings presented here shed light on the effect of labour market policies for business cycle dynamics that is often completely absent from the policy debate.

Although the analysis presented in this chapter was compiled entirely during the pre-COVID-19 era, it has striking implications for recovery from the global COVID recession. When the COVID recession started, there were high hopes that the recession would be brief and the recovery fast. With this type of scenario in mind, many developed market economies tried to maintain the worker-firm matches and to prevent an increase in unemployment to mitigate the costs of search in the recovery. However, as the recession progressed, COVID-19 disrupted many industries and changed the way business is done. In light of this chapter's findings, it is possible that preventing the separation of existing employer-employee matches will hinder the restructure of industries and prevent or limit a much-needed re-allocation of labour in the post-COVID years.

From a theoretical standpoint, the results may prove to be of value for the construction of structural models that can accommodate the link between EPL and TFP via factor misallocation conditional on a shock-induced business cycle. This is also the motivation for the analysis in the next chapter.

Chapter 2

Firing Restrictions and Cyclical Misallocation

2.1 Introduction

In this chapter, I explore the implications of firing restrictions for the dynamics of misallocation. While the link between firing restrictions and misallocation had been explored in the economic literature, the dynamics thereof are largely understudied. In the previous chapter, I discussed the capacity of firing restrictions to affect cyclical dynamics by inducing increased degrees of labour misallocation. The results are consistent with such an explanation but do not offer direct evidence. Such evidence would be extremely challenging to obtain, as it would have to consist of a cross-country panel of establishment-level or worker-level data with a consistent and comparable measure of the marginal product of labour over a relatively long time frame. As such, the study of this phenomena would require the use of a theoretical device. Thus, in this chapter I will try to adapt the workhorse search and matching model with endogenous separation to account for the dynamic link between firing restrictions and labour misallocation. After modelling and understanding the forces at play, I will attempt to utilize this model to learn, given the available data, how much of the TFP decline observed in the previous chapter can be accounted for by such a misallocation channel.

Contribution. In this chapter I demonstrate the capacity of firing restrictions to affect misallocation during a business cycle using a search and matching model which incorporates termination costs and advance notice. The model builds upon the work of Lagos (2006), but allows for an endogenous choice of capital and includes a novel treatment of termination notice within a search model. The model yields an aggregation result that illustrates the capacity of firing restrictions to generate a cyclical decline in TFP stemming from labour misallocation. This aggregation result may be useful for future empirical works aimed at providing a more detailed decomposition of TFP and applying misallocation adjustments to construct purified aggregate technology measures and isolate the effects of different policies.

This model also provides conceptual and technical contributions to the modelling of firing restrictions within search and matching models. Conceptually, unlike the standard textbook models, e.g. Pissarides (2000), firing restrictions here do not take the shape of firing taxes which is a simplification one often encounters in the literature. Rather, I model firing restrictions as output-loss costs, which are non-pecuniary, thus capturing the procedural elements of existing policies. I also avoid the single-dimensional approach to firing restrictions and instead allow for termination notice in the model. In this analysis, firing restrictions are not exogenous taxes but entail a cost in output and in turn-over time. On the technical side, the model is calibrated to yield a very realistic wage dispersion that is challenging to obtain within this class of models.

Related Literature. This chapter is related to three strands of literature. First, along the methodological line, it relates to the literature on EPL in search and matching models, e.g., Garibaldi (1998), Pissarides (2000), Lagos (2006), Blanchard and Tirole (2008), and Bentolila et al. (2012).[1] Second, it is related to the literature that studies TFP and conducts decompositions thereof such as the works of Basu and Fernald (2002), Basu et al. (2006), and Baqaee and Farhi (2019).[2] Last, this work is conceptually related to the literature on the sullying and cleansing effects of the business cycle as discussed in the works of Caballero and Hammour (1991) and Barlevy (2002).

2.2 Methods

In what follows, I illustrate how firing restrictions can affect the transmission of an aggregate shock using a simple one-sector model. Firing restrictions will consist of a firing cost and a period of termination notice.[3] During the notice period, the worker awaits termination and

[1] This literature is vast and growing, I thus cite only directly related works.

[2] for a comprehensive review of this literature see Syverson (2011).

[3] This is not a normative work, so I do not model why does this regulation exist. For a comprehensive treatment of the political economics of the issue see Saint-Paul (2000). The key intuition for why firing restrictions arise is that, in a frictional economy, there are rents associated with employment, and the

thus has no incentive to exert effort in production. Legal constraints bind the firm to continue employing the worker under the same wage. Total separation costs from an employee are thus the sum of the cost of firing and wage paid for the notice period's duration. In terms of aggregate production, this separation cost can be conceived as an adjustment cost associated with the aggregate labour input. The more costly the adjustment is, the less likely it is to occur, which means that the firm will be less inclined to separate from less productive workers. This incentive lowers aggregate productivity which is the average productivity of all matches.

This link between separation costs and productivity is presented in Lagos (2006), who shows that firing costs reduce aggregate steady-state productivity. His analysis builds on the framework of the textbook endogenous separation search and matching model found in Mortensen and Pissarides (1994) and in Pissarides (2000) and links the reservation productivity level, the lowest productivity realisation of a match that does not result in termination, with aggregate productivity. The lower the reservation level, the lower is the aggregate TFP. The model I construct follows the two previous models closely but with the following alterations.

First, I add termination notice instead of just a lay-off tax. This extension is not novel and has been implemented by Garibaldi (1998) and Bentolila et al. (2012). I use the same mechanics to allow for a delayed firing mechanism, but I endogenise the wage paid during the notice period.[4] When a matched pair chooses to separate, the worker produces the minimum possible amount and is paid the last wage earned by her until a firing-permission arrives and induces payment of the firm's firing cost and final separation of the pair. Second, since I am interested in business cycle dynamics, I add aggregate risk into the model. Third, I add a capital choice at the individual job level into the model and a reduced-form risk premium shock. This allows me to draw a clear comparison with the previous chapter's results which describe the impulse responses to a risk premium shock.

This theoretical device abstracts from many potential channels of influence for firing restrictions. Such abstractions include the policies' potential impact on research and devel-

median voter is likely to be an employed person trying to maintain or seek rents.

[4] Garibaldi (1998) assumes that the firm can extract the full rent from the employee, so there is no bargaining, and Bentolila et al. (2012) assume that the wage paid during notice is the same as the average wage in the economy. I allow the firm-worker pair to bargain during the regular employment period using standard Nash bargaining. However, the bargaining problem is solved given the knowledge that regulation imposes upon the firm to continue paying the bargained wage to the worker until the end of the notice period.

opment expenditure as in Saint-Paul (2002), their potential for distributional effects as in Kahn (2007), their link to nominal rigidities as in Zanetti (2011), and their effect on long-term human capital accumulation as in Gaetani and Doepke (2016). The reason for this simplifications is twofold. The first is that it provides analytical tractability, and the second is that most of these elements have a bearing on long-term growth and market structure, while my interest lays in the cyclical dynamics along shorter horizons. Hence, the merits of using a tractable search and matching model as a theoretical device outweigh, in my view at least, its inherent limitations.

2.2.1 The Model

A firm in the model is an employer-employee pair that produces a single homogeneous good using capital, k, a common productivity factor, p, and an idiosyncratic component, x, which quantifies efficiency units of labour. Efficiency units of labour at the individual job level are drawn from a common primitive distribution with CDF $\mathrm{G}(x)$ and a compact support $[x_{\min}, x_{\max}]$. Each job may experience an idiosyncratic shock that arrives at rate λ which re-draws x from $\mathrm{G}(x)$. The arrival of such a shock may further trigger a separation choice. I assume that the match cannot separate immediately due to firing restrictions but that the separation decision results in the pair entering into a termination notice period. The worker under notice receives her last wage until separation occurs. This worker produces with the minimum amount possible of efficiency units $x_{\min}$, and its eventual separation from the firm arrives at a rate ϕ which corresponds to notice duration.

The Firm. Each efficiency unit of labour allows the firm to produce output using a production function $\mathrm{f}(k)$ which is assumed to be homogeneous of degree $\alpha < 1$. This implies locally decreasing returns to scale, which I interpret as a limitation on the span of control. I assume that there is a perfectly competitive market for capital that is rented by the firm from households at a rental rate ρ and that capital supply is perfectly elastic, so that aggregate capital is demand-driven. The price of capital is given by $\rho = r + \delta + \xi$, where r is the natural rate of discount in the economy, δ is the depreciation rate, and ξ is the risk premium. The firm chooses capital by equating its marginal product to its marginal cost at the efficiency unit level. Unlike den Haan et al. (2000), I do not explicitly model a household that saves and consumes. A possible way in which the risk premium can be micro-founded in an even richer model is by adding a stochastic shock to the households' preferences regarding holding safe liquid assets as in the work of Fisher (2015) (i.e., a flight-to-quality shock).

The value function $\mathrm{J}(x, \mathbf{s})$ of the producing firm is given by

$$
\begin{aligned}
&r\mathrm{J}(x,\mathbf{s}) = xp[\mathrm{f}(k(\mathbf{s})) - \rho k(\mathbf{s})] - \mathrm{w}(x,\mathbf{s}) + \lambda \int_{x_{\min}}^{x_{\max}} \max\{\mathrm{J}(y,\mathbf{s}), \mathrm{J}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s})\}\,\mathrm{dG}(y) \\
&- \lambda\mathrm{J}(x,\mathbf{s}) + \tau E[\max\{\mathrm{J}(x,\mathbf{s}'), \mathrm{J}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s}')\} - \mathrm{J}(x,\mathbf{s}) \mid \mathbf{s}], \qquad (2.1)
\end{aligned}
$$

where $\mathbf{s}$ denotes the aggregate state of the economy, $\mathrm{w}(x, \mathbf{s})$ denotes the bargained wage of a worker with x efficiency units at state $\mathbf{s}$, and $\mathrm{J}^n(\mathrm{w}(x, \mathbf{s}), \mathbf{s})$ denotes the firm's value of being in a state of notice. The firm discounts its production profits by r. It takes into account the possibility of two shocks, a match-specific idiosyncratic shock with arrival rate λ after which the firm will choose whether or not to stay matched with the worker or to give notice of separation, and an aggregate shock that arrives with hazard rate τ which embodies the same choice.[5] If termination notice was given, the wage level is fixed at $\mathrm{w}(x, \mathbf{s})$ and cannot be updated. Thus, the value of a firm during the state of notice is given by:

$$
\begin{aligned}
&r\,\mathrm{J}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s}) = -\mathrm{w}(x,\mathbf{s}) + x_{\min}p[\mathrm{f}(k(\mathbf{s})) - \rho k(\mathbf{s})] \qquad (2.2)\\
&+ \phi(\mathrm{V}(\mathbf{s}) - \mathrm{J}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s}) - Fp\mathrm{f}(k(\mathbf{s}))) + \tau E[\mathrm{J}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s}') - \mathrm{J}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s}) \mid \mathbf{s}],
\end{aligned}
$$

where ϕ is the hazard rate associated with the arrival of a firing permission and ending the notice period, $\mathrm{V}(\mathbf{s})$ is the value of a vacancy, and the firing cost is $Fp\mathrm{f}(k)$. When viewed from the individual firm's point of view, it is more convenient to think of $Fp\mathrm{f}(k)$ as a tax on separation rather than an output loss cost. However, from the aggregate firm's point of view, which will be discussed later, I interpret $Fp\mathrm{f}(k)$ as an output loss cost and not as a tax. The main reason for this is that I consider $Fp\mathrm{f}(k)$ as a non-pecuniary adjustment cost at the aggregate level and not as a tax with redistributive effects. The firing cost is a cost in lost output by way of using existing and paid for labour and capital in the effort of firing a worker. This, in reality, would consist of paying a lawyer, meetings with unions, conducting a hearing before the notice is given, and so on. This turns F into the number of efficiency units of labour that must be spent in such a process and $Fp\mathrm{f}(k)$ into a quantity in terms of output of another job that is choosing capital optimally as in Equation 2.1. This modelling choice is reminiscent of the way labour adjustment costs are modelled in Gertler and Trigari

[5] I consider a change in the aggregate state as a redraw of certain model parameters from a discrete known state-space. To economize on notation, I do not denote the state-dependence of each parameter, thus facilitating generality and avoiding cumbersome notations such as $\rho(\mathbf{s})$.

(2009), except that I assume a linear cost structure that is a regulatory parameter.

The Worker. Analogously, the value function for the worker W is given by

$$\begin{aligned} r\,\mathrm{W}(x,\mathbf{s}) \;=\; & \mathrm{w}(x,\mathbf{s}) \;+\lambda \int_{x_{\min}}^{x_{\max}} \max\{\,\mathrm{W}(y,\mathbf{s})\;,\;\mathrm{W}^n(\,\mathrm{w}(x,\mathbf{s})\;,\mathbf{s})\,\}\,\mathrm{dG}(y) \\ & -\lambda\,\mathrm{W}(x,\mathbf{s}) \;+\tau E[\max\{\,\mathrm{W}(x,\mathbf{s}')\;,\;\mathrm{W}^n(\,\mathrm{w}(x,\mathbf{s})\;,\mathbf{s}')\,\} -\;\mathrm{W}(x,\mathbf{s})\;|\;\mathbf{s}], \end{aligned} \tag{2.3}$$

and the value function during notice W^n is

$$\begin{aligned} r\,\mathrm{W}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s}) \;=\; & \mathrm{w}(x,\mathbf{s}) + \phi(\,\mathrm{U}(\mathbf{s}) \;-\; \mathrm{W}^n(\,\mathrm{w}(x,\mathbf{s})\;,\mathbf{s})\,) \\ & + \tau E[\,\mathrm{W}^n(\,\mathrm{w}(x,\mathbf{s})\;,\mathbf{s}') \;-\; \mathrm{W}^n(\,\mathrm{w}(x,\mathbf{s})\;,\mathbf{s})\,], \end{aligned} \tag{2.4}$$

where $\mathrm{U}(\mathbf{s})$ is the value from being in a state of unemployment.

Bargaining and The Separation Choice. As is standard in the search and matching literature, the wage is given by a continuous-time Nash bargaining problem. In this model, wage bargaining is slightly more conceptually challenging because of the presence of termination notice. The introduction of termination notice imposes that the bargained wage will be the wage during the advance notice period and, in essence, makes the outside option of each side dependent upon the wage. I will show that this dependence is not problematic in my set-up and that one need not keep track of the wage itself to obtain all of the model dynamics for job creation and destruction. The key intuition behind this result is that as long as the bargaining problem is still a transferable utility game, any mandated transfer can be offset by the bargaining mechanism via changing the wage.

The only reason for a pair to change their working arrangement by changing the wage or separating is a re-draw of the aggregate or the idiosyncratic state. Without changing these factors, each existing match will never cease to produce, and no separations and termination notices will ensue. Thus, I present two bargaining problems. The problem of a continuing pair, which is given by:

$$\mathrm{w}(x,\mathbf{s}) = \arg\;\max\,(\,\mathrm{W}(x,\mathbf{s}) \;-\; \mathrm{W}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s})\,)^{\beta}(\,\mathrm{J}(x,\mathbf{s}) \;-\; \mathrm{J}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s})\,)^{1-\beta}, \tag{2.5}$$

and that of the updating pair

$$\mathrm{w}^{\star}\left(x^{\star},\mathbf{s}^{\star}\right) = \arg\ \max\left(\mathrm{W}\left(x^{\star},\mathbf{s}^{\star}\right) - \mathrm{W}^{n}\left(\mathrm{w}\left(x,\mathbf{s}\right),\mathbf{s}^{\star}\right)\right)^{\beta}\left(\mathrm{J}\left(x^{\star},\mathbf{s}^{\star}\right) - \mathrm{J}^{n}\left(\mathrm{w}\left(x,\mathbf{s}\right),\mathbf{s}^{\star}\right)\right)^{1-\beta}, \tag{2.6}$$

where the wage is updated from its previous level $\mathrm{w}(x,\mathbf{s})$, which was the result of (2.5) under the state $(x,\mathbf{s})$, given a new state $(x^{\star},\mathbf{s}^{\star})$. The key difference between (2.5) and (2.6) is that in (2.5) the wage affects the outside option, while in (2.6), the outside option is fixed.

Lemma 2.2.1. *The choice of separation has the Markov property. The bargaining problems (2.5) and (2.6) are governed by the same surplus level* $\mathrm{M}(x,\mathbf{s})$*, and separation depends only on the current realization of* $(x,\mathbf{s})$ *and not on wage history.*

Proof. The two problems have the following standard first-order conditions:[6]

$$\beta\left(\mathrm{J}(x,\mathbf{s}) - \mathrm{J}^{n}\left(\mathrm{w}(x,\mathbf{s}),\mathbf{s}\right)\right) = (1-\beta)\left(\mathrm{W}(x,\mathbf{s}) - \mathrm{W}^{n}\left(\mathrm{w}(x,\mathbf{s}),\mathbf{s}\right)\right), \tag{FOC1}$$

$$\beta\left(\mathrm{J}(x^{\star},\mathbf{s}^{\star}) - \mathrm{J}^{n}\left(\mathrm{w}(x,\mathbf{s}),\mathbf{s}^{\star}\right)\right) = (1-\beta)\left(\mathrm{W}(x^{\star},\mathbf{s}^{\star}) - \mathrm{W}^{n}\left(\mathrm{w}(x,\mathbf{s}),\mathbf{s}^{\star}\right)\right). \tag{FOC2}$$

As a result, one can define the match surplus levels for problems (2.5) and (2.6) correspondingly as:

$$\mathrm{M}(x,\mathbf{s}) = \mathrm{J}(x,\mathbf{s}) - \mathrm{J}^{n}\left(\mathrm{w}(x,\mathbf{s}),\mathbf{s}\right) + \mathrm{W}(x,\mathbf{s}) - \mathrm{W}^{n}\left(\mathrm{w}(x,\mathbf{s}),\mathbf{s}\right), \tag{M1}$$

$$\mathrm{M}'(x^{\star},\mathbf{s}^{\star}) = \mathrm{J}(x^{\star},\mathbf{s}^{\star}) - \mathrm{J}^{n}\left(\mathrm{w}(x,\mathbf{s}),\mathbf{s}^{\star}\right) + \mathrm{W}(x^{\star},\mathbf{s}^{\star}) - \mathrm{W}^{n}\left(\mathrm{w}(x,\mathbf{s}),\mathbf{s}^{\star}\right). \tag{M2}$$

Let us now define the sum of the values during the notice period as $\mathrm{M}_n(\mathbf{s}) = \mathrm{J}^{n}\left(\mathrm{w}(x,\mathbf{s}),\mathbf{s}\right) + \mathrm{W}^{n}\left(\mathrm{w}(x,\mathbf{s}),\mathbf{s}\right)$. Importantly, $\mathrm{M}_n(\mathbf{s})$ is only a function of the aggregate state $\mathbf{s}$ and not of the wage level during the notice period. One can show this by summing together Equations (2.2) and (2.4) to obtain

$$r\,\mathrm{M}_n(\mathbf{s}) = x_{\min}p\left[\mathrm{f}(k(\mathbf{s})) - \rho k(\mathbf{s})\right] + \phi\left(\mathrm{U}(\mathbf{s}) - \mathrm{M}_n(\mathbf{s}) - Fp\mathrm{f}(k(\mathbf{s}))\right) + \tau E\left[\mathrm{M}_n(\mathbf{s}') - \mathrm{M}_n(\mathbf{s}) \mid \mathbf{s}\right]. \tag{2.7}$$

[6] The reason that these first order conditions maintain the standard form is that, as in the simple search and matching model, bargaining with or without termination notice is a transferable utility game for two agents with the same planning horizon. As such, the following statements hold: $\frac{\partial\,\mathrm{J}(x,\mathbf{s})}{\partial w} = -\frac{\partial\,\mathrm{W}(x,\mathbf{s})}{\partial w}$, and $\frac{\partial\left(\mathrm{J}(x,\mathbf{s}) - \mathrm{J}^{n}\left(\mathrm{w}(x,\mathbf{s}),\mathbf{s}\right)\right)}{\partial w} = -\frac{\partial\left(\mathrm{W}(x,\mathbf{s}) - \mathrm{W}^{n}\left(\mathrm{w}(x,\mathbf{s}),\mathbf{s}\right)\right)}{\partial w}$. These derivatives are rather complicated and cancel out immediately, so in the interest of clarity I omit them from the main text and relegate them to Appendix B.1.

Thus, given the aggregate state $\mathbf{s}$, the surplus level that corresponds to both problems is:

$$\mathrm{M}(x,\mathbf{s}) = \mathrm{M}'(x,\mathbf{s}) = \mathrm{J}(x,\mathbf{s}) + \mathrm{W}(x,\mathbf{s}) - \mathrm{M}_n(\mathbf{s}) . \tag{2.8}$$

Equation (2.8) can be interpreted to mean that regardless of the wage, or any other mandated transfer structure that would be mandated during the notice period from one side to the other, the separation choice depends only on the current state $(x,\mathbf{s})$ as long as the sum of the outside options remains unaffected.[7] Separation in the model would result when $\mathrm{M}(x,\mathbf{s}) < 0$. Thus, for each pair, separation maintains a Markov property by virtue of being independent of past realizations.

Furthermore, at the aggregate level, separations in the model do not depend on the wage distribution but only on the distribution of x and the aggregate state. Since time is continuous in this set-up, the aggregate wage distribution is composed only of the solutions to (2.5), as the wage that solves (2.6) would prevail for only an infinitesimal length of time before renegotiation according to (2.5) would occur. □

Match Surplus and The Reservation Level. The above bargaining problems illustrate that the key determinant of separations in the model is the match surplus $\mathrm{M}(x,\mathbf{s})$. I will show that for each aggregate state, there exists a minimal realization of x to which I refer as the reservation level, denoted by $\mathrm{R}(\mathbf{s})$ such that $\mathrm{M}(\mathrm{R}(\mathbf{s}),\mathbf{s}) = 0$. This means that a re-draw will result in separation in state $\mathbf{s}$ if and only if $x < \mathrm{R}(\mathbf{s})$.

After some tedious but straightforward algebra, one can derive the following expression for the surplus level:[8]

$$\begin{aligned}&(r+\lambda+\tau)(\mathrm{M}(x,\mathbf{s}) + \mathrm{M}_n(\mathbf{s})) = xp(\mathrm{f}(k(\mathbf{s})) - \rho k(\mathbf{s}))+ \\ &\lambda\left[\mathrm{M}_n(\mathbf{s}) + \int_{x_{\min}}^{x_{\max}} \max(\mathrm{M}(y,\mathbf{s}),0)\,\mathrm{dG}(y)\right] + \tau[E[\max\{\mathrm{M}(x,\mathbf{s}'),0\} + \mathrm{M}_n(\mathbf{s}') \mid \mathbf{s}]].\end{aligned} \tag{2.9}$$

Lemma 2.2.2. *If there is a level of x in state $\mathbf{s}$ such that, $\mathrm{M}(x,\mathbf{s})$ is positive, i.e., there is some production in state $\mathbf{s}$, then there exists a unique minimum level of x in state $\mathbf{s}$ for which the match continues to produce together. This level is defined here as the reservation level of efficiency units of labour $\mathrm{R}(\mathbf{s})$. The reservation level is the unique zero of $\mathrm{M}(x,\mathbf{s})$*

[7] Examples under which such is not the case, occur when the wage affects the size of the surplus itself, e.g., in the presence of distortionary taxes.

[8] See Appendix B.2 for an explicit step-by-step derivation of this equation.

at state $\mathbf{s}$*. Any realization of* x *below the reservation level will result in separation.*

For a formal proof, see Appendix B.3. The important part of the proof is that the function $\mathrm{M}(x, \mathbf{s})$ is monotonically increasing in x for each aggregate state. In the deterministic case where $\tau = 0$, the result is trivial with $\frac{\partial \mathrm{M}(x,\mathbf{s})}{\partial x} = p\frac{\mathrm{f}(k) - \rho k}{r+\lambda}$ resulting in strictly monotonically increasing surplus. The stochastic case is slightly more technically complex and is thus placed in the Appendix. A key feature to have in mind here is that the value function $\mathrm{M}(x, \mathbf{s})$, which is linear in the deterministic case, is piece-wise linear for each state $\mathbf{s}$ in the stochastic case. Suppose for the sake of example that there are two possible states denoted, 1 and 2, and that without loss of generality, $R(1) \geq R(2)$. One can then divide the support into three parts as follows: The simplest part is the interval$[\,\mathrm{R}(1)\,, x_{\max}]$ in which an aggregate shock results in continuing the production of the pair. Thus, the option value encapsulates the probability of continuing production under an alternative state. On the interval $[\,\mathrm{R}(2)\,, \mathrm{R}(1)\,)$, a producing pair that is transitioning from state 2 into state 1 will separate immediately. Thus, the option value now takes into account the probability that an aggregate shock will result in separation, thereby changing the slope of the value function compared with that in the previous interval. The last interval $[x_{\min}, \mathrm{R}(2)\,)$ has no producing realizations in it and the value function is negative in each state. Thus, if there are a possible states, the function $\mathrm{M}(x, \mathbf{s})$ is piece-wise linear with a break points and $a+1$ intervals. In each one of these intervals, the value function is linear with an exact slope that is described in Appendix B.3.

Job Creation. Firing restrictions will affect the hiring decision by changing the expected value of the resulting match. However, by design, the restrictions will only apply to existing matches and not to newly forming ones. At the point of meeting, the employee and the employer have as their outside options unemployment and a vacant job correspondingly, instead of the notice period that the continuing pair will face. As such, I now turn to the problem of the newly forming pair or the problem of the outsiders which is

$$\mathrm{w}_h\,(x, \mathbf{s}) = \arg\ \max\left(\mathrm{W}\,(x, \mathbf{s}) - \mathrm{U}\,(\mathbf{s})\right)^{\beta}\left(\mathrm{J}\,(x, \mathbf{s}) - \mathrm{V}\,(\mathbf{s})\right)^{1-\beta}, \tag{2.10}$$

where the wage of the newly hired worker will be $\mathrm{w}_h\,(x, \mathbf{s})$ with $\mathrm{U}\,(\mathbf{s})$ denoting the value from being unemployed and $\mathrm{V}\,(\mathbf{s})$ is the value of a vacancy.

Unlike the bargaining problems discussed earlier, the problem (2.10), is quite standard as the outside option for each side does not depend on the wage. In the literature, one sometimes encounters this type of outsider problem but with a firm value different from $\mathrm{J}(x, \mathbf{s})$, referred to, for example, as $\mathrm{J}^{\mathrm{h}}(x, \mathbf{s})$. This is done because the hiring wage is $\mathrm{w}_h(x, \mathbf{s})$ and not $\mathrm{w}(x, \mathbf{s})$. Importantly, at the moment after hiring is done, the wage will be renegotiated and the bargaining would result in the wage level $\mathrm{w}(x, \mathbf{s})$. Thus, $\mathrm{J}(x, \mathbf{s})$ and $\mathrm{J}^{\mathrm{h}}(x, \mathbf{s})$ are the expected values of two financial assets yielding identical expected dividend streams other than the divided at the first period. In a discrete-time model, this difference is meaningful and must be taken into account. However, in a continuous-time model, the difference in wages takes place only for an infinitesimal amount of time and $\mathrm{J}(x, \mathbf{s})$ and $\mathrm{J}^{\mathrm{h}}(x, \mathbf{s})$ are equal to one another as a single point-wise discontinuity does not alter the value of an integral. The same case can be made for the household.

As in the previous bargaining problems, this problem one can be analysed by examining the match surplus associated with (2.10) which is:

$$\mathrm{M}_h(x, \mathbf{s}) = \mathrm{J}(x, \mathbf{s}) + \mathrm{W}(x, \mathbf{s}) - \mathrm{U}(\mathbf{s}) - \mathrm{V}(\mathbf{s}). \tag{2.11}$$

As is standard in search and matching models, I assume free entry which means that $\mathrm{V}(\mathbf{s}) = 0$ for every state $\mathbf{s}$. Using this assumption and Equation (2.8) one can obtain the following relationship:

$$\mathrm{M}_h(x, \mathbf{s}) = \mathrm{M}(x, \mathbf{s}) + \mathrm{M}_n(\mathbf{s}) - \mathrm{U}(\mathbf{s}) . \tag{2.12}$$

Thus, the relationship between the surplus at hiring and the surplus in continuation is linear and depends upon the values of the gained notice period and forgone unemployment $\mathrm{M}_n(\mathbf{s}) - \mathrm{U}(\mathbf{s})$ which can be larger or smaller than zero given the model parameters.[9]

Importantly, since $\mathrm{M}_h(x, \mathbf{s})$ depends on x only via $\mathrm{M}(x, \mathbf{s})$, their derivatives with respect to x are equal. Thus, at each state $\mathbf{s}$, there is a unique zero for $\mathrm{M}_h(x, \mathbf{s})$. However given that $\mathrm{M}_n(\mathbf{s}) - \mathrm{U}(\mathbf{s})$ is not necessarily equal to zero, the solution to $\mathrm{M}_h(x, \mathbf{s}) = 0$ is probably different than $\mathrm{R}(\mathbf{s})$.

At this point, the assumptions regarding information play a key role. If it is assumed that x is known exactly at the meeting time, then the model has two reservation levels, one above which hiring occurs and one below which termination occurs. Three problems ensue according to this assumption: First, it is very unrealistic and unlikely that following an instant's interaction a pair will know the exact quality of their respective match as we

[9] For example, in the deterministic case where $\tau = 0$ with $x_{\min} = 0$ one obtains that $(r + \phi)\,\mathrm{M}_n(\mathbf{s}) = \phi(\mathrm{U}(\mathbf{s}) - Fp\mathrm{f}(k))$ which results in $\mathrm{M}_n(\mathbf{s}) < \mathrm{U}(\mathbf{s})$ because $Fp\mathrm{f}(k)$ is positive and ϕ is positive. One can then choose a higher value of $x_{\min}$ that would alter this result for some or all states.

are dealing with a single search pool. Second, a quantitative implication of having two reservation levels, which will be illustrated in detail when I discuss the calibration, is that the distribution of x among existing matches, and the wage distribution, as a result, will have a very distinct kink at the higher of the two reservation levels. This is an unrealistic feature for a wage distribution and any assumption that results in this feature is open to criticism as a result of this unrealistic implication. Third, on a technical level, the model becomes more difficult to deal with and it is harder to draw analytical conclusions. If it is assumed that no knowledge of x at the point of hiring exists, hiring is solely based upon expectations of x, which will be identical for every pair. This assumption is analytically appealing, but it has one very problematic feature. A large amount of newly hired workers will be fired on their first day as, in the absence of information, hiring will occur at $x < \mathrm{R}(\mathbf{s})$.

I choose a middle-way between these two extreme assumptions that is based on the following rationale. The no-information case is unlikely at the extreme since, in reality, firms do conduct interviews and have available some screening mechanism. Workers do some screening for job openings themselves, be it looking for information on-line or simply asking around about their potential employer. Such screening is naturally imperfect but allows admissible matches to form. I assume that the bilateral screening technology reveals to both sides whether or not their matching will be admissible in the current state of the world. Technically put, the information set at the time of the meeting is symmetric and binary. Both sides receive the same information from their screening technology, which is either $x < \mathrm{R}(\mathbf{s})$ in which case, they continue to search, or $x \geq \mathrm{R}(\mathbf{s})$ in which case they choose to form a match.[10]

I assume the standard Cobb-Douglas matching function $\mathrm{m}(u, v) = \sigma u^{\eta} v^{1-\eta}$ with $\theta = \frac{v}{u}$ denoting labour market tightness. Given the screening technology, a vacant job encounters a job seeker with rate $\mathrm{q}(\theta) = \frac{m}{v}$, and a job seeker encounters a vacant job with rate $\theta \mathrm{q}(\theta)$. The vacancy-filling rate is $\mathrm{q}(\theta(\mathbf{s}))(1 - \mathrm{G}(\mathrm{R}(\mathbf{s})))$, and the job-finding rate is $\theta(\mathbf{s})\ \mathrm{q}(\theta(\mathbf{s}))(1 - \mathrm{G}(\mathrm{R}(\mathbf{s})))$. By choosing $\theta(\mathbf{s})$ and $\mathrm{R}(\mathbf{s})$, the firm controls job creation and destruction at each state.

Value Functions During Search. Given the matching mechanism just described, I can now proceed to discuss the final two value functions, those of the searching firm and the

[10] I abstract from the problem of strategically choosing the cut-off value, which may result in some immediate separations in the economy as modelling formally the screening choice is beyond the scope of this analysis.

unemployed worker. I assume that the searching firm must have some amount of capital available and ready for the new worker to produce with in advance of the actual hiring. Thus search costs will be proportional to the cost of capital that would have been used in production. As such, the value from a job vacancy is given by

$$r\,\mathrm{V}(\mathbf{s}) = -pc\rho\,\mathrm{k}(\mathbf{s}) + \mathrm{q}(\theta(\mathbf{s}))\int_{\mathrm{R}(\mathbf{s})}^{x_{\max}} \mathrm{J}(y,\mathbf{s})\ \mathrm{dG}(y) \ + \tau E[\mathrm{V}(\mathbf{s}') - \mathrm{V}(\mathbf{s}) \mid \mathbf{s}], \tag{2.13}$$

where the searching firm pays the flow cost of search by renting a proportion cp of the capital rental cost that a single efficiency unit would require, given by $\rho\mathrm{k}(\mathbf{s})$, which it takes as a given, where p is the aggregate productivity parameter. The reason that I choose this cost structure is to capture the notion that a vacancy entails some amount of idle capital with an opportunity cost associated with it. With rate $\mathrm{q}(\theta(\mathbf{s}))\,(1 - \mathrm{G}(\mathrm{R}(\mathbf{s})))$, the vacant job is filled with an admissible worker and the pair can begin to produce.

The value function can be simplified by two ways. First, free entry means that $\mathrm{V}(\mathbf{s}) = 0$ in every state. Second, the value function $\mathrm{J}(x,\mathbf{s})$ is related to the hiring surplus. This relationship is given by the first-order condition of (2.10), together with the free entry condition is:

$$\beta\,\mathrm{J}(x,\mathbf{s}) - (1-\beta)(\mathrm{W}(x,\mathbf{s}) - \mathrm{U}(\mathbf{s})) = 0. \tag{2.14}$$

which means that $\mathrm{J}(x,\mathbf{s}) = (1-\beta)\,\mathrm{M}_h(x,\mathbf{s})$. Taken together with Equation (2.13), the job-creation condition is given by:

$$cp\rho\,\mathrm{k}(\mathbf{s}) = \mathrm{q}(\theta(\mathbf{s}))\,(1-\beta)\int_{\mathrm{R}(\mathbf{s})}^{x_{\max}} \mathrm{M}_h(y,\mathbf{s})\ \mathrm{dG}(y)\ . \tag{2.15}$$

The value from being in a state of unemployment is given by

$$r\,\mathrm{U}(\mathbf{s}) = z + \theta(\mathbf{s})\ \mathrm{q}(\theta(\mathbf{s}))\int_{\mathrm{R}(\mathbf{s})}^{x_{\max}} [\mathrm{W}(y,\mathbf{s}) - \mathrm{U}(\mathbf{s})]\,\mathrm{dG}(y) \ + + \tau E(\mathrm{U}(\mathbf{s}') - \mathrm{U}(\mathbf{s}) \mid \mathbf{s}),$$

where z is the flow value of being unemployed. Using Equation (2.14), which implies that $\mathrm{W}(x,\mathbf{s}) - \mathrm{U}(\mathbf{s}) = \beta\,\mathrm{M}_h(x,\mathbf{s})$ one finally obtains:

$$\begin{aligned} r\,\mathrm{U}(\mathbf{s}) &= z \\ &+ \theta(\mathbf{s})\ \mathrm{q}(\theta(\mathbf{s}))\ \beta\int_{\mathrm{R}(\mathbf{s})}^{x_{\max}} \mathrm{M}_h(y,\mathbf{s})\ \mathrm{dG}(y) \ + \tau E(\mathrm{U}(\mathbf{s}') - \mathrm{U}(\mathbf{s}) \mid \mathbf{s}) \end{aligned} \tag{2.16}$$

The model solution can be completely characterized by solving the system of equations that is composed of (2.7), (2.9), (2.11), (2.15), and (2.16). Numerically speaking, the integral expression can be solved using integration by parts, which will be discussed in Section 2.2.3.

2.2.2 Aggregation

Population Composition. The population size is normalized to unity and is composed of three groups: unemployed persons u, employed persons e, and those employed under termination notice n, where $u + e + n = 1$. Given the previously described mechanisms for hiring and terminations, aggregate termination will depend on the distribution of x across the productive realizations. This distribution, which will be denoted by $\mathrm{H}(x)$, has the following law of motion:

$$\begin{aligned}
\mathrm{H}_{t+1}(x)\, e_{t+1} &= e_t(\mathrm{H}_t(x) - \mathrm{H}_t(R_{t+1})) + \theta_{t+1}\,\mathrm{q}(\theta_{t+1})\, u_t(\mathrm{G}(x) - \mathrm{G}(R_{t+1})) \\
&+ \lambda e_t[(1 - \mathrm{H}_t(x))(\mathrm{G}(x) - \mathrm{G}(R_{t+1})) - (\mathrm{H}_t(x) - \mathrm{H}_t(R_{t+1}))(1 - \mathrm{G}(x))] \\
&- \lambda e_t(\mathrm{H}_t(x) - \mathrm{H}_t(R_{t+1}))\,\mathrm{G}(R_{t+1}), \qquad (2.17)
\end{aligned}$$

where t and $t+1$ denote time. I shift momentarily into discrete-time notation as it can help clarify the non-linear dynamics of the model. The first term in the right-hand side relates to the immediate outflow from employment into termination notice that results when the reservation level increases. Note that when the reservation level remains unchanged or decreases we have that $\mathrm{H}_t(R_{t+1}) = 0$ since there were no producing realizations below R_{t+1} during period t. If the reservation level were to increase, a positive amount of separations of mass $e_t\mathrm{H}_t(R_{t+1}) > 0$ would occur. The second expression represents inflow into employment at x or below it. The last three terms represent changes in the distribution from idiosyncratic shocks that result in, lowering x, increasing x, or separation of active matches respectively.

Together with this law of motion, the population dynamics in the model can be characterized by the following laws of motion for the three masses:

$$u_{t+1} = u_t - \theta_{t+1}\,\mathrm{q}(\theta_{t+1})\,(1 - \mathrm{G}(R_{t+1}))u_t + \phi n_t, \qquad (2.18)$$

$$\begin{aligned}
e_{t+1} &= e_t + \theta_{t+1}\,\mathrm{q}(\theta_{t+1})\,(1 - \mathrm{G}(R_{t+1}))u_t \\
&- [\lambda\,\mathrm{G}(R_{t+1})\,(1 - \mathrm{H}_t(R_{t+1})) + \mathrm{H}_t(R_{t+1})]e_t, \qquad (2.19)
\end{aligned}$$

$$n_{t+1} = n_t - \phi n_t + [\lambda\,\mathrm{G}(R_{t+1})\,(1 - \mathrm{H}_t(R_{t+1})) + \mathrm{H}_t(R_{t+1})]e_t. \qquad (2.20)$$

Population Composition in The Deterministic Model. I find that it is useful, for the sake of the discussion that follows, to observe the deterministic steady-state values for the masses and for the distribution $\mathrm{H}(x)$. The deterministic steady-state population masses are:

$$u = \frac{\phi\lambda\,\mathrm{G}(R)}{\theta\,\mathrm{q}(\theta)\,(1 - \mathrm{G}(R))(\phi + \lambda\,\mathrm{G}(R)) + \phi\lambda\,\mathrm{G}(R)},$$
$$e = \frac{\phi\theta\,\mathrm{q}(\theta)\,(1 - \mathrm{G}(R))}{\theta\,\mathrm{q}(\theta)\,(1 - \mathrm{G}(R))(\phi + \lambda\,\mathrm{G}(R)) + \phi\lambda\,\mathrm{G}(R)},$$
$$n = \frac{\lambda\,\mathrm{G}(R)\,\theta\,\mathrm{q}(\theta)\,(1 - \mathrm{G}(R))}{\theta\,\mathrm{q}(\theta)\,(1 - \mathrm{G}(R))(\phi + \lambda\,\mathrm{G}(R)) + \phi\lambda\,\mathrm{G}(R)}.$$

For the distribution, one can use Equation (2.17) to obtain that

$$\mathrm{H}(x) = \left[\frac{u}{e\lambda}\theta\,\mathrm{q}(\theta) + 1\right](\mathrm{G}(x) - \mathrm{G}(R)),$$

and by substituting in to the above expressions the values for the steady-state masses we obtain

$$\mathrm{H}(x) = \frac{\mathrm{G}(x) - \mathrm{G}(R)}{1 - \mathrm{G}(R)}. \tag{2.21}$$

Viewed from the perspective of R as the cut-off level for the screening technology, this is simply Bayes' rule applied to $\mathrm{G}(x)$, i.e., the deterministic steady-state of $\mathrm{H}(x)$ consists of all the possible realizations of $\mathrm{G}(x)$ conditional upon them being admissible ones. In the stochastic case, this stylized result slightly breaks down because one is dealing with long-term expectations. As a result of the fact that there are several levels of R, one for each aggregate state, leading to some discontinuities in the long-term expectations for this distribution. However, the deterministic case is instructive for understanding the relationship between R and $\mathrm{H}(x)$. The reservation level $R(\mathbf{s})$ is the realized lower bound of $\mathrm{H}(x)$ in state $\mathbf{s}$, and it affects the density of productive realizations at each value of x. The higher the value of R is, the greater is the density concentrated at each level of x above R.

Aggregate Quantities. Aggregate output Y is given by:

$$Y = p\,\mathrm{f}(k)\left[e\int_R^{x_{\max}} x\,\mathrm{d}\,\mathrm{H}(x) + n x_{\min}\right] - Fp\,\mathrm{f}(k)\,\phi n, \tag{2.22}$$

where k, as previously, denotes the level of capital chosen at the efficiency unit level, $p\mathrm{f}(k)$ is then production per efficiency unit of labour, and $e\int_R^{x_{\max}} x \,\mathrm{d}\,\mathrm{H}(x) \quad + x_{\min} n$ is the aggregate amount of such units. The last term is the output-loss cost associated with the final termination of employment relationship at the end of the notice period. The cost $Fp\,\mathrm{f}(k)$ is paid for the outflow of terminated employees, which is ϕn.[11] Although I omit time and state notation this expression is true globally. Importantly, the level of output depends not only upon the capital choice and the aggregate labour input used in production $L = e + n$, but upon the current composition of L, via the sizes of e and n, the distribution $\mathrm{H}(x)$, and the adjustment cost parameter F. Economically speaking, output in this economy depends upon the quantity e and the quality $\mathrm{H}(x)$ of actively producing matches, upon the number of matches under termination notice n, their production value and the cost of their termination.

However, it is more convenient to examine output using the following expression

$$Y = p\,\mathrm{f}(k) \left[e\int_R^{x_{\max}} x \,\mathrm{d}\,\mathrm{H}(x) \quad + n(x_{\min} - F\phi) \right],$$

from which I can define the effective distribution of efficiency units in the economy as:

$$\mathrm{H}_E(x) = \begin{cases} \frac{e}{n+e}\,\mathrm{H}(x) & \text{if} \quad R \leq x \leq x_{\max} \\ \frac{n}{n+e} & \text{if} \quad x = x_{\min} - F\phi \end{cases}. \tag{2.23}$$

This equation means that one can interpret the composition of aggregate labour L as having an efficiency units distribution $\mathrm{H}_E(x)$. This distribution has an atomistic mass that depends on the number of workers under notice out of the aggregate labour $\frac{n}{n+e}$ at $x = x_{\min} - F\phi$ efficiency units which is lower than $x_{\min}$ as a result of the termination costs leading to output loss.

Along the same line, one can define the aggregate effective capital as the sum of capital over all effective producing efficiency units which is

$$K_E = k\left[e\int_R^{x_{\max}} x \,\mathrm{d}\,\mathrm{H}(x) \quad + n(x_{\min} - F\phi) \right]. \tag{2.24}$$

Aggregate Production. With the previous notations at hand, let us examine the aggregate production function in the economy. Let $\overline{x_E}$ be the mean of the efficiency-unit

[11] These costs can alternatively be defined as associated with the inflow into notice and the results that follow remain unaltered in any significant way.

distribution $\mathrm{H}_E(x)$, then using Equation (2.23) I obtain

$$\overline{x_E} = \left[\frac{e}{n+e}\int_R^{x_{\max}} x \,\mathrm{d}\,\mathrm{H}(x) \quad + \frac{n}{n+e}(x_{\min} - F\phi)\right]. \tag{2.25}$$

Equation (2.25) can be used to further simplify Equation (2.24) as $K_E = k\overline{x_E}L$, and Equation (2.22) can be reduced to $Y = p\,\mathrm{f}\left(\frac{K_E}{\overline{x_E}L}\right) L\overline{x_E}$. Finally, by utilizing the homogeneity of degree α

$$Y = p\overline{x_E}^{1-\alpha} K_E{}^{\alpha} L^{1-\alpha}, \tag{2.26}$$

this expression omits the time and state dependence of $\overline{x_E}$ and of the factors for brevity but holds globally.

2.2.3 Calibration

In this section, I calibrate the model to perform a quantitative exercise whose goal is to illustrate the potential effects of firing restrictions on business cycle dynamics. I calibrate the model's deterministic steady state from Section 2.2.1 to match job flows and institutional parameters in France. My reason for choosing France is mainly one of data availability. This calibration and simulation exercise should not be viewed as an attempt to capture the complexity of France's labour market and its institutions but rather to outline the cyclical implications of firing restrictions. In the next section, I use the calibrated model and counterfactual institutional structures to demonstrate the propagation of an exogenous shock in the simulated economy and explore the relative importance of the different channels.

Calibration Targets. The model is calibrated to match France's quarterly job-finding rate of 20% and separation hazard of 3.4% based on a transformation into quarterly frequencies of the estimates of these rates from Hobijn and Sahin (2009). As in Shimer (2005), the steady-state value of θ is normalized to unity and σ, the matching efficiency parameter, is calibrated to match the finding rate. The calibration of firing restrictions is based on Bentolila et al. (2012), that place the replacement rate at 55%. Since the model features wage heterogeneity, z is calibrated to be 55% from the average wage in the model economy under a deterministic steady state. Similarly, also following Bentolila et al. (2012), F, the firing costs parameter is calibrated to 33% of the average quarterly output of a job.[12] These

[12] The comparison between my set-up and that of Bentolila et al. (2012) is challenging because the authors normalize the maximum production value to unity and assume that a new job produces the maximum

two hazards, two ratios and one normalization, are my calibration targets, and these are matched exactly by choosing the values of λ, σ, F, z and c.

Directly Calibrated Parameters. To complete the institutional set-up I build on Bentolila et al. (2012) and calibrate $\phi = 0.75$ which corresponds to four months. As in Bentolila et al. (2012), the discount factor is set to $r = 0.01$, the bargaining power is $\beta = 0.5$, and $\eta = 0.5$. I normalize the common productivity factor p to yield that $p(\mathrm{f}(k) - \rho k) = 1$, and set the capital share at $\alpha = 0.33$ so that $\mathrm{f}(k) = k^{0.33}$. I calibrate the depreciation rate of capital to $\delta = 0.02$, and the steady-state risk premium to $\xi = 0$. During the simulation I will choose a mean zero process for ξ.

Calibration Strategy for $\mathrm{G}(x)$. The calibration of $\mathrm{G}(x)$ is of great importance for the cyclical behaviour of the model as it dictates the nature of the option value at each state for every job. However, this calibration also presents a conceptual challenge. How does one observe $\mathrm{G}(x)$? The model structure imposes that only sufficiently high realisations are present in the data, i.e., one can only observe the realised distribution $\mathrm{H}(x)$ and not the model primitive $\mathrm{G}(x)$. To add to this challenge, the only manifestation of $\mathrm{H}(x)$ that can be empirically observed in the data is the earning distribution. In Appendix B.4, I show that the wage is linearly dependent in x. Therefore the earning distribution $\mathrm{D}(w)$, can be related to $\mathrm{H}(x)$ by applying a simple linear transformation whose values correspond to the model parameters. This approach is highly data-intensive as the entire earning distribution is necessary for its implementation, and it does not solve the truncation problem. By looking at the deterministic steady-state value of $\mathrm{H}(x)$, I can see that there is a range of realisations and their corresponding densities, both of which I would never be able to observe in the data. Specifically, how can one assume the structure of realisations that are possible in principle but would never manifest in reality? The lowest possible realization of $\mathrm{G}(x)$ is unknown, along with all the values and densities of x on the interval $[\, x_{\min}, R\,)$.

To overcome these conceptual challenges, I take the following approach to calibrating $\mathrm{G}(x)$. First, in the absence of a better prior, I set $x_{\min} = 0$ which seems natural and is equivalent to the assumption that the worst worker possible is the one that produces nothing. Second, I follow the work of Lagos (2006) by assuming that $\mathrm{G}(x)$ takes a type I Pareto form with CDF:[13]

amount possible. Thus, choosing the same ratio of 33% is conservative, as the average job in Bentolila et al. (2012) produces less than unity, and the actual ratio in the model is somewhat higher.

[13]On a purely technical level, to reconcile the above two statements, namely $x_{\min} = 0$ and a distribution

$$\mathrm{G}(x) = 1 - \left(\frac{\zeta}{x}\right)^{\gamma}. \tag{2.27}$$

The reasons for assuming a type I Pareto distribution are twofold. First, this form effectively solves the truncation problem. Truncating $\mathrm{G}(x)$ at R, by using the closed-form solution for $\mathrm{H}(x)$ given in Equation (2.21) I obtain that:

$$\mathrm{H}(x) = \frac{\mathrm{G}(x) - \mathrm{G}(R)}{1 - \mathrm{G}(R)} = \frac{\left(\frac{\zeta}{R}\right)^{\gamma} - \left(\frac{\zeta}{x}\right)^{\gamma}}{\left(\frac{\zeta}{R}\right)^{\gamma}} = 1 - \left(\frac{R}{x}\right)^{\gamma}, \tag{2.28}$$

which makes $\mathrm{H}(x)$ also into a type I Pareto, with R as a scale parameter and with the same tail index γ. Second, and as a direct result of this, the wage distribution in the model will be, a linear mapping of $\mathrm{H}(x)$, thus making the earnings distribution implied by the model into a skewed distribution with a power-law in the right tail and a tail index of γ. Not only is a skewed earnings distribution a realistic outcome to consider but the entire distribution can be inferred from γ, the previously mentioned parameters and the steady-state value of R.

Thus, the last piece of the challenge of calibrating $\mathrm{G}(x)$ is finding the value of γ. Since γ is the tail index of a type I Pareto distribution, it bears a direct connection to the earnings distribution's Gini coefficient. A type I Pareto distribution has a Gini coefficient of $Gini(\mathrm{H}) = (2\gamma - 1)^{-1}$, where γ is the tail index.[14] Therefore, I target the Gini coefficient for the distribution of earnings before transfers in France. The average Gini coefficient for the income distribution of the working age population in France before taxes and transfers for 2012 - 2017 is 0.452.[15] As a result, I arrive at a tail index of $\gamma = 1.61$.

One complication that arises from this approach is comparing the empirical distribution that gave rise to the observed Gini coefficient and the model distribution. The wage distribution in Appendix B.4 relates to the wage distribution of the actively producing realisations, while the Gini coefficient captures both producing realisations and workers under termination

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that has a minimal realisation of ζ, I substitute x in all the equations in the computations to be $x - \zeta$ as to yield a minimum level of $x_{\min} = 0$ and a distribution that follows a type I Pareto.

[14] For a comprehensive treatment of inequality measures and generalized Pareto distributions see Arnold (2008).

[15] The Gini data is taken from the OECD database at `https://stats.oecd.org/`. The OECD's database changes the income definition after 2011 for these measurements. As a result I choose only years following 2011 to not mix income definitions. The value exhibits only small changes from year to year, and the choice of the time-frame will not change the results meaningfully.

notice. Reconciling the discrepancy between the model object and the empirically observed one can done by examining the model counterpart of the empirical distribution. The Markov property for separations given in Lemma 2.2.1 means that separations are independent of current realization of the wage so the wage distribution under notice $\mathrm{D}^{n}(w)$ is identical to the distribution among productive pairs $\mathrm{D}^{e}(w)$. The distribution of wages for workers under notice evolves according to

$$n_{t+1}\,\mathrm{D}^{n}_{t+1}(w) = \mathrm{D}^{n}_{t}(w)\,n_t - \phi n_t\,\mathrm{D}^{n}_{t}(w) + \lambda\,\mathrm{G}(R_t)\,[\mathrm{D}^{e}_{t}(w) - \mathrm{D}^{e}_{t}(\mathrm{w}(R_t))]e_t + \mathrm{D}^{e}_{t}(\mathrm{w}(R_t))\,e_t,$$

where this is the exact law of motion for the mass n, but this time we keep track of the wage level from which entry and exit occur. In a deterministic steady state this equation reduces to $\mathrm{D}^{n}(w) = \frac{\lambda\,\mathrm{G}(R)}{\phi}\frac{e}{n}\,\mathrm{D}^{e}(w)$, which after substituting in the steady-state masses yields $\mathrm{D}^{e}(w) = \mathrm{D}^{n}(w) = \mathrm{D}(w)$.

The last two elements of $\mathrm{G}(x)$ to be considered are the values for ζ, and for $x_{\max}$. The parameter ζ is a scale parameter for x since all other calibrated targets will be either flows and hazards or ratios of the average wage or production value, I have some latitude with this parameter, and so I normalise it to $\zeta = 1$, all other parameters will be calibrated to match that scale of the distribution. Note that I could achieve all the calibration targets listed in the next paragraph with an altered scale. The reason I need a value for $x_{\max}$ is to provide an upper support for the simulation exercise to apply integration by parts, so given the Pareto structure of Equation (2.27) I simply choose $x_{\max}$ such that $\mathrm{G}(x_{\max}) = 0.999$.

2.3 Results

2.3.1 The Calibration

As described above, I directly calibrate $\phi, \eta, \beta, p, \delta, r, \alpha, \gamma, \zeta, x_{\min},$, and $x_{\max}$. By using the aforementioned parameter values along with Equation (2.7), (2.9) , (2.15), and (2.16) while substituting in to it the definition of $\mathrm{M}_h(x)$ from Equation (2.11). Since I am calibrating the deterministic steady state, $\tau = 0$, and the match surplus is a linear function of x. Thus, I can use integration by parts and instead of Equation (2.9), I use the following two equations:

$$(r+\lambda)(\mathrm{M}(x_{\max}) + M_n) =$$
$$x_{\max} p(\mathrm{f}(k) - \rho k) + \lambda \left[M_n + \mathrm{M}(x_{\max}) - \frac{\partial \mathrm{M}(x)}{\partial x} \int_R^{x_{\max}} \mathrm{G}(y)\, \mathrm{d}y \right], \tag{2.29}$$
$$\mathrm{M}(x_{\max}) + (R - x_{\max}) \frac{\partial \mathrm{M}(x)}{\partial x} = 0, \tag{2.30}$$

where the last equation follows from the definition of the reservation level as the zero of the match surplus and from the linearity of the deterministic case. The same form of integration by parts is used for the integral expressions in Equation (2.15), and (2.16) where the integral expression becomes

$$\int_R^{x_{\max}} \mathrm{M}_h(y)\, \mathrm{dG}(y) = \mathrm{M}(x_{\max}) + (M_n - U)(1 - \mathrm{G}(R)) - \frac{\partial \mathrm{M}(x)}{\partial x} \int_R^{x_{\max}} \mathrm{G}(y)\, \mathrm{d}y \ .$$

Thus, the model solution is given by a system of five equations in the five unknowns $R, \theta, \mathrm{M}, \mathrm{M_n}$ and U.

This solution to this system of five equations in five unknowns gives values for the rest of the parameters. The calibration is given in full in column 1 of Table 3. A surprisingly good outcome in the resulting calibration is the wage dispersion which is a non-targeted moment. To target wage dispersion, the calibration of $\mathrm{G}(x)$ is insufficient as the other parameters, namely $\beta, p, \alpha, \delta, \lambda, F$, and r will directly affect the slope and the intercept of the linear mapping from $\mathrm{G}(x)$ into the wage distribution. If the intercept were too large relative to the slope, variation in x one would obtain insufficient wage dispersion, too small, and one would obtain too much wage dispersion. Moreover, indirectly, all the other parameters will influence this as the intercept of this map is a function of the steady-state value of R.

According to Eurostat data on earnings for full-time workers in France for 2014, the earnings between the 90th and 10th percentiles is 2.85.[16] The calibrated model delivers a corresponding ratio of 2.70. This number is exceptionally good for this type of model, especially given the critique of wage dispersion in this class of models by Hornstein et al. (2011). I attribute the high wage dispersion in the model to the relatively rich modelling of labour market rigidities and the use of a Pareto distribution. These allow the calibration

[16]This number is based on data retrieved from Eurostat at `https://ec.europa.eu/eurostat/web/labour-market/earnings/database`, for France regarding the 10th and 90th percentiles of the monthly earnings distribution for full-time workers.

strategy to deliver a technical improvement to the quantitative characteristics of this class of search models. However, I will later demonstrate that this result is sensitive to the choice of the other parameters.

2.3.2 Simulation

In this section I introduce aggregate uncertainty to the model via an increase in the risk premium ξ and explore quantitatively the effects of firing restrictions on the dynamics of the business cycle. I choose a simple stochastic process with two states as follows:

$$\xi = \begin{bmatrix} -0.1r \\ +0.1r \end{bmatrix}, \Pi = \begin{bmatrix} 0.95 & 0.05 \\ 0.05 & 0.95 \end{bmatrix}, \quad \tau = 1. \tag{2.31}$$

This process describes an economy having two possible aggregate states. A good state in which households are willing to rent capital more cheaply at a rate of $0.9r + \delta$, and a bad state in which households require a larger premium on forgoing current consumption and rent capital at a rate of $1.1r + \delta$. I use a persistent shock because the model, like other models of this kind, lacks internal propagation as the controls R and θ will respond immediately to a change in the aggregate state.

To isolate the role of each component in the policy set, I simulate four sets of impulse responses, all of which illustrate the convergence of the model economy from being in a bad state, state 2, to its long-term expectations. The first set of impulse responses is for the baseline calibration I described above and is given in column 1 of Table 3. The last three are counter-factual calibrations having only firing costs, only termination notice or no firing restrictions at all. To eliminate the firing costs I set $F = 0$, and to eliminate the termination notice I calibrate ϕ to correspond to an average duration, $\frac{1}{\phi}$, of one working day per quarter which for France is $\phi = 251/4$. These counter-factual calibrations are given in columns 2, 3, and 4 of Table 3.[17]

Numerically speaking, given the significant non-linearity of the model, I exploit the property of piece-wise linearity of the value function $\mathrm{M}(x, \mathbf{s})$ for each state $\mathbf{s}$ and use integration by parts at each linear segment of the function. Thus, as the calibration was done using a system of five equations, the stochastic case consists of a system of five equations per aggregate state.

[17] Working with these high hazard rates necessitates simulating very short periods. Thus, I use as a unit of time periods that correspond to 0.01 of a working quarter, i.e., for 62.75 working days a quarter and eight working hours per working day, a period of about five hours.

2.3.3 Significance of Firing Restrictions for Business Cycle Dynamics

The impulse responses to a temporary increase in ξ for the baseline calibration and the three counter-factual ones described in Table 3 are depicted in Figure 16. The baseline calibration is presented in black, the counter-factual case with only termination notice in blue, the one with only firing costs in red, and the one without firing restrictions at all in green. An increase in the risk premium generates a business cycle as it generates an increase in capital cost and reduces firm profitability. The impulse responses suggest that regardless of the calibration used, the shock results in a drop in output and employment and a rise in unemployment as one would expect in a business cycle. The cycle is characterized by firms becoming increasingly selective in their hiring practices, i.e., R increases, and hiring intensity declines as the market becomes less tight, i.e., θ declines.

2.4 Discussion

2.4.1 The Model Framework and Its Implications for Aggregate Cyclical Behaviour

The model is a partial equilibrium model in which firms optimally choose capital and hire labour in a heavily frictional environment. Some of these frictions are natural and some institutional. Search frictions are a natural feature of the labour market as there is an inherent need for time and information to search for labour. High-quality institutions and infrastructure may alleviate some of the costs and challenges associated with the search for labour, but the essential need for search is natural and unavoidable. However, institutional frictions arise directly from the institutional set-up in place and can be altered by policy-makers.

Firing restrictions are a particular instance of these institutional frictions. Termination notice and red-tape costs associated with firing lead to reduced productivity and may interact with the business cycle in a fashion that amplifies its effects. In what follows, I illustrate these statements using the model's framework.

Productivity in The Model. At first glance, Equation (2.26) seems to be the classical Cobb-Douglas production function with the productivity process given by $p\overline{x_E}^{1-\alpha}$. The parameter p is a match-level exogenous productivity parameter. However, $\overline{x_E}^{1-\alpha}$ is endogenous as it arises from the model fundamentals and can be interpreted in several ways. One interpretation is that it is a labour-augmenting technology process. This expression is a part of the productivity process linked to the labour input and arises directly from the quality of the workers that compose L, the aggregate labour in the economy. However, this is not a growth model, and if one considers the fact that $p\overline{x_E}^{1-\alpha}$ is time-dependent, one would see that it has a stationary behaviour that is given by model parameters. Thus, this interpretation, though appealing, provides little insights.

What is $\overline{x_E}$? The value of x at the match level is proportional to the marginal product of labour. The marginal product of one worker in the economy is $xp\,\mathrm{f}(k)$, the match-level output. Viewed through the lens of the seminal works of Restuccia and Rogerson (2008) and Hsieh and Klenow (2009), the dispersion of x can be interpreted as factor misallocation, i.e., dispersion in the marginal products of factors of production across firms and establishments, namely that of labour. Therefore, using the growth accounting interpretation of Equation (2.26) results in:

$$\hat{Y} = \underbrace{\hat{p}}_{\text{Technology}} + \underbrace{(1-\alpha)\hat{x}_E}_{\text{labour misallocation}} + \underbrace{(1-\alpha)\hat{L} + \alpha\hat{K}_E}_{\text{Factor quantities}}, \tag{2.32}$$

where $\hat{Y}$ denote the log change from steady-state levels. This endogenous and time-varying TFP which results from misallocation is analogous to the aggregation result in Moll (2014), but there the source of frictions is situated in the capital market and not the labour market.

Conceptual Framework - Under-Utilization vs Misallocation. If the simplistic Solow-residual approach to measuring TFP changes is adopted, the results would differ from the TFP term $p\overline{x_E}^{1-\alpha}$ due to the difference between aggregate capital and aggregate effective capital. This sensitivity to capital utilization is a known problem of such measurements that more sophisticated measurement techniques are trying to deal with, e.g., Basu et al. (2006). One could argue that there should be an adjustment in this model for under-utilization of labour that comes from the termination notice mechanism. Thus, one could claim that the expression for TFP is also not utilization adjusted and that the second term in Equation (2.32) should be further broken down into a labour under-utilization term and a labour misallocation term. I argue that this is not the case and that the distinction arises from a fundamental conceptual difference.

Under-utilization implies choice. The firm can make better use out of its factors of production and chooses as an endogenous choice arising from internal costs or constraints not to do so. The firm could have some option value from this under-utilized capital, keeping the capacity for a future increase in utilization if the conditions merit such a change in optimal behaviour. Misallocation, however, is a deviation from the first-best allocation that arises from market conditions. If a benevolent social planner could re-allocate the worker from a state of notice to a state of employment or from a state of unemployment to a state of employment, the planner would do so to increase welfare. However, the frictions prevent the market from achieving this result on its own. This distinction is the reason I interpret $\overline{x_E}$ as a misallocation term.

This aggregation result can prove useful for future research focused on comparing productivity and growth across countries and sectors of the economy. Equation (2.32) and Equation (2.25) can be combined in decomposition exercises aimed at constructing TFP series for international comparisons of productivity which take into account differences in the institutional set-up across different countries and sectors.

Steady-State TFP. I begin my examination of steady-state TFP by understanding the simplified economy with no firing restrictions at all. In that economy $F = 0$ and $\phi \to \infty$; thus we simply have $L = e$, and $n = 0$. The mean of $\mathrm{H}(x)$ is defined as $\overline{x} = \int_R^{x_{\max}} x \, \mathrm{d}\,\mathrm{H}(x)$, one obtains that $\overline{x_E} = \overline{x}$ or that $\overline{x_E}$ is proportional to the average of the marginal products of labour. I call this limited case a flexible economy, and the general case a restricted economy. Comparing the value of $\overline{x_E}$ in the two cases yields that:

$$\overline{x_E}^{\text{restricted}} = \frac{e}{n+e}\overline{x}^{\text{restricted}} + \frac{n}{n+e}\left(x_{\min} - \frac{F\phi}{p\,\mathrm{f}(k)}\right) < \overline{x}^{\text{flexible}} = \overline{x_E}^{\text{flexible}} .$$

If one supposes that $\overline{x}$ is the same for both cases, this is a trivial result as $\overline{x} > x_{\min}$. The insight which strengthens this result is that $\overline{x}^{\text{restricted}} < \overline{x}^{\text{flexible}}$, why is that? The introduction of firing restrictions to the economy does not change the production value of a job, but it does change the outside option. When separation is costly, the outside option is worse, and the match surplus increases for each level of x. Thus, firing restrictions lower the reservation level, which is the lowest admissible realization of x. The decrease of $\overline{x}$ is the key result of Lagos (2006),[18] so I do not treat it formally in this chapter as the focus is on the cyclical element of misallocation. However, this similarity between the two models merits a short discussion of the relationship between them.

[18] See Theorem 2 in Lagos (2006).

The approach presented in my model owes much to Lagos' work, and the main result in Lagos (2006), the dependence of steady-state productivity in the institutions in place via their effects on the reservation level is preserved in my model, but there are several key differences. First, I view this model as a generalization of Lagos (2006) that allows for some additional elements, namely endogenous capital choice at the job level, aggregate stochastic shocks and, allow for policies under which the surplus for the hiring and firing decisions is not the same.[19] Second, I consider slightly different policies and the interpretation of lay-off costs is that of output loss and not the pecuniary cost. These choices affect the aggregation results.

In Lagos' model, the only way policies affect productivity is by changing the reservation level. In my model, this channel is present, but it is not the only one, and later I will also show that this is not the quantitatively dominant one for cyclical implications. In my case, firing restrictions lead to an output loss even given the same reservation level, and the notice mechanism causes a further decline in aggregate productivity.

Implications For Cyclical Behaviour. If one considers a recession as a decline in the aggregate productivity parameter p, or as an increase in the price of capital ρ via the risk premium ξ, the result is that a recession is a period during which the marginal product of labour $xp\,\mathrm{f}(k)$ is reduced. As such, the match surplus for a given level of x decreases and the reservation level would increase as a result. As this is the lowest level possible for a producing realisation, the economy with no firing restrictions would see an increase in $\overline{x}$. Thus, generating a 'cleansing effect' of the business cycle through an increase in the quality of labour which would manifest empirically as rising TFP. However, an increase in the reservation leads to more separations, thus decreasing the proportion of the actively producing pairs $\frac{e}{n+e}$ and later inducing output loss at the time of final separation. In the presence of firing restrictions, these factors can counteract the 'cleansing effect' and even potentially induce a 'sullying effect', the extent of which will be analysed when I discuss the implications of the quantitative exercise.

Several key insights from the model to bear in mind for the remainder of the analysis are as follows. First, policies affect aggregate productivity in the model via three channels, (i)

[19] This simplifying assumption in Lagos (2006) is discussed at some length in an appendix and not in paper. The argument that Lagos presents for why this limitation is not a major one in his set-up is that he mainly considers lay-off taxes and hiring subsidies, for which this limitation is not necessarily problematic (see footnote no. 50 in Lagos (2006) appendix). Under my institutional set-up, this argument is no longer relevant because of the existence of termination notice and output-loss costs.

by affecting the population composition, (ii) by affecting the reservation level, and (iii) by affecting the scope of output loss caused by separations. Second, as a result of these channels, any cyclical adjustment in the model induces an effect on the cross-sectional distribution of x and thus influences aggregate productivity.

2.4.2 Implications of the Quantitative Exercise

As I have illustrated above, this business cycle triggers the three channels of influence for the amount of misallocation that determines TFP in the economy. As firms become more selective, reservation levels increase which should increase $\overline{x}$ and lead to a TFP increase. Observe the green line in Figure 16 to see only this channel at play. Since H is a skewed distribution, its mean value is relatively unaffected by the small change at the left side of the support, and the increase in TFP is barely noticeable. If firing costs were added to the mix, as in the case of the red line in Figure 16, output would further decline more over the cycle but productivity hardly be affected. The big effect takes place once termination notice is introduced. Termination notice causes TFP to decline visibly over the cycle, as is seen by the drop in TFP in the blue line. Once the two channels are working in tandem, and termination notice is combined with firing costs this effect is further amplified.

Shimer's Puzzle in the Model. There are two immediate criticisms of the above described simulation exercise. First is that the risk premium shock I have introduced is a rather strong one, with an output decline of over 1.5%, but the labour market effects are rather small other than for the baseline. The rise in unemployment is barely perceptible other than in the baseline case, and even there, it is not a very strong one, and the same goes for the employment drop. Second is that the main channel of interest, the misallocation-related TFP decline is of modest magnitude. A TFP decline of 0.139% is significant, but not overwhelming.

The response to these two critiques is that one creates the other. It is a known theoretical phenomenon that simple search and matching models do not generate sufficient amplification from shocks affecting real activity, such as a simple TFP shock to the labour market. This phenomenon is known as Shimer's puzzle (Shimer, 2005). The TFP shock that Shimer considers, a decline in p, in a search and matching model without capital where the production value of a job is p, is isomorphic to my shock, namely that which reduces k where the production value of a job is $px\mathrm{f}(k)$. Thus, my model suffers also from insufficient amplification for the calibration shown here. In what follows, I will demonstrate that it is precisely this lack of amplification that reduces the size of the TFP decline. Additionally, I will illustrate that given that one can generate sufficient amplification from the model, the labour misallocation channel grows in its relative importance.

The literature on Shimer's puzzle is vast and suggests several ways of coping with such a limitation. One approach is to include wage rigidities, e.g., as in the search and matching framework developed in Hall and Milgrom (2008) and employed in Hall (2017). However, modelling endogenous separation and labour market rigidities in the Hall and Milgrom (2008) framework is beyond the scope of the current work. Another possible solution, as pointed out in Hagedorn and Manovskii (2008), henceforth HM, is to calibrate the bargaining power of the employee β to a lower value and increases z, to obtain stronger amplification. Under the standard Shimer-style calibration, z is the replacement rate. In contrast, in an HM style calibration, z is considered the entire value of not working, including home production, unemployment insurance, and leisure. The argument in Hagedorn and Manovskii (2008) is that in a richer model, the worker should be nearly indifferent between employment and unemployment, given that employment is a choice. The reason such a calibration manages to create more amplification is that Hagedorn and Manovskii (2008) target the elasticity of wage with respect to productivity. As Ljungqvist and Sargent (2017) argue, this calibration lowers the fundamental surplus in this economy, i.e., the resources available for vacancy creation by the market, which facilitates stronger amplification. The baseline calibration does better than an economy without firing restrictions in terms of amplification as firing restrictions lower the fundamental surplus in the economy. To see this, mark the difference in labour market response between the black line and the green line in Figure 16.

Since the HM calibration strategy relies on wage elasticity, and my model features wage heterogeneity, I do not implement fully the HM calibration strategy. To the best of my knowledge, there had not been a modification of Hagedorn and Manovskii (2008) to endogenous separation search and matching models and developing one is beyond the scope of the current work. Instead of following the HM calibration strategy to the letter, I use their value for $\beta = 0.052$, the matching function $q(\theta) = \frac{1}{(1+\theta^{\eta_{HM}})^{\frac{1}{\eta_{HM}}}}$, and an average replacement rate of 95.5%, that corresponds to the value of z chosen in Hagedorn and Manovskii (2008).[20] to re-calibrate the model using the same targets as before but with the new replacement

[20] In Hagedorn and Manovskii (2008) the replacement rate is slightly higher since the production value $p = 1$ and $z = 0.955$. To make job creation profitable, the wage w must be such that $w < p$ so the replacement rate would be slightly higher. For the deterministic case in Hagedorn and Manovskii (2008), one can compute the wage as $w = 0.9765$, which gives a 97.8% replacement rate. This difference is not sizeable.

rate and conduct the simulation exercise again along with the same counter-factual firing restrictions as before. I deviate from the HM calibration strategy by normalizing θ to unity in the steady state. This calibration is summarized in column 1 of Table 4 and the simulation results are presented in Figure 17.

The HM-style calibration delivers qualitatively the same results. Namely, in response to the shock, output declines, unemployment rises, and employment falls. Although the output decline is not much stronger, the case with France's level of firing restriction exhibits a maximal decline in TFP of about 0.208%, which is about 50% stronger than the corresponding number from Figure 16. However, even larger values are quite plausible, especially given that during the financial crisis, unemployment rose by significantly more than the 6% implied by the simulation. In France, unemployment rose from 7.16% in the first quarter of 2008 to 8.6% in the first quarter of 2009, which is a 20% increase. The numbers are not exquisitely large since the corresponding figures are 65% for the United States, 37% the United Kingdom, and 80% in Spain. This means that, in reality, there is considerably more labour re-allocation in recessions than the simulation generates. However, the model can help understand how such cyclical phenomena translate into a labour-misallocation-induced TFP decline.

Relating to the previous discussion of wage dispersion, this calibration, although containing the same Pareto form and same tail index γ, performs poorly in terms of wage dispersion. The ratio between the 90th and 10th percentiles is just about 1.1, which is not a very realistic fit. This is mainly because the slope of the linear mapping from x onto the wage is linearly dependent on β, which is nearly ten times smaller in the HM-style calibration relative to the baseline.

Labour Misallocation from an Aggregate Shock. What drives the cyclical decline in TFP in the model, and what determines its size? Recall that TFP is given by

$$TFP = \underbrace{p}_{\text{Technology}} \underbrace{\left[\frac{e}{n+e}\overline{x} + \frac{n}{n+e}(x_{\min} - F\phi)\right]^{1-\alpha}}_{\text{labour misallocation}}. \tag{2.33}$$

This expression holds at every point in time with $\overline{x}, n, e$ changing over time. Denote the labour misallocation term by T, and for the sake of analytical convenience substitute $F =$

$l\overline{x}$.[21] To clarify the notation, time dependent values such as $\overline{x}(t)$ denote values outside of steady state and objects without time dependence, such as $\overline{x}$, denote steady state values. Log-linearizing T around its steady-state value of

$$T = \left[\left(\frac{e}{n+e} + \frac{n}{n+e}(x_{\min} - l\phi) \right) \overline{x} \right]^{1-\alpha},$$

one obtains that

$$T\hat{(}t) = (1-\alpha)\frac{ne}{(n+e)}\frac{1-(x_{\min} - l\phi)}{e+n(x_{\min} - l\phi)}(\hat{e}(t) - \hat{n}(t)) + (1-\alpha)\hat{x}(t), \tag{2.34}$$

where $\hat{T}$ denotes percent deviation in T with respect to its steady-state value. To bring this equation to a more intuitive level, one can recall the laws of motion for the masses, and note that in steady-state $n = \frac{\lambda \mathrm{G}(R)}{\phi} e = \frac{\tau_r}{\phi} e$, where τ_r is the termination rate. This is not to be confused with the separation rate. The termination rate is the rate at which workers transition from being in the state of active employment into termination notice, while the separation rate is the rate at which workers transition from being employed observably (regardless of notice status) into unemployment or $\phi\frac{n}{n+e}$. This notation transforms the above equation into

$$\hat{T}(t) = \psi(\hat{e}(t) - \hat{n}(t)) + (1-\alpha)\hat{x}(t), \tag{2.35}$$

with $\psi = (1-\alpha)\frac{\phi\tau_r}{\tau_r+\phi}\left[\frac{(1-x_{\min}+l\phi)}{\phi+\tau_r(x_{\min}-l\phi)}\right]$.

Economically speaking, the labour-misallocation-induced TFP decline is linearly proportional to the decline in employment and the increase in termination notices. Under the baseline calibration, the value of ψ, the parameter that dictates the change in the misallocation term of TFP, is about $\psi = 0.0383$ for both calibrations. However, since the steady-state mass of workers under notice (n) is small, a fractional change in its value is a large change in $\hat{n}(t)$, and this will be the dominant effect. To illustrate this effect's potential strength, suppose that the termination rate goes up by 10%. This may be only a tiny change in employment level since this is a change in the flow out of active employment, which may be quite slow, but it would translate to a 0.383% productivity decline, which is a sizeable figure.

In Figure 18, I present an illustrative sensitivity analysis of ψ. Each panel in Figure 18 presents the values of ψ given our baseline calibration while changing only two parameter

[21] This is an innocuous transformation, since the firing costs are calibrated to a ratio of the average production value of a job that is $p\overline{x}\mathrm{f}(k)$. Thus, one can substitute the firing costs of $Fp\mathrm{f}(k)$ with $l\overline{x}\mathrm{f}(k)$.

values. Hazard rates are again in quarterly frequencies. Although I do not explore each possible combination of parameter values, the main take away is that the following aspects can amplify the TFP decline in our economy: An increase in the labour share $1-\alpha$; an increase in the frequency of labour turnover τ_r, i.e., a decrease in average job duration; an increase in the length of the notice period $\frac{1}{\phi}$; and an increase in the cost of separation l.

Comparison of the Model Predictions to the Empirical Results from the First Chapter. The quantitative results in the baseline calibration can account for a 0.139% TFP response to a 10% increase in the net cost of capital, and up to 0.208% in the HM-style calibration. These are the peak effects and are obtained in the first year after the shock. The first chapter's empirical results indicate that the differential drop in TFP is about 0.445% after one year. One standard error of EBP during 1985-2013 corresponds to 0.567 percentage points where the average of the Gilchrist and Zakrajšek (2012) credit spread (GZ spread) is 2.082 percentage points. If one considers the risk-free rate as 4 per cent, which is the accepted value for calibration in DSGE models, one will obtain that the average capital price is about 6 per cent and that a one standard error shock in EBP is approximately a 10% increase in the net price of capital. Thus, these two sets of impulse responses can be treated as if they respond to a shock of roughly the same magnitude. As such, the model presented here, with all its caveats and simplifications, may account for between 30% to 50% of the estimated empirical effect un the first chapter.

2.5 Concluding Remarks

This chapter demonstrates the potential of firing restrictions to amplify macroeconomic shocks using a stylised search and matching model. I illustrate the contribution of firing costs and termination notice practices to the propagation of shocks via misallocation-induced TFP decline. Using a quantitative version of the model, I show how a stochastic shock to the cost of capital causes a more pronounced output drop in an economy with firing restriction and that TFP decline is at the source of this variation. The model's log-linearised version lends itself to a formalisation of a sufficient statistic for this channel's strength which may prove valuable for future empirical works or structurally motivated analyses of TFP. Quantitatively, this channel can account for up to 50% of the effect observed in the first chapter while accounting only for intra-sectoral misallocation and not for inter-sectoral misallocation, suggesting that this channel may even be stronger in actuality.

Chapter 3

Employment Protection as an Unemployment Insurance Device with Re-distributive Implications – the Case of Termination Notice[1]

3.1 Introduction

Termination notice is a form of EPL that forces both employer and employee to delay the termination of their employment relationship. This delay is anticipated by both of them and can affect the incentive structure of their entire employment relationship. At the microeconomic level, this legislation makes the separation of firms and workers more costly and thus less likely to occur. Once separated, the worker who was given advanced notice of termination has a higher chance of finding a new job before becoming unemployed as the delay allows her time in which to search for a new position.[2] At the same time, the notice period introduces an incentive for shirking and, under some regimes, may generate adverse incentives and mental distress.[3] On the political-economy level, being a form of employment

[1]The research presented in this chapter was funded in part by a National Insurance Institute of Israel research grant titled, 'Employment protection - structural policy and inequality'.

[2]For evidence on the link between termination notice and instances of unemployment see Jones and Kuhn (1995) and Friesen (1997), and for evidence on the reduced likelihood of termination see Friesen (2005).

[3] See the work of Ichino and Riphahn (2001) for evidence on shirking and EPL, and for evidence of the distressful psychic impact of termination notice see Carlson (2015).

protection, termination notice is a way for the employed group to defend their rents from employment. Since the median voter in the economy is likely to be employed, employment protection policies, such as termination notice, will endogenously arise.[4]

On the macroeconomic level, termination notice is an adjustment cost to labour imposed on the firms by the government, much like the lay-off taxes modelled by Hopenhayn and Rogerson (1993). However, termination notice also serves to insure workers from the income-loss risk associated with unemployment. That being said, there are other means of providing income insurance to households than termination notice.

The most widely discussed insurance devices in the economic literature are publicly funded unemployment insurance (UI) programs. Two elements distinguish a mandated termination notice from UI as an insurance device: the method of funding and the incentive structure it produces. Funding UI is usually done by imposing an income tax, while termination notice is a mandate placed on firms and is thus an employer-funded insurance device. Additionally, both policies affect household incentives differently. UI produces moral hazard, i.e., given that job loss is less costly, the incentive to exert effort in searching for a job is smaller, while termination notice generates an incentive to reduce production during the termination notice period.

My main claim in this work is that termination notice interacts with standard UI measures in non-trivial ways. This interaction stems from the fact that termination notice acts both as an insurance device and as a subsidy for job search. As an insurance device, termination notice is an unofficial part of the UI system, which provides an interim state during which the worker receives a 100% replacement rate that is not funded by taxation but by a mandate placed on the firms. While on termination notice, the worker's wage is paid for by the firm and is legally protected. As such, the worker has a reduced incentive to exert effort in the production process or even a reduced capacity to generate value to the firm. However, the worker does have an incentive to search for a new job. Thus, there is a probability that the worker will not require any official UI before re-employment. Additionally, while on termination notice, the worker's income is taxed, which increases the government's tax income.

This partial shift from providing households with insurance using worker-funded UI to providing it using firm-funded mandates enables the government to provide more insurance under the same taxation level. Moreover, UI entails a moral hazard problem which translates

[4] For a comprehensive treatment of the above statement and the political economy of employment protection, in general, see Saint-Paul (2000).

into a less intense search behaviour on the part of the households than it would have been in the absence of UI. The provision of termination notice is similar to a subsidy for search effort, which can offset moral hazard, at least in part.

In terms of policy-making, the key conclusion from the present research is that termination notice and UI should be jointly studied and jointly designed. The interactions between the two insurance devices are far from trivial, and their potential strength to influence aggregate welfare is meaningful and merits future consideration. This research illuminates the potential of other labour market policies to act as insurance devices and to interact with the presently existing UI systems.

Contribution. The current research extends two standard stylized models by introducing termination notice into these well-studied economic environments. Namely, I extend the Diamond-Mortensen-Pissarides (DMP) search and matching model and an incomplete markets model a-la Bewley (1986), Imrohoroğlu (1989), Huggett (1993), Aiyagari (1994) to demonstrate how termination notice affects frictional labour markets and the household's insurance motive, respectively. These two models and the insights gained from them are combined to allow for the general equilibrium effects of the termination notice. The resulting general equilibrium model is calibrated and used to describe the impact of termination notice on welfare and to discuss optimal insurance policies using termination notice and standard UI as policy tools at the planner's disposal.

Using the calibrated general equilibrium model, I document the channels through which termination notice affects aggregate welfare: (i). Increasing termination notice duration promotes a higher degree of insurance in the economic environment. (ii). As a result, households will save less, making them, on average, poorer in terms of assets. (iii). Firms will reduce hiring because increasing termination notice duration raises the cost of employment. (iv). The bargaining situation between the firm and worker is affected, which results in a wage decline. The last three effects are general equilibrium effects which result from the four previous ones. (v). The UI benefits are reduced because these are set relative to the workers' wage, which had declined, (vi). the return on assets decline due to the lower profitability of firms, and (vii)., the tax base of employed persons grows which lowers the tax rate.

These insights on the mechanisms through which termination notice affects welfare allow me to consider the optimal joint design of UI and termination notice. I show that termination notice is welfare decreasing in the baseline calibration, and its abolishment can make standard UI measures more effective in raising welfare. I discuss when termination notice is more likely to yield a beneficial impact on welfare and illustrate that when workers have a lower bargaining power while bargaining for wages, this device may be employed to achieve a substantial welfare gain.

Methodologically, the current research contributes to the literature by presenting a new GE framework that can be adjusted to many questions relating to insurance and labour market regulation. Specifically, I incorporate moral hazard into an incomplete-market, search and matching model as developed in Krusell et al. (2010), and introduce a computationally simple method to solve for wages in that environment using an approximation method and assuming collective bargaining by a labour union. The model is calibrated using the cross entropy method as presented in de Boer et al. (2005), and Mannor et al. (2003). This calibration procedure also utilises an adaptation of the Hobijn and Sahin (2009) GMM scheme to estimate job flows from unemployment duration data to cases with particularly poor data quality.

Related works. This chapter is mainly motivated by the insights of three theoretical works Pissarides (2001), Blanchard and Tirole (2008), and Pissarides (2010). The two works by Pissarides discuss the use of termination notice as a distinct form of employment protection, its ability to serve as an insurance device, and its non-trivial role as a policy instrument. Pissarides argues that since firms are risk-neutral and households are risk-averse, an employment contract between the two will include insurance provisions in the form of termination notice and that such would endogenously occur. Blanchard and Tirole (2008) argue that employment protection and UI should be jointly studied and analysed. They use a model of a central planner problem to discuss the optimal joint design of UI and employment protection in the form of lay-off taxes. The potential impact of termination notice on the economy in general, and on the UI system in particular, is my justification for considering its use as a legal mandate and not solely as a contractable provision in the spirit of Pissarides' works.

The modelling approach throughout this chapter is much inspired by the critique in Pissarides (2001) on the early studies on employment protection as being "mostly conducted within a framework that does not justify its existence". As such, I use a model that features search frictions, risk aversion and precautionary savings on the side of the household to motivate the need for insurance devices by the working population.

Additionally, this research is conceptually related to three strands in the economic literature. First, it is connected to the vast literature on employment protection at large.[5]

[5]Due to the daunting scope of this literature, I will cite only directly related works in the text, and I refer

Second, it is related to the literature that studies employment protection and especially on termination notice in a search and matching framework, e.g., Garibaldi (1998), Bentolila et al. (2012), and Ben Zeev and Ifergane (2021).

Last, this chapter is related to the literature that analyses optimal UI design in a general equilibrium setting, e.g., Browning and Crossley (2001), Fredriksson and Holmlund (2001), Coles and Masters (2006), and Mitman and Rabinovich (2015). On the methodological level, the present work owes much to the modelling approaches of Chetty (2008), Lentz (2009), Krusell et al. (2010) and to the methods developed by Achdou et al. (2017).

The chapter proceeds as follows: Section 3.2 describes existing termination notice policies and their sources and uses two stylised models to analyse the costs and benefits of termination notice as a policy device in a partial equilibrium environment. Section 3.3 extends these stylised models and combines them to a full general equilibrium model that allows for search and matching along with, incomplete markets, moral hazard, and a government-funded UI and calibrates it to key moments of the Israeli labour market. Section 3.4 conducts several counter-factual policy experiments, along with a decomposition of the welfare implications of the policy change, and conducts a search for optimal policies of termination notice and UI jointly. These results are discusses along with their policy relevance in Section 3.5. The final section concludes.

3.2 The Costs and Benefits of Termination Notice

3.2.1 Motivating Facts - Termination Notice as a Labour Market Institution

Duration of the notice period. In many European countries, the practice of having a legislated duration of termination notice is nearly a century old.[6] Today, nearly all developed market economies have a legislated termination notice. The duration usually depends on the worker's tenure at the time of termination. Table 5 presents the legislated durations for various countries after six months, two, five, ten and twenty years of tenure.[7] Except

the reader to two excellent overviews. One is the monograph on the subject by Skedinger (2010), and the other can be found in chapter 10 of Boeri and van Ours (2013).

[6] For an early review of dismissal regulation see Schwenning (1932).

[7] In countries where the law distinguishes between white and blue-collar workers, the value for white-collar workers is reported. Where the law applies differently to small firms (less than 10-15 workers), such as in Italy, Australia, and Portugal, the value above the cut-off size is reported.

the United States, all countries reported have a legislated termination notice duration for individual contracts. The durations range between a minimum of one week to three months for a worker with six months tenure and two weeks to nine months for a worker with ten years of tenure. The average is one month of notice before termination at six months tenure, 1.3 months at two years of tenure, 1.9 months at five years of tenure, 2.7 months at ten years of tenure, and 3.7 months at twenty years of tenure.

The numbers documented in Table 5 describe the legislated durations, as such they should be considered as the legal minima. Collectively bargained wage agreements may include an extended period of notice, and some procedures may delay the notice period's commencement. To illustrate, suppose the worker is entitled to a hearing prior to the decision of termination and for time in which to prepare for the hearing, as is described in Bentolila et al. (2012) concerning France. In that case, the de facto notice period may be longer and can even be subject to manipulation by the worker.

Conducting cross-country comparisons of legislation is always challenging because of differences in applicability, coverage, and enforcement. In the case of termination notice, several issues should be considered: Who may initiate a termination requiring notification? The employer, the employee, or both? Is the worker required to report in during the notice period or not? Does the law apply, to part-time employment, temporary workers, interns, of informal work, and is it equally enforced for such cases? Are collective dismissals treated the same as individual ones? And what other employment protection measures are in effect? Albeit all these issues, the main message from Table 5 is that in most countries, having a long-term employment relationship is associated with the surety of having a termination notice of several months. This notice period translates to a sizeable time-frame in which the labour income is fixed at its last level by law and the ultimate disciplinary action against the employee, termination of the employment contract, had already taken place. This worker now has an incentive to search for a new job during the notice period, but does not have an incentive to exert productive effort in the current place of employment.

In this section, I present two small-scale model economies that illustrate the costs and benefits of termination notice. The first will feature search frictions and a simplified household side. This economy will serve to illustrate the effect of termination notice on the supply side of the goods market, labour market tightness, and wage bargaining. The second model will demonstrate the insurance motive of the household whose objective is to smooth consumption. The household considers termination notice in isolation from firm-side considerations and general equilibrium effects. In Section 3.3.1, these two models will be combined into a general equilibrium framework which will be used for the remainder of the analysis in this chapter.

3.2.2 The Cost of Termination Notice

Let us begin the analysis by considering the textbook search and matching model from Pissarides (2000). The major difference will be introducing termination notice into the textbook model and exploring the implications of this extension in this well-studied environment. The notice period in the model will have three effects: a delay on job destruction, an effect on wage bargaining, and a new opportunity of workers to search for a job during the notice period.

My extension builds on earlier, more complex, stochastic models that introduce termination notice into the search and matching literature namely the works of Garibaldi (1998), Bentolila et al. (2012), and Ben Zeev and Ifergane (2021). Garibaldi (1998) is the first to introduce termination notice into a search and matching model, and does so with the aim of understanding aggregate fluctuations. His modelling approach is adopted and extended by Bentolila et al. (2012) to consider the effects of the 2008 financial crisis on France and Spain. These two works abstract from the feedback that termination notice generates into the bargaining situation. In particular, the firm and the household bargaining for wage should consider their influence on each other's outside option.[8] The model of Ben Zeev and Ifergane (2021) and of the second chapter of this thesis accounts for this feedback but, like the previous works, assumes no search during the termination notice. The present extension follows from these works, but allows for both the feedback into the bargaining problem and search during the notice period.

Other than the delay element, termination notice introduces two complications into the otherwise standard textbook model. First, like other models of employment protection, it introduces an 'insider-outsider' dynamic by which job seekers and job holders face different institutional protection. The second complication is the fact that a person under termination notice can search for a job during the notice period which increases the value of the outside option. This search during the notice will in turn affect the dynamics of job creation by introducing a 'hold' period. This is because, if an employed person finds a job during

[8] Garibaldi (1998) abstracts from this feedback directly by assuming that the firm can extract the full rent from the worker, and the wage is equal to the outside option. Bentolila et al. (2012) calibrate their model such that the average wage in the economy is the prevailing one during the notice period, and the firm knows this wage and takes it as a known tax.

the notice period, the newly matched employer-employee pair will have to await the final termination of the employment relationship between the worker and the previous employer to start producing.

Formally, let the population have unit measure and be composed of four masses, the employed m_E, the unemployed m_U, those employed with advance notice and are searching m_N, and those no longer searching m_H. The following laws of motion govern the transitions in my model (dots denote temporal derivatives)

$$\begin{bmatrix} \dot{m_U} \\ \dot{m_E} \\ \dot{m_N} \\ \dot{m_H} \end{bmatrix} = \begin{bmatrix} -\theta\,\mathrm{q}\,(\theta) & \theta\,\mathrm{q}\,(\theta) & 0 & 0 \\ 0 & -\lambda_s & \lambda_s & 0 \\ \phi & 0 & -\phi-\theta\,\mathrm{q}\,(\theta) & \theta\,\mathrm{q}\,(\theta) \\ 0 & \phi & 0 & -\phi \end{bmatrix}^T \begin{bmatrix} m_U \\ m_E \\ m_N \\ m_H \end{bmatrix}, \tag{3.1}$$

where λ_s is the termination rate, $\theta\,\mathrm{q}\,(\theta)$ is the job-finding rate, and ϕ is the arrival rate of a firing permission.

Households. A household in the economy discounts its utility at a rate ρ and maximizes discounted utility. The unemployed household gains flow value z and searches for work. Its value function V_U is thus given by

$$\rho V_U = z + \theta\,\mathrm{q}\,(\theta)\ (V_E - V_U), \tag{3.2}$$

where V_E being the value function of the employed person. The employed person receives a bargained wage w. Once employed, the workers contract may be terminated at rate λ_s. The value function of the employed person is

$$\rho\,\mathrm{V}_E\,(w)\ = w + \lambda_s(\,\mathrm{V}_N\,(w)\ -\ \mathrm{V}_E\,(w)\,), \tag{3.3}$$

with V_N being the value from being in a state of termination notice. While in a period of termination notice, one is entitled by legislation to receive one's previous wage, but this time the worker is engaged in labour market search. The value function of a person under notice is thus given by

$$\rho\,\mathrm{V}_N\,(w)\ = w + \phi(V_U -\ \mathrm{V}_N\,(w)\,) + \theta\,\mathrm{q}\,(\theta)\ (\,\mathrm{V}_H\,(w)\ -\ \mathrm{V}_N\,(w)\,). \tag{3.4}$$

If the worker happens to find a job during the notice period, the new match is 'on hold' and the worker has to await the end of the notice period to switch employers. The value from being in this state is[9]

$$\rho\,\mathrm{V}_H(w) = w + \phi(\mathrm{V}_E(w') - \mathrm{V}_H(w)). \tag{3.5}$$

Importantly, by using this set-up, and especially Equations (3.4) (3.5), I assume that the worker cannot force a direct transition to a new job. Alternatively, I could model termination notice by assuming that workers can switch employers immediately without having a hold period. The problem with this modelling approach is that the equilibrium pair of θ, w is not necessarily unique. More intensive search behaviour by firms will reduce the notice period's expected cost, thus generating a new externality in the model. From numerical experiments with this type of model, multiple equilibria are more likely when termination notice duration is quite long. Since I intend to use this stylized model as the basis for a computational model, I choose to model termination notice with the hold period instead of assuming a direct transition to a new employer for the sake of tractability.

Matching. The matching function is assumed to take the standard Cobb-Douglas form but rather than having the unemployed and job vacancies as inputs, the unemployed are now replaced by the total searching population $m_N + m_U$. As such, labour-market tightness is now defined as $\theta = \frac{v}{m_N + m_U}$, and $\mathrm{q}(\theta) = \sigma_f \theta^{-\eta}$ with $\eta \in (0, 1)$.

The Firms. The firms can post a vacant job which is matched with a job seeker at a rate of $\mathrm{q}(\theta)$. A vacancy has a flow cost of pc and once filled will have value J_E. If the job seeker is unemployed, the firm and the worker commence production immediately. However, if matched with a worker under termination notice, the firm has a job 'on hold'. The value of a job vacancy is given by

$$\rho J_V = -pc + \mathrm{q}(\theta)\,\frac{m_U}{m_N + m_U}(J_E - J_V) + \mathrm{q}(\theta)\,\frac{m_N}{m_N + m_U}(J_H - J_V). \tag{3.6}$$

I assume free entry so that at every point in time $J_V = 0$. The value of a job 'on hold' stems solely from its potential to become a producing job with hazard ϕ and is given by

$$\rho J_H = \phi(J_E - J_H). \tag{3.7}$$

[9] Note that w and w' simply differentiate between the wage paid by the current and future employer. The current wage may not affect the bargaining of the next employment contract. However, the resulting economy will be a two-income-state economy with $w = w'$ but this solution is not assumed here.

Thus, the free entry condition is:

$$J_E = \frac{pc}{\mathrm{q}(\theta)\left[\frac{m_U}{m_N+m_U} + \frac{m_N}{m_N+m_U}\frac{\phi}{\rho+\phi}\right]} = \frac{pc}{\mathrm{q}(\theta)\ l}. \tag{3.8}$$

The source of most of the differences between the model laid out here and the textbook model in terms of job creation is l, as it depends on the population masses. This means that unlike in the standard model, outside of steady state, there will be a sluggishly adjusting value of θ. Substituting in the values of the steady-state masses yields that in steady state:[10]

$$l = \frac{\phi(\rho+\phi+\theta\,\mathrm{q}(\theta))}{(\rho+\phi)(\phi+\theta\,\mathrm{q}(\theta))}. \tag{3.9}$$

Once in active production, the filled job produces p and has to pay a wage rate of w. The value of a filled job is

$$\rho J_E = p - w + \lambda_s(J_N - J_E), \tag{3.10}$$

where J_N is the value of the job once termination notice commences. Since the worker is engaged in search and the employer cannot force the worker to produces, production value is reduced to a fraction $\epsilon \in [0,1]$ of its previous value throughout the notice period. The value of the job under notice is thus

$$\rho J_N = \epsilon p - w + \phi(J_V - J_N). \tag{3.11}$$

It is important to observe that $J_N = \frac{\epsilon p - w}{\rho+\phi}$ is not necessarily negative. One can break it down into a tax element, namely $\frac{w}{\rho+\phi}$, and a subsidy element $\frac{\epsilon p}{\rho+\phi}$. In a frictionless economy, $w = p$ since p is the value of the marginal product of labour. However, given labour market frictions, we would obtain that $w < p$ since the employer can extract some rents given the bargaining process described next. Thus, for sufficiently large values of ϵ it is possible to have $J_N > 0$, while for small values of ϵ we still obtain $J_N < 0$. The value of ϵ will continue to play an important role in the rest of the chapter. Reasonable assumptions regarding its value are discussed at length at the end of this section.

Wage Bargaining. Since there are job protection provisions in place in the model, the wage decision at the point of hiring and at every other point onwards differs. The outsider's

[10] For explicit derivation of this expression, see Appendix C.

wage is solved from the standard problem which is

$$w^0 = \arg\ \max\,(V_E - V_U)^{\beta}(J_E - J_V)^{1-\beta}, \tag{3.12}$$

while the insider's problem is given by

$$w = \arg\ \max\,(\,\mathrm{V}_E\,(w)\ -\ \mathrm{V}_N\,(w)\,)^{\beta}(\,\mathrm{J}_E\,(w)\ -\ \mathrm{J}_N\,(w)\,)^{1-\beta}. \tag{3.13}$$

This problem is slightly non-standard, although very much related to the one given in the second chapter, and merits some discussion. As is standard for cases with employment protection policies, an insider-outsider dynamic of the labour markets emerges. One surplus level would govern entry from unemployment to employment, and yet another would persist in any future renegotiation of the wage. In continuous time, the value from a job to the firm and worker J_E, and V_E would be the same for the insider as to the outsider since the wage w^0 lasts for merely an infinitesimal period of time. However, since this instantaneous first wage reflects a sharing rule for the surplus that governs job creation, it will have a bearing on the solution. It is important to stress that a mass of zero workers would actually be paid w^0.

Solution. The above bargaining problems together with the free entry condition in Equation (3.8), along with some tedious but straightforward algebra detailed in Appendix C, enables me to characterize the solution to this system by using three equations. The first, and most complicated to derive, is the wage solution

$$w = \beta p + (1-\beta)z + \rho\beta\frac{p(1-\epsilon)}{\phi} + \frac{\beta\theta pc}{l}\left[1 + \frac{\rho}{\rho+\phi+\theta\,\mathrm{q}\,(\theta)}\right]. \tag{3.14}$$

This wage solution is the classical DMP wage with the addition of the threat of reduced production during the notice period which is given by $\rho\beta\frac{p(1-\epsilon)}{\phi}$ and the value of search during the notice period that is given by $\frac{\rho}{\rho+\phi+\theta\,\mathrm{q}(\theta)}\frac{\beta\theta pc}{l}$.

From the definition of J_E, J_N and the free entry condition in Equation (3.8) the job-creation condition in the model can be derived as

$$p\left(\frac{\rho+\phi+\lambda_s\epsilon}{\rho+\phi+\lambda_s}\right) - w = \frac{pc(\rho+\lambda_s)}{\mathrm{q}\,(\theta)\ l}\frac{\rho+\phi}{\rho+\phi+\lambda_s}. \tag{3.15}$$

The last equation which determines the equilibrium in this model is the definition of the steady-state l, i.e., the delay of job creation which stems from the existence of a termination notice

$$l = \frac{\phi(\rho + \phi + \theta\,\mathrm{q}\,(\theta)\,)}{(\rho + \phi)(\phi + \theta\,\mathrm{q}\,(\theta)\,)}. \tag{3.16}$$

From the value of l we can see that by abolishing termination notice, the case of $\phi \to \infty$, we obtain that $l \to 1$ and the wage solution and job-creation condition collapse into the standard textbook equations for a search and matching model with exogenous separation.

Now with a full system in place, I conduct a comparative statics exercise to understand the implications of varying termination notice in the search and matching model. The main result here is that the longer the termination notice is, the less tight the labour market will be. That is, termination notice reduces the incentive for job creation.

Proposition 3.2.1. *Decreasing the duration of termination notice (increasing ϕ) results in increased labour market tightness for sufficiently low values of ϵ.*

Proof. To reiterate, the steady-state equilibrium of the system is given by the following three equations:

$$w = \beta p + (1 - \beta)z + \rho\beta\frac{p(1 - \epsilon)}{\phi} + \left[1 + \frac{\rho}{\rho + \phi + \theta\,\mathrm{q}\,(\theta)}\right]\frac{\beta\theta pc}{l} \tag{3.17}$$

$$p\left(\frac{\rho + \phi + \lambda_s\epsilon}{\rho + \phi + \lambda_s}\right) - w = \frac{pc(\rho + \lambda_s)}{\mathrm{q}\,(\theta)\;l}\frac{\rho + \phi}{\rho + \phi + \lambda_s} \tag{3.18}$$

$$l = \frac{\phi(\phi + \theta\,\mathrm{q}\,(\theta)\, + \rho)}{(\phi + \theta\,\mathrm{q}\,(\theta)\,)(\rho + \phi)}, \tag{3.19}$$

In what follows, I analyse the comparative statics of this system in a graphical representation and illustrate the result using a calibrated version of the system.

Graphically it is constructive to examine the system, as is done in the standard search and matching representation, in the θ, w plane while treating l as a function of θ. As such, understanding the behaviour of this function should be our point of departure. It can be shown that $l\,(\theta)$ is a monotonically decreasing function of θ.[11] The function is also bounded by $l\,(0) = 1$ and by $\lim_{\theta\to\infty} l = \frac{\phi}{\phi+\rho}$. Taken together, this behaviour of l means that as in the standard search and matching model, the job creation curve slopes downwards on the θ, w plane and that the wage curve slopes upwards along the same plane, yielding a unique equilibrium. Finally, observe that holding the value of θ constant, the steady-state value of

[11] To verify this statement, observe that $\frac{\mathrm{d}\,\mathrm{l}(\theta)}{\mathrm{d}\,\theta} = -\frac{\rho(1-\eta)\,\mathrm{q}(\theta)}{(\phi+\theta\,\mathrm{q}(\theta)\,)^2}\frac{\phi}{\rho+\phi} < 0$.

l will increase as ϕ increases. With these insights in mind, we can proceed to examine the θ, w plane.

The wage curve. For a given value of θ, an increase in ϕ, which also means an increase in l, will unambiguously decrease the wage. Thus, the wage curve will shift to the right. Intuitively speaking, reducing the duration of the notice period, holding labour market conditions constant, will weaken the bargaining position of the worker and strengthen that of the employer; thus, the wage will decrease. The converse also holds, i.e., reducing ϕ will shift the curve to the left.

The job creation curve. Two conflicting forces affect the job-creation curve. Since examining the job creation curve as w as a function of θ is more convenient, consider the reordered expression

$$w = \frac{p\epsilon\lambda_s}{\rho+\phi+\lambda_s} + \frac{\rho+\phi}{\rho+\phi+\lambda_s} p\left(1 - \frac{c(\rho+\lambda_s)}{\mathrm{q}\left(\theta\right)\, l}\right). \tag{3.20}$$

First, observe the special case of $\epsilon = 0$. If ϵ, the job creation condition is given by

$$w\left(\epsilon = 0, \theta\right) = \underbrace{\frac{\rho+\phi}{\rho+\phi+\lambda_s}}_{\text{Duration mark-up}} \cdot \underbrace{p\left(1 - \frac{c(\rho+\lambda_s)}{\mathrm{q}\left(\theta\right)\, l}\right)}_{\text{Job-creation curve DMP}}.$$

This can be simply interpreted because both expressions in the right hand side of the equation are positive and increasing in ϕ for every equilibrium in which there is job creation. To see this, first, recall that ρ, ϕ, and λ_s are all positive so the duration mark-up is also positive. Second, dividing the second expression by $\rho + \lambda_s$ yields $\frac{p}{\rho+\lambda_s} - \frac{pc}{\mathrm{q}(\theta)\, l}$, which is the total discounted production value of a job minus the flow cost of job-creation pc divided by the job-filling rate. If we have that $\frac{p}{\rho+\lambda_s} - \frac{pc}{\mathrm{q}(\theta)\, l} < 0$, it means that there is no incentive to create jobs in this economy, for any positive wage rate, only a negative wage will justify the firms job creation cost. To conclude, for $\epsilon = 0$, increasing ϕ, or decreasing the length of notice, shifts the job-creation curve to the right and increases θ for every wage rate.

If ϵ were strictly positive, we could restate the job creation curve as:

$$w\left(\theta\right) = \frac{p\epsilon\lambda_s}{\rho+\phi+\lambda_s} + w\left(\epsilon = 0, \theta\right).$$

As explained above, increasing ϕ shifts $w\left(\epsilon = 0, \theta\right)$ to the right, but, this time it also creates a conflicting force that lowers $\frac{p\epsilon\lambda_s}{\rho+\phi+\lambda_s}$ and shifts the job creation curve to the left. Which of these forces is stronger is a quantitative question that depends upon the choice of calibration. Still, for a sufficiently low value of ϵ, the result is that both the job creation condition and the wage equation shift to the right, leading to an increase in labour-market tightness. The converse also holds, lowering ϕ will decrease labour market tightness for sufficiently low values of ϵ. □

What will be a reasonable value of ϵ? I began by defining that $\epsilon \in [0, 1]$. In terms of practical reality, this means that I assume the worker does not cause damage in the place of employment and that the worker does not suddenly become more productive after termination notice was given. The former can be ruled out by anecdotal evidence of employers allowing employees to be absent from the place of employment during that time, or by simply stating that the employer has the power to exercise this right[12] if the realised ϵ is sufficiently low. The latter, a swan song productivity boost, is also unlikely because the worker has no incentive to produce during this period, but does have an incentive to look for a new job. The reduced production incentive arises from the fact that the ultimate sanction against a shirking employee is the termination of the employment relationship. When this sanction has already been used, the employee sees no point in exerting effort given that her wage is unaffected by the effort choice.

Suppose we step outside the bounds of the described model into a richer environment. In that case, termination is a choice that occurs when continuing employment no longer generates a sufficient value to both sides. Thus, either the production value of the job has decreased or a more appealing outside option had materialized. Under both instances, the aforementioned incentive to exert less effort on production during the notice period holds.

Within the context of Proposition 3.2.1, what will constitute a sufficiently small value of ϵ? To illustrate that rather large values of ϵ may not be sufficient, on their own, to generate a positive effect on job creation, let us perform the following simple experiment. Using the calibration of the simple search model from Shimer (2005), but without the stochastic elements, let us add termination notice of varying lengths to the U.S. calibration counterfactually for $\epsilon = 0$ and $\epsilon = 1$. Results from this comparative statics exercise are given in Figure 19. For the case of $\epsilon = 0$, the model suggests that imposing one month of termination notice will yield about a 20% decline in equilibrium labour market tightness and for one quarter of termination notice the corresponding decline is about 60%. For the case of $\epsilon = 1$,

[12] Israeli notice regulation explicitly allows this course of action.

these declines are smaller by orders of magnitude but, importantly, labour market tightness is still reduced, even for the most extreme case.

Note, that corollary to Proposition 3.2.1 is the fact that the wage effect is ambiguous, and Figure 19 also illustrates this. For many likely calibrations, the wage will decline as the effect on the bargaining power is small due to the short duration of the notice relative to that of the entire employment contract.

This model, as useful as it may be in understanding firm-side considerations and the impact of this policy device on job creation, falls short on the household side. Termination notice is usually discussed as being a part of employment protection policies as a whole. As such, its intended goal is to protect the worker from shocks to her income by allowing for an interim period between employment and unemployment during which time the worker may find a new job opportunity. To be able to consider the insurance motive properly, we need a theoretical tool that takes into account the household's insurance needs and preferences with respect to risk. With this aim in mind, I now proceed to examine the insurance motive of the worker and the role of termination notice thereby.

3.2.3 The Insurance Motive and Termination Notice

I take the standard incomplete market model as given in Huggett (1993) as a point of departure. Suppose there is an economy populated with a measure one of hunter-gatherer households. Each period spent hunting yields more income than a period spent gathering. However, hunting opportunities arrive and disappear at exogenous hazard rates. Thus, as in Hugget's original paper, the economy has two income states $y \in \{z, w\}$, where $z < w$. Since we are interested in termination notice as a labour market institution, we can call hunting employment and gathering unemployment or the outside option. This analysis abstracts from firm side considerations which where explored earlier.

In this economy, termination notice is an interim state during which the agent gains the information that the hunting opportunity is about to expire and that she should start searching for a new one. The entire labour market structure introduced before is replaced now with a simple two-income-state representation given by

$$\Lambda_2 = \begin{bmatrix} -f & f \\ s & -s \end{bmatrix}, \tag{3.21}$$

where $f = \theta\,\mathrm{q}(\theta)$ is the finding rate, which is fixed and assumed exogenous for now, and

$s = \phi \frac{m_N}{m_E + m_N + m_H}$ which is a function of the equilibrium masses and ϕ. Substituting in the equilibrium masses from the system given by Equation (3.1)[13] yields that

$$s = \frac{\lambda \phi^2}{\lambda \phi + \phi(\phi + \theta \, \mathrm{q}(\theta)) + \lambda(\theta \, \mathrm{q}(\theta))}.$$

The household maximizes discounted utility from consumption given an asset position a. The household's problem is thus given by

$$\rho \, \mathrm{V}_i(a) = \max_c \quad \mathrm{u}(c) + \frac{\partial V_i}{\partial a} \frac{\partial a}{\partial t} + \Lambda_{2,i} \, \mathrm{V}(a) \, , \tag{3.22}$$

subject to the asset accumulation rule $\frac{\partial a}{\partial t} = y_i + ra - c$, where c denotes consumption, y_i flow income in state i, ρ the discount rate, r the return on assets, and $\mathrm{u}(c)$ the instantaneous utility from consumption. $\mathrm{V}_i(a)$ is the value function of the household in state $i \in \{U, E\}$ which denote unemployment or the low income state, and employment or the high income state. The vector $\mathrm{V}(a)$ denotes the column vector whose transpose is $\mathrm{V}(a)' = [\mathrm{V}_U(a), \mathrm{V}_E(a)]$ which is multiplied by the transition matrix Λ_2. Using the above model, it is now possible to observe the partial equilibrium effect of changing the duration of termination notice in this model.

Proposition 3.2.2. *Holding all prices and incomes constant, the household, regardless of its state, prefers to have as long a notice period as possible.*

Proof. If we differentiate the system of the two value functions $\mathrm{V}_U(a), \mathrm{V}_E(a)$ with respect to ϕ, we obtain the following system:

$$(\rho I - \Lambda_2) \Delta_s V \frac{\partial s}{\partial \phi} = \begin{bmatrix} 0 \\ \mathrm{V}_U(a) - \mathrm{V}_E(a) \end{bmatrix}, \tag{3.23}$$

where I is the two-by-two identity matrix and $\Delta_s V$ is the column vector containing the partial derivatives of the value functions with respect to s. Suppose that the inequalities $\rho < s$, and $\rho < f$ hold. Since ρ is the natural discount rate, for most reasonable calibrations it will be strictly smaller than the job finding rate and the separation rate. One can verify that the matrix $(\rho I - \Lambda_2)$ is a non-singular M-matrix and thus its inverse exists and consists

[13] See Appendix C for explicit solutions.

of strictly positive entries.[14] Note also that $\frac{\partial s}{\partial \phi} > 0$.[15] Hence, the sign of all the derivatives is determined by the sign of $V_U(a) - V_E(a)$ which is negative since it denotes the difference between a household in a low income state and in a high income state with the same asset position. Increasing ϕ lowers the utility of each household, thus increasing the notice period duration, $\frac{1}{\phi}$, will increase their welfare. □

It is important to stress here that in this economy, increasing notice duration will increase output and thus, the welfare result is quite simple. Additionally, this result will hold in equilibrium if and only if it will not be offset by a change in the price of assets that will counteract it. However, this fundamental insurance motive is the motivation for considering termination notice as a separate part of the unemployment insurance (UI) system.

It is also noteworthy that there is a slight simplification involved with the reduction into two income states from the four-state description given in the model of Section 3.2.2. If the households were aware of the richer process that governs their income, their behaviour would change in response to their different position within the structure of the labour market. Households facing a higher risk of job loss will exhibit more precautionary savings than the rest of the employed cohort. However, I will show in Section 3.4 that this simple intuition is borne out in a much richer set-up that considers an even more complex income process.

3.2.4 UI and Termination Notice.

UI is a policy device widely utilized to insure the working population against risks to their labour income. UI is often structured by setting a duration for benefits eligibility and a replacement rate which is a ratio of the current income that is due to the worker from the insurer at the occurrence of an unemployment spell. The main problem with using UI is that the search effort of the unemployed cannot be monitored perfectly, and thus the insurance creates a moral hazard problem, i.e., the unemployed person has the incentive to lower search effort in the presence of insurance and thus increases the costs to the provider. Given the desirability of insurance from a welfare perspective, and the moral hazard problem, the economic literature has been concerned with developing methods for providing UI optimally.

[14] To verify this, note that $(\rho I - \Lambda_2)$ is a Z-matrix, with strictly positive main diagonal and non-positive entries elsewhere. To prove that it is an M-matrix, note that it is a strictly diagonally dominant matrix with strictly positive row sums.

[15] It can be verified that $\frac{\partial s}{\partial \phi} = \frac{\lambda^2\phi^2 + \lambda\phi^2\theta\, q(\theta) + 2\phi\lambda^2(\theta\, q(\theta))}{(\lambda\phi + \phi(\phi + \theta\, q(\theta)) + \lambda(\theta\, q(\theta)))^2} > 0$.

In the language of the UI literature, termination notice is an insurance device that provides for a 100% replacement rate at no cost to the provider. The cost of providing termination notice falls on the firms in the form of a mandate. Thus, the policy device raises two questions: First, why should the central planner intervene by legislating termination notice instead of letting voluntary termination notice be contracted by the firm and the worker? And second, can this tool improve welfare?

The answer to the first question arises directly from the problem of designing optimal UI. In most countries, the government provides for UI since insurance is valuable and the central planner can increase welfare by providing it. In so doing, it affects the economic environment in several ways that amount to distorting the equilibrium allocation between consumption and effort spent on job search. The planner generates this distortion by increasing the flow value of unemployment as a result of UI benefits, and by reducing the flow value of employment via taxation. Effectively, optimal UI balances the marginal gain from insurance with the marginal welfare cost of the resulting distortion in equilibrium allocation.[16] If the planner were able to subsidize job search and reduce the impact of the UI scheme on the value of employment by some policy instrument, it would be socially valuable. Introducing a legislated termination notice allows for job search during the notice period by using the future reduction in income as a search incentive in the present and thus alleviating, to some degree, the moral hazard problem.[17] This also reduces the cost of providing the same level of UI benefits since a person who receives termination notice has some positive probability to find a job prior to entering unemployment.

Regarding the second question, the potential effectiveness of termination notice as an insurance device complementary to the conventional UI system, is a more complex quantitative question. Given the already conflicting forces explained in Propositions 3.2.1 and 3.2.2, the only way to account jointly for all these forces along with the existence of moral hazard is to construct a general equilibrium system that can account for them. With this aim in mind, I proceed by describing the general equilibrium model in Section 3.3 and analyse the impact of termination notice in the remainder of the chapter.

[16]See Baily (1978) and Chetty (2006) for in-depth treatment of optimal UI design.

[17]Note that in the case of perfect insurance, there is still no incentive to engage in costly search.

3.3 Methods

In this section, I lay out the structure of the economic environment required for the general equilibrium analysis of termination notice. The quantitative exercise in this and the subsequent sections will be carried out using key moments of the Israeli labour market and its regulatory structure.

3.3.1 General Equilibrium Model

Households. There is a continuum of measure one of households in the economy. Let $i \in \Gamma$ denote a type in the model type-space $\Gamma = \{E1, E2, N1, N2, U1, U2\}$ and m_i denote the population mass of households of type i. E denotes being in a state of employment which can take two forms, employment on trial period $E1$ and regular employment $E2$. Since Israeli labour market regulation applies differently to workers with more or less than one year of tenure, the distinction between two worker types is required. If an employed person in the trial period is terminated, this person immediately transitions to unemployment $U1$. The termination of a regular worker, type $E2$, however, is carried out by transitioning into a period of termination notice $N1$. The termination notice is a state in which the worker is still employed by the firm under the same wage but exerts efforts in finding a new job. Finding a job in this state results in the formation of a job 'on hold' and transitioning to state $N2$ and an unfruitful search will result in termination and the transition to $U1$. While on hold, the worker is in a relationship with two employers, the current one and the future one. The worker's wage is paid by the former, and the two employers do not interact with each other. The last state in the economy is that of prolonged unemployment $U2$, that begins after $U1$ has ended without a job opportunity. During prolonged unemployment, the worker is entitled to a lower replacement rate than in $U1$.

Households maximize discounted utility from consumption $\mathrm{u}(c)$, and can save assets a. Households are subject to idiosyncratic risks of income loss from unemployment and have to spend effort x to search for a new job which causes a flow disutility $\Psi(x)$. $\mathrm{u}(\cdot)$ and $\Psi(\cdot)$ are assumed to be twice differentiable, monotonic, and increasing in their arguments. $\mathrm{u}(\cdot)$ is assumed to be concave and $\Psi(\cdot)$ to be convex. As such, households solve a dynamic programming problem with one state variable which is their asset holdings a. In states $\{E1, E2, N2\}$, the household has one control variable, consumption $c_i(a)$, and in states $\{N1, U1, U2\}$ it has an additional control variable, the effort exerted in job search x_i. The household problem is given by

$$\rho\,\mathrm{V}_i\,(a)\;=\max_{c,x}\;\;\mathrm{u}\,(c)\;-\;\Psi\,(x)\;\cdot I+\frac{\partial V_i}{\partial a}\,\mathrm{s}_i\,(a)\;+\sum_{j\in\Gamma}\;\Lambda_{ij}\,(a)\;\;\mathrm{V}_j\,(a)\;\;, \tag{3.24}$$

where ρ is the discount rate, $\Lambda\,(a)$ is the Markov transition matrix which will be detailed shortly, and I is an indicator variable that takes the value of 1 if the household is in a state in which engagement in search is required and 0 otherwise. The law of motion for the state is given by

$$\mathrm{s}_i\,(a)\;=\frac{\partial a}{\partial t}=\gamma a-\;\mathrm{c}_i\,(a)\;+\;(1-\tau)\,\mathrm{y}_i\,, \tag{3.25}$$

where γ denotes the net return on asset holdings, τ denotes the rate of income tax that funds the UI system, and y_i denotes the before taxes flow income in state i. Asset accumulation is subject to a borrowing constraint $a \geq \underline{a}$. Transitions between income states are governed by the continuous-time Markov matrix $\Lambda\,(a)$ which is given by

$$\Lambda\,(a)\;= \tag{3.26}$$

$$\begin{bmatrix} -\lambda_{E1}-\lambda_s & \lambda_{E1} & 0 & 0 & \lambda_s & 0 \\ 0 & -\lambda_s & \lambda_s & 0 & 0 & 0 \\ 0 & 0 & -\phi-\;\mathrm{x}_N\,(a)\;\lambda_f & \mathrm{x}_N\,(a)\;\lambda_f & \phi & 0 \\ \phi & 0 & 0 & -\phi & 0 & 0 \\ \mathrm{x}_{U1}\,(a)\;\lambda_f & 0 & 0 & 0 & -\,\mathrm{x}_{U1}\,(a)\;\lambda_f-\lambda_{U1} & \lambda_{U1} \\ \mathrm{x}_{U2}\,(a)\;\lambda_f & 0 & 0 & 0 & 0 & -\,\mathrm{x}_{U2}\,(a)\;\lambda_f \end{bmatrix}$$

The hazards λ_{E1} and λ_{U1} are the exit hazards from $E1$ to $E2$ and from $U1$ to $U2$, respectively. $\frac{1}{\lambda_{E1}}$ is the duration of the trial period and $\frac{1}{\lambda_{U1}}$ is the duration of the period of UI entitlement under which a higher replacement rate prevails. The separation hazard is λ_s and the length of the notice period is $\frac{1}{\phi}$, which is the main policy parameter of interest. The outflows from all states requiring search are functions of the effort level exerted by the household, which makes the matrix Λ a function of a. I assume that the finding rate is linear in the effort level exerted. It is noteworthy that the finding rate at each state is not a probability, but a flow hazard and thus is not bounded from above by unity. This functional form is the continuous-time analogue of a form used by Lentz (2009) and is approximately similar to the one used by Chetty (2008). Finally, λ_f is the finding rate per unit of effort exerted.

Population Composition. Let H_i, the cumulative distribution of assets for households of type i, have measure m_i, with its density function $\frac{\partial H_i}{\partial a} = \mathrm{h}_i(a,t)$ evolving over time given the following Kolmogorov forward equation:

$$\frac{\partial\, \mathrm{h}_i(a,t)}{\partial t} = -\frac{\partial}{\partial t}\left[\mathrm{h}_i(a,t)\ \mathrm{s}_i(a)\right] + \sum_{j\in\Gamma} \Lambda_{ij}^T(a)\ \mathrm{h}_j(a,t)\ \ . \tag{3.27}$$

The system of these Kolmogorov equations will yield the masses via $m_i = \int_{\underline{a}}^{\infty} \mathrm{h}_i(a)\ \mathrm{d}a$.

The Matching Mechanism. Search effort and job vacancies are matched to yield new jobs. I denote aggregate search effort by $X = \sum_{i\in\{N1,U1,U2\}} \int_{\underline{a}}^{\infty} \mathrm{x}_i(a)\,\mathrm{d}\,\mathrm{H}_i(a)$, and labour market tightness by $\theta = \frac{v}{X}$, where v is the vacancy stock. The matching function $\mu(X,v)$ is assumed to be homogeneous of degree one and monotonically increasing in both arguments. As a result, one can use this matching mechanism to obtain the transition hazards. The per-effort-unit job finding rate is denoted by

$$\lambda_f = \frac{\mu(X,v)}{X}, \tag{3.28}$$

and the vacancy filling rate by

$$q = \frac{\mu(X,v)}{v}. \tag{3.29}$$

Each agent, a firm or a household, takes θ, and thus λ_f and q, as a given. The existence of a continuum of households means that the effort choice on the part of the household will be done while abstracting from strategic considerations so that one's choice of effort is incapable of affecting the aggregates.

Income. The households have the following source of income: capital income which is the return on asset holdings γa, labour income if the household is employed, and UI if not. During states $U1$ and $U2$ the household has UI benefits of b_1 and b_2. While employed in each of the E states the households bargains for their wage rate with the firm given their asset levels. During the notice period, in state $N1$ or $N2$, the households continue to receive, by legal mandate, the value of their last wage. All of these incomes are subject to income tax.

The Asset Market. Since the workers face uninsurable idiosyncratic risks to their income, they can only self-insure via precautionary saving, i.e., wealth accumulation. Following Krusell et al. (2010), I assume two liquid assets, capital and equity, with a no-arbitrage condition. This set-up eliminates the portfolio choices of the household and allows one to consider only net asset positions as a state variable.

The households accumulate assets a, which can take two forms, capital k and equities χ. There is a continuum of firms, owned by households that use capital and labour to produce a single homogeneous consumption good. Equities are defined as claims on aggregate profits and not as a claim on the profits of a single firm. This asset structure limits the capacity of an individual to short a firm which employs her for self-insurance. The rental rate of capital is denoted by r and its depreciation by δ. Thus, the price P of an equity χ which yields instantaneous dividend d must satisfy the no-arbitrage condition

$$\gamma = r - \delta = \frac{d}{\mathrm{P}}. \tag{3.30}$$

This means that only total assets a matter from the perspective of the households budget constraint since both assets yield a net return of $\gamma = r - \delta$. The firms will take γ as their discount factor as this is the required return by their owners who can switch from equity to capital that yields γ net return.

The Firms I assume that the firm employs one worker and uses capital to produce. The instantaneous production is given by a Cobb-Douglas production function $pk^{\alpha}l^{1-\alpha}$ with a productivity parameter p, and a capital share α. The firm rents capital at a perfectly competitive market with rate r and pays the bargained wage rate. Capital is assumed to be perfectly mobile, and the firm chooses capital by equating r to the value of the marginal product. All the firms produce a single homogeneous final consumption good whose price is normalized to one.

Wage-Setting. The wage is set using a Nash bargaining problem between a labour union that bargains collectively for all workers of the same type and their employer which identical across all matches of the same type. Each union bargains as if it is the median employed person who is a member of that union. This mechanism is a deviation from the standard form in the literature and requires some explanation.

Consider the wage-setting mechanism of Krusell et al. (2010), whereby each employer-employee pair bargains for the wage level with the asset level of the employee as the only source of heterogeneity. This gives rise to a wage schedule that is monotonically increasing in asset level. Qualitatively, it is an appealing feature that generates wage dispersion in the model, enriches the model environment, and contributes to its realism. Quantitatively, the wage dispersion in the model is negligible and nowhere near realistic levels. By adding endogenous search efforts to this type of bargaining mechanism the wage schedule is no longer monotonically increasing because the endogenous choice of search effort affects the value of the outside option. In practice, as in Krusell et al. (2010), the wage dispersion in this type of set-up is unrealistically small, but also leads to non-convexities in the household's problem and non-concave value functions. To avoid this non-convexity issue, I introduce collective bargaining by the median worker and thus force the wage functions to be flat regardless of assets.[18]

The two wage levels, w_1, and w_2 are the median solutions, within each worker type, E_1 and E_2, to the following individual bargaining problems between the employee-employer pair. For new workers, who are unprotected by labour regulation, the wage is given by

$$\mathrm{w}_1 = \mathrm{Median}_{H_{E1}} \left[\arg\max \quad (\mathrm{V}_{E1}(a) - \mathrm{V}_U(a))^{\beta} (\mathrm{J}_{E1} - J_V)^{1-\beta} \right], \tag{3.31}$$

and for the worker protected by the notice period the wage is set by

$$\mathrm{w}_2 = \mathrm{Median}_{H_{E2}} \left[\arg\max \quad (\mathrm{V}_{E2}(a) - \mathrm{V}_N(a))^{\beta} (\mathrm{J}_{E2} - J_N)^{1-\beta} \right]. \tag{3.32}$$

where, J_{E1}, J_{E2}, and J_N denote the value of the firm which employs a type $E1$ employee, type $E2$ employee or an employee on termination notice, respectively. Note that these problems are analogous to those given in Section 3.2.2 but this time the workers are risk averse and engaged in precautionary saving, with a modified outside option that takes into consideration the cost of effort to be exerted to be rehired.

The Searching Firms. The firm that searches for a worker pays a constant flow cost of κ and encounters a job seeker with probability q which is given by Equation (3.29). A job vacancy is an asset of the following value:

$$\begin{aligned} \gamma J_V &= -\kappa \\ &+ \mathrm{q} \left[\sum_{i \in \{U1, U2\}} \int_{\underline{a}}^{\infty} \frac{\mathrm{x}_i(a)}{X} \mathrm{J}_{E1} \, \mathrm{d}\,\mathrm{H}_i(a) + \int_{\underline{a}}^{\infty} \frac{\mathrm{x}_{N1}(a)}{X} \mathrm{J}_H \, \mathrm{d}\,\mathrm{H}_{N1}(a) - J_V \right], \end{aligned} \tag{3.33}$$

[18] From a mechanical perspective, I conduct wage bargaining between each pair of employer-employee and choose the median wage level given the population composition. For full details see Appendix D.

where J_{E1} is the value of a newly created job and J_H is the value of a job 'on-hold'.

The Firm 'On-hold'. The job on hold is an asset that consists of the value of option to begin production with a worker immediately after final separation from her current employer. This asset is formed once a job vacancy is matched with a worker that is currently on termination notice Once the current contract is terminated, the job on hold becomes an actively producing job. During the hold period the firm does not incur the cost of search and the worker exerts no effort. The value of the firm on hold is given by

$$\gamma\,\mathrm{J}_H = \phi(\mathrm{J}_{E1} - \mathrm{J}_H). \tag{3.34}$$

The Actively Producing Firms. The producing firms can be of three types $E1, E2$, and N. Labour input is fixed to unity at the firm level for firms with type $E1$ and $E2$ workers. For firms with workers under notice, the worker's labour input is scaled down by $\epsilon \in [0,1]$. The value from these firms is given by:

$$\gamma\,\mathrm{J}_{E1} = \max_k \quad pk^\alpha - rk - \mathrm{w}_1 + \lambda_{E1}(\mathrm{J}_{E2} - \mathrm{J}_{E1}) + \lambda_s(J_V - \mathrm{J}_{E1}), \tag{3.35}$$

$$\gamma\,\mathrm{J}_{E2} = \max_k \quad pk^\alpha - rk - \mathrm{w}_2 + \lambda_s(\mathrm{J}_{N1} - \mathrm{J}_{E2}). \tag{3.36}$$

During the notice period, the worker exerts a lower effort in production so the labour input is scaled down by a factor of $\epsilon \in [0,1]$. On the firm side, it is meaningless to differentiate between a firm with a worker with termination notice that is searching $N1$ and that which had already found a job $N2$ since the firm pays the same wage and gets the same production value in either case. The value function is thus:

$$\gamma\,\mathrm{J}_N = \max_k \quad pk^\alpha\epsilon^{1-\alpha} - rk - \mathrm{w}_2 + \phi(\mathrm{J}_V - \mathrm{J}_N). \tag{3.37}$$

Dividends. The firm of type $i \in \{E1, E2, N\}$ makes instantaneous profits of $\pi_i(a) = pk_i^\alpha l_i^{1-\alpha} - w_i - rk_i$. As such, dividends from firm holdings are composed of the sum total of these instantaneous profits net of search costs by vacant jobs as follows:

$$d = \sum_{i\in\{E1,E2,N\}} \int_{\underline{a}}^{\infty} \pi_i(a)\;\mathrm{d}\,\mathrm{H}_i(a) \quad - \upsilon\kappa. \tag{3.38}$$

Government. The government in the model gives UI to the unemployed and finances it by a proportional tax τ on income that balances its budget in every period. The budget can be summarized as

$$\tau \sum_{i\in\Gamma} \int_{\underline{a}}^{\infty} \mathrm{y}_i(a)\ \mathrm{d}\,\mathrm{H}_i(a) \quad = b_1 m_{U1} + b_2 m_{U2}. \tag{3.39}$$

Aggregate Welfare. I assume a utilitarian aggregate welfare function whereby the aggregate welfare in the economy Ω is given by

$$\Omega = \sum_{i\in\{E1,E2,N1,N2,U1,U2\}} \int_{\underline{a}}^{\infty} \mathrm{V}_i(a)\ \mathrm{d}\ \mathrm{H}_i(a) \quad . \tag{3.40}$$

Observe that this measure is a Rawlsian welfare measure and reflects an individual's preference regarding the society in which they would prefer being born, i.e., this is a comparison of two steady states that do not consider transition dynamics of an actual policy reform. To set the stage for a normative analysis, it will be useful to introduce an additional welfare metric, the constant consumption equivalent variation $\omega^\star$ (the definition closely follows Setty and Yedid-Levi (2021)), as follows. Let ω be a preference shifter that changes the household's instantaneous utility from $\mathrm{u}(c) - I \cdot \Psi(x)$ to $\mathrm{u}((1+\omega)c) - I \cdot \Psi(x)$. Let $\Omega(T,\omega)$ denote the welfare computed with a shifter ω from using the policy vector $T = [\phi, \lambda_{U1}, R_1, R_2]$, i.e., from having a notice duration of $\frac{1}{\phi}$, an unemployment insurance benefits eligibility duration $\frac{1}{\lambda_{U1}}$, and a benefit level set with replacement rates R_1, and R_2. $\Omega(T,\omega)$ is computed without changing the chosen levels of consumptions, effort, and savings, but changing the scale of utility obtained from them through the shifter ω. For a baseline policy triplet T and an alternative T', $\omega^\star$ is the solution to the equation

$$\Omega(T', 0) = \Omega(T, \omega^\star). \tag{3.41}$$

Alternatively stated, $\omega^\star$ answers the question by what factor would the planner have to increase consumption under the baseline policy T to obtain the welfare that would result in the new policy T'. If $\omega^\star$ is positive, than the shift from T to T' improves welfare. For the sake of all following computational exercises, the two metrics are equivalent since I'll use log utility and $\omega^\star$ will be computed directly from Ω, and employed only for its more intuitive interpretation.[19]

[19] To observe this for the case of log utility, note that for each household, introducing the shifter simply transforms its flow utility into $\ln c + \ln(1+\omega) - I \cdot \Psi(x)$, or adds to the lifetime discounted utility the

This concludes the formulation of the model. A formal definition of the recursive stationary equilibrium is relegated to Appendix D.

3.3.2 Calibration

Directly calibrated parameters and functional forms. The model is calibrated at a monthly frequency. I follow Krusell et al. (2010) and set the discount rate $\rho = 0.0036$ to target a net return of assets of about four percent as is standard in the literature. The utility function is assumed to take log form $\mathrm{u}(c) = \ln c$, and $\underline{a} = 0$ is assumed to be the borrowing constraint. As in Chetty (2008), the disutility of effort is assumed to take the form $\Psi(x) = \psi_0 \left(\frac{x}{1+\psi}\right)^{1+\psi}$ which completes the household side parameters.

On the firm side, I assume a capital depreciation rate of $\delta = 0.0066$, a capital share of $\alpha = 0.33$, and normalize the productivity parameter p to unity.[20]

For the matching function, I deviate from the standard Cobb-Douglas form and use the matching function from Ramey et al. (2000)

$$\mu(X, v) = \frac{Xv}{\left(v^{\frac{1}{\eta}} + X^{\frac{1}{\eta}}\right)^{\eta}}, \tag{3.42}$$

which was used also in the analysis of Hagedorn and Manovskii (2008), and adapted to varying search effort in Mitman and Rabinovich (2015). The reason for this choice is that this matching function imposes that the job-finding rate and the vacancy filling rate are bounded between zero and unity without the need for normalizations. This will be explored further when discussing the calibration of the job-finding rate. I set the bargaining power of the workers β to 0.5 as is commonly done in the literature.

I set the value of ϵ to be as conservative as possible with this central parameter. If I were to obtain a favourable welfare result using $\epsilon = 1$ it would be subject to the critique that I merely mechanically increase output in the model economy. However, when $\epsilon = 0$ there is no basis for such concern, and the results will have the interpretation of a lower bound in terms of welfare.

sum $\frac{\ln(1+\omega)}{\rho}$. Thus, summing over all households one can decompose $\Omega(T, \omega^{\star})$ into $\Omega(T, \omega^{\star}) = \Omega(T, 0) + \left[\frac{\ln(1+\omega^{\star})}{\rho}\right]$, and from Equation (3.41) we obtain that $\ln(1+\omega^{\star}) = \rho(\Omega(T', 0) - \Omega(T, 0))$.

[20] The values of α and δ are based on the DSGE model used by the bank of Israel see Argov et al. (2012).

Termination notice in Israel. Israeli law requires a notice period which precedes termination of the employment relationship by either the employer or the employee. The 2001 termination notice law requires that termination notice be given in writing regardless of the initiating side. Its duration is calculated as follows: for salary workers, one day of notice for each month of employment for workers with tenure of under six months; for each additional month until a tenure of one year, 2.5 additional days of notice are required; and for workers with over a year of tenure, one month of notice is required. During the notice period, the employer-employee pair is forced to keep to the same employment practices as previously, i.e., the wage and scope of work should remain unchanged. The law allows the employer to waive the work of the employee under the condition that all the wage due during the notice period be paid in full. I simplify this increasing schedule by setting the value of λ_{E1} to $1/12$ which means that the employee is, on average, unprotected by notice regulation for the first year of employment and is fully protected by the legislation after the first year. The notice duration is set to one month or $\phi = 1$.

Severance pay in Israel Severance pay regulation has much in common with the mechanism of termination notice. Severance pay can also be considered as an insurance device. Severance pay is also a firm-funded mandate, set with respect to the worker's wage, and is a part of the general institution of employment protection. Its existence raises the question of by how much do severance pay and termination notice regulations interact, and thus should it be included in the model. I argue that the way severance pay regulation is structured in Israel makes the interaction neutral, and that this is an advantage of choosing Israel as the focus of the numerical exercises that would follow.

The 1963 severance pay act states that a person employed for at least a year with the same employer is entitled to severance pay in case of dismissal by the employer or in certain exceptions under which the termination of the employment relationship is treated as dismissal in the eyes of the law. Such exceptions include termination initiated by the employee as a result of illness, illness of a relative, changing a place of residence to a designated development or agricultural area or as a result of initiating cohabitation with a partner, enlistment into the armed forces or the police, transition into public service or retirement. Severance payments are calculated as one month's salary for each year of employment for salary workers, with minor adjustments for the calculation in the case of wage workers concerning their tenure. Additionally, the law grants the Minister of Labour the authority to mandate a transfer of severance payments directly to the retirement fund of the employee continuously during the employment period.

Funds transferred as severance pay to the employee's retirement fund are the property of the employee even when the termination of the employment relationship does not count as a dismissal under the law. The employer has no claim over these funds unless the employment contract provides a contingency for such a case explicitly. This mandate is in use since 2014, and employers are required to transfer to their workers' retirement fund most (72%) of the total amount due to them for severance pay on a monthly basis.[21] This mandated mechanism, in essence, makes severance pay in Israel, not a one-time transfer, but a mandated payment that is part of the cost of employment. As such, through the lens of a model, the Israeli severance pay mechanism does not affect the total wage set by the market. The price of labour includes this severance mark-up that will be offset by the wage-setting mechanism.[22] The severance pay mechanism is not distortionary and has a real effect only on minimum wage workers for whom this is the equivalent of a minimum wage increase or through the borrowing constraint if one considers the additional cost of accessing the severance pay funds in the retirement account. This regulatory framework makes the Israeli requirement for severance pay of no consequence in terms of wage setting and in terms of welfare in the model environment.[23]

The Israeli UI system. [24] The UI system in Israel includes the following features: an age-dependent family size-dependent eligibility duration; taxable UI; the replacement rates are not fixed and feature several ladders for marginal replacement rate, similar to how a progressive income tax is computed;[25] and UI is capped at the average wage. To be eligible for UI payments a person must have accumulated twelve months of employment, excluding self-employment, during the last eighteen months. In addition to standard UI benefits, persons unable to secure income may be eligible for income security benefits, which is considerably lower, computed at the household level, means-tested, and increasing with age and number of dependants.

[21] In practice, many employers transfer the full amount.

[22] Consider for example a simplistic spot labour market model where the wage w is set to the value of the marginal product of labour VMP_L imposing the Israeli severance pay act in this model would mean that now $w(1 + 8.33\%) = VMP_L$ and the worker receives a total income of w plus $8.33\%w$ labelled as severance pay.

[23] This statement abstracts from the effect of severance pay on the minimum wage which can be considered separately.

[24] The above description relates to the system before COVID-19.

[25] Two such schedules exist, for workers younger than 28 and older than 28.

Since my analysis abstracts from family structure and age composition of the population, I focus on households in prime working age. I set the replacement rate pre-tax to $R_1 = 60\%$ which is the replacement rate for a person over 28 with an income of $10,000$ ILS.[26] The eligibility duration in the model is set to an average of four months or $\lambda_{U1} = 0.25$.[27] To conclude the calibration of the policy block, I set the replacement rate implied by the existence of income security benefits to $R_2 = 14.75\%$.[28] The model allows for two different wage levels due to the trial period. Still, for the sake of tractability, I set all replacement rates with relation to the average wage in the economy $\bar{w}$, which will also capture later on the cap at the average wage.

Internally calibrated parameters. To complete the calibration I need to internally calibrate the following five parameters: the matching function parameter η, the effort cost scale and shape parameters ψ_0 and ψ, the separation hazard λ_s, and the cost of vacancy κ. All of these values will essentially capture job creation and destruction in the model.

The current model poses several challenges which merit a short discussion. First, while calibrating simple search and matching models, one may calibrate the job finding rate and separation rate and obtain the unemployment rate. The current model features heterogeneity in the job finding rate originating at heterogeneity in asset levels and the searching households' income states. This heterogeneity means that the job finding rate cannot be directly calibrated. Second, the separation rate cannot be directly calibrated by setting the value of λ_s, as some of the shock realisations will result in job to job transitions and not in commencement of an unemployment spell. Thus, calibrating for job flows is a problematic calibration strategy in this set-up.

Instead, I attempt to fit the model's aggregate outcomes to Israel's turn-over dynamics in the following way. I use the five free parameters ψ_0, ψ, η, λ_s, and κ to obtain the best fit possible to the unemployment duration distribution to capture the overall severity of the risk of unemployment to household income and consumption as a result. Five bins are used as targets, which consist of the proportion of unemployed persons unemployed for less than one month, between one and three months, between three to six months, between six

[26]As of Jan. 1st 2019, the average wage for the computation of benefits in Israel is $10,139$ ILS.

[27]These figures are fairly close to those used by Shlomo and Setty (2018) which use a 63% replacement rate and three months of eligibility. The discrepancy lays in the increase of the average wage and from focusing on the younger cohorts of 28-35 years old.

[28]The total benefits for a family of two or more children is $2,949$ ILS which, per adult person in a household, amounts to 14.75% of an average wage of $10,000$ ILS.

to twelve months, and over twelve months. To fit aggregates, I also choose as additional targets an unemployment rate of 4.6%,[29] and a vacancy rate of 3.27%.[30] The final value I target is the duration elasticity with respect to benefits. This value had been discussed at length in the optimal UI literature, and its size is an essential statistic for understanding the severity of the moral hazard problem. Unfortunately, to the best of my knowledge, there is no empirical estimate of this value for the Israeli market. Therefore, I use the value -0.5, an accepted value in the literature, taken from Chetty and Finkelstein (2013).[31] Due to the heterogeneity in job finding rates, I target the mean elasticity of the job-finding rate with respect to benefits generosity for an unemployed person who is entitled to UI (state $U1$). To avoid degeneracies in the distribution, I cap the effort levels such that no household may have an expected unemployment duration of less than one month when choosing effort ($\lambda_f x_i(a) \leq 1$).

I minimize the model's distance from these eight targets by minimizing the sum of squared relative errors from each target. For exact computational details see Appendix D. Column (1) of Table 6 summarizes the resulting calibration. The model's distance from the eight targets is reported in column (1) of Table 7, and the histogram of unemployment durations is presented in Figure 20. The model fits the aggregates and the elasticities almost perfectly and provides a decent fit to the distribution of unemployment by duration. It does not account well for prolonged unemployment, but this is expected, given that the model abstracts from heterogeneity in skill and age.

3.4 Results

3.4.1 Comparative Statics

Using the general equilibrium framework developed and calibrated in the previous section. I conduct a comparative statics exercise to evaluate the impact of changing the legislated notice period on the economy. Namely, I show the counter-factual impact of increasing the length of notice to three months $\phi = \frac{1}{3}$, and decreasing its length to one week $\phi = \frac{13}{3}$ relative to the calibrated baseline $\phi = 1$. The results of this exercise are presented in detail in Figure 21.

[29] The average unemployment rate for persons between ages 25 to 54 in Israel for 2012 - 2019.

[30] The average value from the Bank of Israel series taken at a monthly frequency for the years 2012 - 2019

[31] The literature regarding this number is vast and documents heterogeneity with respect to gender, age, and state of the business cycle. For a review see Tatsiramos and van Ours (2014).

Comparative statics in the general equilibrium model. The results in Figure 21 show that increasing the duration of termination notice reduces the average labour productivity due to the presence of more workers with ϵ labour input in a notice state leading to a reduction in aggregate output. A similar effect for termination notice is documented Ben Zeev and Ifergane (2021). Note that in contrast to the work of Hopenhayn and Rogerson (1993) that analyse the effects of lay-off taxes, the reduction in output and productivity occurs while employment increases and not decreases. The difference lays in the fact that Hopenhayn and Rogerson (1993) examine employment protection only in the form of firing taxes and not in the form of delayed dismissal.

Additionally, increasing the duration of termination notice results in a reduced labour market tightness. This reduction is the total effect of two forces working in opposite directions, namely, a decline in vacancies which lowers θ, and a decline in search effort, which increases it. The firms are less prone to post vacancies given that termination notice acts as a tax on job creation, and households are less engaged in searching for jobs because there is a higher degree of insurance in the economy with the high-income state, $E2$, lasting longer.

The results in Figure 21 exercise illustrates the distributional impact of termination notice. Examining the asset distribution shows that increasing termination notice duration worsens the average household's asset position. However, the median household's asset position is improved by an increase in notice length.

In addition to affecting asset inequality, termination notice has a bearing on income inequality. Increasing the notice duration results in a mild decline in the wage for workers of type $E2$ as the increase in termination notice also improves their bargaining position. However, the wage of the unprotected group, workers of type E_1, declines by about 13% from its baseline level. This sizeable decrease merits a short discussion as it is pertinent to the policy debate in Europe surrounding employment protection policies at large and illustrates how employment protection leads to the formation of dual labour markets.

Dual labour market as a result of employment protection. The comparative statics exercise shown here leads to the emergence of what the political economy literature would describe as an 'insider-outside dynamics' and the employment protection literature would more specifically a dual labour market. Workers who are unprotected by the policies are adversely affected by their presence. These are usually outsiders to the labour market, such as immigrants and young workers at the beginning of their career. The term 'EPL gap' was applied to this divide between groups that are affected differently by employment protection legislation (EPL), and a sizeable body of works try to illustrate the detrimental effects of such a gap and suggest solutions.[32] In the context of this chapter, the emergence is endogenous, and the difference is a rather stark one. There is no on-the-job training or any human capital difference between the groups, the value of their marginal product is identical, and yet the policy induces a significant wage differential between them. This effect emphasises the redistributive nature of the policy in question and illustrates the power of this policy device.

3.4.2 Welfare Implications

At first glance, the results at the aggregate level are in line with what we would expect from classical works on adjustment costs for labour input such as Hopenhayn and Rogerson (1993), but the distributional effect on assets and the decline in unemployment suggest that there is more to the story. The decline in welfare, documented in Figure 21 is a general equilibrium result, it is the sum of several channels of influence that act in tandem. These channels of influence are varied, and most of them can only be discussed in a general equilibrium setting. In what follows, I decompose the resulting change in aggregate welfare for the two counterfactual scenarios depicted in Figure 21, an increase and a decrease in the termination notice, on aggregate welfare. The results are summarized in Figures 22 and 23 correspondingly. [33] These figures present the effects documented here in order, from left to right.

Channels of influence of termination notice on aggregate welfare.

- *Shift in the income process.* At its most basic level, the change in the value of ϕ is merely a shift in the stochastic process that governs the household's income. In line with the analytical result in Proposition 3.2.2, the general equilibrium model indicates that increasing the duration of termination notice increases aggregate welfare as this allows each household to spend more time, on average, in a higher income state. This result is analogous to the argument that, for given prices, wages, and asset position, the household will be better off where there is longer duration of termination notice.

[32] A comprehensive treatment of dual labour markets lays beyond the scope of the current work. For an excellent review of this topic, see Dolado (2017).

[33] This decomposition is done by solving for the value functions of the household for a given change in one of the equilibrium objects in the economy while holding all the other distributions, masses, and prices constant.

Quantitatively, this is the most substantial positive impact of increasing termination notice.

- *Population composition.* The households, now endowed with more insurance by virtue of the altered income process, have a reduced precautionary motive and will now reduce their savings. On average, this results in an asset-poorer population. Additionally, the masses of households of each type will change as a result of variations in job creation and search effort. Thus, aggregate welfare is decreased as it puts more weight on the lifetime utility of poorer households. Conversely, when termination notice is reduced, the precautionary motive goes up, and the opposite result holds.

- *The wage effect.* As shown in Figure 21, the wage declines along with the increase in termination notice duration. This reduces the aggregate welfare as most households are worse off as a result. Note that the assumption that $\epsilon = 0$, has a bearing on this result as it makes employment more costly to the firm, and reduces the value from creating a job. As such, this magnitude of the wage's impact on welfare should be seen as an upper limit. Quantitatively, it is by far the strongest channel of influence on aggregate welfare.

- *The job creation effect.* Increasing the duration of termination notice reduces θ. As was the case with the wage decline, the decline of θ lowers welfare as it lowers the value of λ_f, making each unit of search effort less likely to bear fruit, which ultimately leads households to expect more prolonged unemployment spells. The reduction of search effort, leads to an income process that is expected to stay longer in the low income state. This serves to lower the welfare in much the same way as the increase in ϕ raised it. Quantitatively, this effect is quite small.

- *The effect on UI benefits.* Lowering the average wage in the economy means that given a fixed replacement rate, the benefits are also reduced accordingly, leading to a decline in welfare.

- *The effect on asset returns.* The increase in termination notice affects the net return on assets by slightly lowering it because it reduces the firms' profitability. As a result, welfare is slightly reduced as the change in net return is small.

- *Tax-base effect.* Increasing termination notice duration increases employment. Increasing employment means that the burden of funding UI is lowered and the government can levy taxes at a reduced rate to finance UI at the same replacement rate. Quantitatively speaking, this tax cut has a sizeable impact on aggregate welfare.

In addition to these channels, the decomposition includes a small residual term which is due to the general equilibrium interaction of these channels. This decomposition sheds light on the complex interplay that labour market policies can have in general equilibrium and shows the potential problems that arise from examining such policies in a partial equilibrium environments. The variety of channels prevents me from concluding that termination notice is merely an unnecessary adjustment cost. The impact on welfare will depend on which of these forces is dominant. With these insights in mind, I proceed to the social planner's problem in the next section.

3.4.3 Optimal Policy Design

Suppose that the social planner seeks to maximize the same utilitarian welfare function defined in Equation (3.40). Then, the planner's problem is to maximize welfare, subject to consistency with the definition of recursive stationary equilibrium in the model.

The standard practice in the optimal UI literature is to take only replacement rates and benefit durations as choice variables for the social planner. My central claims in this paper is that optimal UI should not be considered in isolation from labour laws and that the two should be jointly designed.

The planner has five policy parameters with which to achieve the goal of maximizing welfare. These include the two replacement rates R_1, R_2, the duration of the high benefits regime λ_{U1}, the duration of the trial period ϕ, and the length of the trial period λ_{E1}.

In what follows, I will exclude λ_{E1} from the choice set of the social planner for two reasons. First, technically speaking, very long duration of the trial period or minimal values of λ_{E1} effectively nullify the effect of termination notice on welfare. Second, the reasons for which the trial period is required are not explicitly modelled here. Because the intent behind a trial period has nothing to do with insurance or moral hazard but rather with the process of individual-level uncertainty while entering into a new employment relationship. The trial period may allow the parties to assess the quality of their realized match and to separate costlessly if a mismatch occurs. My framework does not include mismatch or the mechanism of mutual assessment of match-quality. Therefore, I do not attempt to optimize welfare with this policy device and consider in-depth only the UI system and the length of the termination notice.

Optimal policies. I conduct several searches for optimal policies and document the results of these in Table 8. Row (1) reports the baseline policies and normalizes the baseline welfare to allow for a straightforward comparison between the scenarios. First, in row (2) I allow the social planner to control only the length of termination notice and set ϕ optimally. This results in the social planner chooses to abolish termination notice entirely and this results in a modest welfare gain of 0.146%. Second, given the existing termination notice and benefit duration, I allow the planner to control replacement rates. This results in 0.193% welfare gain relative to the baseline level from policies of $R_1 = 45.08\%$ and $R_2 = 0$ for a period of four months. It serves to show that existing policies offer too much insurance given their costs and given the labour market regulation in place. This is documented in row (3) of Table 8.

In row (4) of Table 8, I allow the social planner to take full control of the UI system or to maximize welfare using R_1, R_2 and λ_{U1}. This results in a UI system whereby the newly unemployed person receives full replacement or $R_1 = 100\%$[34] for an expected duration of little over six weeks following which, the unemployed are left completely uninsured ($R_2 = 0$). This policy set takes labour market regulation as completely exogenous and yields a welfare gain of about 0.289% relative to the baseline level.

Finally, in row (5) of Table 8, I allow the social planner full control of all four policy parameters, including the duration of termination notice. This results in an economy where termination notice is abolished, and the unemployed are entitled to about six and a half weeks of UI eligibility with a a full replacement rate ($R_1 = 100\%$) following which the unemployed are unemployed with no benefit eligibility unless they found a new job. This set of policies yields a welfare gain of 0.462% relative to existing policies. This leads one to conclude that termination notice should be abolished and that this legislative adjustment allows the UI system to perform better in terms of welfare.

In relation to the literature, the replacement rates computed here are similar to those in Shlomo and Setty (2018) for Israel but the duration of benefit eligibility documented here is nearly twice as brief. Among many differences in aim and modelling choices between Shlomo and Setty (2018) and the current research the difference probably results mainly from the fact that Shlomo and Setty (2018) allow for a fixed disutility from work while I model varying disutility from job search. This modelling choice means that the optimal policy must drive the unemployed to search more intensely.

[34] This is obtained as a corner solution as I cap the replacement rates at 100%.

3.5 Discussion

These numerical results for Israel apply only to the working-age population of persons able to work and does not include a comprehensive treatment of disability benefits or retirement funds. The exercises performed here should be treated as illustrative of the impact that termination notice as a non-conventional insurance device has on the design of optimal UI and the considerations that matter thereto.

Can termination notice be beneficial? A key adverse effect of termination notice is the fact that, at least from the quantitative standpoint depicted in Figures 22 and Figures 23, its use induces a substantial decline in wages. The reason behind this wage decline is that the firms are using the wage in the unprotected period w_1 as a way to offset some of the costs of termination notice. If, however, that was not the case and wages were less responsive overall, its positive insurance and tax-base effects might manifest as an increase in aggregate welfare. Therefore, if one believes that the employees are particularly weak in the bargaining situation to begin with, then one would obtain a less responsive wage, and a larger welfare gain.

To demonstrate this intuition, I repeat my calibration exercise but now calibrate the model to two values of worker bargaining power $\beta = 0.25$ and $\beta = 0.75$. These calibrations are given in column (2) and (3) of Table 6 and their fit is reported in the corresponding columns of 7. Using these and the baseline parametrisation, I plot welfare as a function of notice duration, and normalize its value at $\phi = 1$ in all three case to 100 for comparability.[35] The comparison is given in Figure 24. Observe that the lower the bargaining power parameter β is, the more meaningful termination notice becomes. We can see that the policy may provide sizeable benefits and the solution to welfare maximization is obtained for a non-trivial value, as a result its lower impact on wages. When β is high, however, the converse holds and termination notice is reduced to a mere adjustment cost.

The actual size of workers' bargaining power is difficult to gauge and may vary across industries. One may argue that when workers are not heavily unionised, are easily replaceable, and their outside prospects are particularly poor, it is likely that their bargaining power will be lower. Thus, termination notice may be beneficially used as a policy in sectors where the workers are easily replaceable by the firm and hold little bargaining ability, such as with low-

[35] Given the monotonic relationship described in footnote 19, I use the raw welfare levels, this has the same interpretation as using $\omega^{\star}$.

skill workers. However, refocusing the discussion to within the limits of the model economy, where clear cut conclusions can be drawn, the parametrization that provides the best fit to the targets among those parametrizations examined in Table 7 is the one where bargaining power is low. This result suggests that there may be a justification for termination notice on the aggregate level, but further analysis is required and lays beyond the scope of the current research.

Observe, that this result on bargaining power should be taken as merely suggestive as this is not a full-scale optimal policy exercise, conditioning on the bargaining power, rather, it is an exploration that uses the intuition gain from the decomposition exercise to suggest a new focus for further research into termination notice. The policy in question introduces a substantial direct cost to firms, and indirectly may harm the households while providing insurance in the process, and interacting with standard unemployment insurance in several ways. Given the complex nature of these interactions further empirical studies may benefit from focusing on workers with a weak bargaining power, and realizing the theoretically anticipated direction of the heterogeneity in response.

3.6 Concluding Remarks

In this chapter, I analyse the effects of termination notice as an insurance device. I illustrate the household's insurance motive and the disincentives on the firm's side using two tractable stylised models and combine them to conduct a quantitative general equilibrium analysis of termination notice using moments of the Israeli labour market.

I decompose the effects of termination notice on welfare and show that the its impact on welfare is far from trivial. The key benefits of having termination notice are that it provides an increased insurance level and lowers the income tax. The main disadvantages are the behavioural shift in savings and a decline in wages that result from it. The policy affects both wealth and income inequality, suggesting that it has a complex cross-sectional impact on the economy. I show that the abolition of termination notice in the baseline model may contribute to the effectiveness of conventional UI measures. Last, I show that termination notice can be beneficial in sectors or economies where workers have little bargaining power.

These results may prove useful for policy-makers in the future as they contribute to the ongoing policy debates on labour market regulations, employment protection policies, and unemployment insurance.

General Discussion

The aim of this thesis was to demonstrate the potential effects of labour market institutions in general and employment protection measures in particular on the macroeconomic environment. These effects stem from the unique nature of the employment contract as an economic transaction in which the employer and employee engage in costly search to form a relationship. This relationship persists until its continuation is no longer mutually beneficial. The separation of this match creates challenges for both sides, and it is the place where dismissal regulation takes effect. The presence of such measures alters the incentive structure of the worker and the firm during the match's existence and even at the time of search.

Although this work focuses on the implications of termination notice and lay-off costs as the main policy tools of interest, but some of the conclusions apply to other policy tools as well. I show that these policies lead the economy to cope differently with business cycles by inducing misallocation and amplifying and prolonging output's decline in response to an adverse shock. I also show that these policy tools, when employed in harmony with other policies, with the aim to provide households with insurance have the potential to improve welfare. Employment protection policies are not the only policy devices which may affect either of these, and the insights of the present research may be incorporated into the analysis of any policy device that induces cross-sectional misallocation or alters the precautionary savings behaviour of households.

The legal frameworks in which agents are situated or the 'rules of the game' often receive much attention through the prism of strategic interactions between the directly affected agents. When aggregated up to the macroeconomic level, this work shows that such rules may yield entirely different environments based upon these micro-foundations. Taken thus, the models presented in this work serve to illustrate the importance of building sound micro-foundations for the policies analysed and for avoiding an over-simplification of policies. Every theoretical framework presented here would have been much reduced, both in terms of complexity and implications, by using lay-off taxes instead of their more realistic counterparts.

The field of macroeconomics began in the aftermath of the Great Depression; by this time, many countries already had well-developed employment protection regimes. As these lines are being typed, the world is, hopefully, starting to recover from the COVID-19 recession. The COVID-19 recession disrupted labour markets and challenged us to reconsider what it means to be employed? The emergence of the so-called 'Gig-economy' had already changed our view of employment relationships, and COVID-19 pushed this to new extremes. During the current recession, we have heard voices pushing for a wider safety net, a safety net that would accommodate new forms of employment, and we have seen the inception of new policies, such as Germany's furlough scheme. The recovery from this recession will probably accelerate processes that will lead to new forms of work and employment relationships. Combined with the desire for a wider social safety net, these processes will lead to new forms of labour market regulations. The insights provided in this work may prove valuable in designing labour market policies in the post-COVID-19 world in a way that will allow for increased social security along with better re-allocation dynamics.

To conclude, the works presented in this thesis show the macroeconomic implications of employment protection. Hopefully this research will enrich the policy debate surrounding labour market institutions, especially during the post-COVID-19 era, will motivate future research along this understudied area and prove useful to future researchers working on similar issues. As an Israeli researcher, I also hope that my use of Israeli data and the focus on Israeli policies will be useful to future researchers working on the Israeli economy and those who wish to contribute to the formation of better economic policy in the country. Accordingly, I restate my gratitude to the National Insurance Institute of Israel and the Planning and Budgeting Committee of the Israeli Council for Higher Education's scholarship for research of the Israeli economy for their generous support of my work.

Bibliography, Appendices, Figures, and Tables

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Appendix A

Data Sources and Definitions of Variables Chapter One

Appendix A.1 EPL Indicators

Definition of Variables. EPL is defined as the OECD's index 'Strictness of employment protection - individual dismissals (regular contracts)' (EPR V1) which is measured according to a method of hierarchies of hierarchies on a 0 to 6 scale. The index aggregates several different scores spread over three equally weighted categories: procedural inconvenience (notification procedures and timing), notice and severance pay for no-fault individual dismissal, and difficulty of dismissal. The method of calculation is shown in Table 1. The series is used as an annual data series and assumed identical over the course of each calendar year. Additionally, I use the EPT V1 series for protection fo temporary employment. This series is measured in a similar fashion to that of the EPR V1 series, but this time as an aggregate of measures that limit the use of fixed-term and agency workers, and govern their utilization. Finally, I add the OECD series of employment protection from collective dismissals which is an aggregate of scores on the criteria, procedures and costs involved with collective dismissals according to the OECD predetermined weights.

Sample. The panel for these variables includes the EPR V1, and EPT V1 indicators' values for the years of 1985-2014 for 21 countries during the following time periods (for collective dismissals the series is available for all the following countries for the years 1998-2013, and 1998-2014 for the United Kingdom): Australia 1985-2013; Austria 1985-2013; Belgium 1985-2013; Canada 1985-2013; Denmark 1985-2013; Finland 1985-2013; France

1985-2013; Germany 1985-2013; Greece 1985-2013; Ireland 1985-2013; Italy 1985-2013; Japan 1985-2013; Netherlands 1985-2013; New Zealand 1990-2013; Norway 1985-2013; Portugal 1985-2013; Spain 1985-2013; Sweden 1985-2013; Switzerland 1985-2013; United Kingdom 1985-2014; United States 1985-2013.

Appendix A.2 Credit Supply Shock

Definition of Variable. To measure global credit supply shocks, I exploit the Gilchrist and Zakrajšek (2012) credit supply shock series. Gilchrist and Zakrajšek (2012) use micro-level data to construct a credit spread index which they decompose into a component that captures firm-specific information on expected defaults and a residual component that they term the excess bond premium. The most updated series of the excess bond premium variable is available from Simon Gilchrist's website [1] and is my measure of credit supply shock. It is taken in monthly values from 1985:m1-2014:m12. Quarterly and annual values are averages of the corresponding raw monthly values for 1985:Q1-2014:Q4.

Appendix A.3 National Accounts Data

Definition of Variables. Output is GDP measured by the expenditure approach, consumption is private final consumption expenditure, investment is gross fixed capital formation, imports, exports are imports and exports of goods and services and government expenditure is general government final consumption expenditure. All series are taken as volume indexes using OECD reference year and are seasonally adjusted. I use the data as log-first-differences. Output per-capita is defined as the quarterly GDP per capita in U.S. dollars, using constant prices, fixed PPP, and is seasonally adjusted. The series are obtained from the OECD database at http://stats.oecd.org/ and taken as log-first-differences.

Sample. The panel includes observations for the years 1985-2014 for 21 countries during the following time periods: Australia 1985:Q1-2013:Q4; Austria 1988Q1-2013:Q4 (output per capita 1995:Q1-2013:Q4); Belgium 1995:Q1-2013:Q4; Canada 1985:Q1-2013:Q4; Denmark 1995:Q1-2013:Q4; Finland 1990:Q1-2013:Q4; France 1985:Q1-2013:Q4; Germany 1991:Q1-2013:Q4; Greece 1995:Q1-2013:Q4; Ireland 1997:Q1-2013:Q4 (output per capita 1998:Q1-

[1] The permanent link for this updated excess bond premium series is https://www.federalreserve.gov/econresdata/notes/feds-notes/2016/files/ebp_csv.csv.

2013:Q4); Italy 1985:Q1-2013:Q4 (output per capita 1995:Q1-2013:Q4); Japan 1994:Q3-2013:Q4 (output per capita 2007:Q3-2013:Q4); Netherlands 1988:Q1-2013:Q4 (output per capita 1995:Q1-2013:Q4); New Zealand 1990:Q1-2013:Q4 (output per capita 1991:Q1-2013:Q4); Norway 1985:Q1-2013:Q4 (output per capita 1995:Q1-2013:Q4); Portugal 1995:Q1-2013:Q4; Spain 1995:Q1-2013:Q4; Sweden 1985:Q1-2013:Q4 (output per capita 1993:Q1-2013:Q4); Switzerland 1985:Q1-2013:Q4 (output per capita 1991:Q1-2013:Q4); United Kingdom 1985:Q1-2013:Q4 (output per capita 1995:Q1-2013:Q4); United States 1985:Q1-2013:Q4.

Appendix A.4 Unemployment

Definition of Variable. The panel utilizes the OECD harmonized unemployment (all persons) series in a monthly frequency. The series is taken as log-first-differences retrieved from the OECD's database at http://stats.oecd.org/.

Monthly sample. The monthly panel for unemployment includes observations for the years 1985-2014 for 19 countries (data for New Zealand and Switzerland is unavailable) during the following time periods: Australia 1985:M1-2013:M12; Austria 1993:M1-2013:M12; Belgium 1985:M1-2013:M12; Canada 1985:M1-2013:M12; Denmark 1985:M1-2013:M12; Finland 1988:M1-2013:M12; France 1985:M1-2013:M12; Germany 1991:M1-2013:M12; Greece 1998:M4-2013:M12; Ireland 1985:M1-2013:M12; Italy 1985:M1-2013:M12; Japan 1985:M1-2013:M12; Netherlands 1985:M1-2013:M12; Norway 1989:M1-2013:M12; Portugal 1985:M1-2013:M12; Spain 1986:M4-2013:M12; Sweden 1985:M1-2013:M12; United Kingdom 1985:M1-2014:M12; United States 1985:M1-2013:M12.

Appendix A.5 Population and Labour Force Participation

Definition of Variables. I define labour force participation as the ratio between the active population (persons actively engaged in search or currently in employment) and the working age population. Both measures include all persons aged 15 and over, other than for Spain, the United Kingdom, and the United States, for which the lower bound is 16. I also make use of the ratio between the employed population to the working age population (employment to population ratio), again for the same ages. The raw data includes three data series (employed, active, and working age population) expressed in thousands of persons. The resulting ratios are taken as log-first-differences. All raw series used for the creation of these ratio series are from the OECD database at http://stats.oecd.org/.

Sample. The quarterly panel for these ratios includes observations for the years 1985-2014 for 21 countries during the following time periods: Australia 1985:Q1-2013:Q4; Austria 1999:Q1-2013:Q4; Belgium 1999:Q1-2013:Q4; Canada 1995:Q1-2013:Q4; Denmark 1999:Q1-2013:Q4; Finland 2000:Q1-2013:Q4; France 2003:Q1-2013:Q4; Germany 2005:Q1-2013:Q4; Greece 1998:Q1-2013:Q4; Ireland 1999:Q2-2013:Q4; Italy 1998:Q1-2013:Q4; Japan 1985:Q1-2013:Q4; Netherlands 2000:Q1-2013:Q4; New Zealand 1990:Q1-2013:Q4; Norway 2000:Q1-2013:Q4; Portugal 1998:Q1-2013:Q4; Spain 1999:Q1-2013:Q4; Sweden 2001:Q1-2013:Q4; Switzerland 2010:Q1-2013:Q4 (available only for Q2 for 1999-2009); United Kingdom 1999:Q2-2014:Q4; United States 1985:Q1-2013:Q4.

Appendix A.6 Vacancies

Definition of Variable. I define vacancies as the ratio between the stock of vacancies normalized by the working age population from the previous subsection, which includes all persons aged 15 and over, other than for Spain, the United Kingdom, and the United States for which the lower bound is 16. The raw data includes two data series (total vacancy stock, and working age population) expressing numbers of persons and seasonally adjusted. The resulting normalized series is taken as log-first-differences. All raw series are from the OECD database at http://stats.oecd.org/.

Sample. The quarterly panel for vacancies includes observations for the years 1985-2014 for 12 countries (Canada, Denmark, France, Greece, Ireland, Italy, Japan, Netherlands, and New Zealand are missing) during the following time periods: Australia 1985:Q1-2008:Q2 and 2009:Q4-2013:Q4; Austria 1999:Q1-2013:Q4; Belgium 1999:Q1-2004:Q1; Finland 2000:Q1-2013:Q4; Germany 2005:Q1-2013:Q4; Norway 2000:Q1-2013:Q4; Portugal 1998:Q1-2013:Q4; Spain 1999:Q1-2005:Q1; Sweden 2001:Q1-2013:Q4; Switzerland 2010:Q1-2013:Q4 (available only for Q2 for 1999-2009); United Kingdom 1999:Q2-2014:Q4; United States 2001:Q1-2013:Q4.

Appendix A.7 Real Wage

Definition of Variable. I define real wage as the ratio of total compensations in local currency and in current prices deflated using the country's own consumer price index taking 1985 as a base year and dividing by the number of employed persons. The raw data includes three data series (the consumer price index, total compensations, and employed population) which are seasonally adjusted. The resulting ratio, the average real wage per employed person, is taken as log-first-differences. All raw series used for the creation of this series are from the OECD's database at http://stats.oecd.org/.

Sample. The quarterly panel for the above ratios includes observations for the years 1985-2014 for 17 countries (Canada, Japan, New Zealand, and the United States are missing) during the following time periods: Australia 1985:Q1-2013:Q4; Austria 1995:Q1-2013:Q4; Belgium 1995:Q1-1997:Q4, 1999:Q1-2013:Q4; Denmark 1995:Q1-2013:Q4; Finland 1998:Q1-2013:Q4; France 2003:Q1-2013:Q4; Germany 1991:Q1-2013:Q4; Greece 1995:Q1-2013:Q4; Ireland 1998:Q1-2013:Q4; Italy 1998:Q1-2013:Q4; Netherlands 1998:Q1-2013:Q4; Norway 2000:Q1-2013:Q4; Portugal 1998:Q1-2013:Q4; Spain 1999:Q1-2013:Q4; Sweden 2001:Q1-2013:Q4; Switzerland 2010:Q1-2013:Q4 (available only for Q2 for 1999-2009); United Kingdom 1999:Q2-2014:Q4; United States 1985:Q1-2013:Q4.

Appendix A.8 Capacity Utilization

Definition of Variable. I define capacity utilization as the rate of capacity utilization from the OECD business tendency surveys for manufacturing industries. The raw data is in percentage points, seasonally adjusted, and used as log-first-differences. The series is from the OECD database at http://stats.oecd.org/.

Sample. The quarterly panel for this series includes observations for the years 1985-2014 for 18 countries [2] during the following time periods: Austria 1996:Q1-2013:Q4; Belgium 1985:Q1-2013:Q4; Denmark 1987:Q1-2013:Q4; Finland 1991:Q1-2013:Q4; France 1985:Q1-2013:Q4; Germany 1985:Q1-2013:Q4; Greece 1985:Q1-2013:Q4; Ireland 1985:Q1-2008:Q3;

[2] Data for Canada is missing. Data for Australia and Japan is available, however, the range of values for these two countries is not comparable to the ones for the other countries. To illustrate, according to the raw series the range of values for Australia is from -44 to 13, for Japan -36 to 13, and for all other countries from 47.4 to 93.4

Italy 1985:Q1-2013:Q4; Netherlands 1985:Q1-2013:Q4; New Zealand 1990:Q1-2013:Q4; Norway 1987:Q1-2013:Q4; Portugal 1985:Q1-2013:Q4; Spain 1985:Q1-2013:Q4; Sweden 1995:Q1-2013:Q4; Switzerland 1985:Q1-2013:Q4; United Kingdom 1985:Q2-2014:Q4; United States 1985:Q1-2013:Q4.

Appendix A.9 Total Factor Productivity

Definition of Variable. TFP is defined as the OECD MFP (multifactor productivity) series. The raw data is an index using 2010 as a base year, seasonally adjusted, and used as log-first-differences. The series is from the OECD database at http://stats.oecd.org/.[3]

Sample. The panel for this variable includes values for the years 1985-2014 for 19 countries (Greece and Norway are missing) during the following time periods: Australia 1985-2013; Austria 1996-2013; Belgium 1985-2013; Canada 1985-2013; Denmark 1985-2013; Finland 1985-2013; France 1985-2013; Germany 1985-2013; Ireland 1985-2013; Italy 1985-2013; Japan 1985-2013; Netherlands 1985-2013; New Zealand 1990-2013; Portugal 1985-2013; Spain 1985-2013; Sweden 1985-2013; Switzerland 1992-2013; United Kingdom 1985-2014; United States 1985-2013.

Appendix A.10 Hours Worked

Definition of Variable. Hours worked per-employed person are defined as the OECD series average annual hours worked which is the total number of hours actually worked per year divided by the average number of people in employment per year. The series on total hours worked is the product of this series with the annual average of the number of employed persons series described above. The raw data is in numbers of hours and used as log-first-differences. The series is from the OECD database at http://stats.oecd.org/.

Sample. The panel for these variables includes values for the years 1985-2014 for 21 countries during the following time periods: Australia 1985-2013; Austria 1995-2013; Belgium 1985-2013 (Total hours missing for 1998); Canada 1985-2013; Denmark 1985-2013 (total hours missing for 1985-1989); Finland 1985-2013 (total hours missing for 1985-1997); France 1985-2013 (total hours missing for 1985-2002); Germany 1991-2013; Greece 1985-2013 (total

[3] For more information on the series see http://www.oecd.org/sdd/productivity-stats/2352458.pdf.

hours missing for 1985-1988); Ireland 1998-2013; Italy 1995-2013 (total hours missing for 1995-1997); Japan 1985-2013; Netherlands 1985-2013 (total hours missing for 1985-1997); New Zealand 1990-2013; Norway 1985-2013 (total hours missing for 1985-2000); Portugal 1985-2013 (total hours missing for 1985-1998); Spain 1985-2013 (total hours missing for 1985-1998); Sweden 1985-2013 (total hours missing for 1985-2000); Switzerland 1991-2013 (total hours missing for 1991-1997); United Kingdom 1985-2014 (total hours missing for 1985-1998); United States 1985-2013.

Appendix A.11 Union Density

Definition of Variable. Union density is defined as the OECD series on trade union density rates which is the ratio of union members divided by the total number of employees based on administrative data. If such data is unavailable, survey data had been imputed instead. The series is available at an annual frequency, assumed identical within each calendar year, in a similar fashion to the EPL series, and taken from the OECD database at http://stats.oecd.org/.

Sample. The panel for this variable includes values for the years 1985-2014 for 21 countries during the following time periods: Australia 1985-2013; Austria 1985-2013; Belgium 1985-2013; Canada 1985-2013; Denmark 1985-2013; Finland 1985-2013; France 1985-2013; Germany 1985-2013; Greece 1985, 1990, 1992, 1995, 1998, 2001-2002, 2004-2006, 2008, 2011,2013; Ireland 1985-2013; Italy 1985-2013; Japan 1985-2013; Netherlands 1985-2013; New Zealand 1990-2013; Norway 1985-2013; Portugal 1985-1990, 1995, 1997, 2002-2004, 2006, 2008, 2010-2011; Spain 1985-2013; Sweden 1985-2013; Switzerland 1985-2013; United Kingdom 1985-2014; United States 1985-2013.

Appendix A.12 Collective Bargaining Coverage

Definition of Variable. Collective bargaining coverage is defined as the OECD series of the same name which is the ratio of employees covered by collective agreements, divided by all wage earners with a right to bargaining. The series is available at an annual frequency, and thus I assume it is identical within each calendar year, in a similar fashion to my treatment of the EPL series. The series is taken from the OECD database at http://stats.oecd.org/.

Sample. The panel for this variable includes values for the years of 1985-2014 for 21 countries during the following time periods: Australia 1985, 1990, 1998, 2000, 2002, 2004, 2006, 2008, 2010, 2012; Austria 1985, 1990, 1995, 2000, 2005, 2008, 2010, 2013; Belgium 1985, 1990, 1995, 2000, 2002, 2008, 2013; Canada 1985-2013; Denmark 1985, 1990, 1993, 1997, 2000, 2004, 2006-2007, 2009-2010, 2013; Finland 1985, 1989, 1995, 2000, 2002-2006, 2008-2013; France 1985, 1990, 1997, 2004, 2008-2009, 2012; Germany 1985, 1990, 1995-2013; Greece 1985, 1990, 1995, 2000-2013; Ireland 2000, 2005, 2009; Italy 1985, 1990, 1995, 2000-2013; Japan 1985, 1988, 1990, 1995, 2000, 2005-2013; Netherlands 1985-1990, 1992-1993, 1996, 2000-2013; New Zealand 1990. 1992-2003, 2007, 2010-2011; Norway 1985, 1990, 1994, 1998, 2002, 2006, 2009, 2013; Portugal 1985, 1990, 1995, 1999-2013; Spain 1985, 1990, 1993-2013; Sweden 1985, 1990, 1994-1995, 1998, 2000, 2002, 2005, 2007, 2011, 2013; Switzerland 1985, 1990-1992, 1994, 1996, 1999, 2001, 2003, 2005, 2007, 2009-2010, 2012-2013; United Kingdom 1985, 1990, 1994-2014; United States 1985-2013.

Appendix A.13 Net Replacement Rate

Definition of Variable. Net replacement rate is defined as the OECD series on the generosity of unemployment benefits, which reports replacement rates after 6 months of unemployment for an adult with an average wage partner and two children including housing benefits eligibility. Series available at `http://stats.oecd.org/`.

Sample. The panel for this variable includes annual values for the years 2001-2014 for 21 countries during the following time periods: Australia 2001-2013; Austria 2001-2013; Belgium 2001-2013; Canada 2002-2013; Denmark 2001-2013; Finland 2001-2013; France 2001-2013; Germany 2001-2013; Greece 2001-2013; Ireland 2001-2013; Italy 2001-2013; Japan 2001-2013; Netherlands 2001-2013; New Zealand 2001-2013; Norway 2001-2013; Portugal 2001-2013; Spain 2001-2013; Sweden 2001-2013; Switzerland 2001-2013; United Kingdom 2001-2014; United States 2001-2013.

Appendix A.14 Separation Rate and Job-Finding Rate

Definition of Variables. Both series are taken from the decomposition of OECD data on employment into flows carried out in Elsby et al. (2013) using the final data series after both series had been tested and adjusted for duration dependence should it exist. These series are available from the author's website at https://sites.google.com/site/mikeelsby/data.

Sample. The panel for these variables include annual values for monthly flow hazards for the years 1985-2009 for 17 countries during the following time periods: Australia 1985-2009; Canada 1985-2009; France 1985-2009; Germany 1985-2009; Ireland 1985-1997, 1999, 2001-2009; Italy 1985-2009; Japan 1985-2009; New Zealand 1987-2009; Norway 1985, 1988-2009; Portugal 1986-2009; Spain 1985-2009; Sweden 1985-2004, 2007-2009; United Kingdom 1985-2009; United States 1985-2009.

Appendix B

Model Solution for Chapter Two

Appendix B.1 Derivatives of the Value Functions to Obtain the First Order Conditions of the Bargaining Problem

Using the expressions for $\mathrm{J}^n\left(\mathrm{w}\left(x,\mathbf{s}\right),\mathbf{s}\right)$, and $\mathrm{W}^n\left(\mathrm{w}\left(x,\mathbf{s}\right),\mathbf{s}\right)$ given by Equations (2.2) and (2.4), it is possible to use the envelope theorem to obtain the following derivatives:

$$\frac{\partial\,\mathrm{J}^n\left(\mathrm{w}\left(x,\mathbf{s}\right),\mathbf{s}\right)}{\partial w} = -\frac{1}{r+\phi}, \tag{B.1.1}$$

$$\frac{\partial\,\mathrm{W}^n\left(\mathrm{w}\left(x,\mathbf{s}\right),\mathbf{s}\right)}{\partial w} = \frac{1}{r+\phi}. \tag{B.1.2}$$

These equations are interpreted as follows: each additional unit of wage given to the worker during notice is worth its present discounted value from now to infinity with the discount rate r and termination hazard ϕ. Note that these have opposite signs, so one unit given to the worker is one unit taken from the firm.

For $\mathrm{J}\left(x,\mathbf{s}\right)$ and $\mathrm{W}\left(x,\mathbf{s}\right)$, the situation is slightly more complex because of the presence of the variational inequalities. I denote the aggregate state-space of the model by Λ with finite cardinality a and let the transitions be governed by the Markov matrix Π with $\pi_{i,j}$ denoting the transitional probabilities from state i to state j. Let us define for each x its set of continuation states $\Lambda^c(x) \subseteq \Lambda$ as the aggregate states whose realisation will cause the match to continue. Similarly, for each aggregate state $\mathbf{s}$ I define $X^c(\mathbf{s}) \subseteq [x_{\min}, x_{\max}]$ as the subset of all realisations of x, the idiosyncratic component, that would result in the match's continuation. Now, one can derive the following expression from Equation (2.1):

$$(r+\lambda+\tau)\frac{\partial \mathrm{J}(x,\mathbf{s})}{\partial w} = -1 + \lambda \int_{y \notin X^c(\mathbf{s})} \frac{\partial \mathrm{J}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s})}{\partial w} \mathrm{dG}(y) + \tau \sum_{\mathbf{s}' \notin \Lambda^c(x)} \frac{\partial \mathrm{J}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s})}{\partial w} \pi_{\mathbf{s},\mathbf{s}'} + \tau \sum_{\mathbf{s}' \in \Lambda^c(x)} \frac{\partial \mathrm{J}(x,\mathbf{s}')}{\partial w} \pi_{\mathbf{s},\mathbf{s}'}, \tag{B.1.3}$$

where Equation (B.1.1) can be used to yield

$$(r+\lambda+\tau)\frac{\partial \mathrm{J}(x,\mathbf{s})}{\partial w} - \tau \sum_{\mathbf{s}' \in \Lambda^c(x)} \frac{\partial \mathrm{J}(x,\mathbf{s}')}{\partial w} \pi_{\mathbf{s},\mathbf{s}'} = -1 - \left(\lambda \int_{y \notin X^c(\mathbf{s})} \frac{\partial \mathrm{J}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s})}{\partial w} \mathrm{dG}(y) + \tau \sum_{\mathbf{s}' \notin \Lambda^c(x)} \frac{\partial \mathrm{J}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s})}{\partial w} \pi_{\mathbf{s},\mathbf{s}'} \right) \frac{1}{r+\phi}. \tag{B.1.4}$$

Letting $\Delta \frac{\partial \mathrm{J}(x,\mathbf{s})}{\partial w}$ denote the a length column vector of derivatives of $\mathrm{J}(x,\mathbf{s})$ with respect to the wage in each state $\mathbf{s}$ in the state space, these a equations can be stacked to obtain that:

$$\Delta \frac{\partial \mathrm{J}(x,\mathbf{s})}{\partial w} = -(\mu(\mathbf{s}) - \tau\, \Pi^c(x))^{-1} \left[1 + (\lambda\, \mathrm{Prob}(y \notin \mathrm{X}^c(\mathbf{s})) + \tau\, \mathrm{Prob}(\mathbf{s}' \notin \Lambda^c(x)\,|\mathbf{s})) \frac{1}{r+\phi} \right], \tag{B.1.5}$$

where μ is an $a \times a$ diagonal matrix whose entries are $\mu_{\mathbf{s},\mathbf{s}} = \mathrm{r}(\mathbf{s}) + \lambda(\mathbf{s}) + \tau$, $\Pi^c(x)$ is the Markov matrix Π after substituting all entries $\pi_{i,j}$ such that $j \notin \Lambda^c(x)$ with zeros[1], and $\mathrm{Prob}(y \notin \mathrm{X}^c(\mathbf{s}))$ and $\mathrm{Prob}(\mathbf{s}' \notin \Lambda^c(x)\,|\mathbf{s})$ are column vectors of length a containing the corresponding probabilities denoted in the parenthesis for each state.

To see that a solution to Equation (B.1.5) exists and is unique, let us first examine the matrix

$$T = (\mu - \tau\, \Pi^c(x)).$$

The diagonal entries of T are either $(\mathrm{r}(\mathbf{s}) + \lambda(\mathbf{s}) + \tau) - \tau\, \pi_{\mathbf{s},\mathbf{s}}$ or $(\mathrm{r}(\mathbf{s}) + \lambda(\mathbf{s}) + \tau)$ and are strictly positive since r and λ are the discount rate and a Poisson arrival rate, respectively, and $0 \le \pi_{\mathbf{s},\mathbf{s}} \le 1$. The off-diagonal elements are either zero or $-\tau\, \pi_{\mathbf{s},\mathbf{s}'}$. Taken together,

[1] I do not consider state dependence of τ, as any such design can be equivalently represented by changing the elements of Π.

these make T a Z-matrix. Moreover, the matrix is semi-positive since there exists a vector, namely, $\mathbf{i}$ the a length unit vector, such that $T\mathbf{i} > 0$, where $>$ is the element-wise order. That makes T a non-singular M-matrix which has the property of being inverse positive.

Second, let us observe that in addition to T^{-1} having only non-negative entries, the vector

$$\left[1 + (\lambda \,\mathrm{Prob}\,(y \notin \mathrm{X}^c\,(\mathbf{s})\,) + \tau\,\mathrm{Prob}\,(\mathbf{s}' \notin \Lambda^c\,(x)\,|\mathbf{s}\,)\,)\frac{1}{r+\phi}\right]$$

consists of strictly positive entries, thus the signs of all these derivatives are negative and are given by the solutions to Equation (B.1.5).

Now, one may turn to the worker's side of the problem, using the same notations and Equation (2.3) to yield

$$\begin{aligned}(r+\lambda+\tau)\frac{\partial\,\mathrm{W}\,(x,\mathbf{s})}{\partial w} =& 1 + \lambda\int_{y\notin \mathrm{X}^c(\mathbf{s})} \frac{\partial\,\mathrm{W}^n\,(\,\mathrm{w}\,(x,\mathbf{s})\,,\mathbf{s})}{\partial w}\,\mathrm{dG}\,(y) \\ &+ \tau\sum_{\mathbf{s}'\notin \Lambda^c(x)} \frac{\partial\,\mathrm{W}^n\,(\,\mathrm{w}\,(x,\mathbf{s})\,,\mathbf{s})}{\partial w}\pi_{\mathbf{s},\mathbf{s}'} + \tau\sum_{\mathbf{s}'\in \Lambda^c(x)} \frac{\partial\,\mathrm{W}\,(x,\mathbf{s}')}{\partial w}\pi_{\mathbf{s},\mathbf{s}'}\,,\end{aligned} \tag{B.1.6}$$

where Equation (B.1.2) can be used to obtain

$$\begin{aligned}&(r+\lambda+\tau)\frac{\partial\,\mathrm{W}\,(x,\mathbf{s})}{\partial w} - \tau\sum_{\mathbf{s}'\in \Lambda^c(x)} \frac{\partial\,\mathrm{W}\,(x,\mathbf{s}')}{\partial w}\pi_{\mathbf{s},\mathbf{s}'} = \\ &1 + \left(\lambda\int_{y\notin \mathrm{X}^c(\mathbf{s})} \frac{\partial\,\mathrm{W}^n\,(\,\mathrm{w}\,(x,\mathbf{s})\,,\mathbf{s})}{\partial w}\,\mathrm{dG}\,(y) + \tau\sum_{\mathbf{s}'\notin \Lambda^c(x)} \frac{\partial\,\mathrm{W}^n\,(\,\mathrm{w}\,(x,\mathbf{s})\,,\mathbf{s})}{\partial w}\pi_{\mathbf{s},\mathbf{s}'}\right)\frac{1}{r+\phi}.\end{aligned} \tag{B.1.7}$$

Letting $\Delta\frac{\partial\,\mathrm{W}(x,\mathbf{s})}{\partial w}$ denote the a length column vector of derivatives of $\mathrm{W}\,(x,\mathbf{s})$ with respect to the wage in each state $\mathbf{s}$ in the state space, let us again stack the resulting a equations and use the same notations to obtain:

$$\begin{aligned}&\Delta\frac{\partial\,\mathrm{W}\,(x,\mathbf{s})}{\partial w} = \\ &(\,\mu\,(\mathbf{s})\, - \tau\,\Pi^c\,(x)\,)^{-1}\left[1 + (\lambda\,\mathrm{Prob}\,(y\notin X^c\,(\mathbf{s})) + \tau\,\mathrm{Prob}\,(\mathbf{s}'\notin \Lambda^c\,(x)\,|\mathbf{s})\,)\frac{1}{r+\phi}\right].\end{aligned} \tag{B.1.8}$$

Following the same line of reasoning as before, the solutions to this system exist and are unique. Furthermore, taken together Equations (B.1.5) and (B.1.8) mean that for every aggregate state we obtain $\frac{\partial \mathrm{W}(x,\mathbf{s})}{\partial w} = -\frac{\partial \mathrm{J}(x,\mathbf{s})}{\partial w}$ which along with Equations (B.1.1) and (B.1.2) yield

$$\frac{\partial \mathrm{W}(x,\mathbf{s})}{\partial w} - \frac{\partial \mathrm{W}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s})}{\partial w} = -\left[\frac{\partial \mathrm{J}(x,\mathbf{s})}{\partial w} - \frac{\partial \mathrm{J}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s})}{\partial w}\right]. \tag{B.1.9}$$

Appendix B.2 Deriving the Match Surplus Equation

Recall the definition of the match surplus from Equation (2.8):

$$\mathrm{M}(x,\mathbf{s}) = \mathrm{J}(x,\mathbf{s}) + \mathrm{W}(x,\mathbf{s}) - \mathrm{M}_n(\mathbf{s}).$$

Multiplying by r and substituting Equations (2.1) and (2.3) into the above expression yields:

$$\begin{aligned} r\,\mathrm{M}(x,\mathbf{s}) = {} & \mathrm{w}(x,\mathbf{s}) + \lambda \int_{x_{\min}}^{x_{\max}} \max\{\mathrm{W}(y,\mathbf{s}),\ \mathrm{W}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s})\}\,\mathrm{dG}(y) - \lambda\,\mathrm{W}(x,\mathbf{s}) \\ & + \tau E[\max\{\mathrm{W}(x,\mathbf{s}'),\ \mathrm{W}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s}')\} - \mathrm{W}(x,\mathbf{s}) \mid \mathbf{s}] + xp[\mathrm{f}(k(\mathbf{s})) - \rho k(\mathbf{s})] - \mathrm{w}(x,\mathbf{s}) \\ & + \lambda \int_{x_{\min}}^{x_{\max}} \max\{\mathrm{J}(y,\mathbf{s}),\ \mathrm{J}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s})\}\,\mathrm{dG}(y) - \lambda\,\mathrm{J}(x,\mathbf{s}) \\ & + \tau E[\max\{\mathrm{J}(x,\mathbf{s}),\ \mathrm{J}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s}')\} - \mathrm{J}(x,\mathbf{s}) \mid \mathbf{s}] - r\,\mathrm{M}_n(\mathbf{s}). \end{aligned}$$

Cancelling out the wage, using the definitions of $\mathrm{M}(x,\mathbf{s})$ and $\mathrm{M_n}(\mathbf{s})$, and the identity $\mathrm{M}(x,\mathbf{s}) + \mathrm{M}_n(\mathbf{s}) = \mathrm{J}(x,\mathbf{s}) + \mathrm{W}(x,\mathbf{s})$ we obtain:

$$\begin{aligned} & (r+\lambda+\tau)(\mathrm{M}(x,\mathbf{s}) + \mathrm{M}_n(\mathbf{s})) = xp(\mathrm{f}(k(\mathbf{s})) - \rho k(\mathbf{s})) + \\ & + \lambda\left[\int_{x_{\min}}^{x_{\max}} \max\{\mathrm{W}(y,\mathbf{s}),\ \mathrm{W}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s})\}\,\mathrm{dG}(y) + \int_{x_{\min}}^{x_{\max}} \max\{\mathrm{J}(y,\mathbf{s}),\ \mathrm{J}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s})\}\,\mathrm{dG}(y)\right] \\ & + \tau[E[\max\{\mathrm{W}(x,\mathbf{s}'),\ \mathrm{W}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s}')\} \mid \mathbf{s}] + E[\max(\mathrm{J}(x,\mathbf{s}),\ \mathrm{J}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s}')) \mid \mathbf{s}]]. \end{aligned}$$

This equation can be further simplified by keeping in mind that the first order conditions of the problem impose a surplus sharing of the form $\mathrm{W}(x,\mathbf{s}) - \mathrm{W}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s}) = \beta\,\mathrm{M}(x,\mathbf{s})$ and $\mathrm{J}(x,\mathbf{s}) - \mathrm{J}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s}) = (1-\beta)\,\mathrm{M}(x,\mathbf{s})$. This means that $\mathrm{W}(x,\mathbf{s}) >$

$\mathrm{W}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s})$ and $\mathrm{J}(x,\mathbf{s}) > \mathrm{J}^n(\mathrm{w}(x,\mathbf{s}),\mathbf{s})$ if and only if $\mathrm{M}(x,\mathbf{s}) > 0$, which implies that the value of the expression inside all the maximum operators will be determined solely by $\mathrm{M}(x,\mathbf{s})$. This results in

$$\begin{aligned}&(r+\lambda+\tau)(\mathrm{M}(x,\mathbf{s})+\mathrm{M}_n(\mathbf{s})) = xp(\mathrm{f}(k(\mathbf{s}))-\rho k(\mathbf{s}))\\&+\lambda\int_{x_{\min}}^{x_{\max}}\max(\mathrm{M}(y,\mathbf{s})+\mathrm{M}_n(\mathbf{s}),\mathrm{M}_n(\mathbf{s}))\,\mathrm{dG}(y)\\&+\tau[E[\max\{\mathrm{M}(x,\mathbf{s}')+\mathrm{M}_n(\mathbf{s}'),\mathrm{M}_n(\mathbf{s}')\}\mid\mathbf{s}]],\end{aligned}$$

which can be further simplified into

$$\begin{aligned}&(r+\lambda+\tau)(\mathrm{M}(x,\mathbf{s})+\mathrm{M}_n(\mathbf{s})) = xp(\mathrm{f}(k(\mathbf{s}))-\rho k(\mathbf{s}))+\\&\lambda\left[\mathrm{M}_n(\mathbf{s})+\int_{x_{\min}}^{x_{\max}}\max(\mathrm{M}(y,\mathbf{s}),0)\,\mathrm{dG}(y)\right]+\tau[E[\max\{\mathrm{M}(x,\mathbf{s}'),0\}+\mathrm{M}_n(\mathbf{s}')\mid\mathbf{s}]].\end{aligned} \tag{B.2.1}$$

Appendix B.3 Uniqueness of The Reservation Level

This section proves Lemma 2.2.2, which states that if there is any production at an aggregate state $\mathbf{s}$, then the match surplus has a unique zero, which is the reservation level of x in that state.

Recall that the match surplus is given by Equation (2.8) as

$$\begin{aligned}&(r+\lambda+\tau)(\mathrm{M}(x,\mathbf{s})+\mathrm{M}_n(\mathbf{s})) = xp(\mathrm{f}(k(\mathbf{s}))-\rho k(\mathbf{s}))+\\&\lambda\left[\mathrm{M}_n(\mathbf{s})+\int_{x_{\min}}^{x_{\max}}\max(\mathrm{M}(y,\mathbf{s}),0)\,\mathrm{dG}(y)\right]+\tau[E[\max\{\mathrm{M}(x,\mathbf{s}'),0\}+\mathrm{M}_n(\mathbf{s}')\mid\mathbf{s}]].\end{aligned}$$

As in B.1, let us denote the aggregate state-space of the model by Λ with finite cardinality a and let transitions be governed by the Markov matrix Π with $\pi_{i,j}$ denoting the transition probability from state i to state j. Define for each x the continuation states of x as the aggregate states in which $\mathrm{M}(x,\mathbf{s}) \geq 0$, and denote this subset as $\Lambda^c(x) \subseteq \Lambda$. The derivative of $\mathrm{M}(x,\mathbf{s})$ with respect to x is thus

$$(r+\lambda+\tau)\frac{\partial \mathrm{M}(x,\mathbf{s})}{\partial x} = p(\mathrm{f}(k(\mathbf{s})) - \rho k(\mathbf{s})) + \tau \sum_{\mathbf{s}'\in\Lambda^c} \pi_{\mathbf{s},\mathbf{s}'} \frac{\partial \mathrm{M}(x,\mathbf{s}')}{\partial x}. \quad \text{(B.3.1)}$$

I denote by $\Delta_x \mathrm{M}(x,\mathbf{s})$ the column vector of length a which contains all the derivatives $\frac{\partial \mathrm{M}(x,\mathbf{s})}{\partial x}$. For this part only, I explicitly spell out the state dependence of all the parameters and choice variables. Thus, the derivative of the match surplus in each state with respect to x is given by the system

$$\mu\, \Delta_x \mathrm{M}(x,\mathbf{s}) = \mathrm{p}(\mathbf{s})\,(\mathrm{f}(k(\mathbf{s})(\mathbf{s})) - \rho(\mathbf{s})\; k(\mathbf{s})) + \tau\, \Pi^c(x)\; \Delta_x \mathrm{M}(x,\mathbf{s}), \quad \text{(B.3.2)}$$

where μ is again an $a \times a$ diagonal matrix whose entries are $\mu_{\mathbf{s},\mathbf{s}} = \mathrm{r}(\mathbf{s}) + \lambda(\mathbf{s}) + \tau$, $[p(\mathrm{f}(\mathrm{k}(\mathbf{s})) - \rho\,\mathrm{k}(\mathbf{s}))]$ denotes a column vector of length a, and $\Pi^c(x)$ is the Markov matrix Π after substituting all entries $\pi_{i,j}$ such that $j \notin \Lambda^c(x)$ with zeros.

$$\Delta_x \mathrm{M}(x,\mathbf{s}) = (\mu - \tau\;\; \Pi^c(x))^{-1}[p(\mathrm{f}(\mathrm{k}(\mathbf{s})) - \rho\,\mathrm{k}(\mathbf{s}))], \quad \text{(B.3.3)}$$

To see that the solution exists and is unique, first recall from Appendix B.1 that the matrix

$$T = (\mu - \tau\;\; \Pi^c(x))$$

is a non-singular M-matrix which has the property of being inverse positive.

Second, in addition to T^{-1} having only non-negative entries, the vector $[p(\mathrm{f}(\mathrm{k}(\mathbf{s})) - \rho\,\mathrm{k}(\mathbf{s}))]$, is strictly positive as capital is chosen optimally from $\mathrm{f}'(\mathrm{k}(\mathbf{s})) = \rho$. Thus, from Euler's homogeneous function theorem one sees that

$$\mathrm{f}(\mathrm{k}(\mathbf{s})) - \rho\,\mathrm{k}(\mathbf{s}) = (1-\alpha)\,\mathrm{f}(\mathrm{k}(\mathbf{s})) > 0.$$

Finally, one obtains that the solution to Equation (B.3.3) is the result of multiplying a non-singular matrix with non-negative entries by a strictly positive vector which results in $\Delta_x \mathrm{M}(x,\mathbf{s})$ being strictly positive for all states. Thus, the match surplus is strictly increasing in x and if it has a zero in state $\mathbf{s}$, then this zero is necessarily unique.[2]

[2] If there is no zero, but there is production, that would be equivalent to $\mathrm{R}(\mathbf{s}) = x_{\min}$. If there is no production $\mathrm{R}(\mathbf{s}) > x_{\max}$.

A key feature about the derivatives is that they do not depend on x other than via the matrix $\Pi^c(x)$. Thus, as long as the matrix $\Pi^c(x)$ does not change, the surplus is linear and increasing in x. Since there are a states, without loss of generality, I can order them by their reservation levels as follows: $\mathrm{R}(1) \geq \mathrm{R}(2) \geq \cdots \geq \mathrm{R}(a)$, and define $a+1$ intervals on the support between them, the first of them being $[\mathrm{R}(1), x_{\max}]$, followed by $[\mathrm{R}(2), \mathrm{R}(1))$, until $[x_{\min}, \mathrm{R}(a))$. For each of these intervals, the form of $\Pi^c(x)$ is the same as the dependence upon x comes into play here only from the separation possibility encapsulated within the option value. Thus, the function $\mathrm{M}(x, \mathbf{s})$ is piece-wise linear and increasing in x, with points of discontinuity for the derivative situated at each of the reservation levels.

Appendix B.4 The Wage Solution in the Deterministic Case

To solve for the wage in the deterministic case, I begin with recalling the firm's value function and the match surplus without aggregate risk:

$$(r+\lambda)(\mathrm{M}(x) + M_n) = xp(\mathrm{f}(k) - \rho k) + \lambda\left[M_n + \int_R^{x_{\max}} \mathrm{M}(x)\ \mathrm{G}(y)\ \mathrm{d}\,y\right], \tag{B.4.1}$$

$$\begin{aligned}(r+\lambda)\,\mathrm{J}(x) &= xp[\mathrm{f}(k) - \rho k] - \mathrm{w}(x) \\ &+ \lambda\left[\mathrm{J}^n(\mathrm{w}(x)) + \int_R^{x_{\max}} \mathrm{J}(y) - \mathrm{J}^n(\mathrm{w}(x))\ \mathrm{dG}(y)\right].\end{aligned} \tag{B.4.2}$$

Substituting $x = R$ into Equation (B.4.2) yields:

$$\begin{aligned}(r+\lambda)\,\mathrm{J}(R) &= Rp[\mathrm{f}(k) - \rho k] - \mathrm{w}(R) + \\ \lambda&\left[\mathrm{J}^n(\mathrm{w}(R)) + \int_R^{x_{\max}} \mathrm{J}(y) - \mathrm{J}^n(\mathrm{w}(R))\ \mathrm{dG}(y)\right].\end{aligned} \tag{B.4.3}$$

Recall the definition of the reservation level as $\mathrm{M}(R) = 0$ and the surplus sharing rule that is the first order condition for (2.5) which is $\mathrm{J}(x) - J^n = (1-\beta)\,\mathrm{M}(x)$. From Lemma 2.2.1, we know that the problems (2.5) and (2.6) split the same surplus level. Thus

$$\int_R^{x_{\max}} \mathrm{J}(y) - \mathrm{J}^n(\mathrm{w}(x))\ \mathrm{dG}(y) = \int_R^{x_{\max}} \mathrm{J}(y) - \mathrm{J}^n(\mathrm{w}(R))\ \mathrm{dG}(y) = \int_R^{x_{\max}} (1-\beta)\,\mathrm{M}(y)\ \mathrm{dG}(y)\ .$$

Using this identity one can subtract $\mathrm{J}(R)$ from $\mathrm{J}(x)$ to obtain:

$$\begin{aligned}(r+\lambda)(\mathrm{J}(x)-\mathrm{J}(R)) &= (x-R)p[\mathrm{f}(k)-\rho k]-(\mathrm{w}(x)-\mathrm{w}(R)) \\ &+\lambda[\mathrm{J}^n(\mathrm{w}(x))-\mathrm{J}^n(\mathrm{w}(R))].\end{aligned} \tag{B.4.4}$$

Repeating the same procedure for Equation (B.4.1) by subtracting from the equation, itself with $\mathrm{M}(R)=0$ it is possible to obtain

$$(r+\lambda)\,\mathrm{M}(x) = (x-R)p(\mathrm{f}(k)-\rho k). \tag{B.4.5}$$

Now, I substitute the surplus sharing rule, and the value of

$$\mathrm{J}^n(\mathrm{w}(x)) = -\frac{\mathrm{w}(x)+\phi F p\mathrm{f}(k)-x_{\min}p(\mathrm{f}(k)-\rho k)}{r+\phi},$$

into Equation (B.4.4) to obtain:

$$(r+\lambda)((1-\beta)\,\mathrm{M}(x)) = (x-R)p[\mathrm{f}(k)-\rho k]-\left(\frac{\lambda}{r+\phi}+1\right)(\mathrm{w}(x)-\mathrm{w}(R)).$$

This expression will be further simplified by substituting in Equation (B.4.5) instead of $\mathrm{M}(x)$ and reversing the signs to obtain:

$$\beta((x-R)p(\mathrm{f}(k)-\rho k)) = \left(\frac{\lambda+r+\phi}{r+\phi}\right)(\mathrm{w}(x)-\mathrm{w}(R)),$$

which after rearranging yields

$$\mathrm{w}(x) = \frac{r+\phi}{r+\phi+\lambda}\beta((x-R)p(\mathrm{f}(k)-\rho k))+\mathrm{w}(R)\,. \tag{B.4.6}$$

Furthermore, since $\mathrm{M}(R)=0$, from the surplus sharing rule it follows that $\mathrm{J}(R) = \mathrm{J}^n(\mathrm{w}(R))$. Using this equality in Equation (B.4.3) along with the value of $\mathrm{J}^n(\mathrm{w}(R))$ yields

$$\begin{aligned}0 =& Rp[\mathrm{f}(k)-\rho k]-\mathrm{w}(R)+\lambda\left[\int_R^{x_{\max}}(1-\beta)\,\mathrm{M}(y)\,\mathrm{dG}(y)\right] \\ &-r\frac{x_{\min}p(\mathrm{f}(k)-\rho k)-\mathrm{w}(R)-\phi F p\mathrm{f}(k)}{r+\phi},\end{aligned}$$

which after some rearrangement results in

$$\begin{aligned} \mathrm{w}(R) =& \frac{r+\phi}{\phi}\left[Rp[\mathrm{f}(k) - \rho k] + \lambda(1-\beta)\int_R^\infty \mathrm{M}(y)\ \mathrm{dG}(y)\ \right] \\ &+ \frac{r\phi Fp\mathrm{f}(k) - rx_{\min}p(\mathrm{f}(k) - \rho k)}{\phi}. \end{aligned} \tag{B.4.7}$$

The resulting expression shows that the wage at the reservation takes into account the notice period's duration, the expected production value and its duration, the production value at R and the option to enter into a period of notice from any other wage level in the future.

Appendix C

Solution to the Simple Search Model of Chapter Three

This appendix presents the explicit derivation of Equations (3.14), (3.15) and (3.16).

The population composition. Using the laws of motion in Equation (3.1), and the fact that the masses sum up to unity, the equilibrium masses can be derived as

$$m_U = \frac{\lambda\phi^2}{\lambda\phi^2 + \phi(\theta\,\mathrm{q}\,(\theta)\,)(\theta\,\mathrm{q}\,(\theta)\, + \phi) + \lambda\phi\theta\,\mathrm{q}\,(\theta)\, + \lambda(\theta\,\mathrm{q}\,(\theta)\,)^2}, \tag{C.0.1}$$

$$m_N = \frac{\lambda\phi\theta\,\mathrm{q}\,(\theta)}{\lambda\phi^2 + \phi(\theta\,\mathrm{q}\,(\theta)\,)(\theta\,\mathrm{q}\,(\theta)\, + \phi) + \lambda\phi\theta\,\mathrm{q}\,(\theta)\, + \lambda(\theta\,\mathrm{q}\,(\theta)\,)^2}. \tag{C.0.2}$$

Combining these to the value of l as defined by Equation (3.8) yields:

$$l = \left[\frac{u}{u+n} + \frac{n}{u+n}\frac{\phi}{r+\phi}\right] = \left[\frac{\phi(r+\phi+\theta\,\mathrm{q}\,(\theta)\,)}{(\phi+\theta\,\mathrm{q}\,(\theta)\,)(r+\phi)}\right]. \tag{C.0.3}$$

The wage solution. To solve for the wage, one needs to start from the first order condition for the bargaining problem (3.13) which is:

$$\beta(J_E - J_N) = (1-\beta)(V_E - V_N). \tag{C.0.4}$$

It is convenient to examine the problem in terms of the surplus level $S = V_E - V_N + J_E - J_N$ associated with it, which after substituting in the definitions for V_E and J_E results in

$$(r+\lambda)S = p - r\,\mathrm{V}_N - rJ_N. \tag{C.0.5}$$

The sum $J_N + V_N$ cab be expressed as

$$r\,\mathrm{V}_N + rJ_N = \epsilon p + \phi(V_U - V_N) + \theta\,\mathrm{q}\,(\theta)\,(V_H - V_N) + \phi(J_V - J_N). \tag{C.0.6}$$

Subtracting V_N from V_H or Equation (3.4) from Equation (3.5) yields the following relationship

$$(r + \phi + \theta\,\mathrm{q}\,(\theta)\,)(V_H - V_N) = \phi(\,\mathrm{V}_E - V_U),$$

which substituted into Equation (C.0.6) yields

$$(r+\phi)(\,\mathrm{V}_N + J_N) = \epsilon p + \phi V_U + \theta\,\mathrm{q}\,(\theta)\,\frac{\phi}{r+\phi+\theta\,\mathrm{q}\,(\theta)}(\,\mathrm{V}_E - V_U). \tag{C.0.7}$$

Now, we turn our attention to the outsider's problem 3.12, which has the first order condition

$$\beta(J_E - J_V) - (1-\beta)(V_E - V_U) = 0. \tag{C.0.8}$$

It is again convenient to define the surplus level S^0 which is given by $J_E - J_V + V_E - V_U$, and using Equation (3.8), the definition of V_U and the fact that $\mathrm{V}_E - V_U = \frac{\beta}{1-\beta}J_E$ we obtain

$$rV_U = z + \theta\,\mathrm{q}\,(\theta)\,\beta S^0 = z + \frac{\beta}{1-\beta}\frac{\theta pc}{l}. \tag{C.0.9}$$

This expression can be substituted into Equation (C.0.7), which along with Equation (3.8), and the insight that $\mathrm{V}_E - V_U = \frac{\beta}{1-\beta}J_E$ yields after some tedious algebra

$$(r+\phi)(\,\mathrm{V}_N + J_N) = \epsilon p + \frac{\phi}{r}z + \phi\left[\frac{1}{r} + \frac{1}{r+\phi+\theta\,\mathrm{q}\,(\theta)}\right]\frac{\beta}{1-\beta}\frac{\theta pc}{l}. \tag{C.0.10}$$

Using this expression in Equation (C.0.5), we can express the surplus as

$$S(r+\lambda) = p - \frac{r}{r+\phi}\left[\epsilon p + \frac{\phi}{r}z + \phi\left[\frac{1}{r} + \frac{1}{r+\phi+\theta\,\mathrm{q}\,(\theta)}\right]\frac{\beta}{1-\beta}\frac{\theta pc}{l}\right]. \tag{C.0.11}$$

The surplus can also be described as follows:

$$(r + \lambda)(J_E - J_N) = (r + \lambda)(1 - \beta)S,$$

which combined with the fact that $(r + \lambda)J_E = p - w + \lambda J_N$, and that $(r + \phi)J_N = \epsilon p - w$ allows us to write the surplus as

$$(r + \lambda)S = \frac{1}{1 - \beta}\left[p - w - r\frac{\epsilon p - w}{r + \phi}\right]. \tag{C.0.12}$$

Equating the two expressions of the surplus as given by Equation (C.0.11) and Equation (C.0.12) allows us to finally obtain the expression

$$w = \beta p + (1 - \beta)z + r\beta\frac{p(1 - \epsilon)}{\phi} + \left[1 + \frac{r}{r + \phi + \theta\, \mathrm{q}(\theta)}\right]\frac{\beta\theta pc}{l}. \tag{C.0.13}$$

The job-creation equation. Combining the free entry relationship $J_E = \frac{pc}{\mathrm{q}(\theta)\, l}$, with $(r + \lambda)J_E = p - w + \lambda(J_N)$ and with $J_N = \frac{\epsilon p - w}{r + \phi}$, after some algebraic manipulation yields

$$p\left(\frac{r + \phi + \lambda\epsilon}{r + \phi + \lambda}\right) - w = \frac{pc(r + \lambda)}{\mathrm{q}(\theta)\ l}\frac{r + \phi}{r + \phi + \lambda}. \tag{C.0.14}$$

Appendix D

Computational Appendix to Chapter Three

This appendix details the solution algorithm used to solve the general equilibrium model. The algorithm owes much to the works of Krusell et al. (2010) and Achdou et al. (2017) and follows along the lines of the definition of the recursive stationary equilibrium in the model economy.

Appendix D.1 Recursive Stationary Equilibrium

The recursive stationary equilibrium in the model economy consists of household value functions $\mathrm{V}_i(a)$ for each $i \in \Gamma$; household policy functions $c_i(a), x_i(a)$; the corresponding laws of motion for assets $s_i(a)$; stationary probability density functions $h_i(a)$; firm value functions $\mathrm{J}_j(a)$ for each $j \in \{V, H, E1, E2, N\}$; policy functions for capital k_j^*; price of equity P; rental rate of capital r; wage rates w_1 and w_2; aggregate vacancies v; aggregate effort X; labour market tightness θ; and dividends d which jointly satisfy the following

1. Consumer optimization - Given the per effort unit job finding rate λ_f, prices r and P, benefits b_1 and b_2, tax rate τ, and the wage functions, the policy functions $c_i(a)$ and $x_i(a)$ solve the optimization problems given by (3.24) with the value functions $\mathrm{V}_i(a)$.

2. Firm optimization - Given r, the bargained wages, the distributions h_i, the law of motions for assets $s_i(a)$, and the transition matrix given by Equation (3.26), the firms solve the optimization problems in (3.34), (3.35), (3.36), and (3.37). Given labour

market tightness θ, and the implied population composition given by $h_i(a)$, the rental rate r, and the policy functions $x_i(a)$, the function J_V satisfies (3.33).

3. Free entry - The number of vacancies is consistent with free entry of firms such that $J_V = 0$.

4. Asset market clearing

$$\sum_{i\in\Gamma} \int_{\underline{a}}^{\infty} a \, \mathrm{d}\, \mathrm{H}_i(a) \quad = (1+\gamma)[K+P] \tag{D.1.1}$$

where the right-hand side of the equation is the supply of assets and the left-hand side is the demand for assets. K denotes aggregate capital which satisfies $K = \sum_{i\in\{E1,E2,N\}} k_i^* m_i$, with k_i^* being the firm-level optimal capital in state i. Since labour is fixed, k_i^* depends only on the state i. The amount of equities, i.e., claims of aggregate profits, must equal unity, and the arbitrage condition in (3.30) must hold.

5. Matching - The transitional probabilities are consistent with the matching function.

6. Wage setting - The wage is set such that it is the solution for the Nash bargaining problems (3.31) and (3.32).

7. Government budget is balanced as in Equation (3.39).

8. Consistency - The distributions $h_i(a)$ are the stationary distributions implied by the transition matrix $\Lambda(a)$ and the policy functions $c_i(a)$ and $x_i(a)$.

Appendix D.2 Solution Algorithm

The solution boils down to solving for the zero of a system of six equations in six unknowns $T(\gamma, \theta, \tau, w_1, w_2, \bar{w}) = 0$. The explicit system is given in stage 9 of the algorithm and it follows from the definition of recursive stationary equilibrium. As such, the solution algorithm is based on non-linear equation systems solvers and proceeds as follows:

1. Guess the values of $\gamma, \theta, \tau, w_1, w_2, \bar{w}$.

2. Given the initial guess for the average wage level, the replacement rates determine b_1 and b_2.

3. Solve the household optimization problem given the guesses and the calibrated parameters using the algorithm for solving the HJB equations and the Kolmogorov forward equations developed by Achdou et al. (2017).[1] This will allow us to obtain the distributions $h_i(a)$, the policy functions $c_i(a)$ and $x_i(a)$, the equilibrium masses m_i, the law of motion for the state variable $s_i(a)$ and the aggregate effort level X.

4. Use the first order condition for capital and the relationship $r = \gamma + \delta$ to solve for the capital choice of the firm and flow profit at each state which is $\pi = pk^{\alpha}l^{1-\alpha} - rk - w$. Given these, the firm's value functions can be simply computed using the following:

$$J_N = \frac{\pi_N}{\gamma + \phi}, \tag{D.2.1}$$

$$J_{E2} = \frac{\pi_{E2} + \lambda_s J_N}{\gamma + \lambda_s}, \tag{D.2.2}$$

$$J_{E1} = \frac{\pi_{E1} + \lambda_{E1} J_{E2}}{\gamma + \lambda_{E1} + \lambda_s}, \tag{D.2.3}$$

$$J_H = \frac{\phi}{\gamma + \phi} J_{E1}. \tag{D.2.4}$$

$$\tag{D.2.5}$$

5. The bargaining problems require maximizing objective functions of the form

$$\left(\Delta V\left(a,w\right)\right)^{\beta}\left(\Delta J\left(a,w\right)\right)^{1-\beta}, \tag{D.2.6}$$

for each value of a, where ΔV and ΔJ are the current state value function minus the outside option value function for each problem. Since V and J are not solved as functions of two state variables a, w but for a given level of w for all a, I use an approximation method. ΔV is increasing in w and ΔJ is decreasing in w so there is a single solution to the problem for each level of a. I exploit this fact to analyse the approximate bargaining problem:

$$\underset{\Delta w}{max} \quad \left(\Delta V(a,w) + \Delta w \frac{\partial \Delta V}{\partial w}\right)^{\beta}\left(\Delta J(a,w) + \Delta w \frac{\partial \Delta J}{\partial w}\right)^{1-\beta}. \tag{D.2.7}$$

Using the envelope theorem for differentiation and the value functions and policy func-

[1] The only meaningful adjustment I need to apply this algorithm is to use the first order condition for the effort level at each iteration given the current guess for the value functions.

tion from 3 and 4 I compute the derivatives

$$\frac{\partial \mathrm{V}_{N2}(a)}{\partial w_2} = \frac{\mathrm{u}'(c_{N2})(1-\tau)}{\rho+\phi}, \tag{D.2.8}$$

$$\frac{\partial \mathrm{V}_{N1}(a)}{\partial w_2} = \frac{\mathrm{u}'(c_{N2})(1-\tau)+\lambda_f \mathrm{x}_{N1}(a)\frac{\partial \mathrm{V}_{N2}(a)}{\partial w_2}}{\rho+\phi+\lambda_f \mathrm{x}_{N1}(a)}, \tag{D.2.9}$$

$$\frac{\partial \mathrm{V}_{E2}(a)}{\partial w_2} = \frac{\mathrm{u}'(c_{E2})}{\rho+\lambda_s}(1-\tau)+\frac{\lambda_s}{\rho+\lambda_s}\frac{\partial \mathrm{V}_{N1}(a)}{\partial w_2}, \tag{D.2.10}$$

$$\frac{\partial \mathrm{V}_{E1}(a)}{\partial w_1} = \frac{\mathrm{u}'(c_{E1})}{(\rho+\lambda_{E1}+\lambda_s)}(1-\tau), \tag{D.2.11}$$

$$\frac{\partial \mathrm{J}_{N}(a)}{\partial w_2} = \frac{-1}{\gamma+\phi}, \tag{D.2.12}$$

$$\frac{\partial \mathrm{J}_{E2}(a)}{\partial w_2} = \frac{-1}{\gamma+\lambda_s}+\frac{\lambda_s}{\gamma+\lambda_s}\frac{\partial \mathrm{J}_{N}(a)}{\partial w_2}, \tag{D.2.13}$$

$$\frac{\partial \mathrm{J}_{E1}(a)}{\partial w_1} = \frac{-1}{\gamma+\lambda_{E1}+\lambda_s}. \tag{D.2.14}$$

Then I compute each value of $\frac{\partial \Delta V}{\partial w}$ and $\frac{\partial \Delta J}{\partial w}$. The approximated problem is easy to solve since it is an unconstrained problem in one variable with the solution

$$\Delta w = -\frac{\beta \Delta J(a,w)\frac{\partial(\Delta V(a,w))}{\partial w}+(1-\beta)\frac{\partial(\Delta V(a,w))}{\partial w}\Delta J(a,w)}{\frac{\partial(\Delta J(a,w))}{\partial w}\frac{\partial(\Delta V(a,w))}{\partial w}} \tag{D.2.15}$$

6. Within each group of workers, I use the solutions of Equation (D.2.15) and the distributions $h_{E1}(a)$, and $h_{E2}(a)$ and find the median value within each group to obtain $MED(\Delta w_1)$, $MED(\Delta w_2)$.

7. I compute the dividends using the flow profits and the vacancy stock $v = X\theta$ using Equation (3.38). Given the net return, I compute the price of equities P.

8. I combine the masses from 3 with the capital solutions from 4 to obtain the aggregate capital stock K. Thus, total asset supply in the economy is $(K+P)(1+\gamma)$.

9. I compute $T(\gamma,\theta,\tau,w_1,w_2,\bar{w}) = 0$ where T is given by the following system:

    - Access demand for assets:

$$T_1 = \sum_{i\in\{E1,E2,N1,N2,U1,U2\}} \int_{\underline{a}}^{\infty} a\, d\,\mathrm{H}_i(a) \quad -(K+P)(1+\gamma). \tag{D.2.16}$$

- Distance from free entry :

$$T_2 = -\kappa + \quad \text{(D.2.17)}$$
$$\mathrm{q}\left[\sum_{i\in\{U1,U2\}} \int_{\underline{a}}^{\infty} \frac{\mathrm{x}_i(a)}{X} \mathrm{J}_{E1}\, \mathrm{d}\,\mathrm{H}_i(a) \quad + \int_{\underline{a}}^{\infty} \frac{\mathrm{x}_{N1}(a)}{X} \mathrm{J}_H\, \mathrm{d}\,\mathrm{H}_{N1}(a)\right].$$

- Government deficit:

$$T_3 = b_1 m_{U1} + b_2 m_{U2} - \tau \sum_{i\in T} \int_{\underline{a}}^{\infty} \mathrm{y}_i(a)\ \mathrm{d}\,\mathrm{H}_i(a) \quad . \quad \text{(D.2.18)}$$

- Wage consistency:

$$T_4 = MED\left(\Delta w_1\right) \quad \text{(D.2.19)}$$

$$T_5 = MED\left(\Delta w_2\right) \quad \text{(D.2.20)}$$

$$T_6 = \frac{w_1 m_{E1} + w2\left(m_{E2} + m_{N1} + m_{E2}\right)}{1 - m_{U1} - m_{U2}} - \bar{w} \quad \text{(D.2.21)}$$

10. If the system is sufficiently close to zero, stop. Else, update the initial guess accordingly, and repeat from 1 until convergence is achieved.

Appendix D.3 Numerical Techniques

Solver. A solver based either on Newton-Raphson method or Good Broyden's method is capable of solving the model. In practice, a solver that combines both methods seems to perform well and converges faster. The Jacobian matrix is computed using finite differences. It is useful to relax the updated solution in the Newton direction, such that at the new guess the value of γ lays between zero and ρ, and that the wage levels and labour market tightness are non-negative. I use backtracking to choose the largest relaxation parameter from a pre-specified set of values (all less than one), such that the new guess is well within these bounds. If the bounds are already violated, which can occur, I use a small pre-set relaxation parameter (0.05).

The wage problem. In Krusell et al. (2010), a multi-grid structure is utilized in order to improve efficiency while solving for the wage function. The asset grid used was finer than the grid used for wage bargaining (1,000 points vs 125 points on the same support) and cubic-spline interpolation was used to connect the two. This has a speed advantage over using the same grid for both needs and, in practice, can smooth out minor numerical errors that would occur in a very fine grid, thus resulting in a smooth wage function. In my case, however, the wage is a scalar and the main source of inaccuracies lays in computing the median for a coarse distribution which may result in small jumps at the solution that would hinder convergence. To mitigate this problem I utilize the multi-grid structure but in a very different way. I use a coarse grid of 10^3 points for the household and firm problems, and a fine grid on the same support with 10^5 to update the wage. The distributions $h_i(a)$ and the value functions, policy functions, and their derivatives are interpolated using cubic-spline to the finer grid. This set-up is practical since solving for (D.2.7) involves no optimization, but just operations on vectors that would yield Δw by Equation (D.2.15).

Stopping criterion. A convergence criterion of $\max(|T|) < 10^{-4}$ yields fast results and performs well. To obtain a meaningful stopping criterion all equations described in stage 9 of the algorithm are solved after normalization. The first two equations and the last one are solved in the form of $0 = 1 - \frac{RHS}{LHS}$, thus the error is interpreted as percentage deviations from equilibrium. The government budget constraint is set such that the deficit divided by output is close enough to zero. The two equations concerning the median update to $w1$ and $w2$ are solved as $\frac{MED(\Delta w_j)}{\bar{w}} = 0$ where the value of $\bar{w}$ is the actual average wage in the economy. The reason for this last normalization is that for some parameter values the solution will be at $w_1 = 0$, thus the normalization is only possible with respect to another value.

Optimal Policy Search. The calibrated model is used to perform a numerical search for optimal policies using the sum of utilities as a welfare criterion. This optimization uses the above solution technique and MATLAB's particle swarm algorithm to maximize the ratio of welfare divided by the baseline welfare in the economy (given existing policies and parameter values) with 10^{-4} as the stopping criterion. This optimization deviates from the above solution technique only by choosing a different initial guess for the value functions of the household. The initial guess that seems to perform best is guessing that the household consumes all of its income at each period as if its income were $\gamma a + w_2$ regardless of the income state. The reason that this guess seems to perform better in practice is that most of the time the average household is in state $E2$ so the value function at that state will significantly affect all other value functions in the problem. The reason for deviating from the algorithm of Achdou et al. (2017) is that when replacement rates are close to zero the initial guess is rather flat for the $U1$ and $U2$ states which leads to slower convergence of the value function.

Appendix D.4 Calibrating the Model

Objective Function. I minimize the sum of squared relative errors of the resulting calibration from the targets using equal weights. Formally, each target, the unemployment rate, the vacancy rate, the duration elasticity, and the five bins of the duration distribution, is denoted by G_i and the objective function is $SSE(z) = \sum_{i=1}^{8} \left(\frac{G_{i,\text{model }(z)}}{G_{i,\text{target}}} - 1 \right)^2$ where z_j denotes the model parameters.

Optimization Routine. I employ the Cross-Entropy Method (CEM) as developed in de Boer et al. (2005). Specifically, I use the Beta as my class of parametric distributions as is done in Mannor et al. (2003). The reason for choosing Beta distributions is that a bounded support is useful in this type of exercise. It prevents the algorithm from choosing extreme parameter values that will yield no solutions and thus will only result in costly evaluations that will yield no information. The algorithm proceeds as follows:

1. Choose a number of evaluations N_{eval}, a smoothing parameter r_s, a size for the elite sample N_{elite}, a tolerance ϵ_T, prior distributions, and bounds for each parameter.

2. Set the iteration counter $x = 1$

3. Draw N_{eval} independent random draws from the prior for each parameter to form a sample of N_{eval} parametrizations.

4. Let z^j denote the j-th parametrization. For each j, evaluate $SSE(z^j)$. If the evaluation fails use $SSE(z_j) = 9999999$.

5. Find the best N_{elite} realisations and use them as the elite sample.

6. Within the elite sample, for each parameter z_k, compute its mean $\overline{z_k} = \frac{\sum_{t=1}^{N_{\text{elite}}} {z_k}^t}{N_{\text{elite}}}$. Proceed by computing the standard deviation of the mean-divided parameter $st.dev(\frac{z_k}{\overline{z_k}})$ for each parameter.

   (a) If $\max st.dev(\frac{z_k}{\overline{z_k}}) \leq \epsilon_T$ stop the loop and choose the best draw as a solution.

7. Else, for each parameter, use the elite sample to compute the method of moment estimates of a_{elite} and b_{elite}, where these are the parameters of a new Beta distribution $Beta(a_{\text{elite}}, b_{\text{elite}})$. This distribution is the one that is most likely to generate the values in the elite sample.

8. Set for each variable k the new distribution $Beta^k_{x+1}(a_x(1-r_s)+r_s a_{\text{elite}}, b_x(1-r_s)+r_s b_{\text{elite}})$, and repeat from 3.

Specifics of the Main Parametrization. For the main parametrization, I implement the above algorithm using the following bounds. I used the uniform distribution or $Beta(1,1)$ as a prior and the supports:

$$LS = (5, 0.0137, 0.01, 0.5, 0.1), US = (35, 0.0416, 2, 20, 2)$$

for κ, λ_s, ψ, ψ_0, and η correspondingly. Each CEM iteration samples $N_{\text{eval}} = 10^3$ calibrations, of which $N_{\text{elite}} = 40$ are chosen as the elite sample. The smoothing parameter is set to 0.7 and the stopping criterion is set to $r_s = 0.01$. The parametrization yields a minimum of $SSE = 0.7549$. To improve speed the algorithm is implemented using a 10^2 point grid for assets with $a_{\max} = 1500$ and a 10^4 point grid for wages. The parameter values, rounded up to 4 digits are $\eta = 0.7024$, $\psi = 0.2012$, $\psi_0 = 11.5601$, $\lambda_s = 0.01374$, $\kappa = 14.9757$. Most of these bounds come from trial and error, and the solution is situated well within them. The exception to this is the value of λ_s which is a very strong parameter and unlike the others, it can be partially observed in reality. λ_s is the hazard of an idiosyncratic shock hitting the employer-employee pair and causing termination notice to be delivered. Thus, the value of $\frac{1}{\lambda_s}$ is the expected duration of a match. This duration is bounded above by the duration of an employment spell which gives a lower-bound value for λ_s. Using a GMM estimation of the Israeli unemployment duration using a two-states model (employment and unemployment) for the 25-54 age cohort[2] I determine that for the relevant years the separation hazard for an unemployed person is 0.0137 and this is the reason for my choice of 0.0137 as the lower bound value of λ_s. This lower bound figure means that a shock hits on average every 73 months. The upper bound is placed at an expected duration of 24 months. The resulting value of λ_s corresponds to shocks arriving on average after 72.8 months or that most realizations of the idiosyncratic shock result in an unemployment spell.

[2]For a detailed description of this exercise, see Appendix E

Appendix E

GMM Estimation Using Israeli Labour Market Data for the Calibration in Chapter Three

Source data description. To estimate the job finding rate and separation rate in Israel I utilise data on labour force size and unemployment by duration available for the years 1995-2019 for all persons aged 25 to 54.[1] The choice of ages is done to be consistent with the rest of the calibration in Section 3.3.2, which also leads me to focus solely on the years 2012 - 2019. The data consists of the total number of persons in the labour force and the number of persons at each unemployment duration bin for each year. Bins are available for duration groups with unemployment durations of less than one month, between one to three months, more than three and less than six months, more than six months and less than a year, over than a year of unemployment, and persons for whom duration data is unavailable.

Data transformation. I first assume that duration data is missing at random and distribute the number of persons for whom duration is missing proportionally into the other five bins. Following this, each bin is divided by the total size of the labour force such that summing all the bins yields the unemployment rate for this year and the population size is normalized to unity within each year.

[1] Data was retrieved from https://stats.oecd.org/

Structural assumptions. I assume the standard two-states representation of employment E and unemployment U that features the following law of motion:

$$\frac{\mathrm{d}\,U}{\mathrm{d}\,t} = s(1-U) - fU, \tag{E.0.1}$$

where $E = 1 - U$ and s and f denote the separation rate and the job-finding rate correspondingly which are the objects of interest for this estimation. The system has a unique steady-state which will be exploited for the estimation for which $U = \frac{s}{s+f}$. This means that, at the steady state of the system the flow from employment to unemployment and the flow from employment to unemployment is fixed at $z = \frac{fs}{s+f}$.

The law of motion above means that job-finding occurs at a constant hazard of f. It follows that the survival function in a state of unemployment is $S(t) = e^{-ft}$. Thus, the total number of persons unemployed with duration τ is $zS(\tau)$.

The normalized number of persons in each bin is given by:

$$u_i = \frac{fs}{f+s}\int_a^b e^{-ft}dt\ , \tag{E.0.2}$$

where the i-th bin is the one which includes durations of anywhere from a to b months.

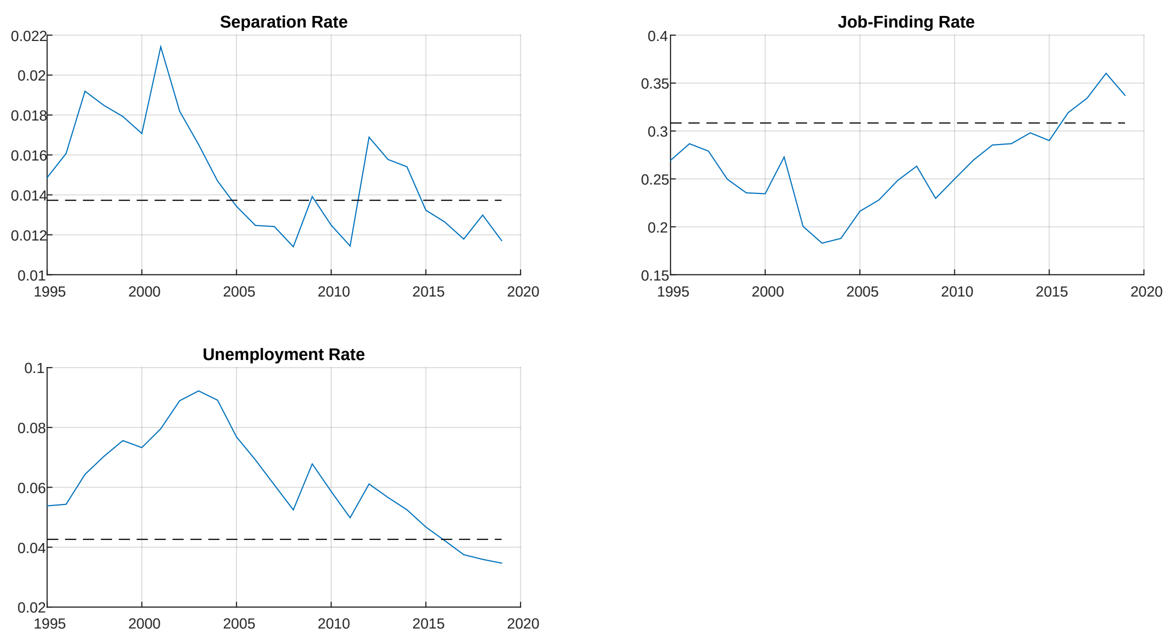
Moment Conditions and Estimation. For each unemployment duration bin I compute its average size for the sample duration $u_{\bar{a-b}}$. The estimation is carried out by solving

$$\min_{s,f} \quad \sum_{i=1}^{4}\left(1-\frac{\overline{u_i}}{\hat{u}_i\,(s,f)}\right)^2 \tag{E.0.3}$$

where $\hat{u}_i\,(s,f)$ is the value computed using the Equation (E.0.2) for a given pair s, f. I use the identity as a weighting matrix as I will not conduct inferences on these estimates.

The procedure and especially the moment conditions described here owe much to the insights in the work of Hobijn and Sahin (2009). Modifications arise from differences in identifying assumptions and data availability. Namely, Hobijn and Sahin (2009) have data on employment and unemployment by duration which allows for two separate estimations, one for each hazard in an independent fashion, using a Gompertz hazard model. As such their model includes an additional scale parameter in the survival function that, due to the limited data availability, my set-up would not be able to identify. As in Hobijn and Sahin (2009) I omit the bin which includes only persons unemployed for over a year as this is the one most susceptible to noise.

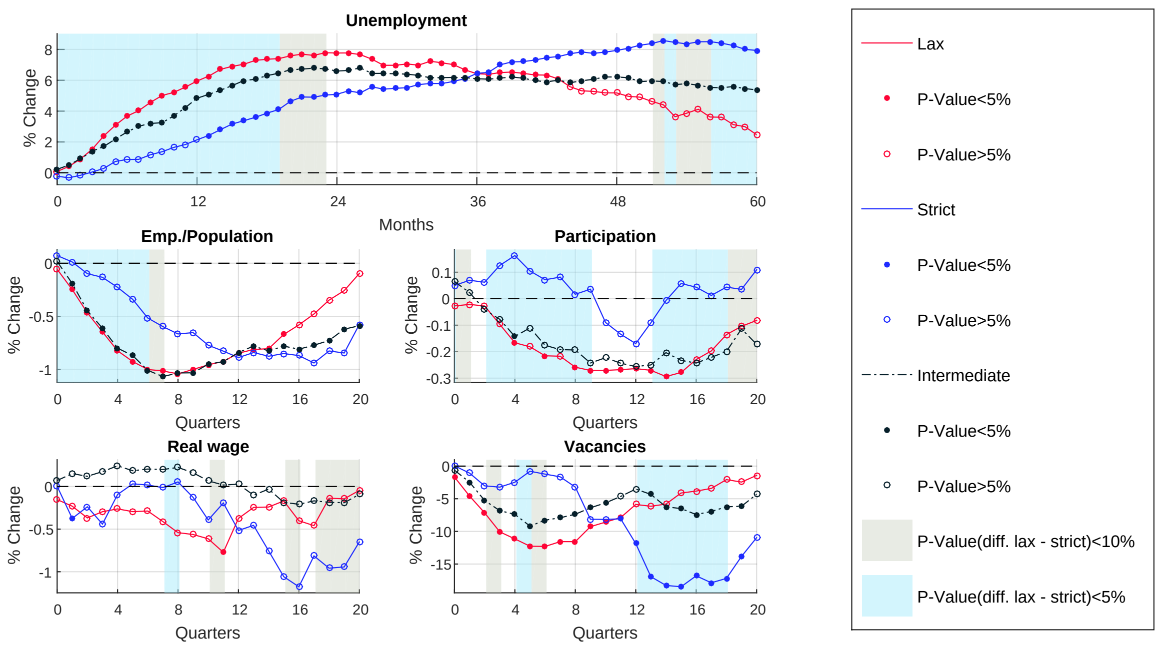
Results. The estimates which minimize the moment conditions are monthly hazards of $f = 0.3083$ and $s = 0.0137$. These imply a steady-state unemployment rate of 4.25%. To illustrate the fit of these numbers to the long-term behaviour of the Israeli labour market, see the figure at the end of this appendix. The upper panels of the figure present a replication of the above estimation but for each year separately to give a range of values for s and f. The lower panel plots the implied steady-state unemployment rate against the actual time series. These results are used in the calibration in Section 3.3.2



Note: The upper two panels plot the results from estimating s and f on an annual basis using the above described procedure, with the long-term estimates in the dashed lines. The lower panel plots the actual unemployment rate with the unemployment rate implied by the long-term estimation results of s and f in the dashed line.

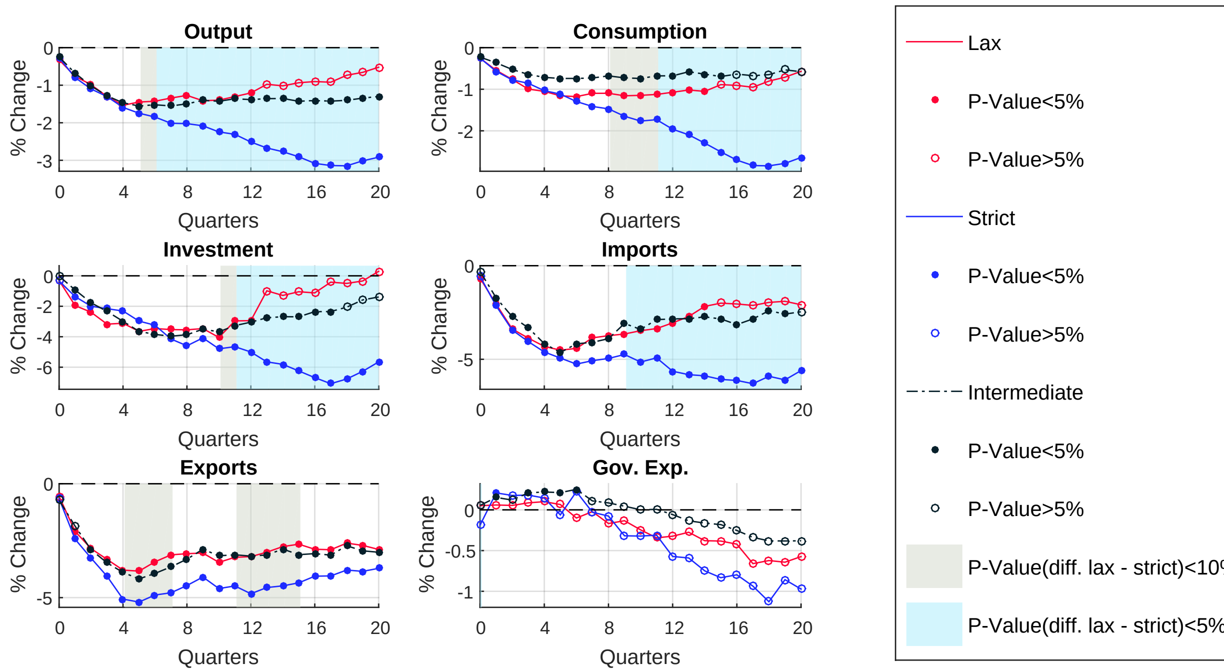
Figures

Figure 1: Impulse Responses to a One Standard Deviation Credit Supply Shock Under Different EPL Regimes - Labour Market Variables



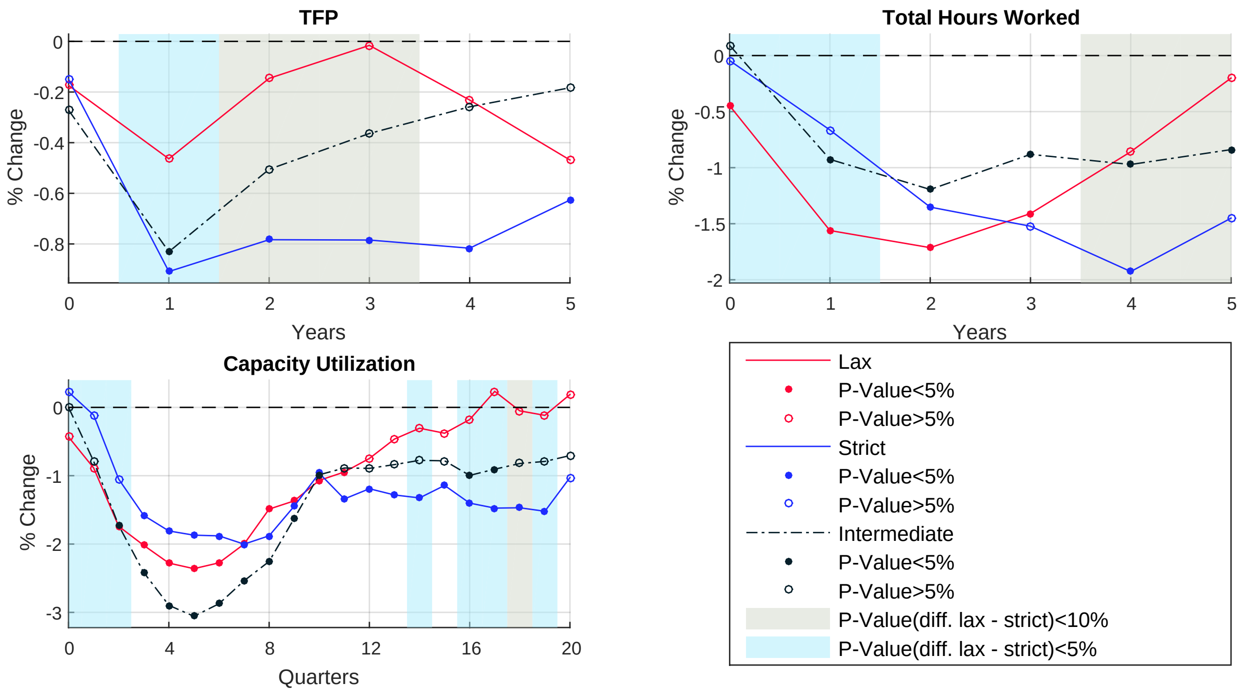
Notes: Impulse response functions for each outcome measure estimated using the state-dependent model described in Equation (1.1). The IRF for strict EPL regime is presented in blue, the IRF for the lax EPL regime in red and the intermediate regime in black. Full data points represent horizons at which the point estimate for the IRF is statistically significantly different than zero (p-value ≤ 0.05). Shaded areas indicate that the difference in response between the strict and lax groups is significantly different from zero (p-value ≤ 0.05 in light-blue shading and p-value ≤ 0.1 in grey). Inference is based on Driscoll and Kraay (1998) standard errors.

Figure 2: Impulse Responses to a One Standard Deviation Credit Supply Shock Under Different EPL Regimes - National Accounts



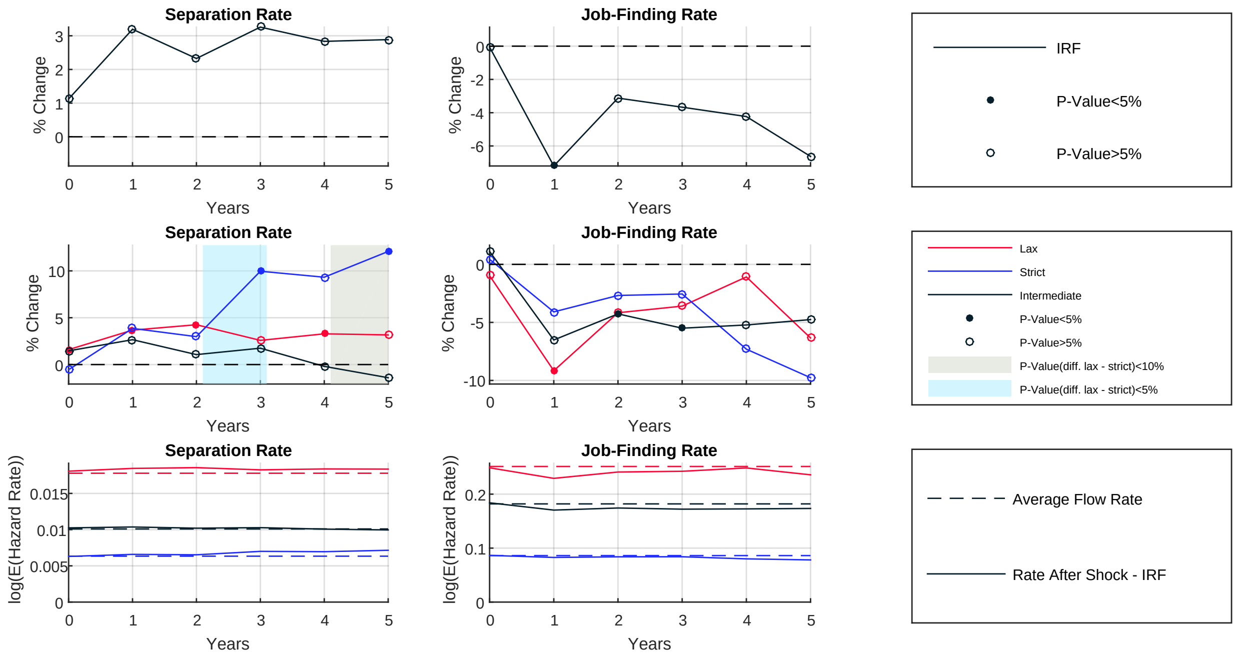
Notes: Impulse response functions for each outcome measure estimated using the state-dependent model described in Equation (1.1). The IRF for strict EPL regime is presented in blue, the IRF for the lax EPL regime in red and the intermediate regime in black. Full data points represent horizons at which the point estimate for the IRF is statistically significantly different than zero (p-value ≤ 0.05). Shaded areas indicate that the difference in response between the strict and lax groups is significantly different from zero (p-value ≤ 0.05 in light-blue shading and p-value ≤ 0.1 in grey). Inference is based on Driscoll and Kraay (1998) standard errors.

Figure 3: Impulse Responses to a One Standard Deviation Credit Supply Shock Under Different EPL regimes - TFP, Hours Worked, and Utilization



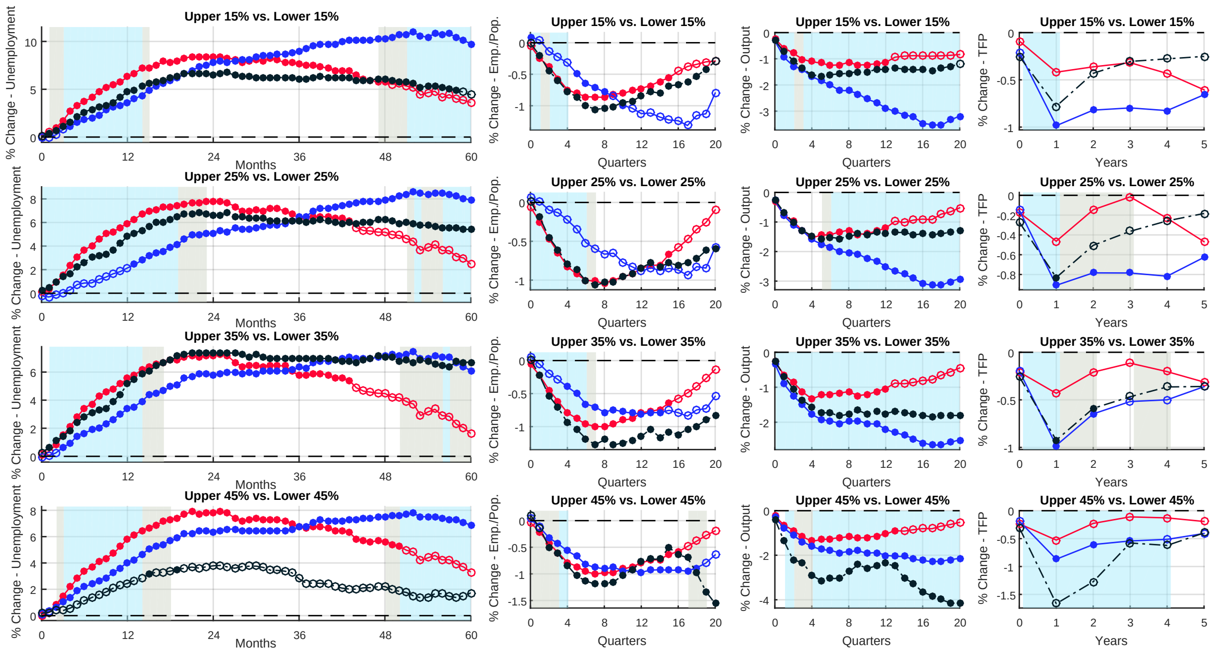
Notes: Impulse response functions for each outcome measure estimated using the state-dependent model described in Equation (1.1). The IRF for strict EPL regime is presented in blue, the IRF for the lax EPL regime in red and the intermediate regime in black. Full data points represent horizons at which the point estimate for the IRF is statistically significantly different than zero (p-value ≤ 0.05). Shaded areas indicate that the difference in response between the strict and lax groups is significantly different from zero (p-value ≤ 0.05 in light-blue shading and p-value ≤ 0.1 in grey). Inference is based on Driscoll and Kraay (1998) standard errors.

Figure 4: Impulse Response to a One Standard Deviation Credit Supply Shock Under Different EPL Regimes - Separation Rate and Job-Finding Rate



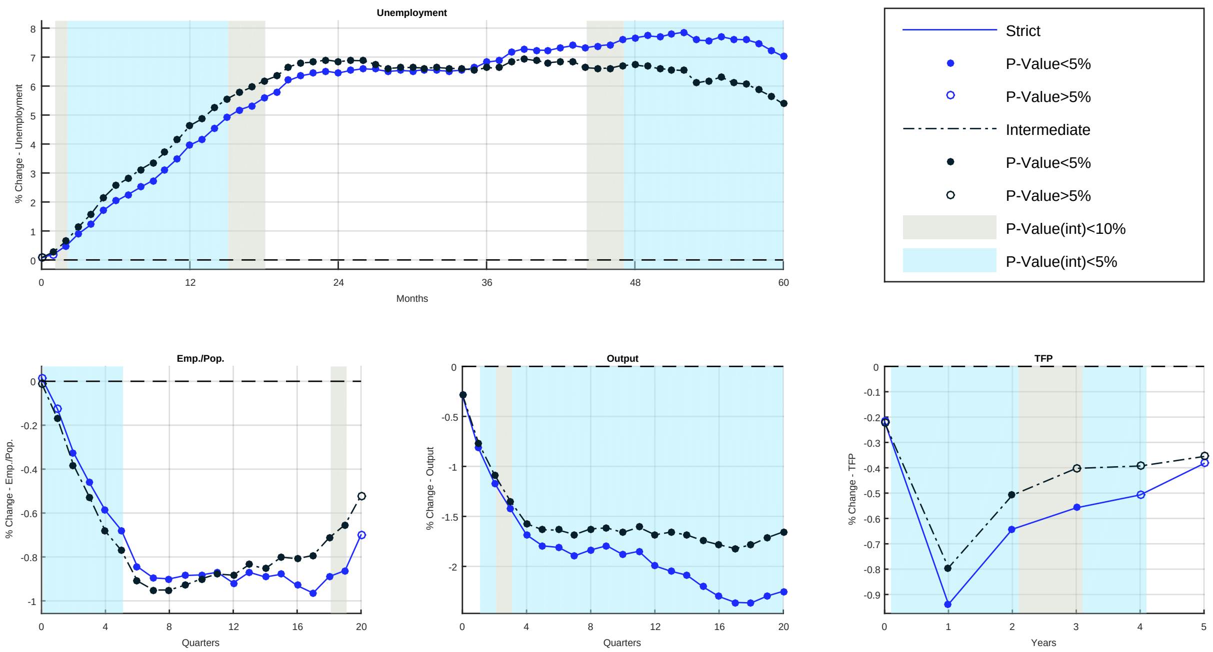
Notes: Impulse response functions for each rate estimated using the local projections without state-dependence are in the first row. Impulse response functions for each rate estimated using the state-dependent model described in Equation 1.1 are presented in the second. The IRF for strict EPL regime is presented in blue, the IRF for the lax EPL regime in red and the intermediate regime in black. Full data points represent horizons at which the point estimate for the IRF is statistically significantly different than zero (p-value ≤ 0.05). Shaded areas indicate that the difference in response between the strict and lax groups is significantly different from zero (p-value ≤ 0.05 in light-blue shading and p-value ≤ 0.1 in grey). The third row illustrates the implied rates obtained from the multiplying average level at each policy group with the impulse response in that particular horizon. All inference is based on Driscoll and Kraay standard errors.

Figure 5: Robustness to Different Cut-off Values



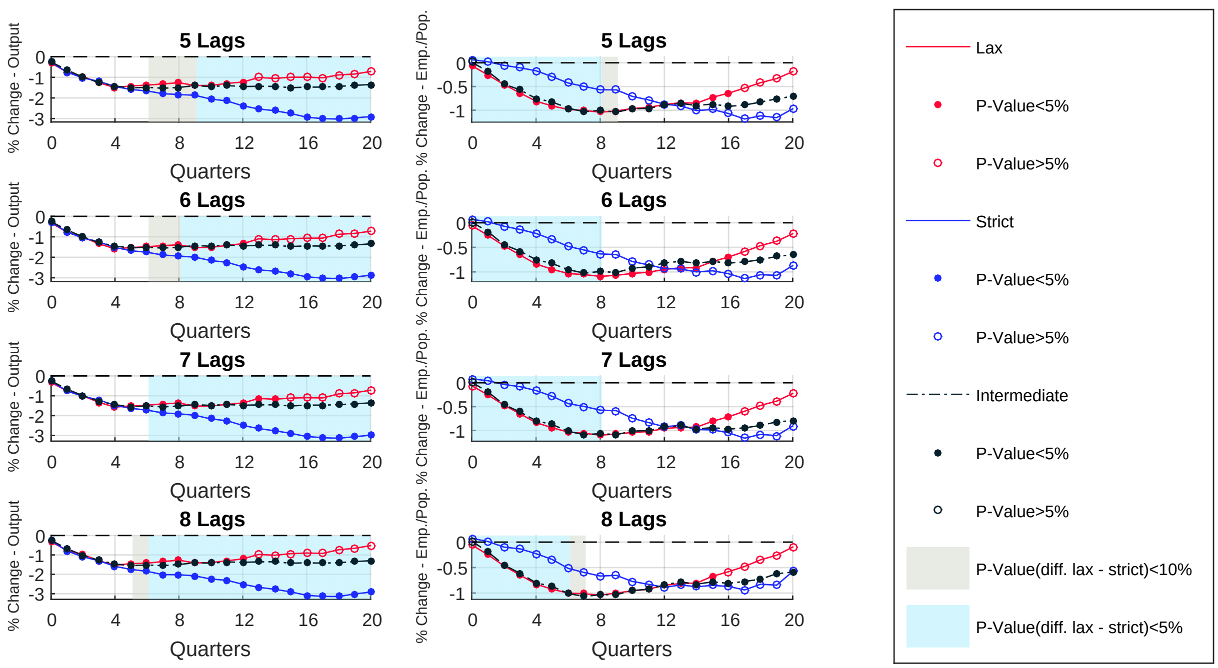
Notes: Impulse response functions for each outcome measure estimated using the state-dependent model described in Equation (1.1) with different cut-off values for EPL regimes. The IRF for strict EPL regime is presented in blue, the IRF for the lax EPL regime in red and the intermediate regime in black. Full data points represent horizons at which the point estimate for the IRF is statistically significantly different than zero (p-value ≤ 0.05). Shaded areas indicate that the difference in response between the strict and lax groups is significantly different from zero (p-value ≤ 0.05 in light-blue shading and p-value ≤ 0.1 in grey). Inference is based on Driscoll and Kraay (1998) standard errors.

Figure 6: Robustness - Continuous Interaction



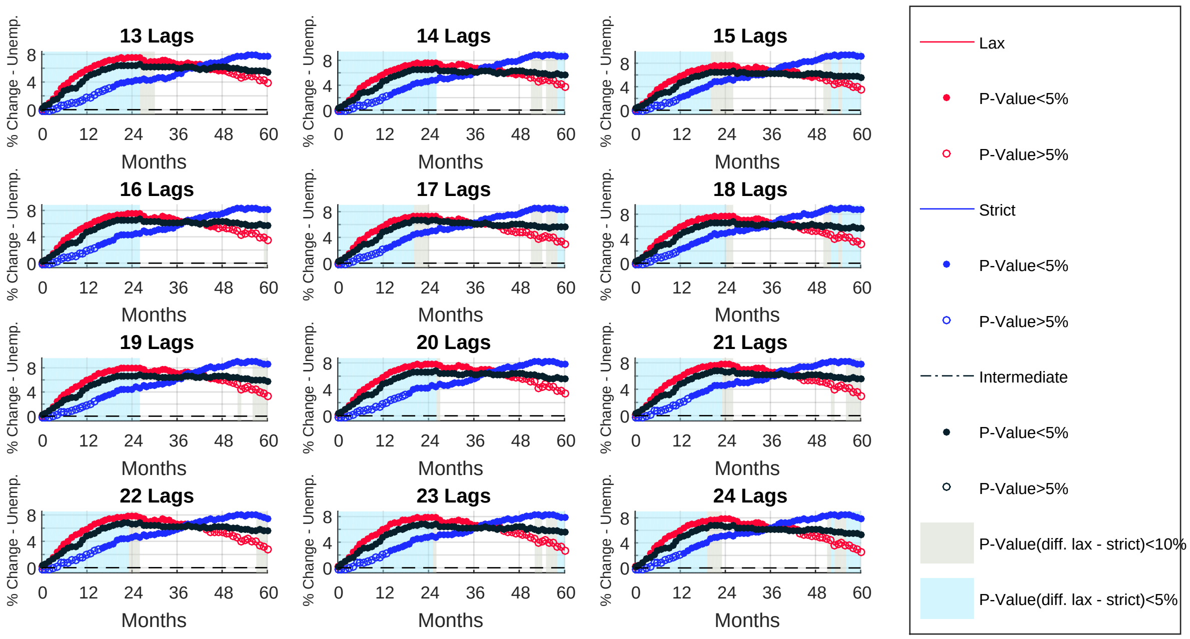
Notes: Impulse response functions for each outcome measure estimated using the state-dependent model described in Equation (1.2) with different cut-off values for EPL regimes. The IRF for the strict EPL regime is presented in blue, and the intermediate regime in black. Full data points in black represent horizons at which the point estimate for β^h_{50th} is statistically significantly different than zero (p-value $\leq$ 0.05).Full data points in blue represent horizons at which the point estimate for $\beta^h + \beta^h_{50th}$ is statistically significantly different than zero (p-value $\leq$ 0.05). Shaded areas indicate that the interaction term β^h in the impulse response is different from zero (p-value $\leq$ 0.05 in light-blue shading and p-value $\leq$ 0.1 in gray). Inference is based on Driscoll and Kraay (1998) standard errors.

Figure 7: Robustness to Different Lag Orders - Quarterly Variables



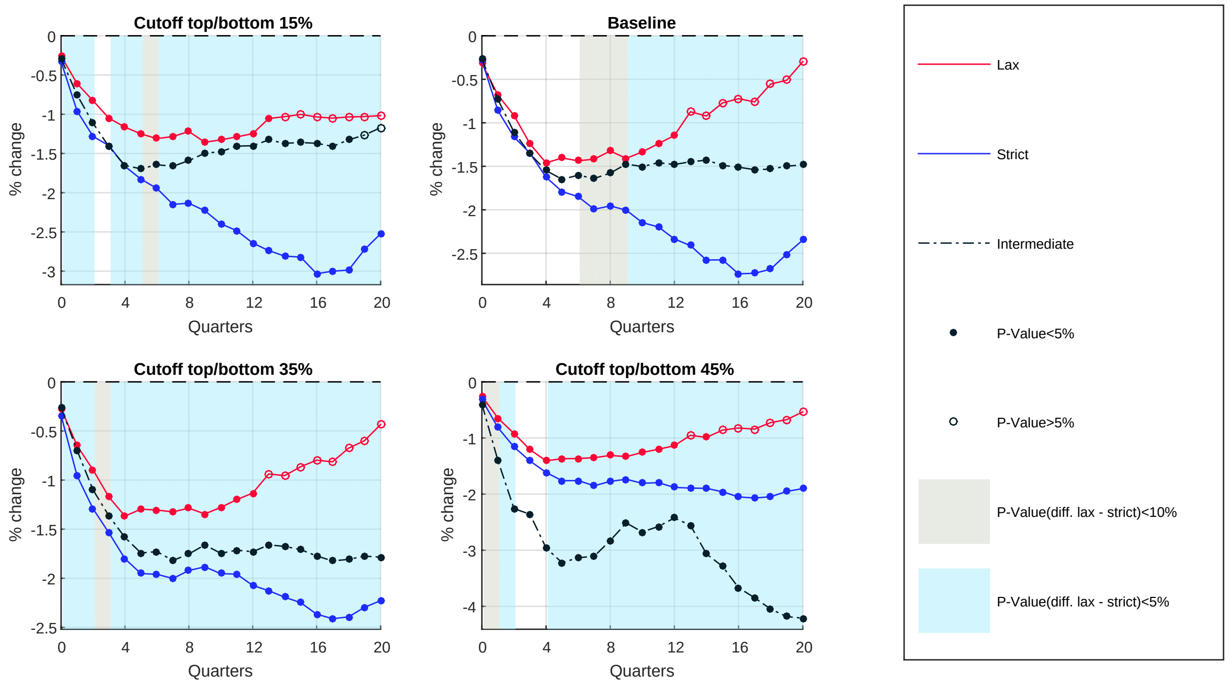
Notes: Impulse response functions for each outcome measure estimated using the state-dependent model described in Equation (1.1) with different lag specification. The IRF for strict EPL regime is presented in blue, the IRF for the lax EPL regime in red and the intermediate regime in black. Full data points represent horizons at which the point estimate for the IRF is statistically significantly different than zero (p-value ≤ 0.05). Shaded areas indicate that the difference in response between the strict and lax groups is significantly different from zero (p-value ≤ 0.05 in light-blue shading and p-value ≤ 0.1 in grey). Inference is based on Driscoll and Kraay (1998) standard errors.

Figure 8: Robustness to Different Lag Orders - Monthly Unemployment



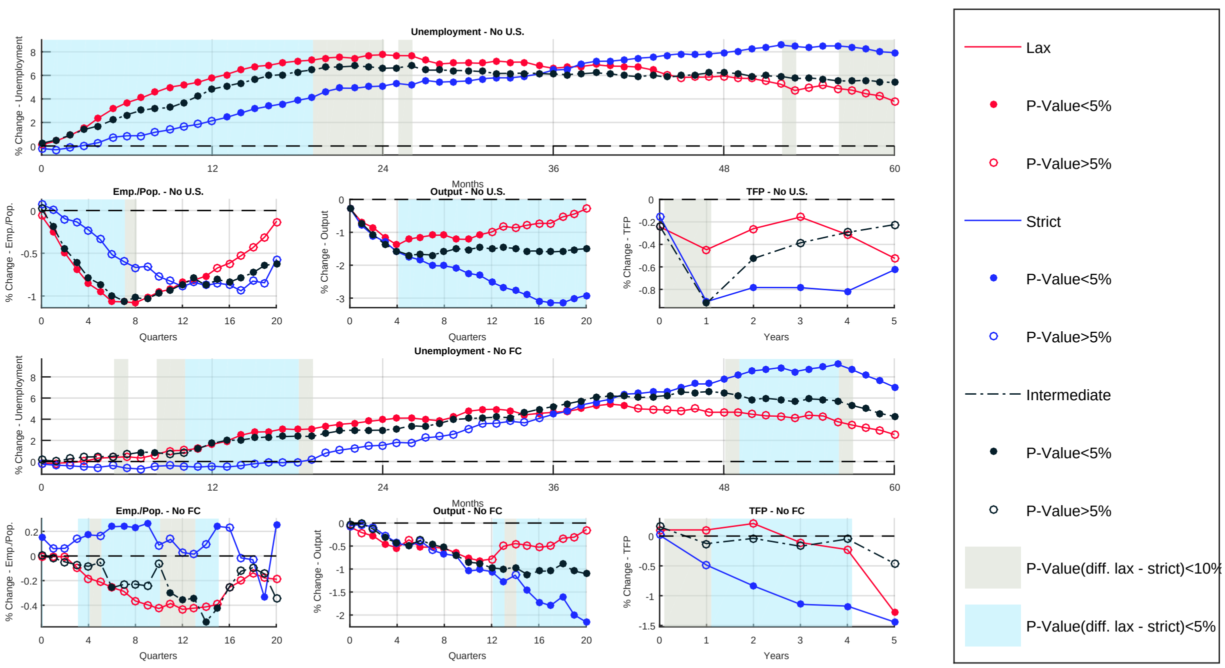
Notes: Impulse response functions for unemployment rates estimated using the state-dependent model described in Equation (1.1) with different lag specifications. The IRF for strict EPL regime is presented in blue, the IRF for the lax EPL regime in red and the intermediate regime in black. Full data points represent horizons at which the point estimate for the IRF is statistically significantly different than zero (p-value ≤ 0.05). Shaded areas indicate that the difference in response between the strict and lax groups is significantly different from zero (p-value ≤ 0.05 in light-blue shading and p-value ≤ 0.1 in grey). Inference is based on Driscoll and Kraay (1998) standard errors.

Figure 9: Robustness to Alternative Output Measure



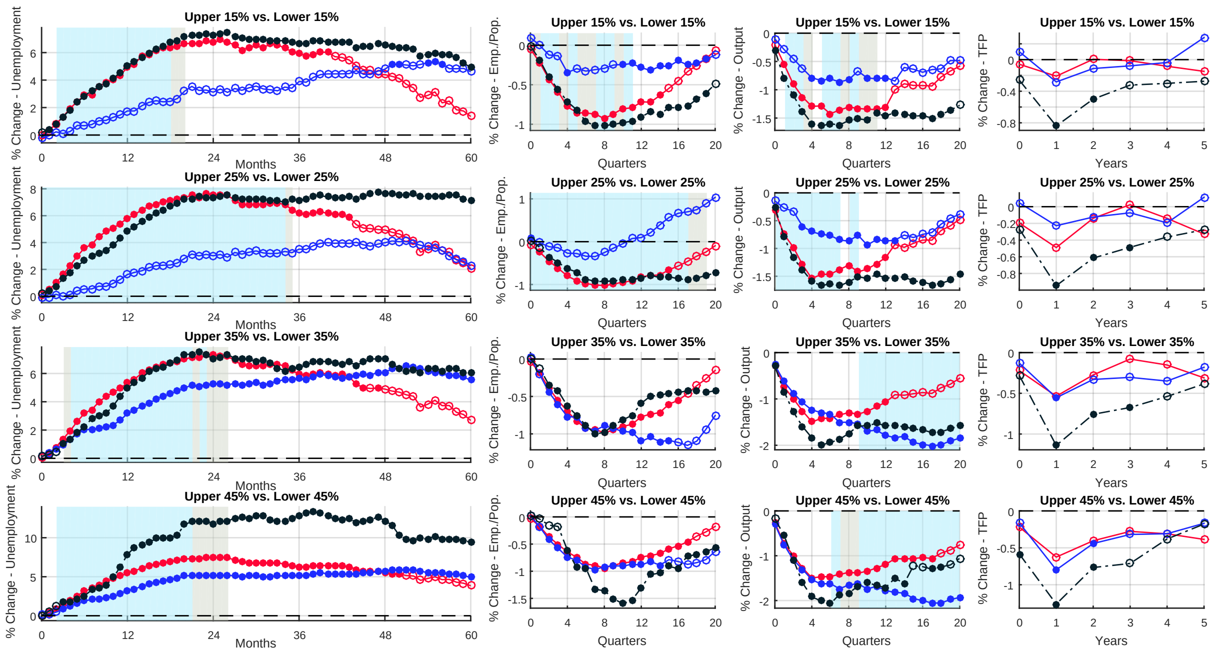
Notes: Impulse response functions output per-capita estimated using the state-dependent model described in Equation (1.1) while also considering different cut-off values for EPL regimes. The IRF for strict EPL regime is presented in blue, the IRF for the lax EPL regime in red and the intermediate regime in black. Full data points represent horizons at which the point estimate for the IRF is statistically significantly different than zero (p-value ≤ 0.05). Shaded areas indicate that the difference in response between the strict and lax groups is significantly different from zero (p-value ≤ 0.05 in light-blue shading and p-value ≤ 0.1 in grey). Inference is based on Driscoll and Kraay (1998) standard errors.

Figure 10: Robustness to Choice of Sample



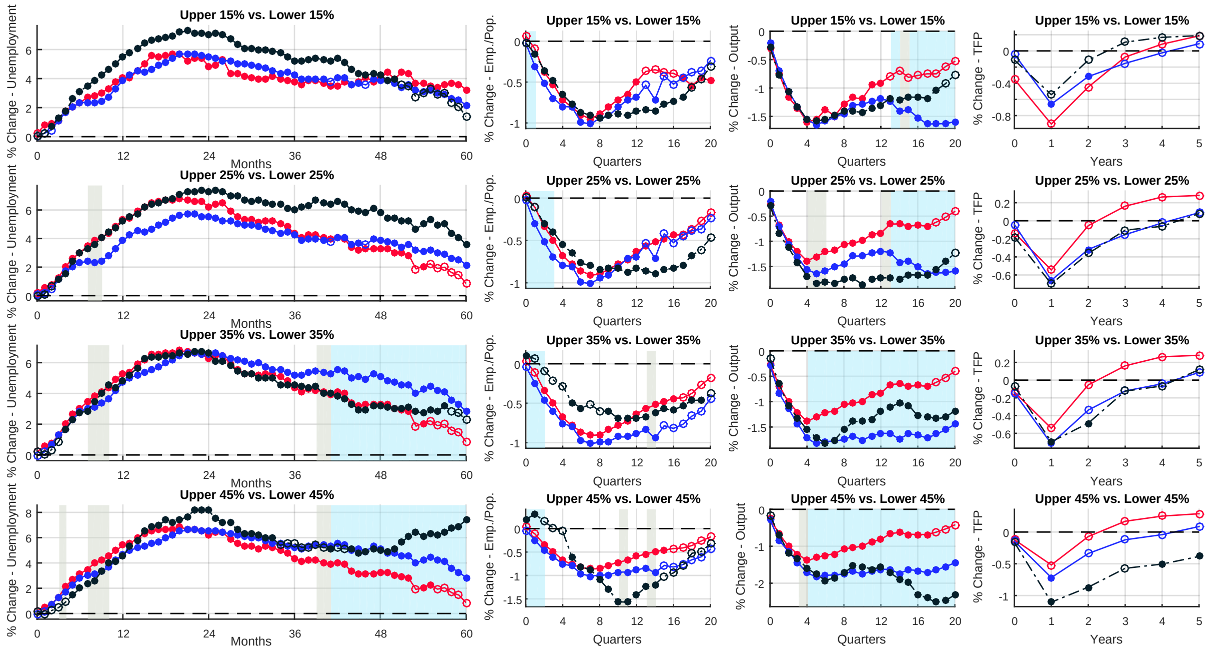
Notes: Impulse response functions for each outcome measure estimated using the state-dependent model described in Equation (1.1) for different sample choices. Abbreviations: No U.S.: sample without the united states; No FC: sample without the 2008 financial crisis. The IRF for strict EPL regime is presented in blue, the IRF for the lax EPL regime in red and the intermediate regime in black. Full data points represent horizons at which the point estimate for the IRF is statistically significantly different than zero (p-value ≤ 0.05). Shaded areas indicate that the difference in response between the strict and lax groups is significantly different from zero (p-value ≤ 0.05 in light-blue shading and p-value ≤ 0.1 in grey). Inference is based on Driscoll and Kraay (1998) standard errors.

Figure 11: Other Institutional Factors - Protection of Temporary Employees



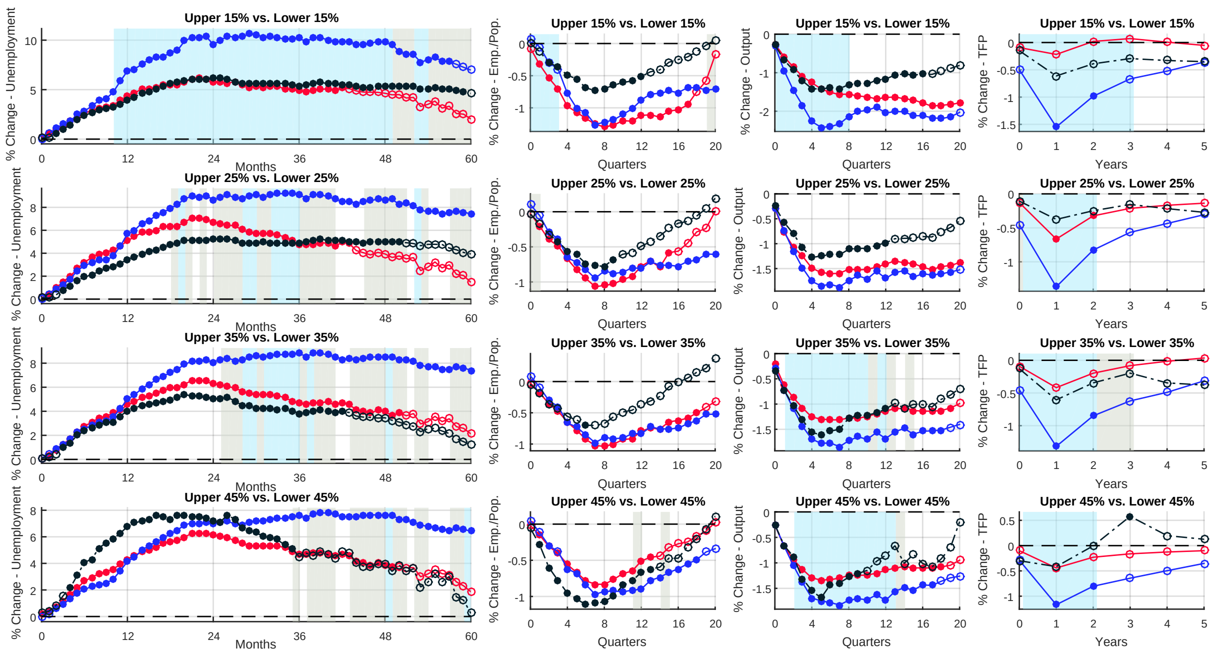
Notes: Impulse response functions for each outcome measure estimated using the state-dependent model described in Equation (1.1) with different cut-off values for EPT regimes. The IRF for strict EPT regime is presented in blue, the IRF for the lax EPT regime in red and the intermediate regime in black. Full data points represent horizons at which the point estimate for the IRF is statistically significantly different than zero (p-value ≤ 0.05). Shaded areas indicate that the difference in response between the strict and lax groups is significantly different from zero (p-value ≤ 0.05 in light-blue shading and p-value ≤ 0.1 in grey). All inference is based on Driscoll and Kraay (1998) standard errors.

Figure 12: Other Institutional Factors - Protection from Collective Dismissals



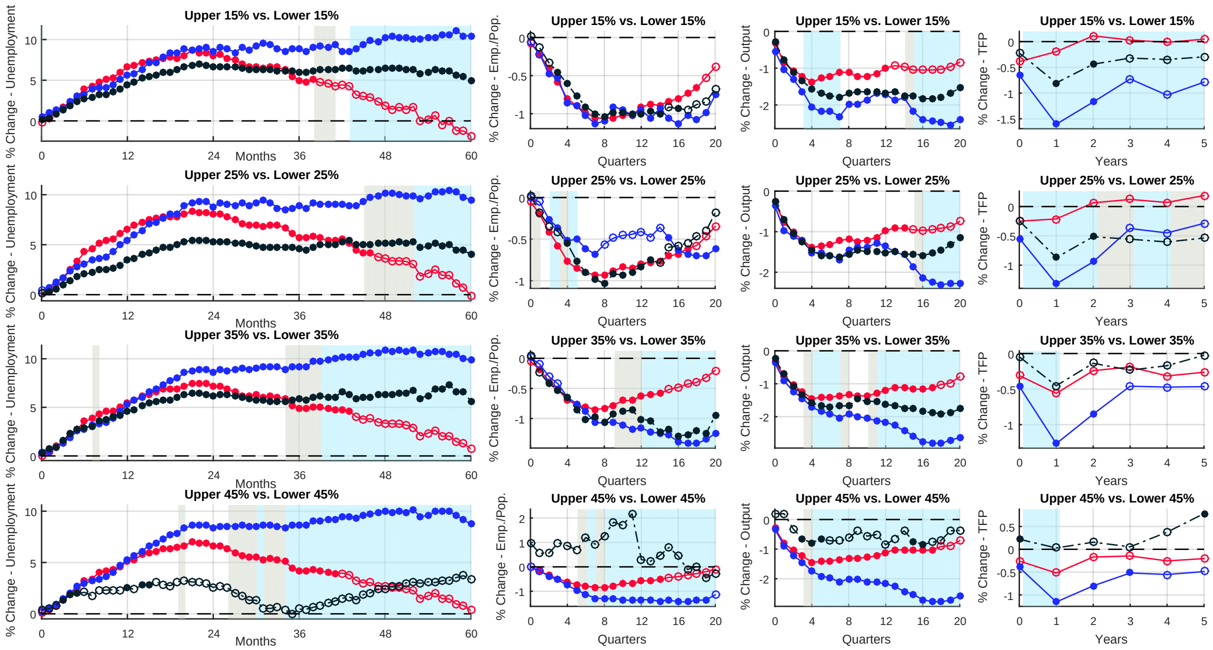
Notes: Impulse response functions for each outcome measure estimated using the state-dependent model described in Equation (1.1) with different cut-off values for EPC regimes. The IRF for strict EPC regime is presented in blue, the IRF for the lax EPC regime in red and the intermediate regime in black. Full data points represent horizons at which the point estimate for the IRF is statistically significantly different than zero (p-value ≤ 0.05). Shaded areas indicate that the difference in response between the strict and lax groups is significantly different from zero (p-value ≤ 0.05 in light-blue shading and p-value ≤ 0.1 in grey). All inference is based on Driscoll and Kraay (1998) standard errors.

Figure 13: Other Institutional Factors - Union Density



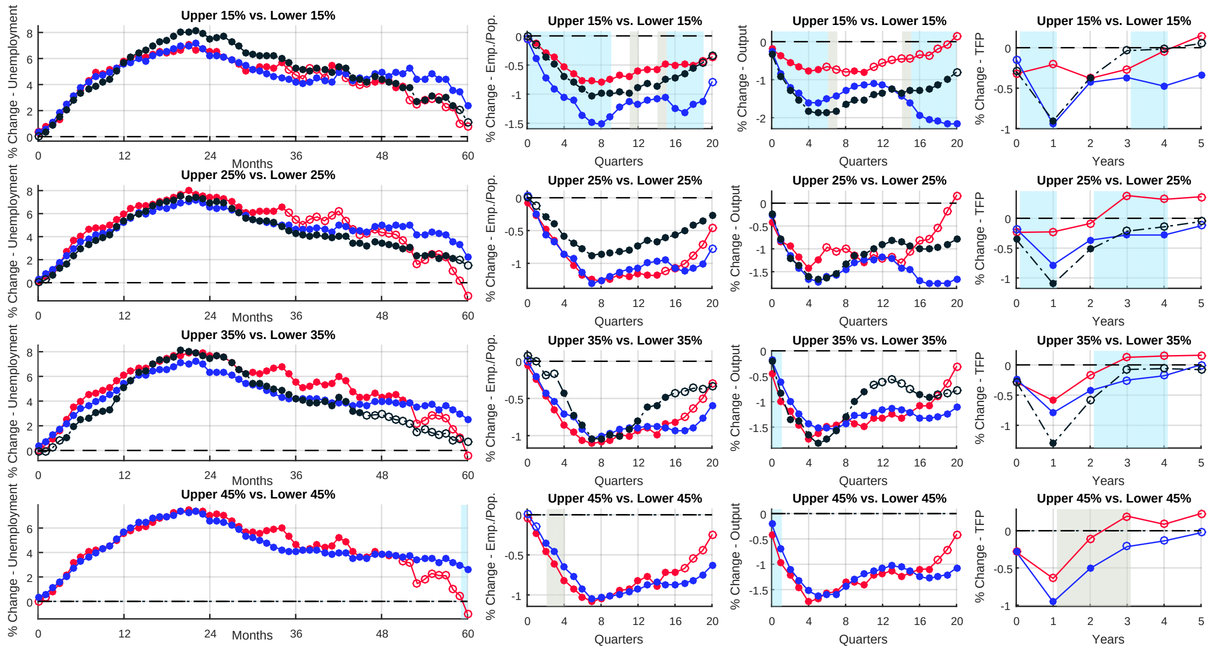
Notes: Impulse response functions for each outcome measure estimated using the state-dependent model described in Equation (1.1) with different cut-off values for levels of union density. The IRF for high union density is presented in blue, the IRF for the low union density in red and the intermediate regime in black. Full data points represent horizons at which the point estimate for the IRF is statistically significantly different than zero (p-value ≤ 0.05). Shaded areas indicate that the difference in response between the high and low groups is significantly different from zero (p-value ≤ 0.05 in light-blue shading and p-value ≤ 0.1 in grey). All inference is based on Driscoll and Kraay (1998) standard errors.

Figure 14: Other Institutional Factors - Collective Bargaining Coverage



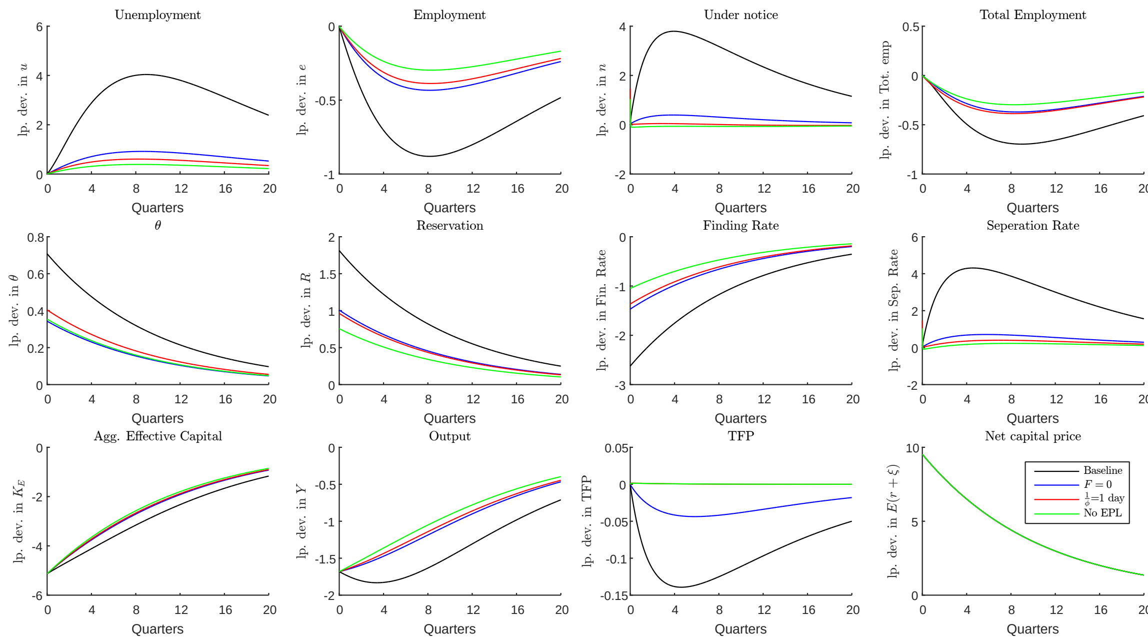
Notes: Impulse response functions for each outcome measure estimated using the state-dependent model described in Equation (1.1) with different cut-off values for collective bargaining coverage levels. The IRF for high collective bargaining coverage levels is presented in blue, the IRF for the low collective bargaining coverage levels in red and the intermediate regime in black. Full data points represent horizons at which the point estimate for the IRF is statistically significantly different than zero (p-value ≤ 0.05). Shaded areas indicate that the difference in response between the high and low groups is significantly different from zero (p-value ≤ 0.05 in light-blue shading and p-value ≤ 0.1 in grey). All inference is based on Driscoll and Kraay (1998) standard errors.

Figure 15: Other Institutional Factors - Net Replacement Rates



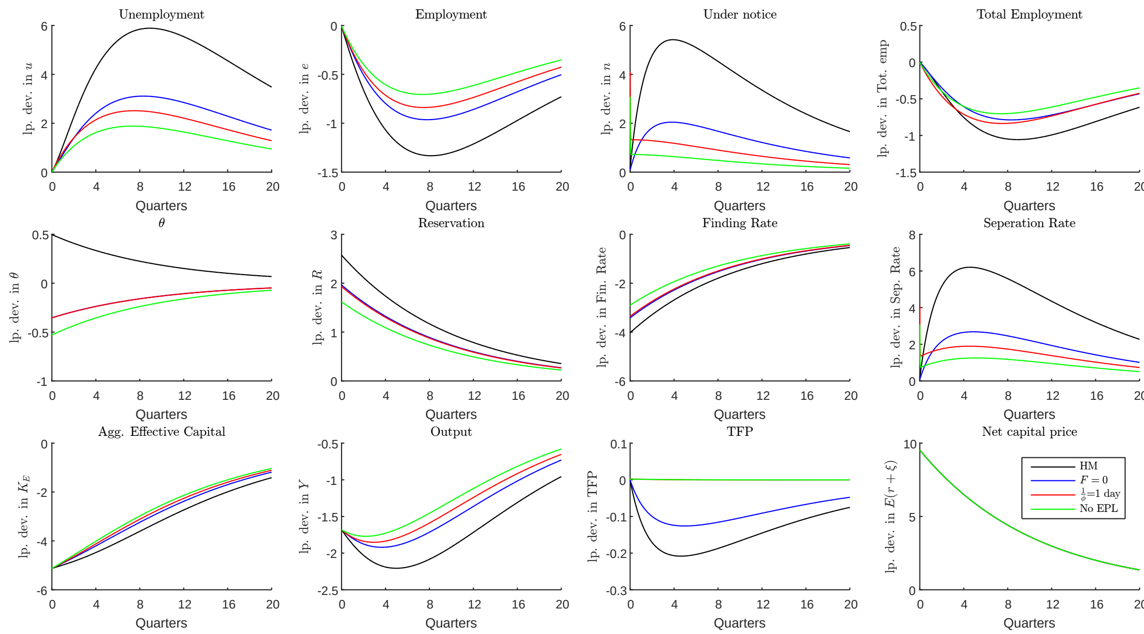
Notes: Impulse response functions for each outcome measure estimated using the state-dependent model described in Equation (1.1) with different cut-off values for replacement rates generosity levels. The IRF for high replacement rate regime is presented in blue, the IRF for the low replacement rate regime in red and the intermediate regime in black. Full data points represent horizons at which the point estimate for the IRF is statistically significantly different than zero (p-value ≤ 0.05). Shaded areas indicate that the difference in response between the high and low groups is significantly different from zero (p-value ≤ 0.05 in light-blue shading and p-value ≤ 0.1 in grey). All inference is based on Driscoll and Kraay (1998) standard errors.

Figure 16: Theoretical Impulse Responses For Baseline Calibration and Counter-Factual Parametrizations.



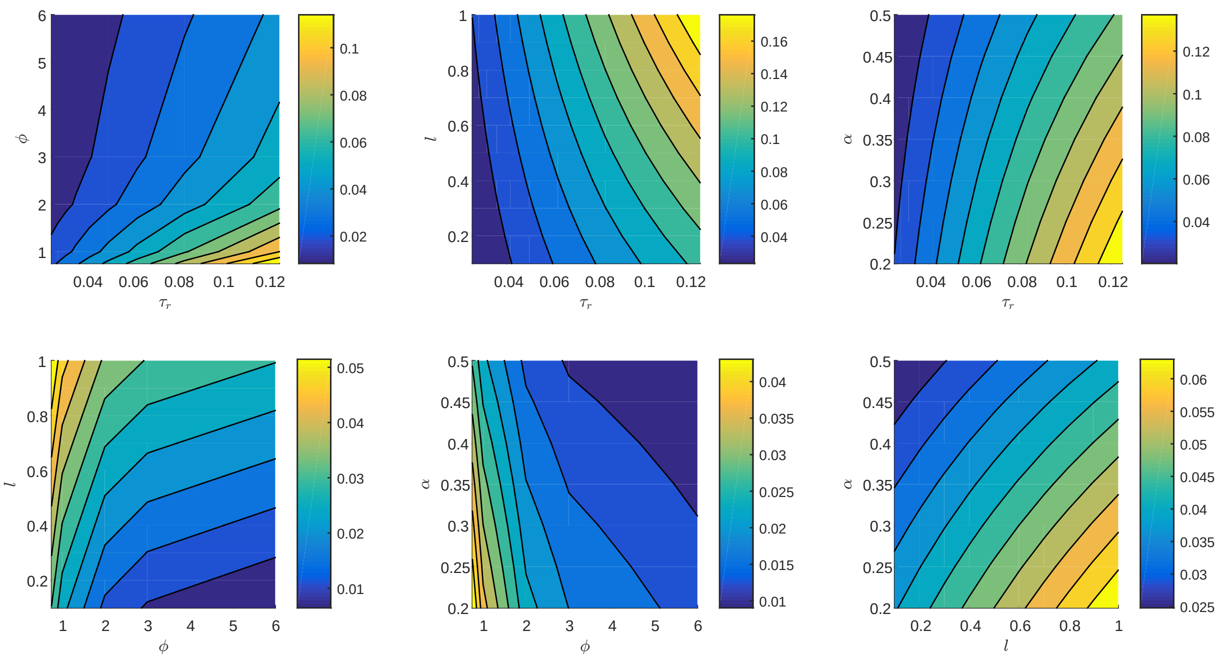
Notes: Theoretical impulse response functions for each variable to a realization of the high risk premium state. Impulse responses for the baseline France calibration and the counter-factual ones given in columns 1 through 4 of Table 3 are presented in black, blue, red, and green correspondingly. Time horizon is in quarters and the vertical axis' units are the log-point changes from steady-state level of each variable in response to the shock.

Figure 17: Theoretical Impulse Responses For Baseline Calibration and Counter-Factual Parametrizations - HM-style Calibration.



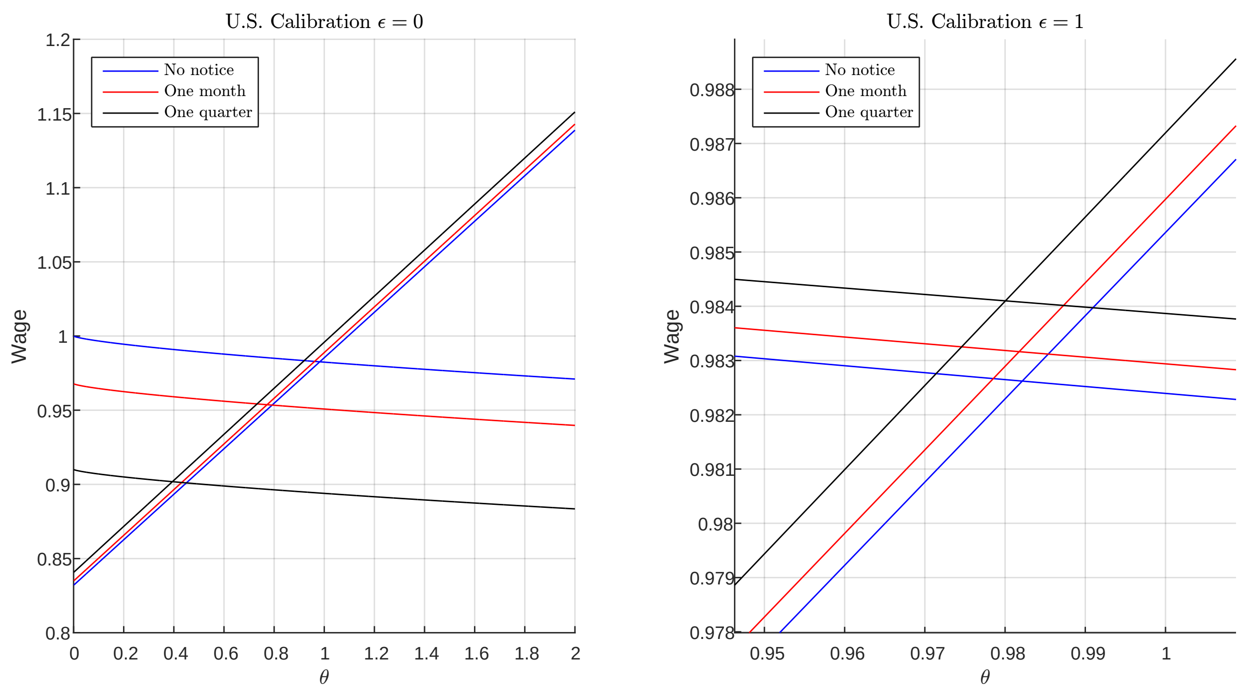
Notes: Theoretical impulse response functions for each variable to a realization of the high risk premium state. Impulse responses for the baseline France calibration and the counter-factual ones given in columns 1 through 4 of Table 4 are presented in black, blue, red, and green correspondingly. Time horizon is in quarters and the vertical axis' units are the log-point changes from steady-state level of each variable in response to the shock.

Figure 18: Sensitivity Analysis for the Value ψ.



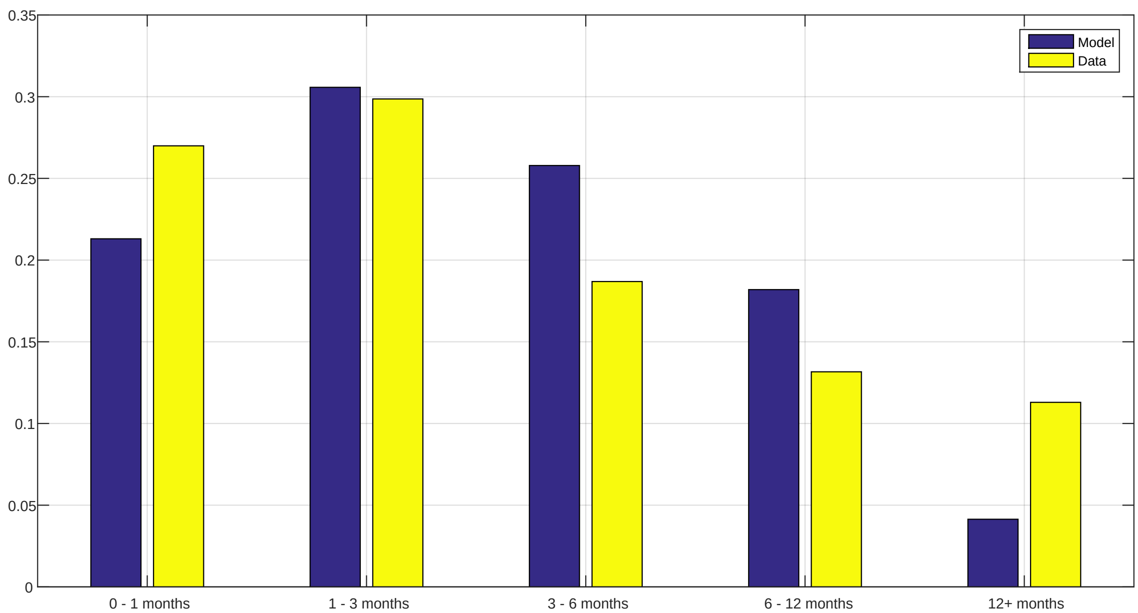
Notes: Each panel gives the possible values of ψ given the the parameter values that correspond to our baseline calibration in Table 3. Namely, a capital share of $\alpha = 0.33$, $\phi = 0.75$, a termination rate of $\tau_r = 0.0356$, firing costs ratio to average quarterly production value of $l = 0.33$,and $x_{\min} = 0$.

Figure 19: Comparative Statics - Termination Notice Length in Search Model



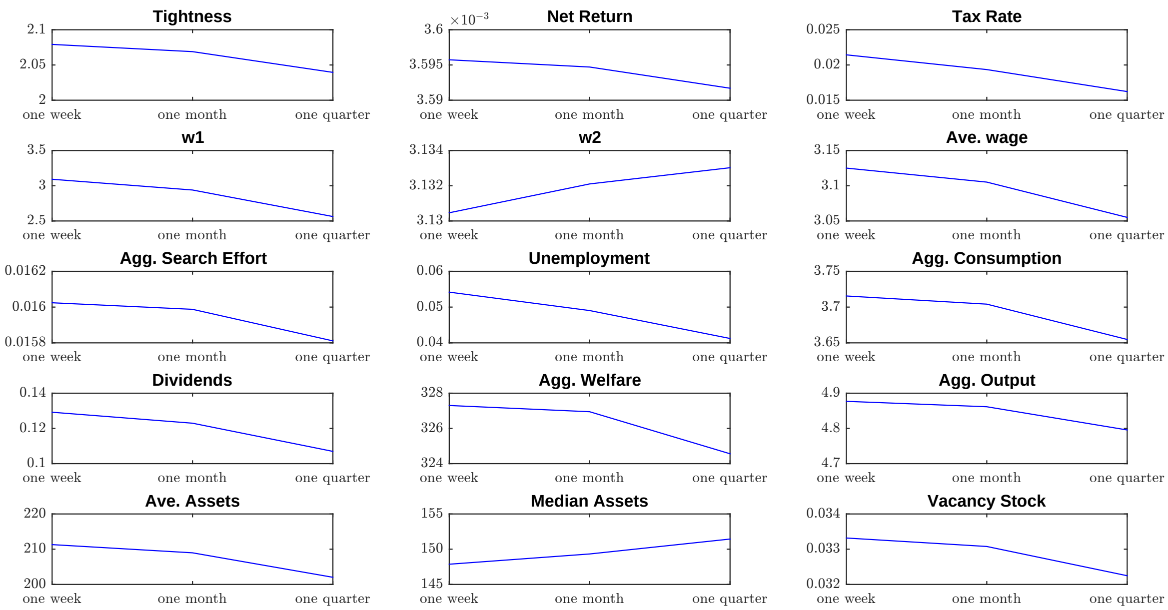
Note: Equilibrium for the search model using calibration from Shimer (2005). Namely $q(\theta) = 1.355\theta^{-0.72}$, $c = 0.213$, $p = 1$, $\lambda_s = 0.1$, $\beta = 0.72$, and $z = 0.4$. Upward sloping lines are the wage curves, and downwards sloping lines the job-creation curve. Blue lines denote the original model with $\phi \rightarrow \text{inf}$, red lines the model with $\phi = 3$ and black lines the model with $\phi = 1$. The left panel shows the equilibrium for the case of $\epsilon = 0$ and the right one for $\epsilon = 1$.

Figure 20: Model Fit - Distribution of Unemployment Durations



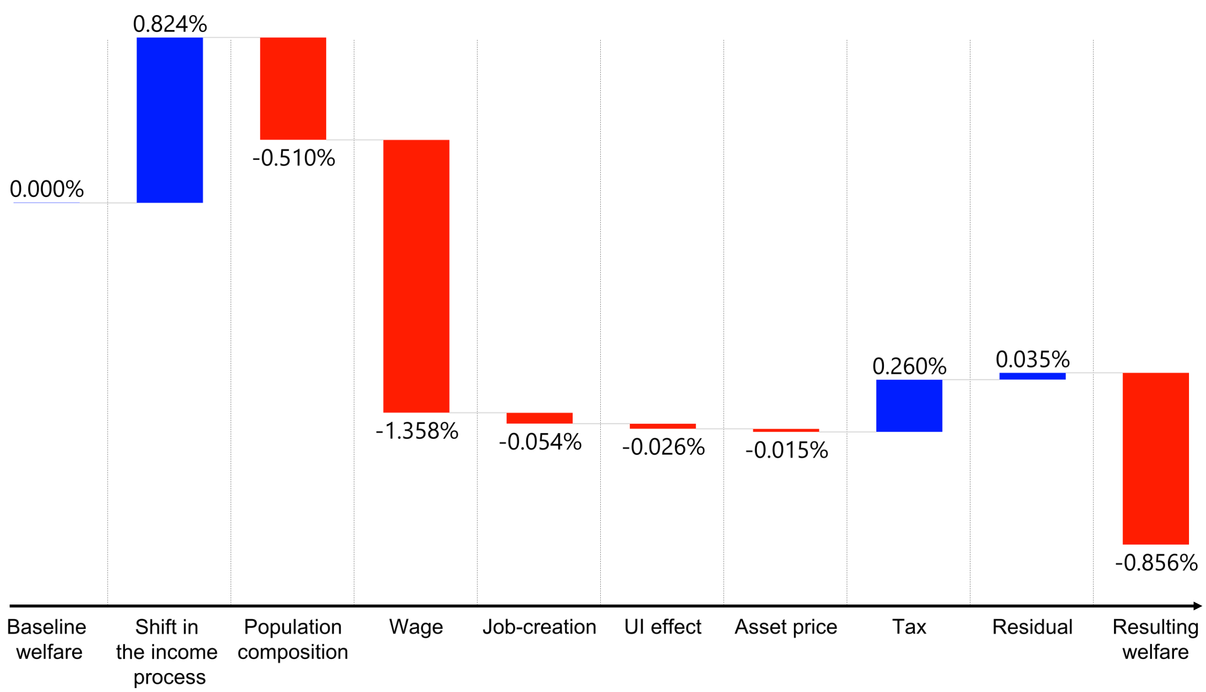
Note: This figure displays in yellow the distribution of unemployment duration for all persons aged 25 to 54. I report averages for each bin for the years 2012 - 2019. In purple, the figure displays the distribution of unemployment durations as implied by the parametrization given in column (1) of Table 6.

Figure 21: Comparative Statics - Termination Notice Length in GE Model



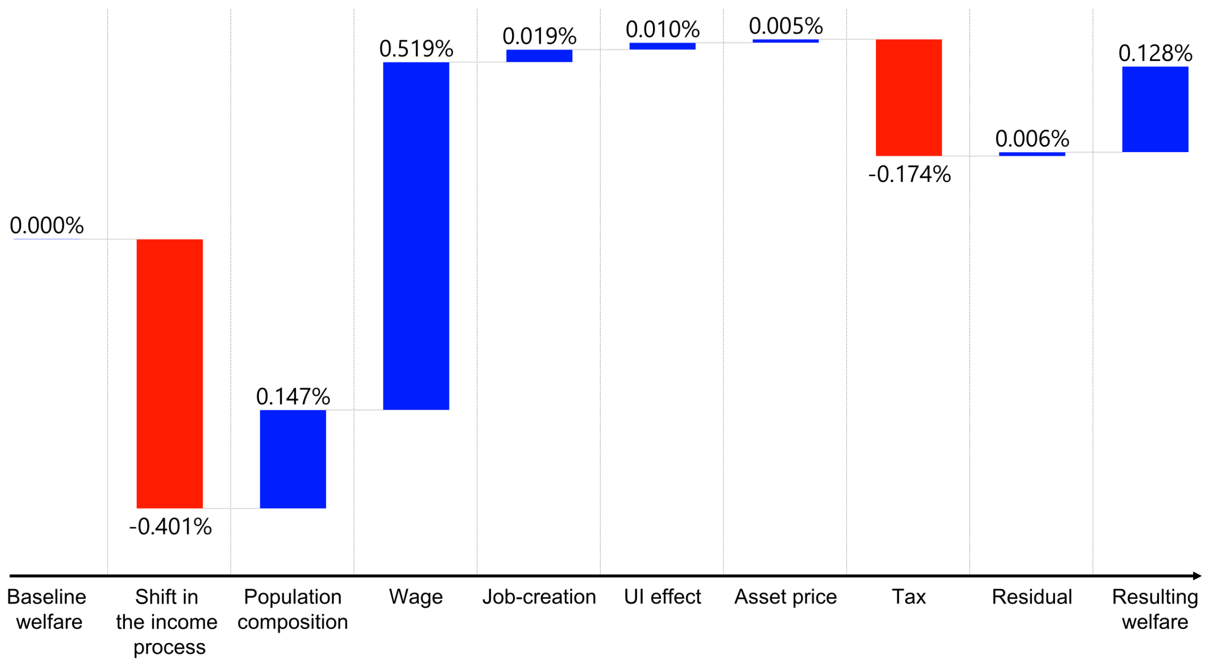
Note: Each panel presents the values of the variable for three different policy regimes. Specifically, a termination notice of one week length $\phi = \frac{13}{3}$, the prevailing regime in Israel of one month of notice $\phi = 1$, and termination notice of one quarter $\phi = \frac{1}{3}$.

Figure 22: Decomposing the Effect of Increasing the Length of Termination Notice on Aggregate Welfare



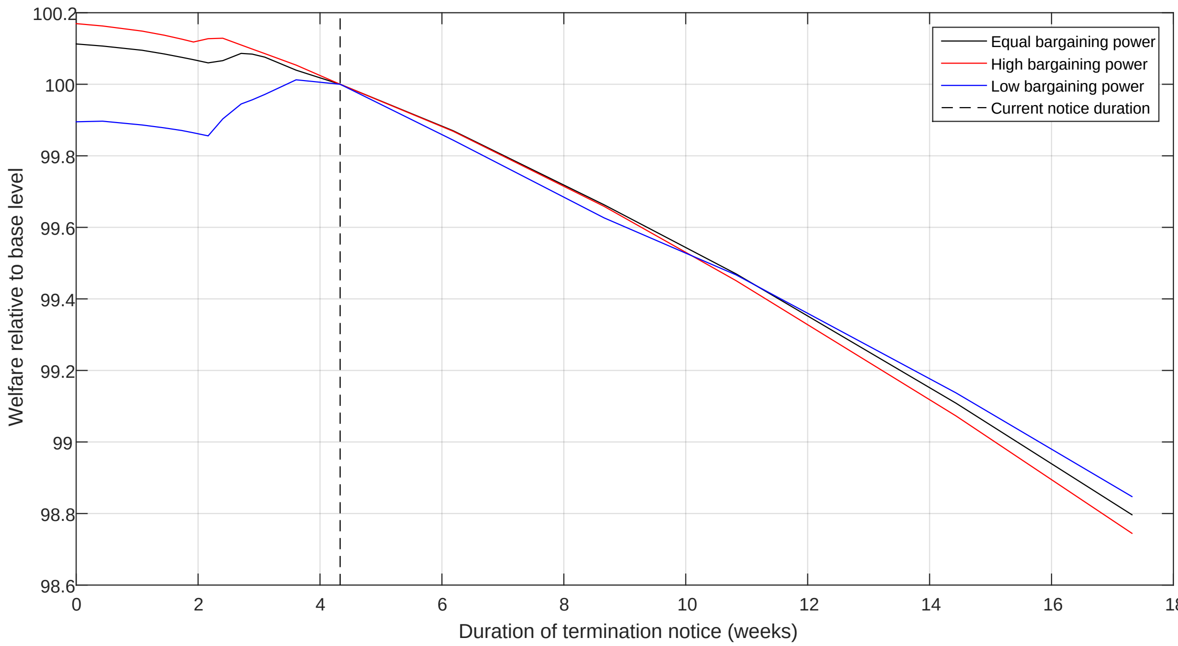
Note: Decomposing the effect of increasing the length of termination notice in Israel from the existing level of one month $\phi = 1$ to one quarter $\phi = \frac{1}{3}$. The effects are broken down in accord with the method described in Section 3.4.2, and are given in the same order (left to right) as described in the main text. Welfare is measured in consumption equivalent ($\omega^{\star}$) terms.

Figure 23: Decomposing the Effect of Decreasing the Length of Termination Notice on Aggregate Welfare



Note: Decomposing the effect of decreasing the length of termination notice in Israel from the existing level of one month $\phi = 1$ to one week $\phi = \frac{13}{3}$. The effects are broken down in accord with the method described in Section 3.4.2, and are given in the same order (left to right) as described in the main text. Welfare is measured in consumption equivalent ($\omega^{\star}$) terms.

Figure 24: Aggregate Welfare as a Function of Notice Duration - Varying Bargaining Power



Note: This figure plots the aggregate welfare function Ω as a function of ϕ, termination notice duration. The x axis presents the length in weeks of termination notice. The black line represents the aggregate welfare assuming the workers and firms have an equal bargaining power (parametrization from column (1) of Table 6), the blue line corresponds to the low bargaining power case (column (2) of Table 6), and the red line to the high bargaining power case (column (3) of Table 6). The dashed line denotes the existing length of notice in Israel (one month) as a reference point. The welfare at the current duration of termination notice is normalized to 100 in all cases to allow for comparability. It is important to stress that this is not a comparison of the welfare levels themselves. The high bargaining power case has higher aggregate welfare than the equal case regardless of policies. The same holds for the comparison of the equal bargaining power case to the low bargaining power case. Thus, this is not an attempt to compare welfare levels across different parametrizations but rather to illustrate the different effect of a policy change in each scenario.

Tables

Table 1: EPL Index - Components and Weights

EPL index	Weights	OECD main series	Weights	OECD basic series
EPR v1 - regular contracts	33.3%	Procedural inconvenience	50.0%	Notification procedures
			50.0%	Delay involved before notice can start
	33.3%	Notice and severance pay for no-fault individual dismissal	14.3%	Length of the notice period at 9 months tenure
			14.3%	Length of the notice period at 4 years tenure
			14.3%	Length of the notice period at 20 years tenure
			19.0%	Severance pay at 9 months tenure
			19.0%	Severance pay at 4 years tenure
			19.0%	Severance pay at 20 years tenure
	33.3%	Difficulty of dismissal	25.0%	Definition of justified or unfair dismissal
			25.0%	Length of trial period
			25.0%	Compensation following unfair dismissal
			25.0%	Possibility of reinstatement following unfair dismissal

Notes: The weights and the basic series are those used by the OECD and retrieved from http://www.oecd.org/els/emp/oecdindicatorsofemploymentprotection.htm.

Table 2: Job Flows and EPL

	Average flow hazards by policy regimes			
	Job finding rate		Separation rate	
	(1) Coef.	(2) P-value	(3) Coef.	(4) P-value
Lax	0.2512	0.0000	0.0178	0.0000
Intermediate	0.1819	0.0000	0.0101	0.0000
Strict	0.0861	0.0000	0.0063	0.0000
	Differences between groups			
	Coef.	P-value	Coef.	P-value
Lax-Intermediate	0.0693	0.0000	0.0077	0.0000
Intermediate-Strict	0.0958	0.0000	0.0038	0.0004
Lax-Strict	0.1651	0.0000	0.0115	0.0000

Notes: The first three rows are obtained from simply regressing the job-finding rate and separation rate data from Elsby et al. (2013) on the three policy dummies without a constant term so as to obtain the group averages. The last three rows indicate the differences between every pair of groups and their statistical significance. Inference is based on Driscoll and Kraay (1998) standard errors.

Table 3: Model Calibration and Stochastic Steady-State Values

	Baseline - France (1)	No firing costs (2)	No notice (3)	No firing restrictions (4)
		Parameter values		
p	0.4500	0.4500	0.4500	0.4500
c	1.2953	1.2953	1.2953	1.2953
λ	0.1756	0.1756	0.1756	0.1756
β	0.5000	0.5000	0.5000	0.5000
ϕ	0.7500	0.7500	62.7500	62.7500
F	0.6231	-	0.6231	-
z	0.8425	0.8425	0.8425	0.8425
r	0.0100	0.0100	0.0100	0.0100
δ	0.0200	0.0200	0.0200	0.0200
α	0.3300	0.3300	0.3300	0.3300
G(x)		$\text{G}(x) = 1 - \left(\frac{1}{x}\right)^{1.61}$		
$q(\theta)$		$0.2509\theta^{-0.5}$		
		Model stochastic steady state		
u	0.1442	0.2865	0.3887	0.4324
n	0.0392	0.0613	0.0012	0.0012
e	0.8166	0.6523	0.6102	0.5664
$\overline{x}$	1.9118	2.4327	2.8395	3.1014
TFP	0.6718	0.7667	0.9011	0.9557
R	0.1397	0.3623	0.5307	0.6429
θ	0.9982	1.1010	1.2088	1.2894
Finding rate	0.2032	0.1601	0.1390	0.1281
Separation rate	0.0343	0.0644	0.1188	0.1312
Output	2.3426	2.3812	2.5995	2.6363

Notes: This table consists of the parameters and of the stochastic steady-state values used for the baseline calibration of the model described in Section 2.2.3, and for the simulation presented in Figure 16.

Table 4: Model Calibration and Stochastic Steady-State Values - HM-Style Calibration

	Baseline - France (1)	No firing costs (2)	No notice (3)	No firing restrictions (4)
	Parameter values			
p	0.4500	0.4500	0.4500	0.4500
c	2.3350	2.3350	2.3350	2.3350
λ	0.1814	0.1814	0.1814	0.1814
β	0.0520	0.0520	0.0520	0.0520
ϕ	0.7500	0.7500	62.7500	62.7500
F	0.6185	-	0.6185	-
z	1.4269	1.4269	1.4269	1.4269
r	0.0100	0.0100	0.0100	0.0100
δ	0.0200	0.0200	0.0200	0.0200
α	0.3300	0.3300	0.3300	0.3300
G(x)	$\text{G}(x) = 1 - \left(\frac{1}{x}\right)^{1.61}$			
$q(\theta)$	$\frac{1}{(1+\theta^{0.4983})^{\frac{1}{0.4984}}}$			
	Model stochastic steady state			
u	0.1477	0.1989	0.2466	0.2695
n	0.0401	0.0530	0.0010	0.0011
e	0.8122	0.7481	0.7524	0.7294
$\overline{x}$	1.9190	2.1212	2.2986	2.4239
TFP	0.6729	0.7098	0.7830	0.8112
R	0.1338	0.2225	0.2951	0.3503
θ	0.9946	1.2301	1.4665	1.6605
Finding rate	0.2030	0.1994	0.1971	0.1947
Separation rate	0.0353	0.0496	0.0867	0.0966
Output	2.3387	2.3813	2.5948	2.6532

Notes: This table consists of the parameters and of the stochastic steady-state values used for the HM-style calibration of the model described in Section 2.2.3, and for the simulation presented in Figure 17.

Table 5: Termination Notice by Job Tenure - Legislated Periods

	Job tenure				
Country	6 months	2 years	5 years	10 years	20 years
Australia	0.3	0.5	1.0	1.0	1.0
Austria	1.5	2.0	3.0	3.0	4.0
Belgium	3.0	3.0	6.0	9.0	15.0
China	1.0	1.0	1.0	1.0	1.0
Denmark	3.0	3.0	4.0	6.0	6.0
Finland	0.5	1.0	2.0	4.0	6.0
France	1.0	2.0	2.0	2.0	2.0
Germany	1.0	1.0	2.0	4.0	7.0
Greece	1.0	2.0	3.0	6.0	16.0
Hungary	1.0	1.0	1.5	1.8	3.0
Italy	1.4	1.6	1.6	2.2	4.0
Israel	0.3	1.0	1.0	1.0	1.0
Japan	1.0	1.0	1.0	1.0	1.0
R. of Korea	1.0	1.0	1.0	1.0	1.0
New Zealand	0.5	0.5	0.5	0.5	0.5
Norway	1.0	1.0	2.0	3.0	3.0
Portugal	0.5	1.0	2.0	2.5	2.5
Russia	2.0	2.0	2.0	2.0	2.0
Spain	1.0	1.0	1.0	1.0	1.0
Sweden	1.0	2.0	3.0	6.0	6.0
Switzerland	1.0	2.0	2.0	3.0	3.0
Turkey	1.0	1.5	2.0	2.0	2.0
UAE	1.0	1.0	1.0	1.0	1.0
UK	0.3	0.5	1.3	2.5	3.0
US	-	-	-	-	-
Mean	1.0	1.3	1.9	2.7	3.7

Note: This table reports the duration of legislated termination notice expressed in months as of 2010. When there is a differentiation under law between white and blue collar workers or between small and large firms, I report the numbers relating to white collar workers and large firms. Data on Israel comes from Israel's 'Advanced notice for dismissal and resignation act' (2001, still in effect). Data on other countries is based on ILO's EPLex database https://eplex.ilo.org/.

Table 6: Calibration Table - General Equilibrium Model

	Parameter	Baseline	Low bargaining power	High bargaining power
Households		(1)	(2)	(3)
ρ	discount rate	0.0036	0.0036	0.0036
ψ_0	disutility from search - scale	11.5601	9.8909	12.9151
ψ	disutility from search - shape	0.2012	0.1208	0.2468
λ_s	separation hazard	0.0137	0.0141	0.1370
Matching				
η	matching function parameter	0.7024	0.7915	0.5387
β	bargaining power parameter	0.5000	0.2500	0.7500
Firms				
α	capital share	0.3300	0.3300	0.3300
p	productivity parameter	1.0000	1.0000	1.0000
ϵ	labour input during notice	-	-	-
κ	flow cost of vacancy	14.9757	36.9386	5.1599
δ	depreciation rate of capital	0.0067	0.0200	0.0200
Policies				
λ_{E1}	hazard of finishing the trial period	0.0833	0.0833	0.0833
λ_{U1}	hazard of ending UI eligibility	0.2500	0.2500	0.2500
ϕ	hazard of exiting the notice period	1.0000	1.0000	1.0000
R_1	replacement rate on UI	0.6000	0.6000	0.6000
R_2	replacement rate on income security program	0.1475	0.1475	0.1475

Note: All hazard rates are in monthly terms.

Table 7: Model Fit With Respect to Each Target

Target		Value	Baseline (1)	Low bargaining power (2)	High bargaining power (3)
Unemp. Rate		4.60%	4.83%	4.79%	4.75%
Vacancy Rate		3.27%	3.31%	3.23%	3.26%
Duration Elasticity		-0.5000	-0.5059	-0.6634	-0.4662
Unemp. Duration (t) Distribution by Bins	$t < 1$ month	27.31%	21.30%	21.49%	21.54%
	$1 < t < 3$	30.34%	30.57%	29.45%	30.83%
	$3 < t < 6$	18.59%	25.79%	23.31%	25.92%
	$6 < t < 12$	12.88%	18.19%	16.58%	18.09%
	$12 < t$	10.87%	4.14%	9.18%	3.62%
SSE			0.75476	0.32605	0.81466

Note: Column (1) - (3) of this table report the model's fit for each parametrization given in the corresponding column of Table 6. SSE for each column is computed as the sum of relative deviations from the target on the same row, as explained in Appendix D.4.

Table 8: Optimal Policies

Policy variables determined by the planner		λ_{U1}	ϕ	R_1	R_2	$\omega^\star$
(1)	Non - Existing policies	0.25	1	0.6	0.1475	
(2)	Only termination notice ϕ	0.25	100	0.6	0.1475	0.1455%
(3)	Only replacement rates - R_1, and R_2	0.25	1	0.4508	0	0.1930%
(4)	All the UI system - R_1, R_2, and λ_{U1}	0.6875	1	1	0	0.2891%
(5)	All policy parameters	0.6711	100	1	0	0.4617%

Note: All hazard rates are in monthly terms.

תקציר

חקיקת מגן בשוק העבודה (לחילופין הגנת עובדים או EPL בלעז) היא מונח גג למשפחת חוקים המגבילה את יכולתם של עובד ומעסיק לכרות חוזה העסקה באופן חופשי. כלי מדיניות מסוג זה מהווים מאפיין בולט ברוב שווקי העבודה בכלכלות המפותחות והם נמצאים בשימוש כבר למעלה ממאה שנה. בתחילת שנות התשעים הגנת עובדים זכתה לתשומת לב משמעותית בדיונים על המדיניות הכלכלית באירופה, ובכלכלות אירופיות רבות הוקלה החקיקה במטרה להגביר את הצמיחה הכלכלית. למרות שכיחותם של כלי מדיניות אלו, חלק משמעותי מההשלכות המקרו-כלכליות שלהם אינו נבחן על ידי הספרות הכלכלית ונעדר מדיון המדיניות כתוצאה מכך. תיזה זו נועדה לבחון בכמה מהפערים הללו בספרות הכלכלית ובדיון הציבורי על הגנת עובדים ולדון בהשלכות של שימוש במכשירי מדיניות אלו.

בכדי לשים את המדיניות המדוברת בהקשר פוליטי, הרעיון של הגנת עובדים נבע מהתהוותם של העובדים בשכר כמעמד חברתי גדול הרואה את האבטלה כסיכון מרכזי להכנסתו. בשוק עבודה חיכוכי, התעסוקה מגלמת בתוכה רנטות. כלומר, הפרט אינו אדיש בין עבודה לתעסוקה. הפרט היה מעדיף להיות מועסק אבל קיומם של חיכוכים מסויימים הנובעים מאופייה של הסביבה, כגון פערי אינפורמציה, מקשה על פרטים מובטלים למצוא עבודה. כאשר קבוצה גדולה מהאוכלוסייה מועסקת בשכר, ובפרט כאשר המצביע החציוני הוא אדם מועסק, יכולה קבוצה זו להשתמש בכוחה הפוליטי ולקדם מדיניות שתבטיח ואף תגדיל את הרנטות שלהם מהתעסוקה. בראשית המאה העשרים הונהגו חוקים שכאלה במדינות רבות. חוקים אלו כוללים, בין היתר, פיצויי פיטורים , הודעה מוקדמת לפני פיטורין והגדרת המושג פיטורין שלא כדין. חוקים אלו מגבילים את חופש החוזה מכיוון שהם משקפים את הדעה כי לא כל חוזי העבודה תקפים, הגם אם נחתמו מרצון ובאופן המוסכם על שני הצדדים. למעשה, מדיניות זו ממסדת סטייה מדוקטרינת "At-will employment", לפיה ניתן לשכור עובדים ולפטר אותם לפי רצון וללא מגבלות למעט ההסכמה ההדדית של העובד והמעסיק על המשך יחסי העבודה בין הצדדים ועל תנאיהם.

מנקודת מבט מאקרו-כלכלית, חקיקה זו מהווה עלות נוספת להתאמת תשומת העבודה בתהליך היצור מצידן של הפירמות. עלות זו יכולה להיות עלות התאמה הנובעת מהחלטה בודדת כגון גיוסו או פיטורו של עובד, או תקורת עלות המתווספת על ההעסקה בשכר. באופן זה, מקשות עלויות אלו על כניסה של פירמות חדשות לענף, הן מהוות שיקול אשר יכול להשפיע על התארגנות מחדש של פירמה קיימת, ובכלכלה בכללותה להאט את יכולת מנגנון השוק, החיכוכי ממילא, להתאים בין עובדים ופירמות באופן מהיר ומיטבי. מצד משקי הבית העובדים, מדובר בחקיקה המאפשרת יותר יציבות בהכנסת משק הבית ומהווה מעין ביטוח מפני אבטלה (באופן חלקי). בעבור משקי הבית המובטלים ושאינם בשוק העבודה מדיניות אלו מקשות מציאת עבודה, מעודדות את היווצרותם של שווקים דואליים ומשרות זמניות, ובכך מקשות על השתלבותן בשוק העבודה של קבוצות אשר נמצאות על שולי ההשתתפות כגון

מהגרים, נשים וצעירים. בשיווי משקל, השפעתם של כוחות אלו על הרווחה הכוללת תהיה תלויה באיזון שבין התמריץ השלילי שהגנת עובדים גוררת על יצירתן של משרות חדשות לבין ערכה של המדיניות באספקת ביטוח למשקי הבית ובהשפעתה על מבנה התעשייה במשק. עבודה זו בוחנת שלוש סוגיות מאקרו-כלכליות העולות מהשימוש במדיניות הגנה על עובדים ובדגש על מגבלות פיטורין.

פרק ראשון

מטרה פרק זה בוחן את השפעת קיומה של הגנת עובדים בצורה של מגבלות על פיטורין של עובדים המועסקים בחוזים רגילים (בניגוד לחוזים זמניים) על הדינאמיקה של משברים כלכליים ועל חומרתם. לשם כך אבחן את תגובתם של משתנים מאקרו-כלכליים לזעזוע כלכלי במדינות שונות החוות את הזעזוע במקביל ונבדלות זו מזו בעוצמת ההגנה החוקית על העובדים בהן. פרק זה מאפשר בחינה של אספקט שלרוב אין עוסקים בו של חוקי עבודה והוא השפעתם על מחזורי עסקים ועל חוסנן הכלכלי של מדינות. בחינה זו הינה בחינה אמפירית-כמותית ואין בה דיון על הבסיס הנורמטיבי של המדיניות. אי לכך, תרומתו של פרק זה היא במתן כימות להשפעתן של מגבלות על פיטורין על מחזור העסקים תוך שימוש בשיטות אקונומטריות מתקדמות יותר מהקיים בספרות ובזעזוע מזוהה ומוגדר במסגרת קוואזי-אקספרמנטלית.

שיטה המחקר משתמש בנתוני פאנל על 21 מדינות OECD בעבור התקופה שבין 1985 לבין 2013. הזעזועים הפיננסיים הגדולים של תקופה זו, בדגש על המשבר הפיננסי של 2008, אשר השפיע על כל הכלכלות המפותחות מאפשר שימוש בזעזועי היצע אשראי בכלכלה האמריקאית כזעזוע משותף אשר השפיע על כל הכלכלות המפותחות במקביל. כלכלות אלו, נבדלות זו מזו במידת ההגנה החוקית על עובדים ובנוקשותן של מגבלות על פיטורין. אני משתמש בזעזועי היצע אשראי אלו, בכדי לאמוד Impulse response functions של משתנים מאקרו כלכליים תוך שימוש בגישת ה-Local projections. משתנים אלו כוללים משתנים שהינם חלק מהחשבונאות הלאומית לרבות תוצר, צריכה פרטית, השקעה, והוצאה ציבורית, וכן משתני שוק עבודה כגון, שיעור האבטלה, שיעור ההשתתפות, שיעור התעסוקה ואף נתוני זרמים ומשרות פנויות בעבור חלק מהמדינות. אני משתמש במדד של ה-OECD לנוקשותה של הגנת העובדים בכדי לאפשר חלוקה של משקים לקבוצות מדיניות שונות המשתנות על פני זמן. האמידה מתבצעת תוך שימוש ב-Fixed effects בעבור צירוף המדינה והמדיניות.

תוצאות עלייה של פרמיית הסיכון יוצרת קושי בגיוס אשראי אשר מובילה לירידה בתוצר ובתעסוקה וכן לעלייה באבטלה. מדינות אשר בהן מונהגות מגבלות פיטורין נוקשות יותר חוות עלייה מתונה יותר באבטלה ושינוי קטן יותר בתעסוקה במהלך השנה וחצי הראשונות של המשבר. לעומת זאת, כשנה וחצי לתוך מחזור העסקים מדינות אלו מתחילות לחוות ירידה חזקה יותר בתוצר אשר הינה מובהקת סטטיסטית ומתמשכת עד לחמש שנים אחרי מועד הזעזוע. עלייה של סטיית תקן אחת בפרמיית הסיכון במדינה בה קיימות מגבלות נוקשות על פיטורין, מובילה לירידת תוצר חמורה יותר בלמעלה משני אחוזים ביחס למצב המוצא באותה מדינה. כמו כן, מדינות אלו חוות עליה באבטלה מספר שנים לתוך המשבר כאשר המדינות שאין בהן מגבלות נוקשות על פיטורין כבר מתחילות להתאושש.

בנוסף על כך הפריון הכולל במשק (TFP) יורד בתגובה לזעזוע היצע האשראי במדינות בהן הגנת העובדים היא חזקה בעוד הפריון אינו מגיב כלל לזעזוע ביתר המדינות וזאת ללא הבדלים נצפים בניצול התשומות וללא פערים בהשקעה שיצרו פערים משמעותיים במלאי ההון. הבדלים אלו עקביים עם הפרשנות כי מחזור העסקים יוצר צורך בהקצאה מחדש של עובדים אשר מגבלות הפיטורין מונעות או מעקבות. כתוצאה מכך, ניתן לראות כי הפריון הכולל במשק יורד לאור היווצרותה של רמה גבוהה מן הרגיל של הקצאת משאבים לא יעילה (misallocation). הממצאים התומכים בפרשנות זו מובהקים גם לאחר שינויים רבים בספסיפיקציה האקונומטרית, שינוי תקופת המדגם, השמטתה של ארה"ב מן המדגם ושינוי הכללים לפיהם מחולקות המדינות לקבוצות מדיניות.

מסקנות הספרות הכלכלית מקשרת מגבלות על פיטורין עם זרמים איטיים יותר של עובדים ומשרות ועם דרגה גבוהה יותר של הקצאה לא יעילה של משאבים המתקיימת בכלכלה באופן יציב (steady-state misallocation). מחקר זה מראה כי קשר זה מתגבר במהלך מחזור העסקים ומחמיר את מידת ההקצאה הלא יעילה באופן אשר גורם לתוצר לצנוח באופן משמעותי. תוצאה זו מראה אפקט שלרוב הספרות וקובעי המדיניות לא עוסקים בו בבואם לדון על חוקי עבודה והוא המחיר הגבוה של חקיקה זו בעתות משבר. החמרתם של משברים כלכליים, ירידת תוצר ועלייה יותר מתמידה באבטלה הינם אפקטים אשר יכולים לפגוע דווקא בשכבות החלשות ביותר בחברה ולהוביל לנזקים כתוצאה ממדיניות מגוננת זו. כמו כן, עבודה זו מאפשרת תיאור של ערוץ פעולה של המדיניות אשר שילובו בניתוחים תיאורטיים יוביל לניתוח מעמיק יותר של מחירו של מחזור העסקים.

פרק שני

מטרה המחקר המוצג בפרק זה בוחן באופן תיאורטי את הקשר בין מגבלות על פיטורין לבין הקצאת משאבים לא יעילה ומחזורי עסקים. פרק זה מציג מודל חיפוש והתאמה של סקטור בודד אשר ניתן לדון בו על איכויות התאמה משתנות בין עובדים לפירמות ולמדיניות הכלכלית יש יכולת להשפיע על ההתפלגות של איכויות אלו. המודל מאפשר ליצור מרמת הפירמה הבודדת העומדת בפני החלטות בחירת הון, גיוס ופיטורין נוסחת הצרפה (Aggregation) לרמת פנקציית היצור של המשק. פונקציית יצור מכילה כמויות ואיכויות של תשומות היצור אשר הינן פונקצייה של מגבלות הפיטורין הקיימות במשק. כיול המודל מאפשר כימות של הערוץ התיאורטי אשר נרמז על ידי תוצאות הפרק הקודם. כיול המודל לנתוני המשק הצרפתי מרמז על כך שהמודל הפשוט מסביר בין שלושים לחמישים אחוזים מן האפקט הנצפה בפרק הקודם. המודל המתואר מאפשר לגזור ביטוי פשוט וניתן לאמידה של מידת ההגברה של זעזוע כלשהו בכלכלה על התוצר דרך הקצאה לא יעילה של עובדים אשר תווצר במשבר כלכלי כתוצאה ממגבלות על פיטורין.

שיטה פרק זה מתבסס על המודל הסטנדרטי של חיפוש והתאמה בשוק העבודה (המודל של דימונד מורטנסן ופיסארידיס, בלעז DMP) ובפרט על הווריאנט המאפשר אנדוגניזציה של החלטת היפרדות בין העובד והמעסיק כתוצאה מזעזועים אידיוסינקרטיים לטיב ההתאמה בין השניים. המודל המפותח בפרק זה הינו הרחבה של מודל מסוג זה אותו מפתח Lagos (2006), במטרה לקשור בין איכות ההתאמות הנוצרות בין עובדים למעסיקים בשוק העבודה לרמת הפריון הכולל במשק. הרחבה זו משפרת את המודל הקיים בכך שהיא לוקחת את המודל ובפרט את

תוצאות ההצרפה שלו לעולם דינאמי, מחוץ למצב העמיד, ולוקחת בחשבון את היתכנותו של סיכון מצרפי. בנוסף המודל מאפשר באופן פשוט בחירת הון ברמת הפירמה ובכך מאפשר קשר נקי יותר בין התוצאות האמפיריות של הפרק הקודם לבין הניתוח התיאורטי בפרק זה.

תרומתו של מודל זה הינה הן בדינאמיקה הניתנת לתיאור על ידו והן במגוון הרחב יותר של סוגי המדיניות אותן הוא מאפשר לנתח. אני משלב במודל עלויות פיטורין כעלויות הבאות לידי ביטוי כאובדן תוצר ולא כמיסים, כפי שהספרות נוהגת, וכן התראה מראש לפני פיטורין. שילובה של ההתראה מראש במודל חדשני בכך שההתראה מראש מייצרת אפקט על בעיית המיקוח על השכר בין העובד למעסיק בקשר אותו היא יוצרת בין פתרון הבעיה לבין נקודת אי ההסכמה שלה. מדיניות אלו לא ניתנות לדיון במסגרת של Lagos והינן חלק מרכזי ממגבלות הפיטורין הקיימות במציאות.

תוצאות המודל ניתן להצרפה לכדי פונקציית יצור מצרפית מסוג קוב דאגלס הנהוגה בספרות, כאשר הביטוי הקובע את רמת הפריון הכולל במשק משתנה על פני זמן והוא פונקציה של המדיניויות הנהוגות וכן של הרכב כח העבודה בו. תוצאה זו מאפשרת פירוק המזכיר בטבעו את שארית סולו הקלאסית אך עם ביטוי נוסף המייצג את חומרתה של ההקצאה הלא יעילה.

אני משתמש בביטוי זה ובנתונים על המשק הצרפתי בו ישנן מספר מגבלות על פיטורין בכדי לכמת את האפקט של זעזוע למחיר ההון של הפירמות על הכלכלה. המודל חוזה כי הגבלות פיטורין יובילו לצניחה חדה יותר בפריון הכולל כתוצאה מהזעזוע וכן לירידה חדה וממושכת יותר בתוצר ובאבטלה.

המודל, ככל המודלים מסוג זה הקיימים בספרות, חשוף לביקורת על היעדר הגברה מספקת מזעזועים בגודל סביר לתגובות בשוק העבודה. למרות ביקורת זו, שהינה בעיה פתוחה בספרות, המודל מצליח כמותית להסביר בין שלושים לחמישים אחוזים מסך התגובה הנצפית בתוצאות האמפיריות של הפרק הקודם ובכך מהווה תימוכין למסקנות הפרק הקודם.

מסקנות המודל המפותח בפרק זה מדגים את המנגנון התיאורטי דרכו יכולה הקצאה לא יעילה של עובדים להיות מוחמרת על ידי מחזור עסקים וכן להוביל לפגיעה חמורה יותר בתוצר על תוואי ההתאוששות. המודל מאפשר אמידה מהירה של אובדן תוצר זה ממספר מצומצם יחסית של נתונים ובכך יכול להיות שימושי לקובעי מדיניות בבואם לבחון את השפעתו של משבר אשר יצור שינויים מסויימים בתעסוקה על בהינתן מגבלות פיטורין הקיימות בו. כמו כן, ניתן לשלב מנגנון זה במודלים עשירים יותר שמטרתם לדבר על הקשר בין מחזור העסקים לפיריון הכולל במשק, או להשתמש בו לפירוקים אמפיריים של הפריון הכולל לרכיביו.

פרק שלישי

מטרה חובת התראה מראש לפני פיטורין קיימת בכל הכלכלות המפותחות למעט בארה"ב (ברמה הפדראלית) אך הספרות המאקרו-כלכלית לרוב לא דנה בה באופן נפרד אלא מקבצת אותה יחד עם מגבלות פיטורין אחרות. ההתראה מראש מאפשרת לעובד זמן בו הוא יכול לחפש עבודה חדשה לאחר פיטוריו בלי להזדקק למערכת הביטוח הלאומי ובכך מהווה מכשיר ביטוח להכנסת משקי הבית. מטרתו של פרק זה היא למדל את מכשיר המדיניות הזה

באופן התופס את תרומותיו ואת הנזקים הנגרמים ממנו. אני משתמש בתובנות אלו בכדי לאמוד מודל שיווי משקל כללי תוך שימוש בנתונים ישראליים, לנתח את המדיניות האופטימאלית לאורו, ולכמת את אובדן הרווחה כתוצאה מהסטייה ממדיניות זו.

שיטה ראשית, אני משלב את ההתראה מראש במודל DMP סטנדרטי באופן המאפשר לעובד לחפש עבודה בתקופת ההתראה מראש ושלוקח בחשבון את השפעת המדיניות על בעיית המיקוח בין העובד למעסיק. אני מראה כי במודל זה מהווה התראה מראש תמריץ שלילי ליצירת משרות במשק וסביר כי תוביל לירידת שכר כתוצאה מכך. תוצאה זו הינה הנזק העיקרי הנגרם ממדיניות זו. שנית, אני מדגים איך דרך נקודת המבט של מודל incomplete markets הנהוג בספרות, התראה מראש מגדילה את רווחת כל הפרטים בשיווי משקל חלקי. תוצאה זו היא מניע הביטוח להפעלת המדיניות. שני מניעים אלו, ערך הביטוח והתמריץ השלילי ליצירת משרות מהווים את המתח העיקרי עליו יוכרע הערך מדיניות זו.

בכדי לאפשר כימות של מתח זה אני משלב שני המודלים למודל שיווי משקל כללי המכיל רצף פרטים המחליקים תצרוכת על פני זמן וחוסכים כדי להתבטח מפני זעזועים אידיוסינקרטיים להכנסת משק הבית, שוק עבודה חיכוכי, מערכת ביטוח לאומי, עלות חיפוש עבודה ובחירת מאמץ אנדוגנית (וכתוצאה ממנה moral hazard). השכר במודל נקבע כתוצאה ממיקוח בין איגודי עובדים לבין פירמות. יצירת משרות במודל עקבית עם כניסה חופשית. שוק ההון מכיל שני נכסים סחירים בצורה של הון המושכר לפירמות ומניות שהינן זכאות לרווחי הפירמות. בין שני נכסים אלו מתקיים תנאי ארביטראז'. המודל מכוייל לנתוני המשק הישראלי ומאפשר את עריכתם של פירוקים של השפעת המדיניות לערוצים השונים וניתוחי רווחה.

תוצאות האפקטים החיוביים המשמעותיים, מבחינה כמותית, של המדיניות הם ההארכה של משכי תעסוקה בממוצע הגורמים לכך שפרטים מתנהלים למול תהליך הכנסות יציב יותר וכן הרחבת בסיס המס למערכת הביטוח הלאומי כך ששיעור המס בשיווי משקל נמוך יותר. האפקטים השליליים המשמעותיים ביותר הם ירידה במניע הביטחון של הפרטים שמורידה את מלאי ההון במשק והופכת את הפרטים לעניים יותר בממוצע וכן ההידרדרות במצבם של המובטלים אשר מובילה לירידה בשכר העבודה דרך מנגנון המיקוח.

מסקנות המודל המכוייל מראה כי עיצוב אופטימאלי של התראה מראש יחד עם מנגנון הביטוח הלאומי מאפשר שיפור ברווחה המצרפית ותומך ביצירת מערכת ביטוח לאומי אפקטיבית יותר. יתרה מכך, מסקנה זו מהווה תימוכין לשילוב חוקי עבודה במודלים סטדנדרטיים המשמשים לעיצוב ביטוח לאומי אופטימאלי. מסקנה זו מתעצמת לאור העובדה שחוקים אלו קיימים כמעט בכל כלכלה מפותחת.

משום שהאפקט השלילי החזק ביותר של ההתראה מראש הוא השפעתה השלילית על השכר, המדיניות תהייה בעלת יכולת לתרום לרווחה החברתית במקומות בהם העובדים חלשים במיוחד בסיטואציית המיקוח מול המעסיקים. זאת משום שכח המיקוח קובע את המידה בה יכול השכר להשתנות במודל. אם כח המיקוח נמוך, השכר יגיב בעוצמה פחותה לשינויים בסביבה הכלכלית דבר שיגדיל את הפוטנציאל של המדיניות לשפר רווחה.

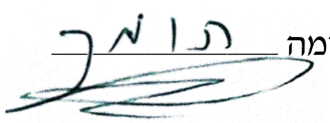
הצהרת תלמיד המחקר עם הגשת עבודת הדוקטור לשיפוט

אני החתום מטה מצהיר בזאת:

חיברתי את חיבורי בעצמי, להוציא עזרת ההדרכה שקיבלתי מאת מנחה.

החומר המדעי הנכלל בעבודה זו הינו פרי מחקרי מתקופת היותי תלמיד מחקר.

תאריך 25.11.2021 שם התלמיד **תומר איפרגן** חתימה



העבודה נעשתה בהדרכת
ד"ר נדב בן זאב
במחלקה לכלכלה
בפקולטה למדעי הרוח והחברה

הגנה על עובדים: מדיניות מבנית, חוסן כלכלי ואי שיוויון

מחקר לשם מילוי חלקי של הדרישות לקבלת תואר "דוקטור לפילוסופיה"

מאת

תומר איפרגן

הוגש לסינאט אוניברסיטת בן גוריון בנגב

אישור המנחה ________________

אישור דיקן בית הספר ללימודי מחקר מתקדמים ע"ש קרייטמן ________________

י"ז אייר תשפ"א 29 באפריל, 2021

באר שבע

הגנה על עובדים: מדיניות מבנית, חוסן כלכלי ואי שיוויון

מחקר לשם מילוי חלקי של הדרישות לקבלת תואר "דוקטור לפילוסופיה"

מאת

תומר איפרגן

הוגש לסינאט אוניברסיטת בן גוריון בנגב

מחקר זה מומן על ידי הביטוח הלאומי

י"ז אייר תשפ"א 29 באפריל, 2021

באר שבע