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By Povilas Lastauskas and Julius Stakėnas

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Abstract

This paper builds a theoretical model that introduces frictional unemployment in a two-sector multi-worker heterogeneous firms model with a dynamic matching process. In doing so, we have a rich environment that combines product, labour, and international markets. A change in labour market policies (unemployment benefits and employment contingent subsidies) transforms the share of exporters and affects average productivity. Empirical evidence confirms a robust positive effect of employment subsidies on openness, little, if any, impact of subsidies and a positive effect of replacement rate on unemployment. Closure of equilibrium plays an important role to explain data facts about employment subsidies: using sectoral arbitrage condition, subsidies cease affecting unemployment and make openness grow, consistently with the empirical evidence. Unemployment benefits, on the other hand, make unemployment and openness rise, independently of sectoral reallocations. In addition, we find that unemployment benefits bear different policy implications with regards to international coordination than employment subsidies.

Keywords: Labour market institutions, heterogeneous multi-worker firms, dynamic matching, openness

JEL Classification: E24, F12, F16

1 Introduction

Recent revival of trade models featuring labour markets has proved to be a fruitful research area. There is a rich literature on trade and unemployment but less is done on policy implications of labour market institutions for an open economy. This paper sheds a new light on the mechanics as to how labour reforms can affect real economy, its firms' structure and openness by building a two sector general equilibrium model à la Helpman *et al.* (2010) with dynamic matching along the lines of Diamond and Mortensen and Pissarides. The main difference compared to the trade literature lies in the fact that we model labour market reforms as choice variables which bear structural changes in an open economy rather than tracking effects of trade liberalisation on labour market variables (as in, for instance, Felbermayr *et al.*, 2012). This approach is motivated by the recent debate on structural reforms, especially inside Europe, where scope for further trade liberalisation may be rather limited.

Our results also differ from the current literature despite the use of a rather standard imperfect labour market model. We concentrate on two policy variables, namely *unemployment benefits* and *employment contingent subsidies*. We assume that unemployment benefits are financed by exogenous production taxes. This implies that a reform of unemployment benefits is not budget-neutral, as typically assumed in the literature. A direct consequence of this assumption is that the share of exporters increases with a rise in unemployment benefits, since more generous benefits make production costlier. This mechanism is rather distinct from the standard search and matching model, where unemployment benefits (financed by lump sum taxes) directly affect only the flow value of unemployment and thus wage bargaining conditional on a given match productivity. With regards to the subsidies, they are provided to job holders on a flow basis as a measure to increase rewards from participation. As we demonstrate, the two commonly employed policies bear different policy implications, in particular, when it comes to reforms coordination since we analyse trading, and thus interlinked, economies.

In addition to the firm-level adjustment mechanisms, our framework is capable of explaining a number of data facts. In particular, unemployment subsidies help to raise openness but have limited capacity to lower unemployment. On the other hand, replacement rate increases unemployment as well as openness. The differences in labour market institutions and the channels through which they operate in the open economy address a concern that has been put forward by Blanchard (2006), in particular that 'it is one thing to say that labour market institutions matter, and another to know exactly which ones and how.' We will, therefore, explore the mechanics of how two labour market institutions work in a trading economy and their effects on macroeconomic performance.[1]

[1]However, we will not analyse the monetary side of an economy, thus implicitly treating, as in, for instance, the euro area, one policy tool for all economies, on which one needs to condition our analysis when drawing policy implications. Clearly, all the statements in the paper are not unconditional. For instance,

As mentioned, our paper, though rooted in the current literature on trade and labour markets, differs in its focus. Unlike two major recent strands, consisting of Helpman *et al.* (2010); Helpman and Itskhoki (2010, 2015) on the one hand[2] and Felbermayr *et al.* (2011a,b); Prat *et al.* (2016), on the other hand,[3] which have shed new light on complex interactions between trade liberalisation, unemployment, and inequality, we focus on the effects of labour market reforms on trade.[4] However, institutions enter only indirectly, through the price effects, unlike our approach, as well as the emphasis, which is not only on outcome variables but also on labour market *policies* in interdependent economies. Another difference lies in the focus of sectoral reallocations, which happen to be crucial for the results of subsidies (this aspect is not critical for the unemployment benefits). Finally, our emphasis is also placed on policy coordination, an aspect that is not sufficiently emphasised in the trade literature but is of practical importance, especially in Europe.

The mechanics of the model can be explained by the reference to Melitz-type adjustments. Since labour market institutions influence equilibrium wages (and thus prices and welfare), they are also featured in firm revenues, and, consequently, cut-off productivities. These, in turn, determine the share (proportion) of exporters and non-exporters, and can be mapped into a country's openness. Since wage costs and labour market tightness work in an opposite way, trading partners can be affected either positively or adversely, and it is of interest to see what generates one or another effect, in particular, having in mind that the literature

Eggertsson *et al.* (2014) is skeptical about the efficiency of structural reforms during a crisis when zero lower bound is binding. However, they show a substantial improvement in competitiveness and output during other times. Yet, as has recently been observed, even the (nominal) zero lower bound is no longer an impossibility, thus, at least partially, compromising a proposed channel that impeded internal nominal adjustments. We do not delve into the discussion about timing of reforms or other policies, thus we unavoidably abstract from a number of real world issues, and just note that all our results should be interpreted in a standard conditionality manner where else is held equal.

[2]Matching frictions are introduced into a Melitz (2003) model, but unlike older work, ex post match-specific heterogeneity in a worker's ability is also accounted for. The authors obtain an increase in wage inequality but rather an ambiguous effect on unemployment after a trade liberalisation. For a more dynamic approach, refer to Itskhoki and Helpman (2014), which analyses the entire adjustment path of firms and workers to changes in trade costs, and find that the decline in the price index compensates for the losses in wage cuts and declines in employment and capital.

[3]Felbermayr *et al.* (2011a) shows that trade can reduce unemployment under linear adjustment costs and symmetric countries, however, labour markets have no impact on trade. A similar, but a more policy-oriented approach, has been offered by Felbermayr *et al.* (2013), which analyses a two-country Armingtonian trade model with frictions on the goods and labour markets in an interdependent environment. In a recent contribution, Felbermayr *et al.* (2015) concentrates on the spillover effects of labour market institutions.

[4]We do allow for dynamic matching, which helps featuring labour market tightness, and thus unemployment, in aggregate variables, and also allow for sectoral arbitrage unlike, for instance, Felbermayr *et al.* (2011a). These changes alter some implications from the one-sector equilibrium, and can constitute a basis for testable hypotheses in the empirical firm-level data studies. A recent study that emphasises the importance of sectoral reallocations for the OECD countries is due to Carrere *et al.* (2015).

has not yet reached a definite answer.[5] The theory, laid down in this paper, is built on a dynamic extension of Helpman *et al.* (2010) and enriched with a few labour market policies. Its main predictions indicate that unemployment benefits drive inefficient firms away from the market, and increases the productivity and relative profitability of domestic firms. Due to the arbitrage condition in a multi-sectoral economy, however, the effect of benefits on productivity alters and increases openness whereas subsidies barely affect labour market tightness, and, therefore, have a limited macroeconomic impact, in line with the empirical evidence. Last, we a conduct a trade-bloc wide shock to all economies, thus mimicking a situation under coordinated policymaking. We find more scope for an international policy coordination when unemployment benefits are targeted by the policymakers due to their stronger effects on the macroeconomy, as compared to policies that target wage subsidies.[6]

The plan of our paper is as follows. In Section 2, we motivate our work drawing a few data facts, which also form the basis for quantitative exercises. Section 3 lays down a dynamic model featuring labour market institutions with heterogeneous multi-worker firms, while Section 4 introduces exporting opportunities. The framework uncovers new results as to how labour market institutions affect the macroeconomy once international trade is taken into account. In particular, Section 5 describes a general equilibrium, which exemplifies how unemployment benefits and subsidies affect macroeconomy, after imposing sectoral arbitrage. A set of simulation exercises to illustrate the mechanics of the model are undertaken in Section 6. Finally, Section 7 concludes and sketches policy implications and directions for further research. The appendices collect all the supporting material.

2 Data Facts

Though the model is of wider appeal, we motivate our work by drawing some lessons from the European experience. Despite a common monetary union and *acquis communautaire*, real euro area economies have had widely different adjustments in labour and goods markets. Indeed, European unemployment has been scrutinised for years to understand its persistently high level (Blanchard and Wolfers, 2000; Blanchard, 2006) along with differences in institutional environment.[7] In addition, European economies, and the European Union in

[5]Indeed, there is no consensus in the literature: the symmetric result is obtained by Felbermayr *et al.* (2013), which predict a positive correlation between bad labour market institutions at home and abroad; to the contrary, a country harms its trading partner by reducing its labour market frictions in Helpman and Itskhoki (2010); last, in a quite different environment, Alessandria and Delacroix (2008) obtain that a rigid economy increases a country's welfare, whereas a flexible one experiences welfare loss due to the terms of trade effects (gains in consumption do not offset the foregone leisure).

[6]This also echoes empirical regularities that fail to establish a robust link between subsidies and unemployment at the aggregate level. Emphasising firm reallocations, we provide a different rationale for this result, compared to the focus solely on the valuations of employment and unemployment.

[7]Indeed, Boeri (2011) stresses that the largest institutional transformations over the period of 1985

particular, play a pivotal role in the global trade, too (in fact, it is the world's largest trading block). Though the literature has shed much light on the impact of trade liberalisation on labour, it is however, needful to learn the effects of labour market policies for open and interconnected economies. We dig into microeconomic adjustments and build a model that relates unemployment to a frictional labour market, changes in the number of traders (openness), and intersectoral adjustments. We first review some data, which both motivate and form the basis for evaluating the importance of our proposed mechanisms.

There is a large literature on the effects (or a lack thereof) of labour market policies and labour market outcomes. For example, unemployment benefits (replacement rates) generally have a positive effect on unemployment (Bassanini and Duval, 2006; Nickell *et al.*, 2005). In contrast, the estimated effect of employment subsidies is rather mixed (we cover empirical evidence from the studies on the expenditure on active labour market policies (hereafter ALMP), one of the main components of which is employment subsidies): Orlandi (2012) finds ALMP are effective in helping to reduce unemployment, whereas Bassanini and Duval (2006) obtain statistically significant estimates only for ALMP interacted with other variables, also demonstrate that expenditure on some ALMP categories (such as training) is more effective than others. To be as close to the theoretical framework as possible, we will use employment incentives as the main policy variable, which entails recruitment subsidies and employment maintenance incentives.

Turning to the summary statistics, some regularities stand out (refer to the Appendix, Table A.1). In particular, there is a substantial spatio-temporal, in addition to the temporal, variation in labour market policies. This is in line with the dynamics of openness of European economies, which is also in stark variation, along both, intensive and extensive margins. Labour market tightness ranges from effectively no vacancies per unemployed to a substantial proportion (0.76) across countries in Europe. We will, therefore, relate labour market institutions not only to labour market tightness but also to the share of traders and the intensity of trade. All these factors help to elucidate intricate interaction between openness and domestic labour markets, and how structural reforms affect firm reallocations and aggregate variables in the way suggested by data.

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to 2008 have taken place in Europe. Recent effects of the global crisis which hit economies with varying consequences also point to structural differences: Germany has demonstrated great resilience during the whirl of economic crisis, coined as 'Germany's jobs miracle', whereas Spanish unemployment has skyrocketed (see Dolado and Stucchi (2008) for more details). The heterogeneous responses, evidenced in Bentolila *et al.* (2010) for France and Spain, require an understanding of the theoretical underpinnings of the efficacy of labour market policies for open economies.

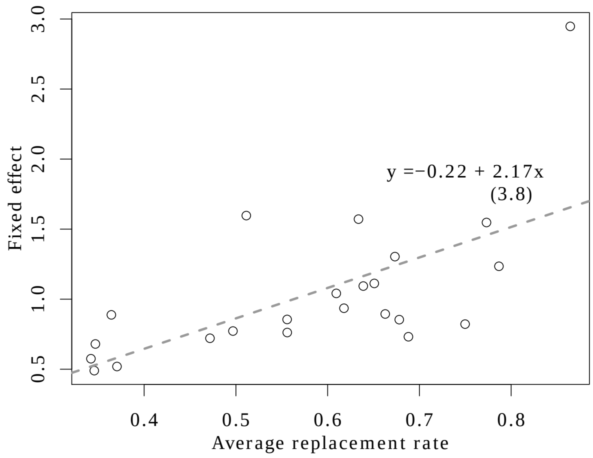

Figure 2.1: Country-specific fixed effects from a regression of openness on the average replacement rate

Some empirical evidence is summarised in Table 2.1 where regression results of labour market policies on unemployment rate and openness are reported. Using pooled least squares, thus ignoring individual and time heterogeneity, we find that replacement rate tends to decrease unemployment and increase openness. Allowing for fixed effects, however, these results get overturned: unemployment rises whereas openness is lowered. A positive effect of unemployment benefits on unemployment, as well as the importance of openness as the channel of spillovers, has also been confirmed in Felbermayr *et al.* (2013).

Turning to employment subsidies, they reduce unemployment significantly only for pooled regression but lose significance for fixed effects. When it comes to openness, subsidies are positively correlated despite the estimation method. Replacement rate, as visualised in Figure 2.1, positively correlates with the fixed effect of openness. Hence, the higher average openness tends to be related to higher average replacement rate (and the inclusion of fixed effects in the regression purges this variation). The extensive margin of trade cannot be uncovered at the country level (since all European countries trade with each other), that is why we employ the sectoral variation from the World Input-Output Database (Timmer *et al.*, 2015).[8] The sectoral extensive margin of trade is positively associated with the employment contingent subsidies but has no relationship with the replacement rate.

[8] We construct a data set, which covers the period from 1995 until 2011 in annual figures. This data give us time series of the extensive margin of trade for 40 countries. We construct this variable as the ratio of all non-zero trade links and all the possible trade links by the domestic industries with industries abroad. A link is defined as non-zero (i.e., active) as long as a given industry exports to any other foreign country. The total possible links by all domestic industries with foreign market is $35 \cdot 35 \cdot 39$, where 35 corresponds to the number of industries and 39 to all the countries except for the domestic country. See Timmer *et al.* (2015) for the construction of the world input-output tables.

Table 2.1: Panel regressions of unemployment rate and openness on labour market institutions

	Pooled OLS	One-way FE	Two-way FE	Test for FE
Rep. rate → Unemployment	-5.00***	4.12***	2.81*	<0.01***
	(-5.11)	(2.69)	(1.92)	
Rep. rate → Openness	1.19***	-0.51***	-0.32***	<0.01***
	(9.54)	(-3.59)	(-3.44)	
Rep. rate → Ext. margin	-0.15	-0.21	-0.25	<0.01***
	(-1.63)	(-1.51)	(-1.56)	
Empl. subsidies → Unemployment	-5.85***	2.95	-2.13	<0.01***
	(-3.02)	(1.01)	(-0.87)	
Empl. subsidies → Openness	3.54***	2.48***	2.01***	<0.01***
	(11.28)	(12.62)	(16.06)	
Empl. subsidies → Ext. margin	0.23***	0.59**	0.39	<0.01***
	(2.74)	(2.42)	(1.48)	

Note: One-way FE refers to (individual) fixed effects, two-way fixed effects refers to individual and time fixed effects. Data sample is an unbalanced panel spanning from 1980 to 2014 for 26 European Union countries. The actual number of observation used for estimation depends on the availability of data for the selected specification. Number of observations used for estimation: "Rep. rate → Unemployment" – 562, "Rep. rate → Openness" – 573, "Rep. rate → Ext. margin" – 400, "Empl. subsidies → Unemployment" – 370, "Empl. subsidies → Openness" – 331, "Empl. subsidies → Ext. margin" – 294. "Test for FE" is an F test for "Pooled OLS" model against "one-way FE", i.e. it tests equality of intercepts across countries (p-values for null hypotheses are presented). Numbers in brackets denote t-statistics for the estimated coefficients. * p<0.1, ** p<0.05, *** p<0.01.

We, therefore, seek to explain the following data facts: (1) a *positive* effect of *replacement rate* on *unemployment*; (2) potential reasons of *varying* effect of *replacement rate* on *openness*, depending on variation used and unobserved heterogeneity; (3) a robust *positive* effect of *employment subsidies* on *openness* and *extensive margin*, (4) *little*, if *any*, impact of *subsidies* on *unemployment*. We thus turn to the theory section to formalise the channels that can give rise to the mentioned empirical regularities.

3 Heterogeneous Firms and Labour Market Institutions

We develop an open economy model with multi-worker heterogeneous firms and frictional labour markets. As the major focus is on labour market institutions for a trading economy, we first describe the main ingredients of labour markets. We introduce matching frictions and derive a Beveridge curve. Later, we move to labour market policies, namely unemployment benefits, employment-conditional incentives and touch upon the vacancy posting costs. Due to a dynamic matching process, we relate labour market tightness to the equilibrium wage (and thus labour market institutions). We finalise this section with sketching value functions for employed and unemployed agents, and for heterogeneous firms.

Before proceeding, we will briefly cover the economic environment. Agents include firms and individuals. The latter either work or search for a job once unemployed (there is no on-the-job search). Firms are subject to productivity shocks and employ multiple workers. The set of states for individuals include employment and unemployment whereas for the firms – non-production and production, and the latter can be split into either serving domestic market or may include exporting, too. Labour market is subject to search and matching frictions (for those looking for a job in the differentiated sector) as well as labour market institutions, unemployment benefits and employment subsidies. Trade is subject to trade costs. Firms engage in monopolistic competition and charge a price that is subject to a constant markup (under the Dixit and Stiglitz-type of preferences). The sequence of the actions is as follows: first, labour market variables are pinned down (labour market tightness and unemployment), which, due to dynamic matching, can be mapped into wages and, thus, the goods market. Once we turn to the general equilibrium with a homogenous sector, it is assumed that workers can frictionlessly reallocate themselves between sectors. This yields a condition that links the unemployment income to the wage in the homogenous sector.

3.1 Search and Matching

This section is rather standard, and we merely introduce some notation.[9] As our framework features home and foreign economies, we reserve subscript i for home and j for foreign economies, also we denote time periods by t. The job finding (or the vacancy filling rate) depends uniquely on the ratio of vacancies, v_{it}, to the unemployment rate, u_{it}, that is, on the degree of labour market tightness, $\theta_{it} \equiv v_{it}/u_{it}$. Denoting the aggregate matching function as $m_{it} = m\left(u_{it},\, v_{it}\right)$, the unconditional probability of a vacancy to match with an unemployed and searching worker is $x_{it} = m\left(u_{it},\, v_{it}\right)/v_{it} = m\left(\theta_{it},\, 1\right)$ with $x'_{it}\left(\theta\right) < 0$ and $x''_{it}\left(\theta\right) > 0$, whilst the probability of an unemployed and searching worker meeting a vacancy is $m\left(u_{it},\, v_{it}\right)/u_{it} = \theta_{it} m\left(u_{it},\, v_{it}\right)/v_{it} = \theta_{it} x_{it}\left(\theta_{it}\right)$. The vacancies and searchers refer to the differentiated sector (one that produces differentiated varieties and engages in international trade) only, as will be clear when we cover the general equilibrium. To achieve closed-form solutions, assume that the matching process complies to the Cobb-Douglas structure, $m\left(u_{it},\, v_{it}\right) = v_{it}^{\eta_i} u_{it}^{1-\eta_i}$, therefore yielding[10]

$$x_{it}\left(\theta_{it}\right) = \frac{m\left(u_{it},\, v_{it}\right)}{v_{it}} = \left(\frac{u_{it}}{v_{it}}\right)^{1-\eta_i} = \theta_{it}^{\eta_i - 1},\ 1 > \eta_i > 0. \tag{3.1}$$

For production to occur, a worker must be matched with a job. As in the seminal

[9] We use borrow some notation from Boeri (2011) and Hawkins and Acemoglu (2014).

[10] Consistently with much of the empirical literature estimating matching functions (Petrongolo and Pissarides, 2001), it is assumed that matching occurs at constant returns to scale. Clearly, when $\eta_i = 1$, there is no weight attached to the externality due to unemployment, and matching is frictionless and perfect. Further, notice that v refers to the aggregate (average) vacancy rate (as we model heterogeneous firms, it is important to allow for different vacancy rates).

contribution by Melitz (2003), a firm's productivity is subject to shocks, occurring at a frequency δ, when a firm dies (in other words, with a probability δ, the current productivity falls below the cut-off level that is required to sustain production). In addition to a firm's death, there is also a probability of separating from the employment relationship even if the firm keeps producing. We denote the probability of a separation by s. In such a case, the evolution of unemployment in the differentiated sector is governed by

$$\Delta U_{it} = (\delta + s_i)(L_{it} - U_{it}) - \theta_{it} x_{it}(\theta_{it}) U_{it}, \tag{3.2}$$

where the labour force has been denoted by L_{it} and the number of the unemployed by U_{it}, so that $(L_{it} - U_{it})$ denotes employment expressed in terms of the number of people at time t.[11] A lower case variable is divided by L_{it}, such that

$$\begin{aligned} \Delta u_{it} &= (\delta + s_i)(1 - u_{it}) - \theta_{it} x_{it}(\theta_{it}) u_{it} \\ &= (\delta + s_i)(1 - u_{it}) - m_{it}, \end{aligned} \tag{3.3}$$

which exemplifies the importance of exogenous shocks and search and matching frictions to generate unemployment. Steady state of (3.2) yields

$$u_i = 1 - \frac{m_i}{\delta + s_i} = \frac{\delta + s_i}{\theta_i x_i(\theta_i) + \delta + s_i} = \frac{\delta + s_i}{\theta_i^{\eta_i} + \delta + s_i}. \tag{3.4}$$

This is also known as the Beveridge curve. The key (endogenous) variable determining the evolution of gross flows in the labour market is the (differentiated sector's) market tightness θ_i (affecting the job creation margin). Notice that this unemployment refers to what will be later called a differentiated sector. To learn about the theoretical effects on sectoral reallocation, we deal with a multisectoral model. However, homogenous sector is thought to be free of labour market frictions, with every job paying a wage of one.[12] Hence, workers, after entering the state of unemployed, are indifferent between a homogenous sector and staying unemployed in the differentiated sector. This guarantees a positive unemployment even with a fully employed homogenous sector.

3.2 Labour Market Institutions

We will consider a set of labour market policies and institutions that can affect equilibrium outcomes in the economy. Namely, we analyse unemployment benefits as a proportion of a

[11] Notice that $(L_{it} - U_{it})$ is the measure of successfully matched labour; instead of this being separate from the product market, our measure of matches will be equated to the total hiring rate, which is an endogenous function from the aggregate perspective but exogenous to the firm, and depends on, among other factors, exposure to international trade.

[12] Therefore, there is no unemployment in the homogeneous sector, that is why the unemployment above refers to both – unemployment in the differentiated sector and the national (aggregate) one.

certain wage in the homogenous sector, ω_{it}, i.e. $b_{it} = \varrho_{it}\omega_i$ and an employment conditional incentive e_{it}. To be more precise, we consider an unemployment benefit such that $b_{it}/\omega_i = \varrho_{it} < 1$, which is offered as a replacement of earnings during a spell of unemployment.[13] The policy parameter ϱ_{it}, in particular, measures the generosity of unemployment benefits, which are assumed to be open-ended and which are provided conditional on unemployment status. Notice that the government sector is not introduced and we abstract from political economy considerations, so we implicitly assume that all the payments to cover these policies are financed from firms by exogenously changing production taxes (there is a frictionless distribution of these payments to the targeted agents e.g. unemployed, job searchers, etc). We also focus on the employment conditional incentive, e_{it}, which is provided to job holders on a flow basis as a measure to increase rewards from participation. This policy instrument can be thought of as a wage subsidy.[14]

We will also touch upon a non-standard policy tool, the vacancy posting cost, $\sigma(v_{it})$, defined as

$$\sigma(v_{it}) = \frac{v_{it}^{\gamma_i}}{\gamma_i}.$$

The parameter γ_i governs the cost function, which is assumed to be convex, $\gamma_i > 1$ (see Kaas and Kircher, 2015 and Hawkins and Acemoglu 2014 for rationalisation). This policy is linked to the expected costs of posting a vacancy (recruitment costs), $\sigma(v_{it})/x_{it}(\theta_{it})$. A lower value of $\gamma_i > 1$ reduces frictions in the vacancy-filling process by activating jobseekers, providing job counselling, placement services, etc.[15] This policy instrument is isomorphic to any measure increasing the job finding rate $\theta_{it}x_{it}(\theta_{it}) = \theta_{it}^{\eta_i}$ as this would also reduce the expected costs of posting a vacancy, $\sigma(v_{it})/x_{it}(\theta_{it})$. Note that the cost of hiring one

[13] For the sake of simplicity, we employ a flat income replacement scheme providing to jobless people the fraction $0 < \varrho_{it} < 1$ of a homogenous sector's labour income, $\omega_i = 1$, independently of the past earnings history of the worker.

[14] This admittedly abstract and limited treatment is line with the empirical and quantitative exercises where labour market policies are exogenously chosen, and are not subjected to any objective function. From the real world's perspective, we ask what would have happened once we deviated from the currently observed institutional measures (without asking why they are observed at the current level in the first place). From the model's perspective, the multi-worker environment with wage bargaining creates externalities and differential effects for heterogeneous firms, and thus justifies the analysis of the effects of labour market institutions on the firm and macro level variables.

[15] By making vacancy posting function "less convex", γ_i also captures technology improvements, which make the labour market less frictional. Though one can relate this parameter to subsidies to vacancy posting, the closer interpretation that affects the very curvature of hiring function is advancement in information and communication technologies, improvement in techniques to match workers to jobs through, for instance, improved data analysis or screening procedures. We do not model the skill distribution but one can extend the current model to account for heterogeneity in labour force along the lines of Helpman *et al.* (2010) or Guadarrama-Baena and Lastauskas (2015); the latter paper considers an additional policy available to governments, namely production taxes that can be channelled to education, thus changing the ability of the labour force. We abstract from the heterogeneity in skills or abilities in the current paper.

marginal worker is $\sigma'(v_{it})$ whereas the expected cost is given by the weighted marginal costs of vacancy posting:

$$\sigma'(v_{it})/x_{it}(\theta_{it}) = v_{it}^{\gamma_i-1}\theta_{it}^{1-\eta_i},$$

where we used the matching process, summarised in (3.1). The cost is increasing in labour market tightness and the convexity parameter γ_i. In order to explore the effects of policies on the aggregate variables, we proceed by defining the value functions for agents and firms.

3.3 Value Functions with Labour Market Institutions

In this section we define the Hamilton-Jacobi-Bellman (HJB) equations for the firms and workers under the continuous time assumption. Let us first write valuations for employees (J_{it}^E). The continuation valuation by workers in the status of unemployment (J_{it}^U) reads as follows,

$$rJ_{it}^U - \frac{\partial J_{it}^U}{\partial t} = b_{it} + \theta_{it}x_{it}(\theta_{it})\,\mathbb{E}\left(J_{it}^E(h_{it};\varphi) - J_{it}^U\right), \tag{3.5}$$

where $\mathbb{E}$ is the expectation operator over the productivity draw φ. The interpretation of (3.5) is standard: the flow yield from the valuation of the state of unemployment at an interest rate r is equated to the unemployment benefit $b_{it} = \varrho_{it}\omega_i$ and the expected capital gain, stemming from finding a new employment. We let the value function for employees depend on the firm's productivity shock, φ, and the measure (number) of employees in that firm, $h_{it}(\varphi)$. The HJB equation for employees, therefore, can be written as

$$\begin{aligned} & rJ_{it}^E(h_{it};\varphi) - \tfrac{\partial J_{it}^E(h_{it};\varphi)}{\partial t} \\ = & \, w_{it}(h_{it};\varphi) + e_{it}(h_{it}) + (s_i+\delta)\left(J_{it}^U - J_{it}^E(h_{it};\varphi)\right) + \left(x_{it}(\theta_{it})v_{it}(\varphi) - s_ih_{it}\right)\tfrac{\partial J_{it}^E(h_{it};\varphi)}{\partial h_{it}}. \end{aligned} \tag{3.6}$$

It states that the value of employment is equal to the current wage, employment-conditional incentive, e_{it}, plus the expected capital gain on the employment relationship (the rate at which an employee switches to unemployment is equal to the separation rate and a firm's destruction shock, whereas a gain (or loss) due to a change in the measure of employees within the firm is captured by the last term; we omit the firm's productivity label for the vacancies, $v_{it}(\varphi)$, to ease notation).

A firm's, that hires h_{it} employees and has productivity φ, value function, $J_{it}^F(h_{it};\varphi)$, that accounts for hires and vacancies, is given by

$$\begin{aligned} & (r+\delta)J_{it}^F(h_{it};\varphi) - \tfrac{\partial J_{it}^F(h_{it};\varphi)}{\partial t} \\ = & \, \pi(h_{it};\varphi) - s_ih_{it}\left(\tfrac{\partial J_{it}^F(h_{it};\varphi)}{\partial h_{it}}\right) + \max_{v_{it}\geq 0}\left\{-\sigma(v_{it}) + x_{it}(\theta_{it})v_{it}\tfrac{\partial J_{it}^F(h_{it};\varphi)}{\partial h_{it}}\right\}, \end{aligned} \tag{3.7}$$

where the net flow profit (after paying for hiring) is defined as

$$\pi(h_{it};\varphi) \equiv \Upsilon_{it}(\varphi)^{1-\beta}A_{it}(\varphi h_{it})^{\beta} - w_{it}(h_{it};\varphi)h_{it}(\varphi) - f_{ii,t} - \mathcal{I}_x f_{ij,t}, \tag{3.8}$$

such that $\Upsilon_{ij,t}(\varphi)$ is a measure of the firm's overall trade intensive margin, β governs elasticity of substitution between goods, $f_{ii,t}$ and $f_{ij,t}$ are fixed production costs to sell at home and abroad ($\mathcal{I}_x$ is an indicator function that is equal one or zero, depending on exporting status), and A_{it} is the demand shifter, all of them to be precisely defined below. As previously, the firm's value is discounted using the effective discount rate, which is $r+\delta$, and accounts for both time preference and the firm destruction rate. The current flow profit (revenue minus the total wage bill and fixed production costs) is further adjusted for the loss of flow of measure $s_i h_{it}$ workers per unit time due to the separation shock s_i, with a flow capital loss per marginal measure of workers, $\partial J_{it}^F(h_{it};\varphi)/\partial h_{it}$. Finally, the firm chooses its vacancy posting strategy, denoted by v, to maximise the difference between the flow capital gains due to the hiring flow of $x_{it}(\theta_{it})\,v_{it}$ workers per unit time and the flow cost of vacancy posting, $\sigma(v_{it})$.

The first-order condition, characterising the optimal choice of vacancy posting, is

$$\frac{\partial \sigma(v_{it})}{\partial v_{it}} = v_{it}^{\gamma_i - 1} = x_{it}(\theta_{it})\,\frac{\partial J_{it}^F(h_{it};\varphi)}{\partial h_{it}}. \tag{3.9}$$

Wages paid by firms to workers are determined following arguments due to Stole and Zwiebel (1996a,b) by assuming that firms and workers bargain over the incremental surplus generated by their employment relationship. Then we assume that wages are determined in such a way that

$$\kappa_i \frac{\partial J_{it}^F(h_{it};\varphi)}{\partial h_{it}} = (1-\kappa_i)\left(J_{it}^E(h_{it};\varphi) - J_{it}^U\right),$$

where κ_i denotes the bargaining power of workers vis-a-vis employers. Using equation (3.7), we obtain the partial derivatives to be used for the wage equation. In particular, employing equation (3.6) yields

$$\begin{aligned}&(r+s_i+\delta)\left(\frac{\partial J_{it}^E(h_{it};\varphi)}{\partial h_{it}}\right) - \frac{\partial^2 J_{it}^E(h_{it};\varphi)}{\partial t \partial h_{it}} \\ &= \frac{\partial w_{it}(h_{it};\varphi)}{\partial h_{it}} + \frac{\partial e_{it}(h_{it})}{\partial h_{it}} + (x_{it}(\theta_{it})\,v_{it} - s_i h_{it})\,\frac{\partial^2 J_{it}^E(h_{it};\varphi)}{\partial h_{it}\partial h_{it}} - s_i \frac{\partial J_{it}^E(h_{it};\varphi)}{\partial h_{it}}.\end{aligned}$$

Wage bargaining helps to arrive at a separable differential equation with the employment level h_{it}, which is still an endogenous object:

$$\begin{aligned}&w_{it}(h_{it};\varphi) \\ &= \beta\kappa_i \textstyle\sum_j \left(1+\mathcal{I}_x(\varphi)\,\tau_{ij,t}^{-\frac{\kappa_i}{1-\beta}}\left(\frac{A_{jt}}{A_{it}}\right)\right)^{1-\beta} A_{it}^{1-\beta}(h_{it}\varphi)^{\beta} h_{it}^{-1} - (1-\kappa_i)\,h_{it}\frac{\partial w_t(h_{it};\varphi)}{\partial h_t} \\ &\quad - (1-\kappa_i)(e_{it}-b_{it}) + (1-\kappa_i)\,\theta_{it} x(\theta_{it})\,\mathbb{E}\left(J_{it}^E(h_{it};\varphi) - J_{it}^U\right).\end{aligned} \tag{3.10}$$

Due to the quite involved and not particularly insightful algebra, full details of the derivations are relegated to Appendix B.2.1.[16]

[16] Further, recall that employment relationships are subject to two types of shocks. At a rate $\delta>0$, an active firm is destroyed; in this case, all its workers are returned to unemployment, and the firm is removed

4 Labour Market Equilibrium for Open Economy

The institution-free wage (when $b_{it} = e_{it} = 0$) obeys the following form (refer to equation (3.10)):

$$w_{it}\left(h_{it};\,\varphi\right) = \kappa_i\left(\tfrac{\Gamma_{it}\varphi^{\beta}}{\kappa_i\beta+1-\kappa_i}h_{it}^{\beta-1} + \theta_{it}v_{it}^{\gamma_i-1}\right), \tag{4.1}$$

where $0 \leq \kappa_i < 1$ measures the relative bargaining strength of workers vis-a-vis employers, and $\Gamma_{ij,t}$ is composed of aggregates and the trade's overall intensive margin $\Upsilon_{ij,t}\left(\varphi\right)$, which depends on a firm specific productivity shock φ, precisely $\Gamma_{ij,t} = \beta\Upsilon_{ij,t}\left(\varphi\right)^{1-\beta}A_{it}$. Its components will become clear once we cover the general equilibrium section. Equation (4.1) shows that wages are increasing in firm productivity, match frictions and market tightness at a rate which is increasing in the bargaining power of workers. The more powerful workers are, the more match surplus they appropriate. This is bargaining power and frictions that allow workers to obtain a mark-up over their reservation wage. Notice that linear, rather than convex, vacancy posting costs imply $\gamma_i = 1$ and render no direct wage dependence on vacancy numbers. In that special instance, we are back to the situation, where wages are proportional to the firm's revenues and labour market tightness, i.e.

$$w_{it}\left(h_t;\,\varphi\right) = \kappa_i\left(\tfrac{\beta}{\kappa_i\beta+1-\kappa_i}\tfrac{r_{it}(\varphi)}{h_{it}} + \theta_{it}\right),$$

where the revenue function is $r_{it}\left(\varphi\right) = \left(\Gamma_{it}/\beta\right)\varphi^{\beta}h_{it}^{\beta}$. Notice that, unlike Helpman *et al.* (2010); Helpman and Itskhoki (2010), wages feature labour market tightness θ_{it}, which affects the bargaining position of workers. This is because of the difference in the value functions, describing the worker's and firm's outside options (unemployment benefits and value with no change in employment, respectively) and a dynamic matching process with slightly differently defined labour market tightness. Therefore, a more than proportional increase in vacancies to unemployment ratio pushes wages up.

Introducing now the set of institutions described above, we obtain a wage equation yielding a weighted average of the institution-augmented reservation wage and productivity of labour, namely

$$w_{it}\left(h_{it};\,\varphi\right) = \kappa_i\tfrac{\Gamma_{it}\varphi^{\beta}}{\kappa_i\beta+1-\kappa_i}h_{it}^{\beta-1} + \left(1-\kappa_i\right)\left(b_{it} - e_{it} + \tfrac{\kappa_i}{1-\kappa_i}\theta_{it}v_{it}^{\gamma_i-1}\right). \tag{4.2}$$

This shows that when κ_i approaches 0, that is, workers have no bargaining power, wages collapse to the unemployment benefit net of the employment conditional incentive, which is indeed a measure aimed at reducing disincentives to accept low-paid jobs. When, instead, κ_i approaches 1, wages in (4.2) appropriate the entire match productivity and are augmented

from the economy with zero scrap value. At a rate $s_i > 0$, each worker is separated from the firm; in this case, the firm continues in existence with all its other incumbent workers. We assume that these shocks are independent across active firms and across employed workers.

by recruitment cost net of the hiring subsidy and the discounted value of the firing tax (which is a lump-sum payment). Under such conditions, however, it would be unprofitable to open up a vacancy (the recruitment costs, net of the hiring subsidy, could not be covered by any ensuing flow of net revenues at match formation). Hence, the need to impose that κ_i is strictly lower than 1. These insights lead to the first result.

Lemma 1. *Wages are increasing in the unemployment benefits, decreasing in the employment-conditional incentive and increasing in the costliness of posting new vacancies, holding the firm's employment level* $h_{it}(\varphi)$ *constant. Namely,*

$$\frac{\partial w_{it}(h_{it};\varphi)}{\partial b_{it}} = 1-\kappa_i > 0,$$
$$\frac{\partial w_{it}(h_{it};\varphi)}{\partial e_{it}} = -(1-\kappa_i) < 0,$$
$$\frac{\partial w_{it}(h_t;\varphi)}{\partial \gamma_i} = \kappa_i \theta_{it} v_{it}^{\gamma_i - 1} \ln v_{it} > 0\,,\, v_{it} \geq 1.$$

The intuition for Lemma 1 is standard. The benefits increase the attractiveness of the outside option to opt for unemployment for the workers, thereby pushing the employment compensation up. The increase in the wage subsidy reduces the wage-related costs. Lastly, the convexity parameter γ_i relates to the costs of posting vacancies. This can be broadly interpreted as recruitment costs that proxy for infrastructure, matching time, and any frictions that make vacancy posting costly. The higher are such costs, the higher are the wages for those already employed, as firms face substantial costs finding new employees. To extend the result in the Lemma 1 to the production economy, one of the goals of the paper, we require the channel from employment (the described effect is still partial) and firms' reallocations.

4.1 Workers

In order to learn the firm-level adjustments, we have to establish a link between labour and the production markets. We first deal with the former from the firm's perspective. In particular, the evolution of the stock of workers of a φ-firm is given by $x_{it}(\theta_{it})\, v_{it}(\varphi) - s_i h_{it}(\varphi)$, whose steady state helps to establish a relationship between the firm's size in terms of employees and the vacancies to be posted:[17]

$$v_i(\varphi) = \frac{s_i h_i(\varphi)}{x_i(\theta)}.$$

Provided firms instantly jump to their optimal hiring measure, employment is given by $h_i(\varphi) = x_i(\theta)\, v_i(\varphi)/s_i$. Notice that this requires a restriction of $x_i(\theta)/s_i < 1$, as firms need to post more vacancies than they eventually hire.[18]

[17] Note that we omit time subscripts for the steady states.

[18] This implies that $s_i > \theta_i^{\eta_i - 1}$, which is hardly testable at the aggregate level, though to generate positive unemployment we have to assume its existence.

To pin down the optimal measure of workers at any firm, we will use a steady state condition. Note that to keep a firm's size constant requires that the number of matched vacancies is equal to separated workers, $x_i v_i(\varphi) = s_i h_i(\varphi)$. This renders a constant flow of vacancy-posting cost, equal to $\sigma_i(v_i(\varphi))$. Then the optimality condition in (3.9) can be written as

$$\frac{\partial J_i^F(h_i;\varphi)}{\partial h_i(\varphi)} = \frac{v_i(\varphi)^{\gamma_i-1}}{x_i(\theta_i)} = (s_i h_i(\varphi))^{\gamma_i-1} x_i(\theta_i)^{-\gamma_i}. \tag{4.3}$$

Using the marginal value of the firm's steady-state, the HJB value function yields

$$(r+\delta+s_i)\,\frac{\partial J_i^F(h_i;\varphi)}{\partial h_i} = \frac{\partial \pi_i(h_i;\varphi)}{\partial h_i},$$

where $x_i(\theta)\,v_i = s_i h_i$. Hence, the marginal profit is given by

$$\frac{\partial \pi_i(h_i;\varphi)}{\partial h_i} = (r+\delta+s_i)\,(s_i h_i(\varphi))^{\gamma_i-1} x_i^{-\gamma_i}. \tag{4.4}$$

Clearly, marginal profit depends on the size of a firm in terms of the employment, labour market tightness, and the convexity of the vacancy posting costs. We thus turn to linking productivity to the firm's labour stock.

4.1.1 Equilibrium Firm's Employment

Using the closed-form expression of the profit in (3.8), gives the optimal size of the φ-productivity firm where we employed the wage expression in (4.2):

$$h_{it}^{\gamma_i-1}\left(\left(\frac{1-\kappa_i}{\kappa_i\beta+1-\kappa_i}\right)\Gamma_{it}\varphi^{\beta}h_{it}^{\beta-\gamma_i} - (r+\delta+s)\,s_i^{\gamma_i-1}x_{it}^{-\gamma_i}\right) = (1-\kappa_i)\left(b_{it} - e_{it} + \frac{\kappa_i}{1-\kappa_i}\theta_{it}v_{it}^{\gamma_i-1}\right), \tag{4.5}$$

which is a non-linear equation in h_t, a closed-form solution of which does not exist (refer to the Appendix B.2.2 for full details). The exporters and non-exporters employ different measures of workers, since exporters are more productive and satisfy not only domestic but also foreign markets.[19] We simulate the changes in hiring rate depending on firms' productivities and the convexity of vacancy-posting costs. Table 4.1 collects parameter values for advanced economies.

[19] To see this, first notice that $\Gamma_{ij,t}$ in (4.5) is different for exporter and non-exporter due to the intensive margin, $\Upsilon_{ij,t}(\varphi)$. For the non-exporter, it is $\Gamma_{it} = \beta A_{it}$, whereas for the exporter, it is $\Gamma_{ij,t} = \beta\left(1+\tau_{ij}^{-\frac{\beta}{1-\beta}}\right)^{1-\beta} A_{it}$, where τ_{ij} stands for bilateral iceberg-type trade costs between i and j.

Table 4.1: Values for parameters and variables used for calibration

Parameter/variable	Value	Explanation
r	0.012	Hawkins and Acemoglu, 2014
δ	0.01667	
s	0.08333	
η_i	0.72	
κ_i	0.72	Shimer, 2005, Hosios condition
β	0.66	Broda and Weinstein, 2006
z	3.4	Bernard *et al.*, 2007
τ	1.3	Ghironi and Melitz, 2005
b	0.58	Our calculations from data
e	0.07	Our calculations from data

Note: Normalisation of $A = 1$, i.e. a demand shifter plays no role in simulations. Data refer to quarterly frequency.

Figure 4.1 depicts the variation of optimal employment for exporting firms with different productivities. Larger productivity implies a larger optimal size of the firm in terms of its hired labour. Larger convexity parameter makes vacancy posting costlier, and, in particular for very productive firms, makes employment larger. This can be rationalised on the grounds of saving on new hiring as the current employment stock is already relatively large, so given a new shock the labour adjustment costs can be avoided or attenuated. The steepness clearly depends on the firm's productivities; so this mechanism is substantially more pronounced for the efficient firms.

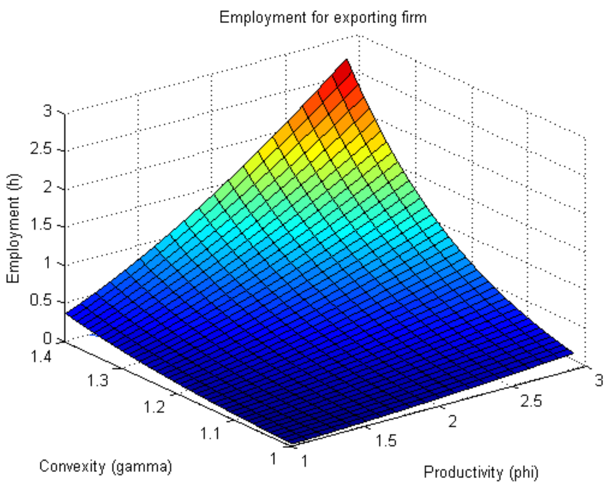

Figure 4.1: The variation of the optimal firm's employment level, depending on the convexity parameter γ

Moreover, the optimal level of employment is clearly a function of labour market policies. Figure 4.2 demonstrates the dependence of unemployment benefits and employment contingent subsidies for exporting firms. The effect of labour market policies is more profound in terms of the optimal size of the firm for more productive firms (the gradient would be larger in magnitude if we considered firms with productivity above the chosen level of 2).

Generally, the effect is quite limited because we take into account both direct and indirect effects through labour market tightness. For instance, unemployment benefits make production costlier; however, the labour market becomes less tight thus reducing the cost of hiring. Though the change is not sizeable, employment does indeed tend to decrease with subsidies and rise with unemployment benefits.[20]

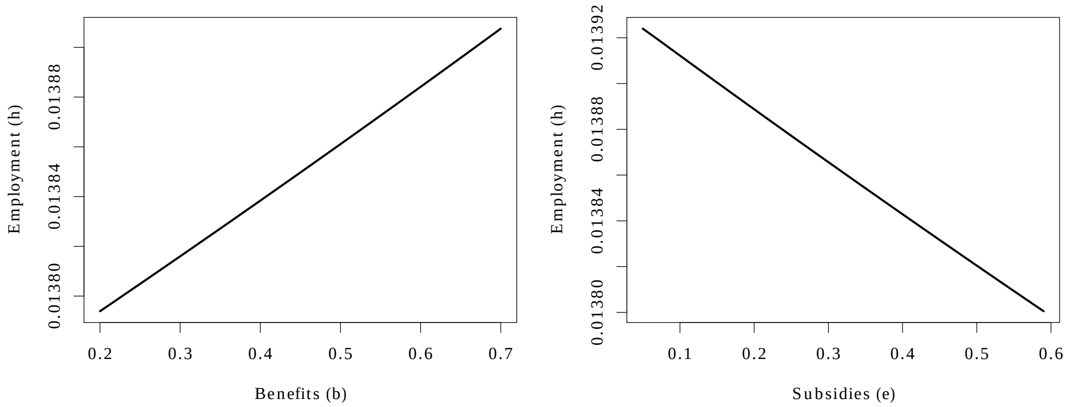

Figure 4.2: The optimal exporting firm's employment level as a function of unemployment benefits and subsidies for $\gamma = 1$, $\varphi = 2$

To gain more intuition, consider linear vacancy-posting costs,

$$\begin{aligned} h_{it}(\varphi) &= \left(\tfrac{\Gamma_{it}\varphi^{\beta}}{\kappa_i\beta+1-\kappa_i}\right)^{\frac{1}{1-\beta}} \left(b_{it} - e_{it} + \tfrac{\kappa_i}{1-\kappa_i}\theta_{it} + \left(\tfrac{r+\delta+s_i}{1-\kappa_i}\right)\theta_{it}^{1-\eta_i}\right)^{\frac{1}{\beta-1}} \\ &= \left(\tfrac{\beta}{\kappa_i\beta+1-\kappa_i}\right)^{\frac{1}{1-\beta}} \Upsilon_{it}(\varphi)\, A_{it}^{\frac{1}{1-\beta}} \varphi^{\frac{\beta}{1-\beta}} \left(b_{it} - e_{it} + \tfrac{\kappa_i}{1-\kappa_i}\theta_{it} + \left(\tfrac{r+\delta+s_i}{1-\kappa_i}\right)\theta_{it}^{1-\eta_i}\right)^{\frac{1}{\beta-1}}. \end{aligned} \tag{4.6}$$

This expression leads to a lemma describing the firm's equilibrium measure of employment.

Lemma 2. *The firm's labour stock varies with the firm's productivity φ and is increasing in it, for both linear and non-linear vacancy posting costs. In a linear case, the elasticity is constant and does not depend on the firm's specific productivity shock,*

$$\epsilon_{h_{it},\varphi} \equiv \frac{\partial h_{it}(\varphi)}{\partial \varphi}\frac{\varphi}{h_{it}(\varphi)} = \frac{\beta}{1-\beta} > 0.$$

Employment sensitivity solely depends on the elasticity of substitution in the goods market. In the non-linear case, however, it is productivity dependent, and hinges on the values of endogenous variables and deep structural parameters.

Proof. See Appendix B.1.1. □

The intuition is quite standard: more productive firms earn higher revenues, could serve export markets if they pass the trade threshold and require a larger measure of workers. In

[20] An alternative is to ignore changes in labour market tightness due to monopolistically competitive firms. However, the figure should be thought of as representing the cut-off or average firm – and thus the cut-off

particular, hiring rate changes positively with the firm's efficiency if the wage rate is not increasing (at too high a rate) in productivity. This is exactly the case, i.e. the wage is productivity independent for a linear case, as demonstrated in the following section.

4.1.2 Equilibrium Wage Rate

Equilibrium wage rate under linear vacancy posting costs is given by[21]

$$w_{it}\left(h_{it};\varphi\right)=w_{it}=b_{it}-e_{it}+\tfrac{\kappa_i}{1-\kappa_i}\left(\theta_{it}+\left(r+\delta+s_i\right)\theta_{it}^{1-\eta_i}\right). \tag{4.7}$$

Consistent with findings in the literature, the wage rate is identical across the firms despite the productivity of the firm (yet this is true for linear vacancy posting costs only; for the recent contribution that analyses the convexity of hiring costs for the wage heterogeneity, see Cosar *et al.*, 2016). Wages, *ceteris paribus*, are increasing in benefits b_{it}, decreasing in employment-contingent subsidies e_{it}, and increasing in the labour market tightness θ_{it} (by the same token, decreasing in vacancy matching probability x_{it}).

The total wage bill for a φ firm is

$$\begin{aligned} w_{it}h_{it}\left(\varphi\right)&=\left(\Theta_{it}+\kappa_i\left(\tfrac{r+\delta+s}{1-\kappa_i}\right)\theta_{it}^{1-\eta_i}\right)\left(\tfrac{\Gamma_{it}\varphi^{\beta}}{\kappa_i\beta+1-\kappa_i}\right)^{\frac{1}{1-\beta}}\left(\Theta_{it}+\left(\tfrac{r+\delta+s}{1-\kappa_i}\right)\theta_{it}^{1-\eta_i}\right)^{\frac{1}{\beta-1}} \\ &=\left(\tfrac{\beta}{\kappa_i\beta+1-\kappa_i}\right)^{\frac{1}{1-\beta}}\Upsilon_{it}\left(\varphi\right)E_{it}\left(P_{it}\varphi\right)^{\frac{\beta}{1-\beta}}\left(\Theta_{it}+\kappa_i\left(\tfrac{r+\delta+s}{1-\kappa_i}\right)\theta_{it}^{1-\eta_i}\right)\left(\Theta_{it}+\left(\tfrac{r+\delta+s}{1-\kappa_i}\right)\theta_{it}^{1-\eta_i}\right)^{\frac{1}{\beta-1}}, \end{aligned} \tag{4.8}$$

where we denote a measure, describing labour markets, as $\Theta_{it}\equiv b_{it}-e_{it}+\frac{\kappa_i}{1-\kappa_i}\theta_{it}$.[22] Therefore, the total wage bill depends on the marginal productivity of the firm, the aggregate variables, subsumed within Γ_{it} (such as prices and expenditure), labour market tightness (vacancies and unemployment), and labour market institutions (unemployment benefits, employment incentives, matching technology).

4.1.3 Equilibrium Vacancies and Labour Market Tightness

To determine the firm's measure of vacancies, we will use the undirected search argument since employees in the model are identical in their abilities. The only difference lies in firm productivities and their sizes. To make sure that all workers are randomly matched, we will follow Helpman *et al.* (2010); Helpman and Itskhoki (2010) and equate the expected cost

productivity is related to a labour market tightness in equilibrium.

[21] For intuition, the effective wage rate, after subtracting benefits and adding incentives, becomes $w_{it}-b_{it}+e_{it}=\frac{\kappa_i}{1-\kappa_i}\left(\theta_{it}+\left(r+\delta+s\right)\theta_{it}^{1-\eta_i}\right)$. It is determined by the labour market tightness, and deep structural parameters of bargaining weight, κ_i, interest rate, r, depreciation rate, δ, and separation rate, s. Aggregate labour market tightness is, however, an endogenous object that depends on successful matches.

[22] We choose to use $\Theta_{it}\equiv b_{it}-e_{it}+\frac{\kappa_i}{1-\kappa_i}\theta_{it}$, which is an endogenous object, i.e. $\Theta_{it}=f\left(\theta_{it}\right)$. We could have called benefits and subsidies as a new variable but this notation helps to simplify expressions. A caveat is that a partial effect is $\partial\Theta_{it}/\partial b_{it}=1$, holding labour market tightness constant, whereas the full effect is $d\Theta_{it}/db_{it}=1+\frac{\kappa_i}{1-\kappa_i}\partial\theta_{it}/\partial b_{it}$. Under the sectoral arbitrage, covered in the following section, $d\Theta_{it}/db_{it}=0$.

of hiring a marginal worker to the worker's expected wages (as otherwise, the unemployed would direct their search to firms offering higher wages in expectation),[23]

$$v_{it} = \left(\frac{w_{it} h_{it}}{\theta_{it}^{1-\eta_i}} \right)^{\frac{1}{\gamma_i}}, \tag{4.9}$$

or, simply, $v_{it} = w_{it} h_{it} / \theta_{it}^{1-\eta_i}$, under linearity of vacancy posting. The expected wage is given by $(h_{it}/v_{it}) w_{it} = \omega_{it} = 1$, where the last two equalities follow from the existence of the homogenous sector with positive production, which makes sure that agents do not direct their search. This is also known as a Harris-Todaro condition, which implies that the expected worker income in the differentiated sector equals the certain wage of one in the homogeneous sector in all time periods (so the time subscript is omitted), $\mathbb{E}[x_i w_i | \varphi > \varphi_{ii}] = x_i w_i = \omega_i = 1$, where φ_{ii} is the i country's firm's productivity that is just sufficient to engage in (domestic) production. Refer to Appendix B.3.3 for full technical details.

To analyse the steady state, recall the steady state hiring rule $h_i(\varphi) = x_i(\theta) v_i(\varphi) / s_i$, which is linked to optimal vacancies, $v_i(\varphi) = w_i h_i(\varphi) / \theta_i^{1-\eta_i}$. Further, note that in equilibrium all wages are equal (see equation (4.7)) and the probability of matching a vacancy with an unemployed worker is given by $\theta_i x_i = \theta_i^{\eta_i}$. The fixed point problem between labour market tightness and wages can be simulated for different values of deep parameters (refer to the Appendix, Figure C.1 and Section B.2.3). Simulation thus allows us to have an idea of labour market institutions affecting both wages and the steady state value of a labour market tightness in a single-sector equilibrium.[24]

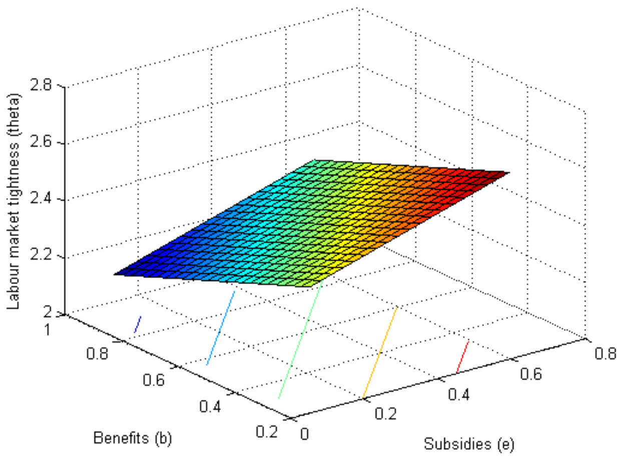

Figure 4.3: Simulation of labour market tightness as a function of benefits and subsidies

[23]The wage is multiplied by $h_{it}/v_{it} < 1$ which accounts for the fact that not all vacancies are matched due to frictions; moreover, $h_i = m_i$, i.e. hirings and matches coincide in equilibrium. Then, $w_{it} h_{it} / v_{it} = v_{it}^{\gamma_i - 1} \theta_{it}^{1-\eta_i}$.

[24]This expression is also useful to explore how labour market tightness reacts to the powers η_i, which determine how frictional the labour market is. Since there is a sign restriction on θ_i, not all powers are

Figure 4.3 depicts labour market tightness as a function of unemployment benefits, b_i, and employment contingent incentives, e_i for the case of linear vacancy posting costs. Conditional on the level of subsidies, an increase in benefits causes a drop in labour market tightness. In contrast, keeping benefits constant, an increase in subsidies causes an increase in labour market tightness. Given labour market part, we are equipped to analyse the goods market in general equilibrium (note that wages in (4.7) move to different directions due to labour market policies and labour market tightness and it is, therefore, important to discuss the way general equilibrium is solved for).

5 General Equilibrium

We have so far considered only the labour market and its structure. The following section overviews a full model with the following environment: agents and their preferences, firms and their technology, and the resulting equilibrium. Note that the homogeneous sector is one way to close the model that captures sectoral reallocations in the most direct way (the previous one-sector equilibrium required to solve a fixed-point problem).[25] We relegate full details to Appendix B.3 and, instead, discuss the major channels through which labour market institutions operate in an open economy.

5.1 Firms and Labour Market Institutions

Using a firm with productivity φ problem (refer to Appendix, in particular, see equation (B.11)), profits can be expressed in terms of the firm's revenue, labour market institutions, and the fixed production and exporting costs as follows (the total wage bill comes from equation (4.8)):[26]

$$\begin{aligned}\pi_{it}(\varphi) &= r_{it}(\varphi) - \left(\beta \frac{r_{it}(\varphi)}{h_{it}(\varphi)} - \theta_{it}^{1-\eta_i}\right) h_{it}(\varphi) - f_{ii,t} - \textstyle\sum_j \mathcal{I}_{ij,t} f_{ij,t} \\ &= (1-\beta)\, r_{it}(\varphi) + \theta_{it}^{1-\eta_i} h_{it}(\varphi) - f_{ii,t} - \textstyle\sum_j \mathcal{I}_{ij,t} f_{ij,t},\end{aligned} \tag{5.1}$$

where we used the fact that wages are not dependent on the employment level.[27] As is clear, the profit function accounts for the vacancy posting costs, and this component varies with the firm's productivity (as does the measure of hired employees). Another property is the constancy in operating profitability (before paying fixed costs, $\tilde{\pi}_{it}(\varphi) \equiv \pi_{it}(\varphi) + f_{ii,t} +$

admitted. However, this requires micro-level data to estimate η_i, thus we, instead, just pick a value found in the literature.

[25] We do implicitly assume that the homogeneous good is produced everywhere and its sector faces no frictions.

[26] Note that $\pi(\varphi)$ should be thought of as the per-period net profit from vacancy posting costs whereas the average long-run net profit is equal to the sunk entry cost f_e.

[27] It is easy to see that $\frac{\partial \pi_{it}(\varphi)}{\partial h_{it}} = \beta \Upsilon_{ij,t}(\varphi)^{1-\beta} A_{it} \varphi^{\beta} h_{it}^{\beta-1}(\varphi) - w_{it} - \theta_{it}^{1-\eta_i} = \beta \frac{r_{it}(\varphi)}{h_{it}(\varphi)} - w_{it} - \theta_{it}^{1-\eta_i} = 0,$

$\sum_j \mathcal{I}_{ij,t} f_{ij,t})$ per employee, under linearity of vacancy costs, i.e.

$$\frac{\tilde{\pi}_{it}(\varphi)}{h_{it}(\varphi)} = \left(\frac{1-\beta}{\beta}\right)(\kappa_i \beta + 1 - \kappa_i)\,\Theta_{it} + \left(1 + \left(\frac{1-\beta}{\beta}\right)(\kappa_i \beta + 1 - \kappa_i)\left(\frac{r+\delta+s}{1-\kappa_i}\right)\right)\theta_{it}^{1-\eta_i}.$$

Hence, the ratio is fully determined by labour market institutions and aggregate labour market tightness. The partial effect of benefits is positive, whereas that of subsidies is negative on the ratio; the full effect requires learning how labour market tightness adjusts with b_{it} or e_{it}. This can be done using previously outlined insights (in particular, refer to Footnote 24), thus helping to establish

$$\frac{\partial \theta_i}{\partial b_i} = \frac{-\theta_i}{(\eta_i - 1)(b_i - e_i) + \frac{\eta_i \kappa_i}{1-\kappa_i}\theta_i}, \; \frac{\partial \theta_i}{\partial e_i} = \frac{\theta_i}{(\eta_i - 1)(b_i - e_i) + \frac{\eta_i \kappa_i}{1-\kappa_i}\theta_i},$$

therefore,

$$\frac{\partial(\tilde{\pi}_{it}(\varphi)/h_{it}(\varphi))}{\partial b_i} = \left(\tfrac{1-\beta}{\beta}\right)(\kappa_i \beta + 1 - \kappa_i)\left(\frac{b_i - e_i + \frac{\kappa_i}{1-\kappa_i}\theta_i + \left(\frac{r+\delta+s}{1-\kappa_i}\right)\theta_{it}^{1-\eta_i}}{b_i - e_i + \frac{\eta_i}{\eta_i - 1}\frac{\kappa_i}{1-\kappa_i}\theta_i}\right) + \frac{\theta_{it}^{1-\eta_i}}{b_i - e_i + \eta_i \frac{\kappa_i}{1-\kappa_i}\theta_i}.$$

Using parameter values from Table 4.1, the total derivative still remains positive. However, it can be negative for different values of benefits and subsidies, and depends on how elasticity of substitution β interacts with the relative bargaining strength of workers, measured by κ_i. Contingent on the combination of deep parameters, subsidy e_i bears a symmetric effect, albeit with a different sign, to b_i. The sign uncertainty will be resolved by a homogenous sector, and arbitrage conditions in a general equilibrium, to which we turn next.

5.2 Recursive Solution

The model is solved, as in Helpman *et al.* (2010), exploiting its recursive structure. We have already pinned down the labour market outcomes, namely optimal wage rate (4.7), labour market tightness (refer to Section 4.1.3 and Appendix B.2.3), as well as hiring rate and vacancies, (4.6) and (4.9), respectively. The remaining endogenous objects include the zero-profit productivity cut-off, φ_{ii} and the exporting threshold, φ_{ij},[28] which determine aggregate variables (demand shifters, A_{it} (and, hence, total expenditure), dual price index, P_{it}, the real consumption index, Q_{it}, the mass of firms, M_{it}, and the size of the labour force, L_{it}).

hence, $w_{it} = \beta \frac{r_{it}(\varphi)}{h_{it}(\varphi)} - \theta_{it}^{1-\eta_i}$.

[28]Cut-off productivities bear important implications for the structure of the economy: the ratio is the extensive margin of trade, thus telling how open an economy is.

5.2.1 Cut-off Productivities

To close the model, we require that the permanent income from unemployment in the differentiated sector, rJ_{it}^{U}, equals the wage in the homogenous sector. Note that this condition is different from a one-shot setting, as in Helpman and Itskhoki (2010), where the requirement is simply the equalisation of the expected wage in the differentiated sector to the wage in the outside sector, as is also the so-called Harris-Todaro condition. Using the value function for the unemployed agent and the certain wage of one in the homogenous sector (refer to the derivation in Appendix B.2.1), we obtain

$$rJ_{i}^{U} = b_{i} + \theta_{i} x_{i}(\theta_{i}) \frac{\kappa_{i}}{1-\kappa_{i}} \frac{\partial J_{i}^{F}(h_{i};\varphi)}{\partial h_{i}} = b_{i} + \frac{\kappa_{i}}{1-\kappa_{i}} \theta_{i} v_{i}^{\gamma_{i}-1},$$

which yields a steady state condition (under linearity)

$$b_{i} + \frac{\kappa_{i}}{1-\kappa_{i}} \theta_{i} = 1. \tag{5.2}$$

Substituting into the equilibrium employment, we obtain that the wage is constant across firms,

$$\begin{aligned} w_{it} &= b_{it} - e_{it} + \tfrac{\kappa_{i}}{1-\kappa_{i}} \theta_{it} + \kappa_{i} \left(\tfrac{r+\delta+s_{i}}{1-\kappa_{i}}\right) \theta_{it}^{1-\eta_{i}} \\ &= 1 - e_{it} + \kappa_{i} \left(\tfrac{r+\delta+s_{i}}{1-\kappa_{i}}\right) \theta_{it}^{1-\eta_{i}}, \end{aligned} \tag{5.3}$$

where the second equality refers to the arbitrage condition already being imposed period by period.[29] To keep wages fixed, there must be a drop in labour market tightness. Labour market tightness and wages influence firm reallocations, it is, therefore, important to understand the main mechanisms. Note that a value function for the unemployed does not feature employment-contingent subsidies – therefore, intersectoral arbitrage changes the one-sector prediction by removing a link between subsidies and labour market tightness. Benefits, however, affect labour market tightness, and, as we have already seen, are transmitted through wages. Subsidies, on the other hand, work directly through wages. Eventually, however, an increase in either e_{it} or b_{it} would make wages drop: either directly or through labour market adjustments. Notice that these mechanisms are in line with the empirical findings in the literature (also refer to Section 2): subsidies have hardly any effect on labour market outcomes whereas unemployment benefits are generally found to decrease tightness and increase unemployment.

To finalise the mechanism on reallocations, we shall employ the free entry condition, which implies that the firm's value, in expected value terms, must equal the sunk entry costs,[30] $\int_{0}^{\infty} J_{it}^{F}(h_{it};\varphi)\, dG(\varphi) = f_{it}$. Note that sunk costs differ from fixed costs, e.g. $f_{ii,t}$,

[29] This is the case when $\gamma_{i} = 1$, non-linear specifications would in principle yield wage dependence on productivity through the vacancies channel (for a different approach, see also Helpman and Itskhoki, 2010).

[30] As is usual, we can use this result to derive the optimum measure of active firms in the economy. However, our aggregate data do not allow us to operationalise this equilibrium result later on. For the

as the latter are borne every period.[31] The zero profit condition for the domestic producer $r_{it}(\varphi_{ii,t})$ from equation (5.1) yields

$$\pi(\varphi_{ii,t}) = (1-\beta)\, r_{it}(\varphi_{iit,}) + \theta_{it}^{1-\eta_i} h_{it}(\varphi_{ii,t}) - f_{ii,t} = 0,$$

or, after a few modifications,

$$\varphi_{ii,t}^{\frac{\beta}{1-\beta}} = \frac{f_{ii,t}}{A_{it}^{\frac{1}{1-\beta}} \left((1-\beta)(r_{it}/h_{it})^{\frac{\beta}{\beta-1}} + \theta_{it}^{1-\eta_i} (r_{it}/h_{it})^{\frac{1}{\beta-1}} \right)}, \tag{5.4}$$

where we used the fact that $\varphi_{ii,t} = \varphi_{ij,t}$ for the marginal exporter (the one at the exporting threshold who is indifferent to exporting and remaining solely a domestic producer). This leads to the following lemma.

Lemma 3. *The domestic threshold productivity is positively associated with* Θ_i*, i.e.* $\frac{\partial \varphi_{ii}^{\frac{\beta}{1-\beta}}}{\partial \Theta_i} > 0$*, holding labour market tightness constant. The structure of active firms changes with labour market policies: the share of exporters increases with rises in unemployment benefits and decreases with employment contingent incentives, namely* $\frac{\partial \varphi_{ii}^{\frac{\beta}{1-\beta}}}{\partial \Theta_i} \frac{\partial \Theta_i}{\partial b_i} > 0$, $\frac{\partial \varphi_{ii}^{\frac{\beta}{1-\beta}}}{\partial \Theta_i} \frac{\partial \Theta_i}{\partial e_i} < 0$.

Proof. See Appendix B.1.2. □

Despite using a domestic productivity threshold, inference is made about exporters, since cut-offs are linked through the free entry condition. As stated in Lemma 3, the change in labour market tightness causes a positive change in the domestic productivity cut-off, i.e. $\left(\partial \varphi_{ii}^{\frac{\beta}{1-\beta}} / \partial \Theta_i \right) (\partial \Theta_i / \partial \theta_i) > 0$. The results can be extended to varying θ_i but then depend on the relative magnitudes of unemployment benefits and subsidies (they also depend on relative sizes of parameters β and κ_i), as covered in Section 5.1. One aspect of the steady state labour market tightness in (5.2) and the arbitrage condition in the wage equation (5.3) is such that it causes a change in benefits to be always negatively related to labour market tightness:

$$1 = -\frac{\kappa_i}{1-\kappa_i} \frac{\partial \theta_{it}}{\partial b_{it}}. \tag{5.5}$$

Hence, there is no difference in considering a change in labour market tightness or unemployment benefits. The condition that the permanent income of unemployment, which is composed of unemployment benefits, is equal to the certain wage of 1 makes a change in labour market tightness isomorphic to benefits.

derivation, we split the value generated by domestic sales and exports and note that only a per-period profit matters when there is no adjustment in the employment.

[31] One can also express sunk costs as an infinite discounted sum of fixed costs where a discount factor relates to a firm death probability.

By considering revenue function and the zero profit condition for the exporter $r_{it}(\varphi_{ij,t})$ from equation (5.1), we obtain the export margin, defined as

$$\pi_{it}(\varphi_{ij,t}) = (1-\beta)\, r_{it}(\varphi_{ij,t}) + \theta_{it}^{1-\eta_i} h_{it}(\varphi_{ij,t}) = f_{ii,t} + f_{ij,t},$$

therefore, yielding

$$\varphi_{ij,t}^{\frac{\beta}{1-\beta}} = \frac{f_{ij,t}}{(\Upsilon_{it}-1)\, A_{it}^{\frac{1}{1-\beta}} \left((1-\beta)(r_{it}/h_{it})^{\frac{\beta}{\beta-1}} + \theta_{it}^{1-\eta_i} (r_{it}/h_{it})^{\frac{1}{\beta-1}}\right)}, \tag{5.6}$$

where we substituted $f_{ii,t}$ from equation (5.4), evaluated at $\varphi_{ij,t}$. Notice that $\Upsilon_{ij,t}(\varphi)$ captures a firm's overall 'market access', which depends on whether it chooses to serve both the domestic and foreign markets or only the domestic market,

$$\Upsilon_{it}(\varphi) \equiv 1 + \mathcal{I}_{ij,t}(\varphi)\, \tau_{ij,t}^{-\frac{\beta}{1-\beta}} \left(\frac{A_{jt}}{A_{it}}\right)^{\frac{1}{1-\beta}} \geq 1, \tag{5.7}$$

where $\mathcal{I}_{ij,t}(\varphi)$ is an indicator variable that equals one if the firm exports and zero otherwise. Dividing (5.6) by (5.4), we get that $\varphi_{ij,t}$ as a function of $\varphi_{ii,t}$ (valid in all periods):

$$(\Upsilon_{it}-1)\left(\frac{\varphi_{ij,t}}{\varphi_{ii,t}}\right)^{\frac{\beta}{1-\beta}} = \frac{f_{ij,t}}{f_{ii,t}}, \tag{5.8}$$

where $\rho_{ij,t} \equiv \varphi_{ii,t}/\varphi_{ij,t} \in [0,\, 1]$ can be thought of as an *extensive margin* of trade as it determines the fraction of exporting firms, $\rho_{ij,t}^{z} = (1-G(\varphi_{ij,t}))\,/\,(1-G(\varphi_{ii,t}))$. The *intensive margin* of trade openness, as captured by the market access variable, $\Upsilon_{ij} > 1$, determines the ratio of revenues from domestic sales and exporting. These two dimensions of trade openness are linked through the relationship between the productivity cut-offs in (5.8). Moreover, we must equate the expected value of entry to the sunk entry cost, which is required for the free entry condition to hold. Hence, using equations (5.4) and (5.6), and the revenue function, we obtain (under linear vacancy posting costs):

$$f_{it} = \bar{\pi}_{it} - f_{ii,t}\left(\frac{\varphi_{min}}{\varphi_{ii,t}}\right)^{z} - f_{ij,t}\left(\frac{\varphi_{min}}{\varphi_{ij,t}}\right)^{z}, \tag{5.9}$$

where $\bar{\pi}_{it} \equiv (1-\beta)\int_{\varphi_{ii}}^{\infty} r_{it}(\varphi)\, g(\varphi)\,/\,(1-G(\varphi_{ii}))\, d\varphi + \theta_{it}^{1-\eta_i}\int_{\varphi_{ii}}^{\infty} h_{it}(\varphi)\, g(\varphi)\,/\,(1-G(\varphi_{ii}))\, d\varphi$ is the average operating profit (before fixed costs) for all the firms in the economy.

5.2.2 Average and Relative Profits

Profitability is important to understand how changes in labour market institutions interact with trade openness. The average operating profit before incurring costs on production and labour market institutions can be expressed as

$$\begin{aligned}\bar{\pi}_{it} = (1-\beta)\int_{\varphi_{ii}}^{\infty}\left(\Upsilon_{it}(\varphi)^{1-\beta}A_{it}\left(\frac{\Gamma_{it}\varphi}{\kappa_i\beta+1-\kappa_i}\right)^{\frac{\beta}{1-\beta}}\left[b_{it}-e_{it}+\frac{\kappa_i}{1-\kappa_i}\theta_{it}+\left(\frac{r+\delta+s_i}{1-\kappa_i}\right)\theta_{it}^{1-\eta_i}\right]^{\frac{\beta}{\beta-1}}\right)\frac{g(\varphi)}{1-G(\varphi_{ii})}d\varphi \\ +\theta_{it}^{1-\eta_i}\int_{\varphi_{ii}}^{\infty}\left(\frac{\Gamma_{it}\varphi^{\beta}}{\kappa_i\beta+1-\kappa_i}\right)^{\frac{1}{1-\beta}}\left(b_{it}-e_{it}+\frac{\kappa_i}{1-\kappa_i}\theta_{it}+\left(\frac{r+\delta+s_i}{1-\kappa_i}\right)\theta_{it}^{1-\eta_i}\right)^{\frac{1}{\beta-1}}\frac{g(\varphi)}{1-G(\varphi_{ii})}d\varphi \\ =\frac{z(1-\beta)}{z(1-\beta)-\beta}\left(\frac{(1-\beta)\Upsilon_{it}^{-\beta}+\theta_{it}^{1-\eta_i}(r_{it}/h_{it})^{-1}\Upsilon_{it}^{-1}}{(1-\beta)+\theta_{it}^{1-\eta_i}(r_{it}/h_{it})^{-1}}\right)\left(f_{ii,t}+f_{ji}\rho_{ij,t}^{z}\right).\end{aligned} \tag{5.10}$$

This leads to the following result:

Lemma 4. *Labour market institutions affect an average profit if and only if there exist firms that engage in trade (i.e. if an economy is not closed).*

In other words, we establish a result that labour market policies have no effect on the average profit if the economy happened to be closed, as there would not have existed an openness margin with differential effects for heterogeneous firms.

Proof. The average profit is a weighted average of domestic and exporting fixed costs, the factor of proportionality being a function of both trade margins, average revenue, and labour market tightness. Trade and firm heterogeneity are critical: labour market institutions cease playing a role on the average profit if an economy happens to be fully closed. To see that, express the average profit in terms of labour market policies, as reported in (5.10), and analyse its behaviour under different settings. For instance, when $\beta \to 0$, $\bar{\pi}_{it}|_{\beta=0} = \left(\frac{1+\theta_{it}^{1-\eta_i}(r_{it}/h_{it})^{-1}\Upsilon_{ij,t}}{1+\theta_{it}^{1-\eta_i}(r_{it}/h_{it})^{-1}}\right)\left(f_{ii,t}+f_{ij,t}\rho_{ij,t}^{z}\right)$. Hence, labour market institutions still affect average profit through average revenues (in the special case of Cobb-Douglas preferences, a corner solution of zero profits would be realised). However, given an economy does not admit partitioning into exporters and non-exporters (so changes in production costs affect all firms in the same way), then there is no channel for labour market institutions to affect average profit as there is only one type of firm, and we are back to the standard result of a profit being proportional to the fixed production costs, i.e. $\bar{\pi}_{it}(\Upsilon_{ij,t}=1, \rho_{ij,t}=0) = \frac{z(1-\beta)}{z(1-\beta)-\beta}\left(\frac{(r_{it}/h_{it})^{\frac{\beta}{\beta-1}}\left((1-\beta)+\theta_{it}^{1-\eta_i}(r_{it}/h_{it})^{-1}\right)}{(1-\beta)(r_{it}/h_{it})^{\frac{\beta}{\beta-1}}+\theta_{it}^{1-\eta_i}(r_{it}/h_{it})^{\frac{1}{\beta-1}}}\right)f_{ii,t} = \frac{z(1-\beta)}{z(1-\beta)-\beta}f_{ii,t}$. □

Further, the existence of only one trade margin still enables labour market institutions to affect average profits (say, all European economies are trading, so at the aggregate level, only the intensive margin is at work). Finally, the free entry equation in (5.9) solves for the demand-shifter A_{it} as a function of parameters, all the labour market institutions, fixed and sunk costs, for given values of foreign demand shifter A_{jt}, which affects the solution only through the intensive margin of trade, $\Upsilon_{ij,t}$. This solution can then be used to solve for the price index P_{it}, recalling that $z > \beta/(1-\beta)$.[32] We use the solutions for the sectoral variables

[32]Further, note that the free entry condition in (5.9) is implicitly non-linear in A_{it} because of the intensive margin $\Upsilon_{ij,t}(A_{it}, A_{jt})$. However, in a symmetric equilibrium $A_{it} = A_{jt}$ implying $\Upsilon_{ij,t} = 1+\tau_{ij,t}^{-\frac{\beta}{1-\beta}}$. Hence in

from above to obtain firm-level variables. Hence, the revenue and the profit functions can be explicitly written as functions of the firm productivity φ and consequently the market access $\Upsilon_{ij,t}$, the zero-profit productivity cut-off φ_{ii}, measures of labour market institutions, and deep parameters.

Similar to the average operating profit for all active firms in the economy, the average operating profit for the non-exporter, $\bar{\pi}_{it,d}$, can be also expressed as:

$$\bar{\pi}_{ii,t} \equiv (1-\beta) \int_{\varphi_{ii}}^{\varphi_{ij}} r_{it}(\varphi) \frac{g(\varphi)}{1-G(\varphi_{ii})} d\varphi + \theta_{it}^{1-\eta_i} \int_{\varphi_{ii}}^{\varphi_{ij}} h_{it}(\varphi) \frac{g(\varphi)}{1-G(\varphi_{ii})} d\varphi \quad (5.11)$$

$$= \frac{z(1-\beta)}{z(1-\beta)-\beta} \left(\frac{(1-\beta)\Upsilon_{it}^{-\beta} + \theta_{it}^{1-\eta_i} (r_{it}/h_{it})^{-1} \Upsilon_{it}^{-1}}{(1-\beta) + \theta_{it}^{1-\eta_i} (r_{it}/h_{it})^{-1}} \right) \left(f_{ii,t} - f_{ij,t} (\Upsilon_{it}-1)^{-1} \rho_{ij}^{z} \right), \quad (5.12)$$

where the procedure to obtain the above expression follows the same logic used in obtaining $\bar{\pi}_{it}$ but for the productivity range $\varphi \in [\varphi_{ii}, \varphi_{ij})$. The ratio of the two average profits is

$$\frac{\bar{\pi}_{ii,t}}{\bar{\pi}_{it}} = \frac{f_{ii,t} - f_{ij,t} (\Upsilon_{it}-1)^{-1} \rho_{ij,t}^{z}}{f_{ii,t} + f_{ij,t}\rho_{ij,t}^{z}} = \frac{f_{ii,t} - f_{ii,t}\rho_{ij,t}^{z-\frac{\beta}{1-\beta}}}{f_{ii,t} + f_{ij,t}\rho_{ij,t}^{z}}. \quad (5.13)$$

Intuitively, if none of the firms export, $\rho_{ij,t} = 0$, then the ratio $\bar{\pi}_{ii,t}/\bar{\pi}_{it} = 1$ as the domestic producer's average profit coincides with the average of the total economy. Should all firms export, the ratio is equal to 0 as $\rho_{ij,t} = 1$, and there are no purely domestic firms in the economy ($\varphi_{ii} = \varphi_{ij}$, hence, $(\Upsilon_{ij}-1)^{-1} = f_{ii,t}/f_{ij,t}$). We are interested in how the relative profitability, and thus the domestic production as opposed to exporting, is affected by changes in the labour market institutions.

Lemma 5. *In a partial equilibrium, the relative profitability of purely domestic firms is decreasing in wage subsidies and increasing in labour market tightness.*

Proof. See Appendix B.1.3. □

Remark. Intuition of this result is important for understanding the reallocations caused by labour market policies. The relative profitability demonstrates the relative gainers and losers after the change in unemployment benefits and employment contingent subsidies. An increase in average profit is mainly generated by a change in the average productivity. Recall that cut-off productivities are positively related to the unemployment benefits. This implies that paying larger benefits hurts relatively inefficient firms more and makes survival more difficult (labour market tightness declines and makes vacancy posting costs higher) – yet, a less tight labour market makes survival easier and lowers wages, thus dominating the overall effect.

To appreciate the mechanics of the above result, we use the domestic cut-off in (5.4) and

a symmetric equilibrium equation, the demand shifter can be solved analytically as a function of parameters, fixed, and sunk costs.

the result that $\partial\varphi_{ii,t}^{\frac{\beta}{1-\beta}}/\partial\Theta_{it} > 0$ (refer to the Lemma 3), therefore, giving

$$\frac{\partial\varphi_{ii,t}^{\frac{\beta}{1-\beta}}}{\partial\theta_{it}} > 0. \tag{5.14}$$

Hence, an increase in unemployment benefits (a drop in labour market tightness), accounting for general equilibrium effects, causes a drop in the cut-off productivity of the domestic producer. However, to make the free entry condition hold, there must be an increase in the threshold productivity of the exporting firm, thereby lowering the measure of exporters and increasing the exporter's cut-off productivity. This causes a drop in the average profit of the domestic producer who survives (but increases that of an exporter). What is more, an increase in the subsidy tends to lower wages directly, surpassing the labour market adjustments. The mechanism is simple – it gets easier for the firm to compete on the world market as its wage costs decrease. Formally,

$$\begin{aligned} \frac{\partial\varphi_{ii,t}^{\frac{\beta}{1-\beta}}}{\partial\Theta_{it}}\frac{\partial\Theta_{it}}{\partial e_{it}} &= \frac{\partial\varphi_{ii,t}^{\frac{\beta}{1-\beta}}}{\partial\Theta_{it}}\left(-1+\tfrac{\kappa_i}{1-\kappa_i}\tfrac{\partial\theta_{it}}{\partial b_{it}}\right) \\ &= \frac{\partial\varphi_{ii,t}^{\frac{\beta}{1-\beta}}}{\partial\Theta_{it}}\left(-1+\tfrac{1}{1+(r+\delta+s_i)(1-\eta_i)\theta_{it}^{-\eta_i}}\right) < 0. \end{aligned} \tag{5.15}$$

Intuition is based on the standard Melitz-type reallocations. But, instead of trade costs, we consider exogenous changes in labour market regulation. In the same way as in Melitz (2003), the labour market plays a crucial role as all adjustments are through changes in relative prices. Clearly, institutional measures in labour markets affect prices which, in turn, change welfare and all real aggregates in the economy. Figure 5.1 demonstrates the simulated behaviour of domestic cut-off productivity φ_{ii}. Unlike Lemma 3, however, we allow for labour market tightness to adjust, given a shock in b_i and e_i.

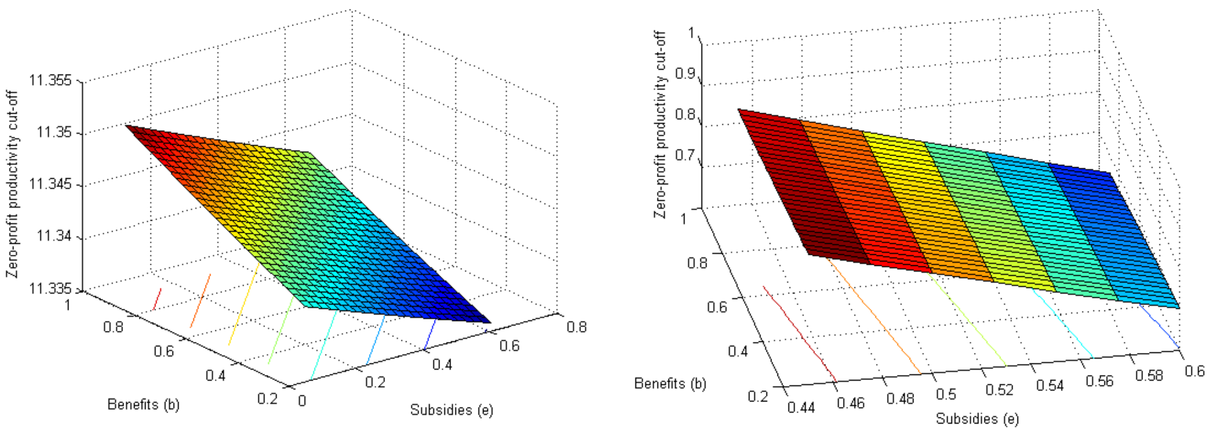

Figure 5.1: Changes in a domestic cut-off productivity due to unemployment benefits and subsidies under one-sector (left) and two-sector (right) general equilibrium

In particular, the left panel in Figure 5.1 depicts the zero profit productivity once the arbitrage condition is binding: we restrict the unemployment benefits to be equal to the wage in a homogeneous sector. The shape of the surface is rooted in a totally exogenous labour market tightness: it is pinned down by a choice of unemployment benefits, and is not subject to a simultaneous solution of wages and labour market tightness as in the right panel of Figure 5.1. Results do indeed change with regard to unemployment benefits. As before, the cut-off productivity drops with an increase in employment subsidies. However, the arbitrage condition now makes unemployment benefits be associated with a reduction in domestic cut-off productivity too.

Therefore, closing general equilibrium by the introduction of a homogeneous sector leads to a different result regarding benefits and openness (with no change regarding subsidies and openness). To understand the difference, recall that cut-off productivity reacts to labour market policies through the average revenue r_{it}/h_{it}, as in equation (5.4). The average revenue exemplifies that, under sectoral arbitrage, the relevant expression becomes $r_{it}(\varphi)/h_{it}(\varphi) = ((\kappa_i\beta + 1 - \kappa_i)/\beta)\left(1 - e_{it} + ((r+\delta+s_i)/(1-\kappa_i))\,\theta_{it}^{1-\eta_i}\right)$. The labour market tightness is pinned down by unemployment benefits. Since an increase in benefits is associated with a decrease in tightness (refer to equation (5.5)), the average revenue tends to decrease. An increase in subsidies affects average revenue negatively, through the wage channel. Hence, the effect on the extensive margin is unidirectional: an increase in b_i or e_i is associated with an increase in the share of exporters, as there is a larger share of firms that can compete on the world's markets due to lower wages domestically.

As a final remark to strengthen intuition, recall that labour market policies are funded by the active firms, and the reallocation is similar to changes in production costs. To see this, consider the full effect on wages:

$$\begin{aligned}\frac{dw_{it}}{d\Theta_{it}} &= 1 + \kappa_i(1-\eta_i)\left(\frac{r+\delta+s_i}{1-\kappa_i}\right)\theta_{it}^{-\eta_i}\frac{\partial\theta_{it}}{\partial\Theta_{it}} \\ &= 1 + (1-\eta_i)(r+\delta+s_i)\,\theta_{it}^{-\eta_i} > 0.\end{aligned}$$

Clearly, $dp_{it}^{\frac{\beta}{\beta-1}}(\varphi_{ii,t})/d\Theta_{it} = (\beta/(\beta-1))\,p_{it}^{\frac{1}{\beta-1}}(\varphi_{ii,t})\,dp_{it}(\varphi_{ii,t})/d\Theta_{it}$, therefore, leading to $dp_{it}(\varphi_{ii,t})/d\Theta_{it} < 0$, which yields $dp_{it}(\varphi_{ii,t})/de_{it} > 0$. Under the sectoral arbitrage condition, the definition of Θ_{it} is changed to $\Theta_{it} = 1 - e_{it}$. Domestic prices rise with subsidies – an average firm is less productive than before due to the drop of the average exporter's productivity. These results rely on the wage being positive with the sufficient condition being $e_i < 1$ (though this is not necessary as there is a positive component of labour market tightness), which bounds subsidies away from a certain wage in the homogeneous sector.

Before moving to the quantitative analysis, let us gather the main insights. The two structural labour market reforms, unemployment benefits and employment contingent subsidies, yield a rich structure on an open macroeconomy. In a two-sector general equilibrium, unemployment benefits affect labour market tightness negatively. The arbitrage condition makes sure that labour market tightness moves in line with unemployment benefits, thus making an agent indifferent to being unemployed in the differentiated sector or working in the homogenous sector. As in case with subsidies, wages go down due to labour market tightness dominating the total effect. Due to these adjustments, economy becomes more competitive at the cost of lower employment (and thus expenditure).

6 Mechanics of the Model

We seek to operationalise our theory by running a few exercises that illustrate the mechanics of the model. We first explore how unemployment benefits alter unemployment and labour market tightness. We proceed by simulating firm reallocations, also intensive and extensive margins of trade. Due to country specific parameters, we can shed some light on the strength of the proposed channels for particular economies. Having macro data, we do not aim to structurally estimate the model; rather, we combine external and internal calibration to shed more light on the main mechanisms, discussed in previous sections. We picked three economies for the illustration: Spain and Portugal were chosen due to the empirical puzzle as described in Blanchard and Jimeno (1995), where the difference in unemployment rates in the seemingly similar Iberian countries is coined as the biggest unemployment puzzle and empirical challenge. Germany has been also added due to its economic importance, openness, also successful labour market reforms that helped to alleviate adverse shocks. Some additional graphs (along with the codes), covering a larger set of economies, are available in the Online Appendix.

We focus on the one- and two-sector equilibria as they happen to be important in contrasting results with the empirical evidence. More precisely, the one-sector equilibrium refers to the case where a fixed point problem is solved for the labour market tightness and labour market institutions as in the Section 4.1.3 (also refer to Figure 4.3). A two-sector equilibrium, on the other hand, is the case when the arbitrage condition is imposed to hold (see Section 4.3). The difference in the results is interpreted as reflecting the importance of sectoral reallocations (since agents can freely move between sectors and the homogenous sector puts the wage floor to wage bargaining).

6.1 Simulations

We estimate the main equations using the method of moments estimator to uncover structural parameters that underlie the theory-implied relationships. We also make use of some external parameters, presented in Table 4.1. We estimate the elasticity of a matching function η_i, a bilateral distance elasticity ϑ_{ij}, a ratio of fixed costs $f_{ij,t}/f_{ii,t}$, and a bargaining weight κ_i. We work under linear vacancy posting costs. Ultimately, we use parameter estimates to simulate outcomes of labour market policy changes.

More precisely, we use the following set of conditions, describing an extensive margin (5.8), an intensive margin (5.7), a labour market tightness (5.2), and unemployment (3.3). Using empirical counterparts, we can infer parameter values that most closely reproduce key features of data and reproduce the workings of the economy for shocks and counterfactuals. The moment equations and inferred parameters are produced in Table 6.1. The last equation of employment has been used to infer the links with trade and aggregate expenditure.

Table 6.1: Model moments and inferred parameters

Model moment	Equation	Reference	What for?
$u_{it} \quad =$	$\left(1+\delta+s_i+\theta_{it}^{\eta_i}\right)^{-1}\left(u_{it-1}+\delta+s_i\right)$	(3.3)	η_i,
$\theta_{it} \quad =$	$\frac{1-\kappa_i}{\kappa_i}\left(1-b_{it}\right)$	(5.2)	κ_i,
$\Upsilon_{ij,t} \quad =$	$1+d_{ij}^{-\vartheta_{ij}\frac{\beta}{1-\beta}}\left(\frac{E_{jt}^{1-\beta}P_{jt}^{\beta}}{E_{it}^{1-\beta}P_{it}^{\beta}}\right)^{\frac{1}{1-\beta}}$	(5.7)	ϑ_{ij},
$\rho_{ij,t} \quad =$	$\left(\Upsilon_{ij,t}-1\right)^{\frac{1-\beta}{\beta}}\left(f_{ij,t}/f_{ii,t}\right)^{-\frac{1-\beta}{\beta}}$	(5.8)	$f_{ij,t}/f_{ii,t}$,
$1-u_{it} \quad =$	$\frac{E_{it}}{\left(\frac{\kappa_i\beta+1-\kappa_i}{\beta}\right)\left(1-e_{it}+\left(\frac{r+\delta+s}{1-\kappa_i}\right)\theta_{it}^{1-\eta_i}\right)(\delta+s_i)}$	Appendix (B.14)	Links E_{it} with u_{it}.

Table 6.2: Coefficient estimates used in the shock simulation

Country	s_i	κ_i	η_i
Austria	0.01	0.67	0.24
Belgium	0.02	0.88	0.41
Finland	0.014	0.81	0.43
Germany	0.011	0.78	0.46
Luxembourg	0.008	0.50	0.17
Portugal	0.01	0.90	0.35
Spain	0.023	0.91	0.46
Sweden	0.009	0.53	0.49
United Kingdom	0.015	0.72	0.51

Note: the estimates for κ_i and η_i were obtained using the method of moments estimator. The separation rate coefficients s are based on estimates in Hobijn and Sahin (2009) (the value for Austria was set to 1%).

We introduced a standard function, which is used in the trade gravity literature, to pin down trade costs, $\tau_{ij}=d_{ij}^{\vartheta_{ij}}$, where d_{ij} is a bilateral distance, and ϑ_{ij} is the elasticity. Notice that the equations can be solved using the recursivity in the two-sector economy: start with the exogenous change in unemployment benefits, which pin down a labour market tightness. It can then be used to infer the unemployment rate, which, in turn, is useful to infer changes in aggregate expenditure. This change can be used to learn about the intensive margin of trade, which, consequently, leads to changes in the extensive margin of trade. The labour market tightness is solved simultaneously with the labour market policies in the one-sector economy (as in Section 4.1.3); otherwise, the structure is the same. Given these measures, we can explore changes in both labour and goods markets. Note that a country-specific shock is analysed under the small open economy assumption (where foreign aggregates are taken as given). For the coordinated shocks, however, we simultaneously implement changes in all aggregates due to deviations from the country-specific levels of labour market variables (we compute bilateral trade for 26 EU countries but report average results for the three selected ones).

6.1.1 Labour Market

We start with overviewing the simulation results about the labour market. In all simulations we change labour market variables by adding the same one standard deviation, which is computed using the overall mean. This choice is dictated by a need to have a clear idea about the source of differences in reactions (which would not be the case with varying shocks) and the empirical practice to track impulse responses to a small shock.

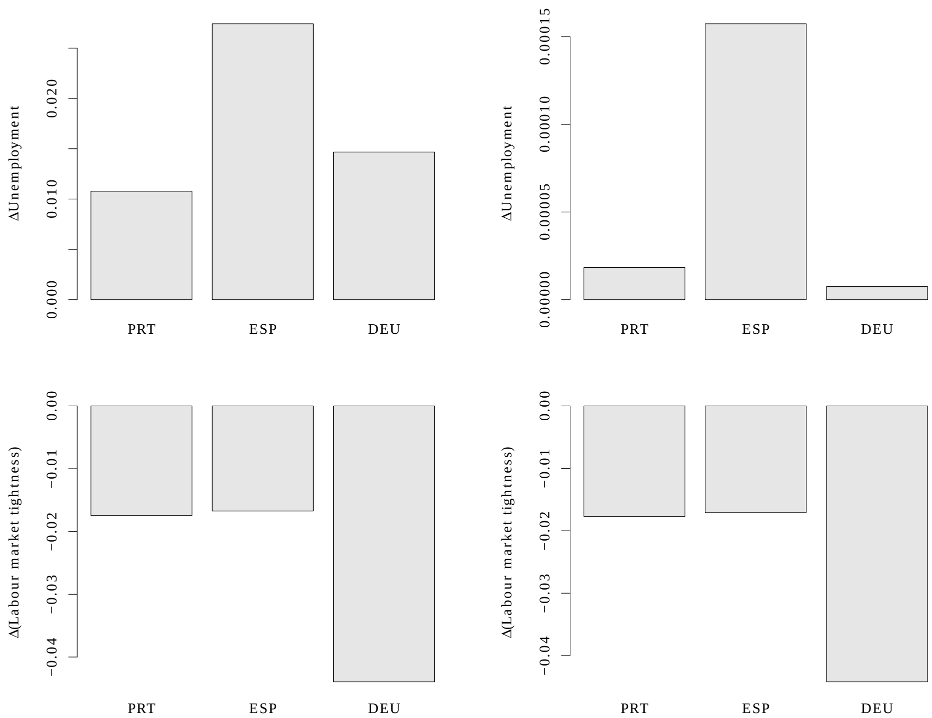

Figure 6.1: Unemployment and labour market changes due to unemployment benefits in the two (left) and one (right) sector equilibrium

Figure 6.1 depicts changes in unemployment and labour market tightness due to unemployment benefits. Benefits tend to make unemployment grow and labour market tightness drop. However, the responses are quite heterogeneous: labour market tightness drops for Germany most substantially whereas Portuguese and Spanish responses are almost identical. There is no difference whether we use one- or two-sector equilibrium. This is no longer the case for the unemployment rate: German unemployment increases the least, so it barely responds to the tightness. Spanish unemployment, on the other hand, increases substantially and is very sensitive to changes in the labour market tightness. Also, the way equilibrium is closed matters for the unemployment rate: though a change in the Spanish unemployment rate is most pronounced, Portuguese and German responses do not preserve the ordering. Further, the absolute changes in unemployment are considerably larger in the two-sector equilibrium.

To have a glimpse in the mechanisms that drive the results, recall that the labour market tightness is determined by the parameter κ_i, which governs the relative bargaining strength of workers vis-a-vis employers (see Table 6.2 for the estimates). The reactions in unemployment, however, entail a non-linear mix of deep parameters (such as a measure of matching frictions η_i and separation rate s_i) and, thus, necessitate simulations. Notice that, due to the arbitrage condition in the two-sector economy (Section 5.2.1), employment contingent subsidies are not featured in the expressions for unemployment and labour market tightness.

6.1.2 Reallocations and Firms' Profitabilities

We illustrate the mechanics of Lemma 5. for general equilibrium with one and two sectors. Figure 6.2 displays how the average operating profit responds to changes in employment subsidies and unemployment benefits. We report the result from a counterfactual of the domestic and region-wide changes, i.e. all economies implementing structural labour market reforms. It is a global effect that accounts for aggregate variables and spatial interdependencies through international trade.

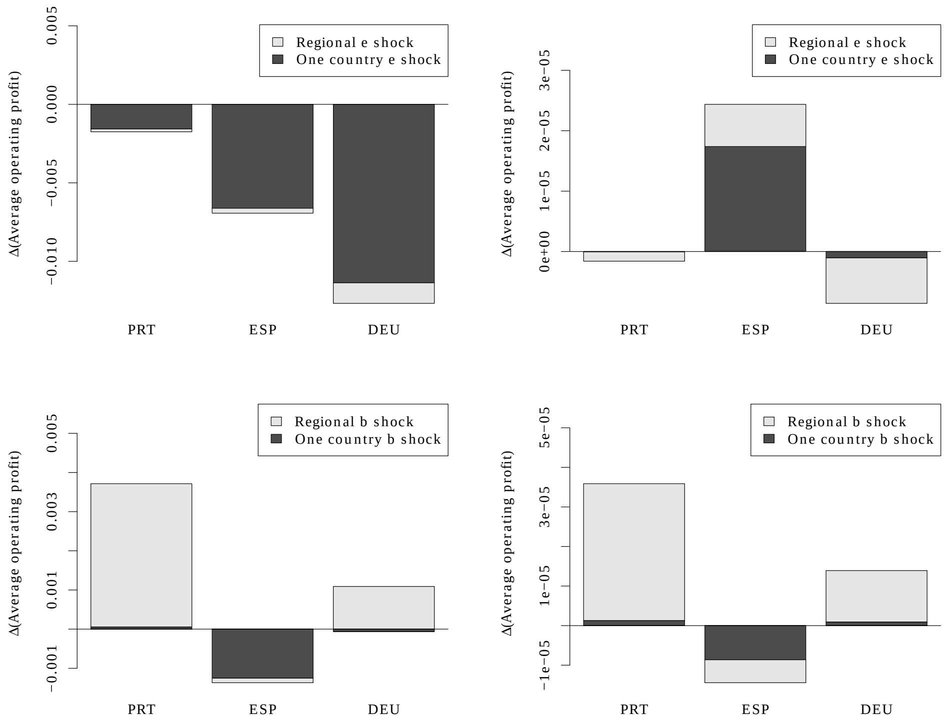

Figure 6.2: Changes in average profit due to the country-specific and region-wide employment contingent subsidies (above) and unemployment benefits (below) in the two (left) and one (right) sector equilibrium

In particular, we investigate how the profit ratios are affected by labour market reforms. Recall that, using Lemma 5, the subsidies, in partial equilibrium, are predicted to decrease the relative profit of a domestic firm, whereas benefits should increase it. In Figure 6.2 we start with the average, rather than the relative profit, and track the outcomes for European economies when a region-wide shocks are implemented (i.e. all countries undergo the changes in policies at the same time, thus mimicking a counterfactual union where labour markets are reformed simultaneously). As before, a two-sector equilibrium yields substantially larger effects in absolute value. As theory predicts, average operating profit drops. This finding is different for the one-sector equilibrium as a positive effect can be generated for Spain (an increase in subsidies makes an average firm more profitable). As for the unemployment benefits, regional shocks bear substantial effects (except for Spain where a country shock drives the result in a two-sector equilibrium). Two main findings emerge: regional implementation of labour market reforms is warranted for the benefits rather than subsidies; and general equilibrium effects can dominate the partial ones, so there is a need for coordination of the "doses" of reforms (and even reductions versus increases for certain countries).

Changes in relative profits in Figure 6.3 largely follow patterns in Figure 6.2. The steepness of profit ratios is considerably larger when economies undergo policy changes solely domestically; this changes when all economies implement the same labour market policy simultaneously (in particular for the two-sector equilibrium). The implication is, therefore, clear: a coordinated reform is needed if one of the goals was limited spillover effects that might be unintentionally produced by a domestic labour market change. To illustrate this point, note that a country specific change in subsidies reduces the profit share from the domestic operations but a regional change slightly increases it for the Spanish economy under sectoral reallocations.

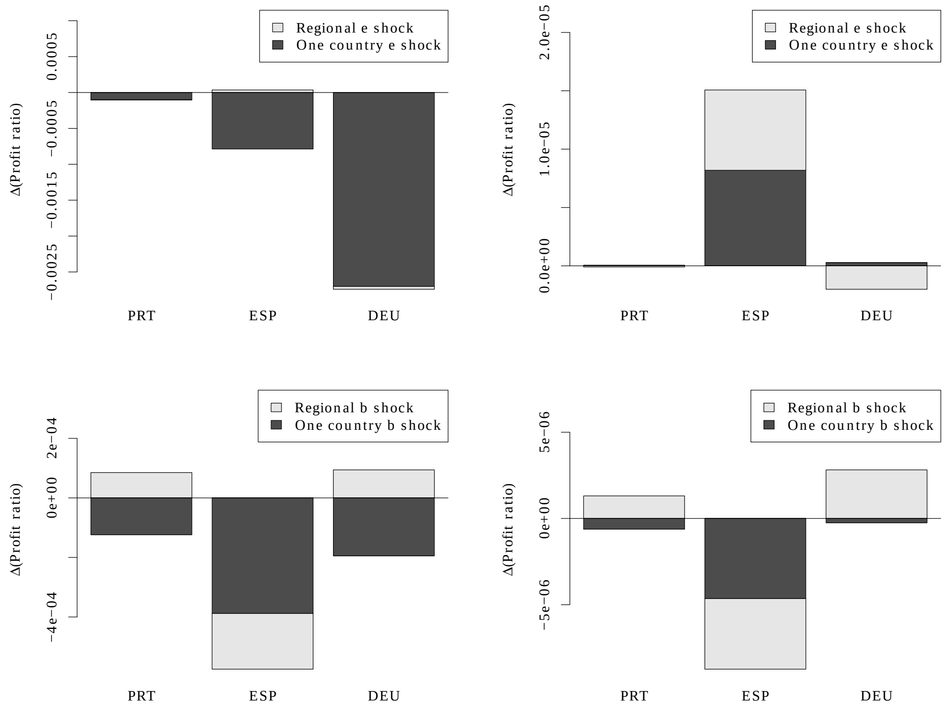

Figure 6.3: Changes in relative profitability due to the country-specific and region-wide employment contingent subsidies (above) and unemployment benefits (below) in the two (left) and one (right) sector equilibrium

What is more, unemployment benefits more to the same direction and preserve the ordering of absolute magnitudes, independently of equilibrium concept. Subsidies, on the other hand, tend to move in various ways. Recall that sectoral reallocations make labour market tightness independent of subsidies; this is not the case for the one-sector equilibrium where both institutions affect wages directly and indirectly. The indirect channel of subsidies (through the tightness) is shut for the two-sector case but works for benefits independently of the number of sectors.

6.1.3 Openness in General Equilibrium

Finally, we conduct two types of counterfactuals with regards to two dimensions of openness, namely intensive and extensive margin. As before, we first shock benefits and subsidies in each economy separately and also implement a regional shock. Figures 6.4 and 6.5 collect evidence about the intensive and extensive margins, respectively.

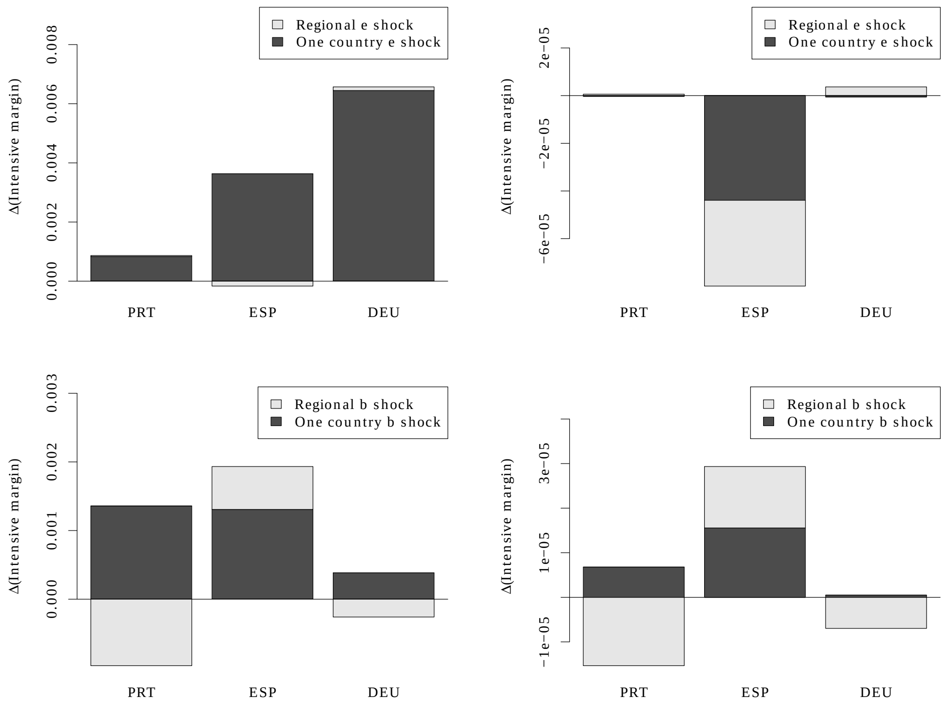

Figure 6.4: Average intensive margin change due to the country-specific and region-wide employment contingent subsidies (above) and unemployment benefits (below) in the two (left) and one (right) sector equilibrium

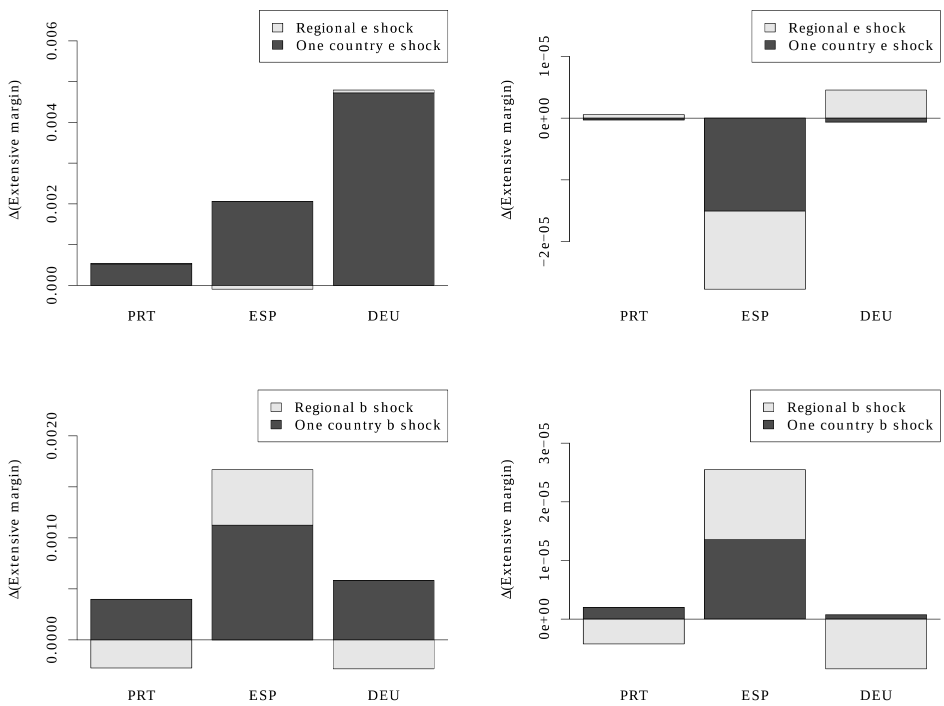

Figure 6.5: Average extensive margin change due to the country-specific and region-wide employment contingent subsidies (above) and unemployment benefits (below) in the two (left) and one (right) sector equilibrium

A few observations stand out: the regional dimension is more important for the unemployment benefits, unlike sectoral arbitrage; to the contrary, the closure of equilibrium matters for the effect of subsidies; and, lastly, there is a substantially more pronounced change in both margins if policy has been implemented in a single economy once sectorial arbitrage is allowed for. This is not that clear for the one-sector equilibrium, yet, the same reasoning holds: main differences arise for the subsidies, not unemployment benefits. Country-specific changes lead to increases in both intensive and extensive margins of trade for the two-sector model. Regional shock, when all economies change the policy measures, leads to heterogeneous effects, as there are possibilities for some economies to become more or less open, depending on the reaction in the trading partners. In the one-sector model, country-specific reforms in subsidies make intensive margin of trade drop whereas the extensive margin go up. Interestingly, a regional shock makes Spanish trade margins drop due to subsidies and increase due to unemployment benefits independently of the equilibrium. Portuguese and German margins of trade move to opposite directions in response to the home and regional shocks for all but two-sector model with subsidies. It does emerge that benefits produce spillovers independently of the equilibrium concept. We also track GDP changes due to unemployment benefits and subsidies, and note that the effect is negative for all but one-sector model with subsidies (refer to Appendix C.2).[33]

All the simulations stress the importance of general equilibrium effects and spatial spillovers. In the model with a sectoral arbitrage, subsidies reduce wages, with the labour market tightness channel being shut, and lead to lower expenditure. This effect makes trade openness (both intensive and extensive margin) grow as well as easies competition with foreign firms (through the cost competitiveness channel). Even in this case, it is not trivial to find out spatial effects in the regional shock as foreign variables are no longer held fixed but react to the reforms at home. Unemployment benefits, on the other hand, has a direct positive effect and an indirect negative effect on wages, with the latter dominating in equilibrium. In the one sector equilibrium, both labour market institutions are simultaneously determined with the labour market tightness. The main difference lies in subsidies which now bear direct and indirect effects.

To summarise, the model captures data facts from the Section 2. The two-sector model can rationalise the first data fact, namely, a positive effect of unemployment benefits on unemployment. Benefits are positively associated with the openness in both models but the regional shock can change the results; this is consistent with the second data fact. The positive effect of subsidies on the intensive and extensive margins of trade can be replicated in the model with the sectoral arbitrage, and the country-specific effect dominates regional spillovers. Finally, the fourth data fact is embedded in the two-sector model where employment subsidies have limited effect due to the sectoral arbitrage (labour market tightness does

[33]Note that quantitative statements cannot be made because results hinge on the choice of measurement units and scale for benefits and subsidies. We, therefore, stick to qualitative interpretation only.

not feature subsidies and thus loses a link with the unemployment rate).

7 Conclusions

We have presented a model with multi-worker heterogeneous firms and established theoretical channels through which labour market policies affect the macroeconomy. This understanding is important for policymakers who seek to revitalise the economy by structural labour market reforms. Our emphasis was on openness, in particular, intensive and extensive margins of trade, and one- and two-sector economy. Theory reveals that unemployment benefits increase wage costs, which affect the least productive domestic firms most severely. This makes survival of non-exporters more difficult. A dampening effect works through the labour market tightness. In general equilibrium with sectoral arbitrage, however, labour market tightness dominates the overall effect, and makes wages drop and trade openness grow. One-sector equilibrium, however, necessitates simulations to learn the overall effect.

Wage subsidies help the least efficient firms to operate, and decrease average productivity and relative profitability of non-exporters. In the two-sector economy, the indirect effect in the sectoral movements is eliminated due to the sectoral arbitrage in the differentiated and homogenous sectors. It gets easier for the least productive firms to survive as their wage costs decrease. However, subsidies have little if any effect on the labour market tightness and their effect on the macroeconomy and firm reallocations is limited. A different result emerges in the one-sector equilibrium where the labour market tightness is a function of subsidies. Theoretical implications and results under one- and two-sector closures of the model can constitute a basis for hypotheses on the empirical firm-level data studies; the model with sectoral arbitrage is largely supported by the country-level data facts.

We have used a method of moments to implement a domestic and regional counterfactual analysis for selected European economies. We found that unemployment benefits affected macroeconomy in a similar way, independently of one- or two-sector economy; however, regional spillovers were substantial and often dominated the single-economy effects. To the contrary, spillovers were negligible for employment subsidies but the closure of the model was crucial to learn the macroeconomic effects.

Policy implications are important. Unemployment benefits affect firms profits more profoundly, whereas employment subsidies barely impact firm reallocations. This means that labour market policies must be aligned with the goals of an economy's competitiveness and openness. It is important to note that the steepness of profit ratios is considerably larger when economies undergo policy changes solely domestically. Hence, a coordinated reform is effective at limiting the effects of structural changes between exporters and non-exporters. Regional shock is also effective in dampening international spillover effects, in particular, when it comes to openness. While employment subsidies may not have effects that are too detrimental for trading partners, unemployment benefits necessitate policy coordination.

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Online Appendix

A Data

A.1 Descriptive Statistics

Table A.1: Data summary statistics

Variable	mean	sd	min	max	obs
Unemployment benefits	0.58	0.16	0.07	0.92	623
Employment incentives	0.07	0.08	0.00	0.46	353
Extensive margin	0.14	0.10	0.00	0.43	442
Intensive margin	1.29	0.14	1.05	1.84	442
Labour market tightness	0.12	0.14	0.00	0.76	330
Unemployment rate	9.13	4.28	1.59	27.47	698

Note: the summary statistics were computed for 26 European Union countries. The data covers period from 1980 to 2015 with varying data availability for different variables.

B Proofs and Derivations

B.1 Proofs

B.1.1 Lemma 2

Proof. We shall sometimes ignore the country subscript if the result is clear without it. For the linear case, take logs on both sides of

$$h_t = \left(\frac{\Gamma_t \varphi^\beta}{\kappa_i \beta + 1 - \kappa_i}\right)^{\frac{1}{1-\beta}} \left(b_t - e_t + \frac{\kappa_i}{1-\kappa_i}\theta_t + \left(\frac{r+\delta+s}{1-\kappa_i}\right) x_t^{-1}\right)^{\frac{1}{\beta-1}}.$$

It then immediately follows that $\epsilon_{h_t,\varphi} = \frac{\beta}{1-\beta} > 0$. For the non-linear vacancy posting costs, differentiate the equation implicitly describing the optimal firm's employment level $h_t(\varphi)$,

$$h_t^{\gamma_i - 1}\left((1-\kappa_i)\frac{\Gamma_t \varphi^\beta}{\kappa_i\beta+1-\kappa_i} h_t^{\beta-1} - (r+\delta+s)\, s^{\gamma_i-1} x_t^{-\gamma_i}\right) = (1-\kappa_i)\left(b_t - e_t + \frac{\kappa_i}{1-\kappa_i}\theta_t v_t^{\gamma_i-1}\right),$$

giving

$$\begin{aligned}(1-\kappa)\frac{\Gamma_t}{\kappa_i\beta+1-\kappa_i}\left(\beta\varphi^{\beta-1}h_t^{\beta-1} + \varphi^\beta(\beta-1)h_t^{\beta-2}\frac{\partial h_t}{\partial\varphi}\right) &= (1-\kappa_i)\frac{\Gamma_t}{\kappa_i\beta+1-\kappa_i}\frac{\varphi}{h_t}h_t^\beta\varphi^{\beta-2}\left(\beta+(\beta-1)\epsilon_{h_t,\varphi}\right)\\ = (\gamma_i-1)(r+\delta+s)\, s^{\gamma_i-1}x_t^{-\gamma_i}h_t^{\gamma_i-2}\frac{\partial h_t}{\partial\varphi} &= (\gamma_i-1)(r+\delta+s)\, s^{\gamma_i-1}x_t^{-\gamma_i}h_t^{\gamma_i-1}\epsilon_{h_t,\varphi}\varphi^{-1},\end{aligned}$$

or, expressed in terms of the elasticity, $\epsilon_{h_t,\varphi} \equiv \frac{\partial h_t}{\partial\varphi}\frac{\varphi}{h_t}$,

$$\epsilon_{h_t,\varphi} = \frac{(1-\kappa_i)\Gamma_t\beta\varphi^\beta}{(\gamma_i-1)(r+\delta+s)(\kappa_i\beta+1-\kappa_i)s^{\gamma_i-1}x_t^{-\gamma_i}h_t^{\gamma_i-\beta} - (1-\kappa_i)\Gamma_t\varphi^\beta(\beta-1)}.$$

The sign of the elasticity is determined recalling a relationship in (4.5), where the left hand side is positive because of the worker's outside option, i.e. $b_t - e_t + \frac{\kappa_i}{1-\kappa_i}\theta_t v_t^{\gamma_i - 1} > 0$. In other words, the employment-contingent subsidy is always assumed to be such that $e_t < b_t + \frac{\kappa_i}{1-\kappa_i}\theta_t v_t^{\gamma_i - 1}$. Then

$$\epsilon_{h_t,\varphi} = \frac{1}{\frac{(\gamma_i-1)(r+\delta+s)(\kappa_i\beta+1-\kappa_i)s^{\gamma_i-1}x_t^{-\gamma_i}h_t^{\gamma_i-\beta}}{(1-\kappa_i)\Gamma_t\beta\varphi^{\beta}} - \left(\frac{\beta-1}{\beta}\right)} > 0,$$

which is equivalent to

$$\left(\frac{\gamma_i - 1}{\beta}\right) \frac{(r+\delta+s)s^{\gamma_i-1}x_t^{-\gamma_i}}{(1-\kappa_i)\frac{\Gamma_t\varphi^{\beta}}{\kappa_i\beta+1-\kappa_i}} h_t^{\gamma_i-\beta} > \frac{\beta-1}{\beta}.$$

The inequality is always satisfied for $\beta \in (0,\, 1)$ and $\gamma_i > 1$. To check if this elasticity is consistent with the linear case, we evaluate it at $\gamma_i = 1$, giving

$$\epsilon_{h_t,\varphi}\big|_{\gamma_i=1} = \frac{\beta}{1-\beta} \ ,$$

as established in the main text.

□

B.1.2 Lemma 3

To prove the lemma's statement start with differentiating threshold productivity for the domestic producer (here denoted by a subscript d), ignoring country and time subscripts,

$$\begin{aligned}
\frac{\partial\varphi_d^{\frac{\beta}{1-\beta}}}{\partial\Theta} &= -\left(1-\kappa_i\right)\left(\frac{\beta\gamma A}{\kappa_i\beta+1-\kappa_i}\right)^{\frac{1}{1-\beta}}\left(\Theta + \left(\frac{r+\delta+s}{1-\kappa_i}\right)x^{-1}\right)^{\frac{1}{\beta-1}}\left(\left(1-\beta\right)\Theta + \left(\frac{r+\delta+s}{1-\kappa_i}\right)x^{-1}\right) \\
&\quad \times \frac{\left(\frac{1}{\beta-1}\left[\Theta+\left(\frac{r+\delta+s}{1-\kappa_i}\right)x^{-1}\right]^{-1}+(1-\beta)\left[(1-\beta)\Theta+\left(\frac{r+\delta+s}{1-\kappa_i}\right)x^{-1}\right]^{-1}\right)}{\left((1-\kappa_i)\left(\frac{\beta\gamma A}{\kappa_i\beta+1-\kappa_i}\right)^{\frac{1}{1-\beta}}\left[\Theta+\left(\frac{r+\delta+s}{1-\kappa_i}\right)x^{-1}\right]^{\frac{1}{\beta-1}}\left[(1-\beta)\Theta+\left(\frac{r+\delta+s}{1-\kappa_i}\right)x^{-1}\right]\right)^2} \\
&= \frac{-\left(\frac{1}{\beta-1}\left[\Theta+\left(\frac{r+\delta+s}{1-\kappa_i}\right)x^{-1}\right]^{-1}+(1-\beta)\left[(1-\beta)\Theta+\left(\frac{r+\delta+s}{1-\kappa_i}\right)x^{-1}\right]^{-1}\right)}{(1-\kappa_i)\left(\frac{\beta\gamma A}{\kappa_i\beta+1-\kappa_i}\right)^{\frac{1}{1-\beta}}\left(\Theta+\left(\frac{r+\delta+s}{1-\kappa_i}\right)x^{-1}\right)^{\frac{1}{\beta-1}}\left((1-\beta)\Theta+\left(\frac{r+\delta+s}{1-\kappa_i}\right)x^{-1}\right)} \\
&= \frac{-\left(\frac{1}{\beta-1}\left[\Theta+\left(\frac{r+\delta+s}{1-\kappa_i}\right)x^{-1}\right]^{-1}+(1-\beta)\left[(1-\beta)\Theta+\left(\frac{r+\delta+s}{1-\kappa_i}\right)x^{-1}\right]^{-1}\right)}{\beta f_{ii,t}}\varphi_d^{\frac{\beta}{1-\beta}}.
\end{aligned}$$

Hence, elasticity is given by

$$\epsilon_{\varphi_d,\Theta} = \Theta\frac{-\left(\left[\left(1-\beta\right)\Theta + \left(\frac{r+\delta+s}{1-\kappa_i}\right)x^{-1}\right]^{-1} - \left(\frac{1}{1-\beta}\right)^2\left[\Theta + \left(\frac{r+\delta+s}{1-\kappa_i}\right)x^{-1}\right]^{-1}\right)}{f_{ii,t}}.$$

Note that

$$\frac{1}{\beta-1}\left(\Theta + \left(\frac{r+\delta+s}{1-\kappa_i}\right)x^{-1}\right)^{-1} + \left(1-\beta\right)\left(\left(1-\beta\right)\Theta + \left(\frac{r+\delta+s}{1-\kappa_i}\right)x^{-1}\right)^{-1} < 0,$$

because $\beta < 1$ and

$$\left(\Theta + \left(\frac{r+\delta+s}{1-\kappa_i}\right)x^{-1}\right)^{-1} > \left(1-\beta\right)^2\left(\left(1-\beta\right)\Theta + \left(\frac{r+\delta+s}{1-\kappa_i}\right)x^{-1}\right)^{-1}$$

is satisfied for any value of $\beta \in (0, 1]$. However, the qualification for the last result is that the terms in brackets are positive (the sufficient condition is $b > e$). It then trivially follows from $\Theta \equiv b - e + \frac{\kappa_i}{1-\kappa_i}\theta$ that

$$\frac{\partial \varphi_d^{\frac{\beta}{1-\beta}}}{\partial \Theta} > 0, \frac{\partial \varphi_d^{\frac{\beta}{1-\beta}}}{\partial \Theta}\frac{\partial \Theta}{\partial b} > 0, \frac{\partial \varphi_d^{\frac{\beta}{1-\beta}}}{\partial \Theta}\frac{\partial \Theta}{\partial e} < 0, \frac{\partial \varphi_d^{\frac{\beta}{1-\beta}}}{\partial \Theta}\frac{\partial \Theta}{\partial \theta} > 0.$$

Note that these are partial effects, still ignoring closure of general equilibrium.

B.1.3 Lemma 5

This lemma tells that in a partial equilibrium, the relative profitability of purely domestic firms is decreasing in wage subsidies and increasing in labour market tightness.

Proof. The proof follows immediately after examining the relevant expression. Namely,

$$\frac{\partial \left(\bar{\pi}_{ii,t}/\bar{\pi}_{it}\right)}{\partial \Theta_{it}} = \frac{-\left(z - \frac{\beta}{1-\beta}\right) f_{ii,t}\rho_{ij,t}^{z-\frac{\beta}{1-\beta}-1}\frac{\partial \rho_{ij,t}}{\partial \Theta_{it}}}{\left(f_{ii,t} + \rho_{ij,t}^{z} f_{ij,t}\right)^2} > 0,$$

where the last inequality follows because $z > \beta/(1-\beta)$ and $\partial \rho_{ij,t}/\partial \Theta_{it} = \partial\left(\varphi_{ii,t}/\varphi_{ij,t}\right)/\partial \Theta_{it} < 0$. It then immediately follows from $\Theta_{it} \equiv b_{it} - e_{it} + \frac{\kappa_i}{1-\kappa_i}\theta_{it} = 1 - e_{it}$ that, since

$$\frac{\partial(\bar{\pi}_{ii,t}/\bar{\pi}_{it})}{\partial \Theta_{it}}\frac{\partial \Theta_{it}}{\partial \theta_{it}} > 0,$$

unemployment benefits, by changing θ_{it} negatively, will make sure that the profit ratio goes down whereas employment subsidies, by affecting Θ_{it} but not tightness, will also make the profit ratio go down. □

B.2 Labour Market

B.2.1 Wage

Start with assuming that wages are determined following Stole and Zwiebel (1996a,b), where, as before, we ignore the country subscript for ease of notation:

$$\kappa_i \frac{\partial J_t^F(h_t;\varphi)}{\partial h_t} = (1-\kappa_i)\left(J_t^E(h;\varphi) - J_t^U\right).$$

Using the equation (3.7), we obtain

$$\kappa_i \frac{\partial J_t^F(h_t;\varphi)}{\partial h_t} = (1-\kappa_i)\left(J_t^E(h;\varphi) - J_t^U\right),$$
$$\kappa_i \frac{\partial^2 J_t^F(h_t;\varphi)}{\partial h_t \partial h_t} = (1-\kappa_i)\frac{\partial J_t^E(h;\varphi)}{\partial h_t},$$
$$\kappa_i \frac{\partial^2 J_t^F(h_t;\varphi)}{\partial h_t \partial t} = (1-\kappa_i)\left(\frac{\partial J_t^E(h;\varphi)}{\partial t} - \frac{\partial J_t^U}{\partial t}\right).$$

Rearrange the value for employed (3.6) into

$$(r+s+\delta)\left(\frac{\kappa_i}{1-\kappa_i}\frac{\partial J_t^F(h_t;\varphi)}{\partial h_t}\right)=\frac{\partial J_t^E(h;\varphi)}{\partial t}+w_t(h;\,\varphi)+e_t(h_t)-rJ_t^U$$
$$+\left(x(\theta_t)v_t-sh_t\right)\frac{\kappa_i}{1-\kappa_i}\frac{\partial^2 J_t^F(h_t;\varphi)}{\partial h_t\partial h_t}.$$

Adapt with the firm's value (3.7) to obtain

$$(r+\delta+s)\frac{\partial J_t^F(h_t;\varphi)}{\partial h_t}-\frac{\partial^2 J_t^F(h_t;\varphi)}{\partial t\partial h_t}$$
$$=\frac{\partial \pi(h_t;\varphi)}{\partial h_t}+\left(x(\theta_t)v_t-sh_t\right)\frac{\partial^2 J_t^F(h_t;\varphi)}{\partial h_t\partial h_t}-\frac{\partial\sigma(v_t)}{\partial h_t},$$

Multiplying by $\frac{\kappa_i}{1-\kappa_i}$ and comparing with the value function for the employed yields

$$\kappa_i\left(\frac{\partial J_t^F(h_t;\,\varphi)}{\partial t\partial h_t}+\frac{\partial\pi(h_t;\,\varphi)}{\partial h_t}-\frac{\partial\sigma(v_t)}{\partial h_t}\right)=(1-\kappa_i)\frac{\partial J_t^E(h;\,\varphi)}{\partial t}+(1-\kappa_i)\left(w_t(h;\,\varphi)+e_t(h_t)-rJ_t^U\right).$$

In a steady state, the value functions are time-independent, therefore,

$$\kappa_i\left(\beta\gamma\left[1+\mathcal{I}_x(\varphi)\tau^{-\frac{\beta}{1-\beta}}\left(\frac{A^\star}{A}\right)\right]^{1-\beta}A\varphi^\beta h^{\gamma\beta-1}-w(h;\,\varphi)-\frac{\partial w(h;\varphi)}{\partial h}h-\frac{\partial\sigma(v)}{\partial h}\right)$$
$$=(1-\kappa_i)\left(w(h;\,\varphi)+e(h)-rJ^U\right),$$

where $\frac{\partial\pi(h;\varphi)}{\partial h}=\beta\gamma\left(1+\mathcal{I}_x(\varphi)\tau^{-\frac{\beta}{1-\beta}}\left(\frac{A^\star}{A}\right)^{\frac{1}{1-\beta}}\right)^{1-\beta}A\varphi^\beta h^{\gamma\beta-1}-w(h;\,\varphi)-\frac{\partial w(h;\varphi)}{\partial h}h$, thus leading to

$$\frac{\partial w_t(h;\varphi)}{\partial h_t}+\frac{1}{\kappa_i}\frac{w_t(h_t;\varphi)}{h_t}=\left(\frac{1-\kappa_i}{\kappa_i}\right)\left(\frac{rJ_t^U}{h_t}-\frac{e(h_t)}{h_t}\right)+\Gamma_t\varphi^\beta h_t^{\gamma\beta-2}-\frac{\partial\sigma(v_t)}{\partial h_t}\frac{1}{h_t},$$

where a generic $\Gamma_t\equiv\beta\gamma\left(1+\mathcal{I}_x(\varphi)\tau^{-\frac{\beta}{1-\beta}}\left(\frac{A_t^\star}{A_t}\right)^{\frac{1}{1-\beta}}\right)^{1-\beta}A_t=\beta\gamma\Upsilon_t(\varphi)^{1-\beta}A_t$. Note that we abstract here from labelling countries by their subscripts, and instead resort to a 'star' notation for a foreign economy.

To solve the above, notice that it is written as a differential equation of the following structure

$$w_t(h_t;\,\varphi)+\kappa_i h_t w_t'(h_t;\,\varphi)=\kappa_i p_t'(h_t;\,\varphi),$$

where $p_t'(h_t;\,\varphi)\equiv\left(\frac{1-\kappa_i}{\kappa_i}\right)\left(rJ_t^U-e_t\right)+\Gamma_t\varphi^\beta h_t^{\gamma\beta-1}-\frac{\partial\sigma(v_t)}{\partial h_t}$. Let's rearrange into

$$w_t'(h_t;\,\varphi)+\frac{w_t(h_t;\varphi)}{\kappa_i h_t}=\frac{p_t'(h_t;\varphi)}{h_t},$$

which is a first-order (separable) differential equation whose general solution is

$$w_t(h_t;\,\varphi)=\frac{\int_0^h\exp\left(\int_0^h(\kappa_i\hbar_t)^{-1}d\hbar\right)\left(\left(\frac{1-\kappa_i}{\kappa_i}\right)\left(\frac{rJ_t^U}{\hbar_t}-\frac{e_t}{\hbar_t}\right)+\Gamma_{it}\varphi^\beta\hbar_t^{\gamma\beta-2}-\frac{\partial\sigma(v_t)}{\partial\hbar_t}\frac{1}{\hbar_t}\right)d\hbar+C}{\exp\left(\int_0^h(\kappa_i\hbar_t)^{-1}d\hbar\right)}.$$

The denominator is an integrating factor, equal to

$$\exp\left(\int_0^h(\kappa_i\hbar_t)^{-1}d\hbar\right)=\exp\left(\frac{1}{\kappa_i}\int_0^h\frac{d\hbar}{\hbar}\right)$$
$$=\exp\left(\frac{1}{\kappa_i}\int_0^h d\ln\hbar\right)=\exp\left(\ln h^{\frac{1}{\kappa_i}}\right)=h^{\frac{1}{\kappa_i}}.$$

Plugging the relevant expressions in our case, we obtain

$$\begin{aligned}
&\int_0^h \exp\left(\int_0^h (\kappa_i \hbar_t)^{-1} d\hbar\right)\left(-\left(\frac{1-\kappa_i}{\kappa_i}\right)\frac{e_t}{\hbar_t}+\frac{\left(\frac{1-\kappa_i}{\kappa_i}\right) rJ_t^U}{\hbar_t}+\Gamma_{it}\varphi^\beta \hbar_t^{\gamma\beta-2}-\frac{\partial\sigma(v_t)}{\partial\hbar_t}\frac{1}{\hbar_t}\right) d\hbar \\
&= \int_0^h \hbar^{\frac{1}{\kappa_i}}\left(-\left(\frac{1-\kappa_i}{\kappa_i}\right)\frac{e_t}{\hbar_t}+\frac{\left(\frac{1-\kappa_i}{\kappa_i}\right) rJ_t^U}{\hbar_t}+\Gamma_{it}\varphi^\beta \hbar_t^{\gamma\beta-2}-\frac{\partial\sigma(v_t)}{\partial\hbar_t}\frac{1}{\hbar_t}\right) d\hbar \\
&= -\left(\frac{1-\kappa_i}{\kappa_i}\right) e_t \kappa_i h_t^{\frac{1}{\kappa_i}}+\left(\frac{1-\kappa_i}{\kappa_i}\right) rJ_t^U \kappa_i h_t^{\frac{1}{\kappa_i}}+\Gamma_{it}\varphi^\beta \frac{\kappa_i}{\gamma\kappa_i\beta+1-\kappa_i} h_t^{\frac{1}{\kappa_i}+\gamma\beta-1}.
\end{aligned}$$

Hence,

$$w_t(h_t;\varphi)=\frac{-\left(\frac{1-\kappa_i}{\kappa_i}\right) e_t\kappa_i h_t^{\frac{1}{\kappa_i}}+\left(\frac{1-\kappa_i}{\kappa_i}\right) rJ_t^U\kappa_i h_t^{\frac{1}{\kappa_i}}+\Gamma_{it}\varphi^\beta\frac{\kappa_i}{\gamma\kappa_i\beta+1-\kappa_i} h_t^{\frac{1}{\kappa_i}+\gamma\beta-1}+C}{h_t^{\frac{1}{\kappa_i}}},$$

where, following Hawkins and Acemoglu (2014), $C=0$, and using the marginal bargaining due to Stole and Zwiebel (1996a,b) and the optimal vacancy posting yield[34]

$$rJ_t^U = b_t + \theta_t x(\theta_t)\frac{\kappa_i}{1-\kappa_i}\frac{\partial J^F(h_t;\varphi)}{\partial h_t} = b_t + \frac{\kappa_i}{1-\kappa_i}\theta_t v_t^{\gamma-1}, \tag{B.1}$$

giving

$$w_t(h_t;\varphi)=\kappa_i\frac{\Gamma_{it}\varphi^\beta}{\gamma\kappa_i\beta+1-\kappa_i}h_t^{\gamma\beta-1}+(1-\kappa_i)\left(b_t-e_t+\frac{\kappa_i}{1-\kappa_i}\theta_t\right).$$

To finalise, one should use the equilibrium level of employment, and end up with a wage which is independent of the productivity shock. Namely,

$$\begin{aligned}
w_t(h_t;\varphi) &= \left(b_t-e_t+\frac{\kappa_i}{1-\kappa_i}\theta_t\right)+\kappa_i\left(\frac{r+\delta+s}{1-\kappa_i}\right)x_t^{-1}\\
&= \left(b_t-e_t+\frac{\kappa_i}{1-\kappa_i}\theta_t\right)+\kappa_i\left(\frac{r+\delta+s}{1-\kappa_i}\right)\theta_t^{1-\eta_i}.
\end{aligned}$$

The log linearised version is given by (where a tilde variable denotes a steady state)

$$\begin{aligned}
\ln\tilde{w}+\frac{1}{\tilde{w}}(w_t-\tilde{w}) &= \ln\left(\tilde{b}-\tilde{e}+\frac{\kappa_i}{1-\kappa_i}\tilde{\theta}+\kappa_i\left(\frac{r+\delta+s}{1-\kappa_i}\right)\left(\tilde{\theta}\right)^{1-\eta_i}\right)\\
&+\frac{1}{\tilde{b}-\tilde{e}+\frac{\kappa_i}{1-\kappa_i}\tilde{\theta}+\kappa_i\left(\frac{r+\delta+s}{1-\kappa_i}\right)(\tilde{\theta})^{1-\eta_i}}\left(b_t-e_t+\frac{\kappa_i}{1-\kappa_i}\theta_t+\kappa_i\left(\frac{r+\delta+s}{1-\kappa_i}\right)\theta_t^{1-\eta_i}-\left(\tilde{b}-\tilde{e}+\frac{\kappa_i}{1-\kappa_i}\tilde{\theta}+\kappa_i\left(\frac{r+\delta+s}{1-\kappa_i}\right)\left(\tilde{\theta}\right)^{1-\eta_i}\right)\right).
\end{aligned}$$

In the steady state, policy intervention is assumed to be absent, hence, $\tilde{b}-\tilde{e}=0$, this gives

$$\begin{aligned}
\ln\tilde{w}+\frac{1}{w^\star}(w_t-\tilde{w}) &= \ln\left(\frac{\kappa_i}{1-\kappa_i}\tilde{\theta}+\kappa_i\left(\frac{r+\delta+s}{1-\kappa_i}\right)\left(\tilde{\theta}\right)^{1-\eta_i}\right)\\
&+\frac{1}{\frac{\kappa_i}{1-\kappa_i}\tilde{\theta}+\kappa_i\left(\frac{r+\delta+s}{1-\kappa_i}\right)(\tilde{\theta})^{1-\eta_i}}\left(b_t-e_t+\frac{\kappa_i}{1-\kappa_i}\theta_t+\kappa_i\left(\frac{r+\delta+s}{1-\kappa_i}\right)\theta_t^{1-\eta_i}-\left(\frac{\kappa_i}{1-\kappa_i}\tilde{\theta}+\kappa_i\left(\frac{r+\delta+s}{1-\kappa_i}\right)\left(\tilde{\theta}\right)^{1-\eta_i}\right)\right).
\end{aligned}$$

[34] Recall that the first order condition of the optimal vacancy posting (3.9) reads as $\frac{\partial\sigma(v_t)}{\partial v_t}=v_t^{\gamma-1}=x(\theta_t)\frac{\partial J^F(h_t;\varphi)}{\partial h_t}$. Thus, $\frac{v_t^\gamma}{\gamma}=\frac{x(\theta_t)v_t}{\gamma}\frac{\partial J^F(h_t;\varphi)}{\partial h_t}=\sigma(v_t)$.

Since $\ln \tilde{w} = \ln \left(\frac{\kappa_i}{1-\kappa_i} \tilde{\theta} + \kappa_i \left(\frac{r+\delta+s}{1-\kappa_i} \right) \left(\tilde{\theta} \right)^{1-\eta_i} \right)$,

$$\begin{gathered} \frac{1}{\tilde{w}} \left(w_t - \tilde{w} \right) = \\ + \frac{b_t}{\tilde{w}} - \frac{e_t}{\tilde{w}} + \frac{\theta_t - \tilde{\theta}}{\tilde{w}} \frac{\kappa_i}{1-\kappa_i} \frac{\tilde{\theta}}{\tilde{\theta}} + \kappa_i \left(\frac{r+\delta+s}{1-\kappa_i} \right) \frac{\theta_t^{1-\eta_i} - \left(\tilde{\theta} \right)^{1-\eta_i}}{\tilde{w}} \frac{\left(\tilde{\theta} \right)^{1-\eta_i}}{\left(\tilde{\theta} \right)^{1-\eta_i}}. \end{gathered}$$

Using bold notation for log-linearised variables,

$$\boldsymbol{w}_t = \frac{b_t}{\tilde{w}} - \frac{e_t}{\tilde{w}} + \frac{\kappa_i}{1-\kappa_i} \frac{\tilde{\theta}}{\tilde{w}} \boldsymbol{\theta}_t + \kappa_i \left(\frac{r+\delta+s}{1-\kappa_i} \right) \frac{\left(\tilde{\theta} \right)^{1-\eta_i}}{\tilde{w}} \boldsymbol{\theta}_t^{1-\eta_i}.$$

We can therefore decompose dynamics in the wage rate into relative changes of employment benefits, subsidies, labour market tightness, and frictions to match jobs to vacancies. Notice, however, that this expression has not yet accounted for the existence of a homogenous sector, and thus does not refer to equilibrium wage rate. See discussion in Section 5.2.

B.2.2 Equilibrium Firm's Employment

To derive an expression for the equilibrium employment under non-linear vacancy posting costs, start with the profit function in (3.8) (to lighten notation, we abstract from a particular destination country):

$$\begin{aligned} \frac{\partial \pi_i (h_i; \varphi)}{\partial h_{it}} &= \beta \Upsilon_{it} (\varphi)^{1-\beta} A_{it} \varphi^\beta h_{it}^{\beta-1} - w_{it} (h_{it}; \varphi) - \frac{\partial w_{it} (h_{it}; \varphi)}{\partial h_{it}} h_{it} (\varphi) \\ = \beta \Upsilon_{it} (\varphi)^{1-\beta} A_{it} \varphi^\beta h_{it}^{\beta-1} &- \kappa_i \frac{\Gamma_{it} \varphi^\beta}{\kappa_i \beta + 1 - \kappa_i} h_{it}^{\beta-1} - (1-\kappa_i) \left(b_{it} - e_{it} + \frac{\kappa_i}{1-\kappa_i} \theta_{it} v_{it}^{\gamma_i - 1} \right) - \frac{\partial w_{it} (h_{it}; \varphi)}{\partial h_{it}} h_{it} (\varphi) \\ &= \beta \Upsilon_{it} (\varphi)^{1-\beta} A_{it} \varphi^\beta h_{it}^{\beta-1} - \kappa_i \beta \frac{\Gamma_{it} \varphi^\beta}{\kappa_i \beta + 1 - \kappa_i} h_{it}^{\beta-1} - (1-\kappa_i) \left(b_{it} - e_{it} + \frac{\kappa_i}{1-\kappa_i} \theta_{it} v_{it}^{\gamma_i - 1} \right) \\ &= \left(\frac{1-\kappa_i}{\kappa_i \beta + 1 - \kappa_i} \right) \Gamma_{it} \varphi^\beta h_{it}^{\beta-1} - (1-\kappa_i) \left(b_{it} - e_{it} + \frac{\kappa_i}{1-\kappa_i} \theta_{it} v_{it}^{\gamma_i - 1} \right), \end{aligned}$$

where we have used $\frac{\partial w_{it} (h_{it}; \varphi)}{\partial h_{it}} = \kappa_i (\beta - 1) \frac{\Gamma_{it} \varphi^\beta}{\kappa_i \beta + 1 - \kappa_i} h_{it}^{\beta-2}$ from (4.2), and $\Gamma_{ij,t} = \beta \Upsilon_{ij,t} (\varphi)^{1-\beta} A_{it}$. Employing a marginal profit definition in equation (4.4), and combining with the one just derived, yields

$$\left(\frac{1-\kappa_i}{\kappa_i \beta + 1 - \kappa_i} \right) \Gamma_{it} \varphi^\beta h_{it}^{\beta-1} - (1-\kappa_i) \left(b_{it} - e_{it} + \frac{\kappa_i}{1-\kappa_i} \theta_{it} v_{it}^{\gamma_i - 1} \right) = (r + \delta + s) \left(s h_{it} (\varphi) \right)^{\gamma_i - 1} x_{it}^{-\gamma_i},$$

or, after rearranging,

$$h_{it}^{\gamma_i - 1} \left(\left(\frac{1-\kappa_i}{\kappa_i \beta + 1 - \kappa_i} \right) \Gamma_{it} \varphi^\beta h_{it}^{\beta - \gamma_i} - (r + \delta + s) s^{\gamma_i - 1} x_{it}^{-\gamma_i} \right) = (1-\kappa_i) \left(b_{it} - e_{it} + \frac{\kappa_i}{1-\kappa_i} \theta_{it} v_{it}^{\gamma_i - 1} \right),$$

which is as reported in the main text.

B.2.3 Steady-state Labour Market Tightness in One-Sector Equilibrium

To analyse the steady state, recall the condition $x_i(\theta_i)\,\theta_i^{\eta_i-1} = \theta_i^{2(\eta_i-1)} = s_i/w_i$,[35] which allows pinning down the steady-state labour market tightness,

$$\begin{aligned}\theta_i &= \left(\frac{s_i}{w_i}\right)^{\frac{1}{2(\eta_i-1)}}\\ &= \left(\frac{s_i}{b_i-e_i+\frac{\kappa_i}{1-\kappa_i}\left(\theta_i+(r+\delta+s_i)\theta_i^{1-\eta_i}\right)}\right)^{\frac{1}{2(\eta_i-1)}},\end{aligned}$$

where the relationship between labour market tightness and the matching probability has been used from equation (3.1). Recall that in equilibrium all wages are equal (see equation (4.7)) and the probability of matching a vacancy with an unemployed worker is given by $\theta_i x_i = \theta_i^{\eta_i}$. However, the above expression is not yet constrained to admit the Harris-Todaro condition, hence, combining the two yields

$$\kappa_i\theta_i = (1-\kappa_i)\left(\left(\frac{w_i(\theta_i)}{s_i}\right)^{\frac{1}{2}} - b_i + e_i\right) - \kappa_i\left(r+\delta+s_i\right)\left(\frac{w_i(\theta_i)}{s_i}\right)^{\frac{1}{2}}. \tag{B.2}$$

This is again a non-linear map, and can be simulated for different values of deep parameters (refer to Figure C.1).

B.2.4 Partial Effects Under Convexity

With convex vacancy posting costs, however, the partial effects are

$$\begin{aligned}\frac{\partial w_{it}}{\partial h_{it}} &= (\beta-1)\,\kappa_i\frac{\Gamma_{it}\varphi^{\beta}}{\kappa_i\beta+1-\kappa_i}h_{it}^{\beta-2} = \frac{(\beta-1)\kappa_i\beta}{\kappa_i\beta+1-\kappa_i}h_{it}^{-2}r_{it}(\varphi),\\ \frac{\partial w_{it}}{\partial v_{it}} &= (1-\kappa_i)(\gamma_i-1)\frac{\kappa_i}{1-\kappa_i}\theta_{it}v_{it}^{\gamma_i-2},\\ \frac{\partial w_{it}}{\partial \varphi} &= \beta\kappa_i\frac{\Gamma_{it}\varphi^{\beta-1}}{\kappa_i\beta+1-\kappa_i}h_{it}^{\beta-1},\end{aligned}$$

whereas the firm's employment elasticity with respect to the convexity parameter γ_i is

$$\epsilon_{h_{it},\gamma_i} = \frac{1+\ln h_{it}^{\gamma\beta}-\gamma\frac{\kappa_i\beta}{\gamma\kappa_i\beta+1-\kappa_i}}{\gamma\beta-1} - \frac{(\gamma\kappa_i\beta+1-\kappa_i)\theta_{it}v_{it}^{\gamma-1}\ln v_{it}^{\gamma}}{(\gamma\beta-1)\Gamma_{it}\varphi^{\beta}h_{it}^{\gamma\beta-1}},$$

which is a function of γ_i itself, as stated in the main text (refer to the Lemma 2).

B.3 General Equilibrium

B.3.1 Agents and Preferences

Let us deal with the benchmark model with a single type of measure of workers and embed the sector in general equilibrium to determine the expected worker income, prices and aggregate income. Assume that (homothetic) preferences are defined over an aggregate consumption index ($\mathcal{C}_{it}$) and

[35] Recall that the condition comes from the steady state hiring rule $h_i(\varphi) = x_i(\theta)\,v_i(\varphi)/s_i$ linked to optimal vacancies, $v_i(\varphi) = w_i h_i(\varphi)/\theta_i^{1-\eta_i}$, thus yielding $h_i(\varphi) = \frac{x_i(\theta_i)w_i h_i(\varphi)}{s_i\theta_i^{1-\eta_i}}$ or $\theta_i^{1-\eta_i}/x_i(\theta_i) = w_i/s_i$.

exhibit risk neutrality:

$$\mathbb{U}_{it} = \mathbb{E}\mathcal{C}_{it}, \qquad (B.3)$$
$$= \mathbb{E}\left(\vartheta^{1-\zeta} q_{0it}^{\zeta} + (1-\vartheta)^{1-\zeta} Q_{it}^{\zeta}\right)^{\frac{1}{\zeta}}, \qquad 0 < \zeta < \beta,$$

where $\mathbb{E}$ is the expectations operator, the parameter ϑ determines the relative weight of the homogeneous and differentiated sectors in consumer preferences, whereas ζ determines substitution between homogeneous and differentiated goods.[36] The aggregate consumption index ($\mathcal{C}_{it}$) is defined over consumption of a homogeneous outside good (q_{0it}) and a real consumption index of differentiated varieties (Q_{it}). This utility function is maximised subject to aggregate expenditure (also income, as the two coincide in equilibrium), $\Omega_{it} = q_{0it} + \int_{\omega \in J} p_{it}(\omega) q_{it}(\omega) d\omega$.[37] Expected indirect utility is, therefore:

$$\mathbb{V}_{it} = \mathbb{E}\left(\frac{x_{it} w_{it}}{\mathcal{P}_{it}}\right), \qquad (B.4)$$

where $\mathcal{P}_{it}$ is the price index of the aggregate consumption index $\mathcal{C}_{it}$.[38] Therefore, the change in expected welfare, as a result of the opening of trade, depends solely on the change in the aggregate price index ($\mathcal{P}_{it}$), which, with our choice of numéraire, depends solely on the change in the price index for the differentiated sector (P_{it}).[39] The real consumption index for the sector (Q_{it}) is, therefore, defined as follows:

$$Q_{it} = \left(\int_{\omega \in J} q_{it}(\omega)^{\beta} d\omega\right)^{\frac{1}{\beta}}, \qquad (B.5)$$

where $q_{it}(\omega)$ denotes consumption of variety ω, and β, as before, controls the elasticity of substitution between varieties.

B.3.2 Firms and Technology

Given the specification of sectoral demand in (B.5), the equilibrium revenue of a firm is:

$$r_{it}(\omega) = p_{it}(\omega) q_{it}(\omega) = A_{it} q_{it}(\omega)^{\beta}, \qquad (B.6)$$

[36]Note that that the differentiated goods and the homogeneous good are closer substitutes than are the differentiated goods among themselves.

[37]The set of all varieties available in the differentiated sector is given by J. Each variety is indexed by ω, which can be linked to a firm productivity shock φ as each firm produces a distinct variety. Further recall that the product market is perfectly competitive in the homogeneous sector and there are no labour market or trade frictions; therefore, a price for a homogeneous good acts as the numéraire ($p_{0i} = \omega_i = 1$ in all time periods).

[38]Then the price index in the differentiated sector is uniquely pinned down from the relationship given the demand shifter (A_{it}) and aggregate income (Ω_{it}). Note that differentiated sector workers receive the same expected indirect utility as workers in the homogeneous sector when both goods are produced, hence, $\mathbb{V}_{it} = 1/\mathcal{P}_{it}$.

[39]As in Helpman *et al.* (2010); Helpman and Itskhoki (2010), the interpretation is standard. Hence, the opening of trade raises the zero-profit productivity cut-off, φ_d. The rise in φ_d implies a lower value of the demand shifter, A_{it}. Given constant aggregate income, Ω_{it}, and a lower value of A_{it}, CES demand implies that the opening of trade reduces the price index for the differentiated sector, P_{it}, which implies higher expected welfare in the open than in the closed economy.

where $A_{it} \equiv E_{it}^{1-\beta} P_{it}^{\beta}$ is a demand-shifter for the sector, i.e. $q_{it}(\omega) = (A_{it}/p_{it}(\omega))^{\frac{1}{1-\beta}} = \left(p_{it}(\omega)/P_{it}^{\beta}\right)^{\frac{1}{\beta-1}} E_{it}$, and E_{it} is the total expenditure on varieties within the differentiated sector while P_{it} is the differentiated sector's ideal price index. After a firm observes its productivity φ, which is independently distributed and drawn from a Pareto distribution $G(\varphi) = 1 - (\varphi_{min}/\varphi)^z$ for $\varphi \geq \varphi_{min} > 0$ and $z > 1$, the firm chooses to exit or enter the sector and whether to produce solely domestically or for both the domestic and the export markets.[40] Once these decisions have been made, the firm and its hired workers engage in strategic bargaining over the division of revenue, as outlined above.

A firm incurs the production's sunk entry cost, $f_{ii,t}$, as well as the fixed cost of exporting, $f_{ij,t}$, both being expressed in terms of units of the numéraire. Additionally, there is an iceberg variable trade cost, $\tau > 1$, measuring the extra amount of goods to be shipped for one unit to arrive in the foreign market. Output of each variety (y) depends on the idiosyncratic productivity of the firm (φ) and the measure of workers hired (h):

$$y_{it}(\varphi) = \varphi h_{it}(\varphi), \tag{B.7}$$

To pin down the prices for any variety j, we use the expression for $q_{it}(\omega)$ to arrive at the the inverse demand function for a firm

$$p_{it}(\omega) = E_{it}^{1-\beta} P_{it}^{\beta} q_{it}(\omega)^{-(1-\beta)}.$$

Using technology, we know that[41]

$$p_{it}(\omega) = \frac{r_{it}(\omega)}{q_{it}(\omega)} = \varphi^{\beta-1} h_{it}^{\beta-1}. \tag{B.8}$$

Since the demand side is equivalent to that in Helpman *et al.* (2010); Helpman and Itskhoki (2010), a firm's total revenue can still be expressed as

$$r_{it}(\varphi) \equiv r_{ii,t}(\varphi) + r_{ij,t}(\varphi) = \Upsilon_{it}(\varphi)^{1-\beta} A_{it} y_{it}(\varphi)^{\beta}, \tag{B.9}$$

where $r_{ii,t}(\varphi) \equiv A_{it} y_{ii,t}(\varphi)^{\beta}$ is the revenue from domestic sales and $r_{ij,t}(\varphi) \equiv A_{jt}(y_{ij,t}(\varphi)/\tau_{ij,t})^{\beta}$ is the revenue from exporting to market j.[42] Variable $\Upsilon_{ij,t}(\varphi)$ captures a firm's overall 'market

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[40] We choose $z = 3.4$ for simulation exercises, refer to Table 4.1. Such a shape parameter implies that the unconditional mean of Pareto distributed random variable is $\mathbb{E}\varphi = \frac{z}{z-1}\varphi_{min} = 1.42$ where $\varphi_{min} = 1$. The conditional mean is $\mathbb{E}(\varphi \mid \varphi > \varphi_d) = \frac{z}{z-1}\varphi_d$, provided that the upper bound is unbounded. The latter is an endogenous object because threshold productivity φ_d is determined from within the model.

[41] Using the optimal employment level in (4.6), the price is given by $p_{it}(\omega) = \frac{\kappa_i\beta+1-\kappa_i}{\beta\gamma_i}\varphi^{-1}\left[\frac{b_{it}-e_{it}+\frac{\kappa_i}{1-\kappa_i}\theta_{it}+\left(\frac{r+\delta+s}{1-\kappa_i}\right)x_{it}^{-1}}{A_t\Upsilon_{ij,t}(\varphi)^{1-\beta}}\right]$. Therefore, the domestic firm's revenue is provided by $r_{it}(\omega) = E_{it}^{1-\beta} P_{it}^{\beta}\varphi^{\beta} h_{it}^{\beta\gamma_i}$. Given consumers' love of variety and a fixed production cost, no firm will ever serve the export market without also serving the domestic market. If a firm exports, it allocates its output $(y_{it}(\varphi))$ between the domestic and all export markets ($y_{ii,t}(\varphi)$ and $y_{ij,t}(\varphi)$, respectively) to equate its marginal revenues in the two markets, which, from equation (B.6), implies $\left[\frac{y_{ij,t}(\varphi)}{y_{ii,t}(\varphi)}\right]^{1-\beta} = \tau_{ij,t}^{-\beta}\left(\frac{A_{jt}}{A_{it}}\right)$.

[42] Notice that, given symmetry, production for exporting (denoted by j) and domestic (denoted by i) markets (where time subscript was omitted to ease notation) follows $\left[\frac{y_{ij}(\varphi)}{y_{ii}(\varphi)}\right]^{1-\beta} = \tau_{ij}^{-\beta}\frac{A_j}{A_i}$ together with $y_{ii}(\varphi) + y_{ij}(\varphi) = y_i(\varphi)$ imply $y_{ii}(\varphi) = \frac{y_i(\varphi)}{\Upsilon_i(\varphi)}$ and $y_{ij}(\varphi) = \frac{y_i(\varphi)}{\Upsilon_i(\varphi)}(\Upsilon_i(\varphi) - 1)$, and hence $r_{ii}(\varphi) = \frac{r_i(\varphi)}{\Upsilon_i(\varphi)}$ and $r_{ij}(\varphi) = \frac{r_i(\varphi)}{\Upsilon_i(\varphi)}(\Upsilon_i(\varphi) - 1)$.

access', which depends on whether it chooses to serve both the domestic and foreign markets or only the domestic market (where j denotes either a generic country or rest of the world):

$$\Upsilon_{it}(\varphi) \equiv 1 + \mathcal{I}_{ij,t}(\varphi)\, \tau_{ij,t}^{-\frac{\beta}{1-\beta}} \left(\frac{A_{jt}}{A_{it}}\right)^{\frac{1}{1-\beta}} \geq 1, \tag{B.10}$$

where $\mathcal{I}_{ij,t}(\varphi)$ is an indicator variable that equals one if the firm exports and zero otherwise ($\Upsilon_{ij,t}(\varphi)$ denotes 'market access' from i to j when an indicator function assumes a value of one, $\mathcal{I}_{ij,t}(\varphi) = 1$).[43]

Combining the production technology with equilibrium wage and hiring rates with (B.9) and (B.10), the net profit maximisation problem can be expressed as:

$$\pi_{it}(\varphi) = \max_{\substack{h_{it} \geq 0 \\ \mathcal{I}_{ij,t} \in \{0,\,1\}}} \left\{ \sum_j \left[1 + \mathcal{I}_{ij,t}(\varphi)\, \tau_{ij,t}^{-\frac{\beta}{1-\beta}} \left(\frac{A_{jt}}{A_{it}}\right)^{\frac{1}{1-\beta}}\right]^{1-\beta} A_{it}(\varphi h_{it})^{\beta} - w_{it}h_{it} - f_{ii,t} - \sum_j \mathcal{I}_{ij,t} f_{ij,t} \right\}. \tag{B.11}$$

Given that a large empirical literature finds evidence of selection into export markets, where only the most productive firms export, we focus on values of trade costs for which $\varphi_{ij} > \varphi_{ii} > \varphi_{min}$. Further, note that a firm's revenue equation (B.9) can be solved explicitly for $r_{it}(\varphi)$ as a function of aggregates, parameters, and firm productivity φ:

$$r_{it}(\varphi) = \Upsilon_{it}(\varphi)^{1-\beta} A_{it}\varphi^{\beta} h_{it}^{\beta} \tag{B.12}$$

$$= \Upsilon_{it}(\varphi)\, A_{it}^{\frac{1}{1-\beta}} \left(\frac{\beta}{\kappa_i\beta + 1 - \kappa_i}\right)^{\frac{\beta}{1-\beta}} \varphi^{\frac{\beta}{1-\beta}} \left(b_{it} - e_{it} + \frac{\kappa_i}{1-\kappa_i}\theta_{it} + \left(\frac{r+\delta+s}{1-\kappa_i}\right)\theta_{it}^{1-\eta_i}\right)^{\frac{\beta}{\beta-1}}, \tag{B.13}$$

where the second line is applicable only to the linear vacancy posting costs. The average revenue per employee is

$$\frac{r_{it}(\varphi)}{h_{it}(\varphi)} = \left(\frac{\kappa_i\beta + 1 - \kappa_i}{\beta}\right) \left(b_{it} - e_{it} + \frac{\kappa_i}{1-\kappa_i}\theta_{it} + \left(\frac{r+\delta+s}{1-\kappa_i}\right)\theta_{it}^{1-\eta_i}\right), \tag{B.14}$$

and is clearly independent of the firm productivity and dependent on labour market policies, benefits and subsidies, and labour market tightness. Ignoring labour market tightness, firms are larger (in terms of revenues) under higher benefits and smaller under larger subsidies. This is because, in the absence of the government sector, changes in labour market institutions act as exogenous taxes or subsidies on firms.

[43] Note that, ignoring time, the intensive margin $\left(\frac{y_i(\varphi)}{y_{ii}(\varphi)}\right)$ is constant across firms since the generic version of a market access is $\Upsilon_i(\varphi) = 1 + \mathcal{I}_{ij}(\varphi)\left(\tau_{ij}^{-\beta}\left(\frac{A_j}{A_i}\right)\right)^{\frac{1}{1-\beta}}$, which is just a function of aggregate (sectoral) variables. We can think of j as the rest of the world. That is, from $\Upsilon_i(\varphi) = 1 + \frac{y_{ij}(\varphi)}{y_{ii}(\varphi)}$, for any $\varphi > \varphi_{ij}$, a firm exports a constant share of its total production.

B.3.3 Harris-Todaro Condition with the Homogenous Sector

It is required that the expected wage in the differentiated sector is equal to the wage in the outside sector, as is also imposed by the Harris-Todaro condition, that is

$$\mathbb{E}\left[w_{it}(\varphi)\middle|\,\varphi>\varphi_d\right]=\frac{\int_{\varphi_d}^{\infty}w_{it}h_{it}(\varphi)\,dG(\varphi)}{\int_{\varphi_d}^{\infty}h_{it}(\varphi)\,dG(\varphi)}=1.$$

Computing each expected value in turn yields

$$\begin{aligned}\int_{\varphi_d}^{\infty}w_{it}h_{it}\frac{dG(\varphi)}{1-G(\varphi_d)}&=\left(\Theta_{it}+\kappa_i\left(\tfrac{r+\delta+s}{1-\kappa_i}\right)x_{it}^{-1}\right)\left(\Theta_{it}+\left(\tfrac{r+\delta+s}{1-\kappa_i}\right)x_{it}^{-1}\right)^{\frac{1}{\beta-1}}z\varphi_d^{z}\left(\tfrac{1}{\kappa_i\beta+1-\kappa_i}\right)^{\frac{1}{1-\beta}}\\&\quad\times\int_{\varphi_d}^{\infty}\left(\beta\gamma\Upsilon_{it}(\varphi)^{1-\beta}A_{it}\varphi^{\beta}\right)^{\frac{1}{1-\beta}}\varphi^{-z-1}d\varphi\\&=\left(\Theta_{it}+\kappa_i\left(\tfrac{r+\delta+s}{1-\kappa_i}\right)x_{it}^{-1}\right)\left(\Theta_{it}+\left(\tfrac{r+\delta+s}{1-\kappa_i}\right)x_{it}^{-1}\right)^{\frac{1}{\beta-1}}\left(\tfrac{1}{\kappa_i\beta+1-\kappa_i}\right)^{\frac{1}{1-\beta}}(\beta\gamma A_{it})^{\frac{1}{1-\beta}}\\&\quad\times\tfrac{z(1-\beta)}{z(1-\beta)-\beta}\left(\varphi_d^{\frac{\beta}{1-\beta}}+(\Upsilon_x-1)\varphi_x^{\frac{\beta}{1-\beta}}\left(\tfrac{\varphi_d}{\varphi_x}\right)^{z}\right).\end{aligned}$$

The expected measure of employed workers is equal to

$$\begin{aligned}\int_{\varphi_d}^{\infty}h_{it}(\varphi)\frac{dG(\varphi)}{1-G(\varphi_d)}&=\left(b_{it}-e_{it}+\tfrac{\kappa_i}{1-\kappa_i}\theta_{it}+\left(\tfrac{r+\delta+s}{1-\kappa_i}\right)x_{it}^{-1}\right)^{\frac{1}{\beta-1}}\left(\tfrac{1}{\kappa_i\beta+1-\kappa_i}\right)^{\frac{1}{1-\beta}}(\beta\gamma A_{it})^{\frac{1}{1-\beta}}\left(\tfrac{\varphi_d}{\varphi_{min}}\right)^{z}\\&\times\int_{\varphi_d}^{\infty}\left(\Upsilon_{it}(\varphi)^{1-\beta}\varphi^{\beta}\right)^{\frac{1}{1-\beta}}z\varphi_{min}^{z}\varphi^{-z-1}d\varphi=\left(b_{it}-e_{it}+\tfrac{\kappa_i}{1-\kappa_i}\theta_{it}+\left(\tfrac{r+\delta+s}{1-\kappa_i}\right)x_{it}^{-1}\right)^{\frac{1}{\beta-1}}\left(\tfrac{1}{\kappa_i\beta+1-\kappa_i}\right)^{\frac{1}{1-\beta}}\\&\times(\beta\gamma A_{it})^{\frac{1}{1-\beta}}z\varphi_d^{z}\int_{\varphi_d}^{\infty}\Upsilon(\varphi)\varphi^{\frac{\beta}{1-\beta}-z-1}d\varphi=\left(b_{it}-e_{it}+\tfrac{\kappa_i}{1-\kappa_i}\theta_{it}+\left(\tfrac{r+\delta+s}{1-\kappa_i}\right)x_{it}^{-1}\right)^{\frac{1}{\beta-1}}\\&\times\left(\tfrac{1}{\kappa_i\beta+1-\kappa_i}\right)^{\frac{1}{1-\beta}}(\beta\gamma A_{it})^{\frac{1}{1-\beta}}\tfrac{z(1-\beta)}{z(1-\beta)-\beta}\left(\varphi_d^{\frac{\beta}{1-\beta}}+(\Upsilon_x-1)\varphi_x^{\frac{\beta}{1-\beta}}\left(\tfrac{\varphi_d}{\varphi_x}\right)^{z}\right)\\&=\left(\Theta_{it}+\left(\tfrac{r+\delta+s}{1-\kappa_i}\right)x_{it}^{-1}\right)^{\frac{1}{\beta-1}}\left(\tfrac{\beta\gamma A_{it}}{\kappa_i\beta+1-\kappa_i}\right)^{\frac{1}{1-\beta}}\left(\tilde{\varphi}_d^{\frac{\beta}{1-\beta}}+(\Upsilon_x-1)\tilde{\varphi}_x^{\frac{\beta}{1-\beta}}\left(\tfrac{\varphi_d}{\varphi_x}\right)^{z}\right).\end{aligned}$$

where Υ_x is an indicator function which is larger than unity if φ_x threshold is passed. Hence, the ratio is

$$\begin{aligned}&x_{it}\frac{\int_{\varphi_d}^{\infty}w_{it}h_{it}dG(\varphi)}{\int_{\varphi_d}^{\infty}h_{it}dG(\varphi)}\\&=x_{it}\frac{\left(\Theta_{it}+\kappa_i\left(\frac{r+\delta+s}{1-\kappa_i}\right)x_{it}^{-1}\right)\left(\Theta_{it}+\left(\frac{r+\delta+s}{1-\kappa_i}\right)x_{it}^{-1}\right)^{\frac{1}{\beta-1}}z\left(\frac{1}{\kappa_i\beta+1-\kappa_i}\right)^{\frac{1}{1-\beta}}(\beta\gamma A_{it})^{\frac{1}{1-\beta}}\frac{1}{z-\frac{\beta}{1-\beta}}\left(\varphi_d^{\frac{\beta}{1-\beta}-z}+(\Upsilon_x-1)\varphi_x^{\frac{\beta}{1-\beta}}\left(\frac{\varphi_d}{\varphi_x}\right)^{z}\right)}{\left(b_{it}-e_{it}+\frac{\kappa_i}{1-\kappa_i}\theta_{it}+\left(\frac{r+\delta+s}{1-\kappa_i}\right)x_{it}^{-1}\right)^{\frac{1}{\beta-1}}\left(\frac{1}{\kappa_i\beta+1-\kappa_i}\right)^{\frac{1}{1-\beta}}(\beta\gamma A_{it})^{\frac{1}{1-\beta}}z\frac{1-\beta}{z(1-\beta)-\beta}\left(\varphi_d^{\frac{\beta}{1-\beta}}+(\Upsilon_x-1)\varphi_x^{\frac{\beta}{1-\beta}}\left(\frac{\varphi_d}{\varphi_x}\right)^{z}\right)}\\&=x_{it}\left(b_{it}-e_{it}+\tfrac{\kappa_i}{1-\kappa_i}\theta_{it}+\kappa_i\left(\tfrac{r+\delta+s}{1-\kappa_i}\right)x_{it}^{-1}\right)=x_{it}\Theta_{it}+\kappa_i\left(\tfrac{r+\delta+s}{1-\kappa_i}\right)=1.\end{aligned}$$

Since wage (under linear vacancy posting costs) is constant across differently productive firms, the conditional average is still equal to the unconditional value of wage rate.

C Other Supporting Material

C.1 Labour Market Tightness

A map between labour market tightness and Harris-Todaro condition in a steady state is given in Figure C.1.

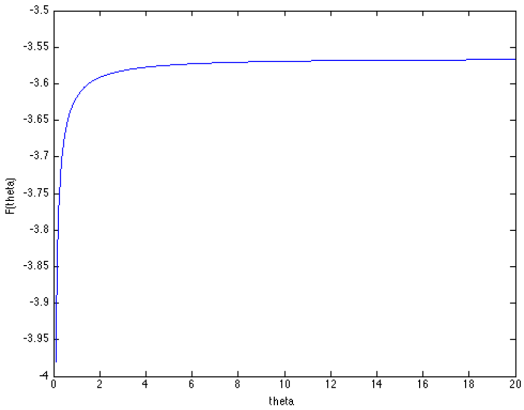

Figure C.1: Values of labour market tightness

C.2 Changes in GDP

Changes in GDP are computed for the same parameter configuration as in the graphs for profits and openness in the main text. The magnitudes of labour market variables are not comparable as expenditure on labour market policies is divided by 100 to make a better comparison with the variable of unemployment benefits (also refer to Table A.1 for summary statistics). These two graphs in Figure C.2 should thus be used for qualitative rather than quantitative inference.

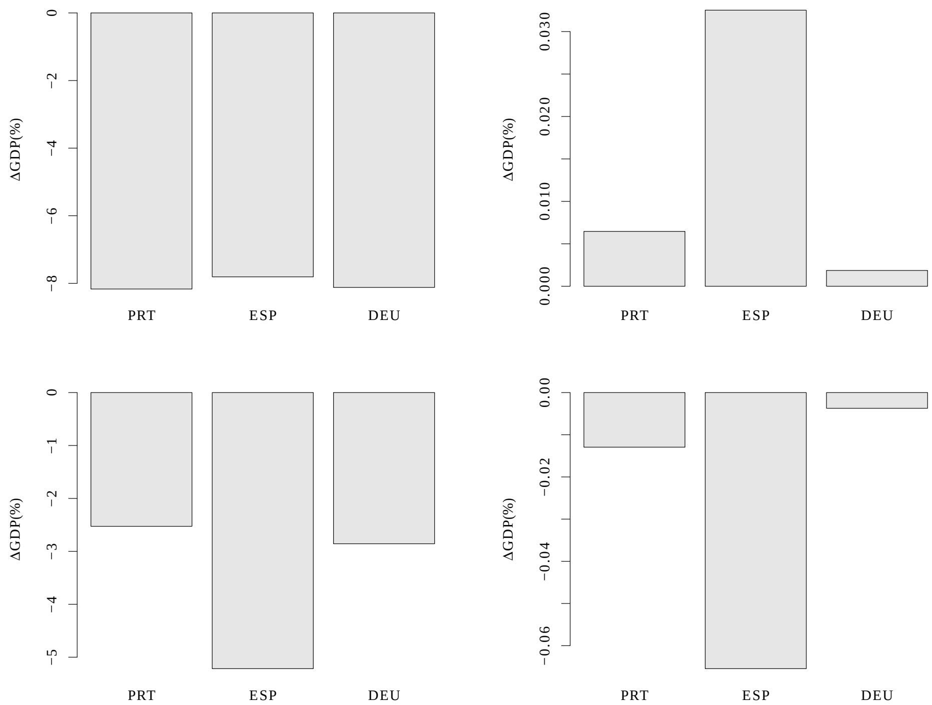

Figure C.2: GDP reactions due to changes employment contingent subsidies (above) and unemployment benefits (below) in the two (left) and one (right) sector equilibrium