1 Introduction

This paper presents the Diamond-Mortensen-Pissarides (DMP) model with heterogeneous firms and workers alongside pooled equilibrium with two-type vacancies based on visa status. The DMP model is widely accepted as the most realistic account of unemployment (Hall, 2012). The model allows for formalising the economic principles governing labour markets, capturing: (1) labour turnover through a stochastic separation framework, (2) job finding rates via labour market tightness influenced by vacancy creation, and (3) wage determination, regulated via Nash Bargaining. The paper aims to build a DMP model to assess and quantify the impact of visa sponsorship costs (VSC) and the minimum salary requirement (MSR) policy on domestic and non-EU graduate unemployment in the UK. The advantage of using a theoretical model in this policy context is the ability to keep structural parameters constant, so as to isolate the impact of the policies. This is especially important since the impact of the two policies at hand — especially MSR — on graduate and non-EU unemployment is intuitively ambiguous: particularly on domestic unemployment, given the crowding-out effect.

The significance of these policies extends beyond simply unemployment. Post-graduation work opportunities are a key factor in attracting international students (Gopal, 2016). In 2018, non-EU students had a net economic benefit of over £22.7 billion to the UK economy (ICEF, 2021). It is therefore crucial to ensure a strong foreign graduate market to incentivize international students to study in the UK and thereby support local economies.

The model is calibrated using appropriate structural parameter values, as well as data from the HESA Graduate Outcomes 2017/2018 survey for the MSR impact, so as to best quantify policy effects on the UK graduate labour market. Two scenarios are assessed to individually isolate the impact of the two policies, focusing specifically on a pooled worker equilibrium. The main findings of this paper indicate that lowering VSC leads to a Pareto-improving outcome; both domestic and non-EU unemployment falls, albeit at a more drastic rate for non-EU graduates. This paper finds that increasing the MSR threshold has a negligible impact on domestic unemployment. However, non-EU graduate unemployment increases significantly. A hypothetical increase in the MSR from £15,000 to £35,000 results in a 0.2% decrease in domestic graduate unemployment, contrasted by a 6% increase for non-EU graduates. The results of this paper allow policymakers to quantify and weigh the impacts of the two policies on unemployment and subsequently drive policy recommendations. This paper contributes to the literature by examining the influence of visa sponsorship costs and minimum salary requirements on graduate vacancy creation and allocation decisions of firms, and unemployment levels among graduate workers with differing visa statuses in the UK.

2 The Diamond-Mortensen-Pissarides Model

2.1 Setting up the Model

This section introduces our graduate labour market model with heterogeneous jobs and workers, extended to include the effects of VSC and MSR.

2.1.1 Main Assumptions

The labour market is populated by a continuum of heterogenous workers and identical firms. All agents are infinitely lived, risk-neutral, and discount the future at a common risk-free rate *r*.

Workers are either domestic (*d*) or foreign (*f*). Please note that this terminology is meant to separate only by visa status — an EU graduate with right-to-work in the UK will still be considered domestic. In our model, we assume that only university graduates compete for graduate jobs. The fraction of foreign graduate workers is denoted by $\rho \in (0,1)$, while the remaining domestic workers are $1-\rho$. This distribution of workers is determined by the immigrant minimum wage policy (see section 3.1.5). Workers can only either be employed or unemployed.

There are two types of jobs: sponsoring foreign visas (*s*) and not sponsoring (*n*). A key assumption is that domestic workers can undertake both jobs, whereas foreign can only work sponsored jobs. Both filled jobs break up at a fixed exogenous separation rate λ.

Let $x_i^j = y_i$ formally denote the output of a matched job between a worker type $i, i = d, f$ and a job $j, j = n, s$. Both workers have different output productivities (y_i), with a domestic graduate producing the same output (y_d) regardless of the job type, and a foreign graduate only producing (y_f) if at a sponsored job. The output match is summarized below:

	Sponsored (s)	Not sponsored (n)
Foreign (f)	$x_f^s = y_f$	0
Domestic (d)	$x_d^s = y_d$	$x_d^n = y_d$

2.1.2 Matching Function

We get rid of the Walrasian auctioneer and assume that job seekers are matched with vacant jobs according to a stochastic matching technology $m(u, v)$, where u and v respectively denote the measure of unemployment and vacancies. The matching function can take many forms; however, it is conventionally assumed to be concave, homogenous to the degree of one, and increasing in each argument (Yashiv, 2007). For simplicity, we assume a Cobb-Douglas function such that:

$$m(u, v) = u^{\mu} v^{1-\mu}$$

where $\mu \in (0,1)$ is our match elasticity. As such, our vacancy filling rate can be defined as

$$\frac{m(u, v)}{v} = \theta^{-\mu} = q(\theta), \text{ where } \theta = \frac{v}{u}$$

In our matching equation, θ is the measurement of the degree of *labour market tightness,* where $\theta > 0$. The job finding rate, at which an unemployed worker meets a vacancy, can be given as:

$$\frac{m(u, v)}{u} = \frac{v}{u}\frac{m(u, v)}{v} = \theta^{1-\mu} = \theta q(\theta)$$

We see that $\theta q(\theta)$ is strictly increasing for all positive values of θ while $q(\theta)$, where $\frac{dq(\theta)}{d\theta} < 0$ and $\frac{d\theta q(\theta)}{d\theta} > 0$. This makes intuitive sense because as the labour market becomes tighter, it is easier for job seekers to find jobs, since there are more vacancies per unemployed person, and vice-verse in a slack labour market.

Job search is assumed to be *undirected*, which implies that while a foreign jobseeker can encounter both types of vacancies, only a match with a sponsored job can be productive. Given that not all search job encounters produce into a fruitful match, it is useful to determine the effective meeting rates. Let ϕ determine the fraction of sponsored vacancies, with $1-\phi$ being the share of non-sponsored vacancies. The effective job-finding rate for an unemployed foreign worker would therefore be $\phi\theta q(\theta)$. For domestic workers, it would still be $\theta q(\theta)$, since they can work both types of jobs. By the same token, let γ be the fraction of unemployed foreign workers, with $1-\gamma$ being the share of unemployed domestic workers. As such, the effective rate at which *any* vacancy meets a domestic worker is given $(1-\gamma)q(\theta)$, and a *sponsored* vacancy meeting a foreign worker is $\gamma q(\theta)$.

2.1.3 Match Surplus and Bellman Value Functions

For job matches between unemployed jobseekers and firm vacancies to be realized, the match surplus has to be nonnegative. In other words, both parties have to be equal to or better off than they were unmatched for a match to formalize. Let W_i^j and U_i for workers type $i, i = d, f$, with the former denoting the utility value of being employed when matched with job vacancies $j, j = n, s$ and the later the value of unemployment. Similarly, let V^j be the value of a vacancy, with the corresponding value of a filled job being J_i^j. As such, for a job match to formalize, it must hold that:

$$S_i^j = \left(J_i^j - V_i^j\right) - \left(W_i^j - U_i^j\right) \geq 0 \qquad (1)$$

where S_i^j is the total job match surplus, given by the respective capital gains of each agent from switching labour market state; for jobseekers $\left(W_i^j - U_i^j\right)$ and firms $\left(J_i^j - V_i^j\right)$. The flow values of unemployment for a foreign worker can be given as:

$$rU_f = b_f + \phi\theta q(\theta)(W_f^s - U_f) \qquad (2)$$

where $b_i > 0$ is an exogenously determined value of leisure, and $\phi\theta q(\theta)(W_f^n - U_f)$ is the capital gains adjusted for probability of switching states. The Bellman unemployment flow value for a domestic worker is:

$$rU_d = b_d + \theta q(\theta)\{\phi \max(W_d^s - U_d, 0) + (1-\phi)(W_d^s - U_d)\} \qquad (3)$$

While similar to rU_f, the capital gains value is adjusted to fit both working a sponsored (W_d^s) and not sponsored job (W_d^n), where $\max(W_d^s - U_d, 0)$ captures the fact that it may not be *worthwhile* for a domestic worker to match with a sponsored job. That said, given our interest in a *pooled equilibrium*, we will adjust parameters to make it beneficial. Furthermore, following Ortega (2000), we set the value of leisure higher for domestic than foreign graduates such that $b_d > b_f > 0$. This is because domestic graduate has access to unemployment benefits in the UK as well as do not experience regulatory time restrictions to find a job.

The flow value of employment for any given worker $i, i = d, f$ working a job $j, j = n, s$ can be given as

$$rW_i^j = w_i - \lambda\left(W_i^j - U_i^j\right) \qquad (4)$$

where $w_i > 0$ is the wage a worker receives, and $-\lambda\left(W_i^j - U_i^j\right)$ is the capital loss from switching from employment to unemployment multiplied by the exogenous probability λ of a match breaking apart.

From the firm's perspective, the value of a filled job with worker $i, i = d, f$ and a job $j, j = n, s$ is

$$rJ_i^j = y_i - w_i - B_i^j - \lambda(J_i^j - V_i^j) \qquad (5)$$

where $y_i > 0$ is the output produced by a worker, w_i is the wage cost, $-\lambda(J_i^j - V_i^j)$ is the effective capital loss for the match breaking apart, and B_i^j is the visa sponsorship cost. B_i^j consists of

$$B_i^j = \tau \qquad (6)$$

where τ is the cost of sponsoring a visa. This includes a fixed fee for which employers pay to the government per sponsored foreign workers as well as cost associated with hiring specialized HR staff to navigate the legal process. If a non-sponsored job hires a domestic worker, they do not have to pay visa sponsorship, such that

$$B_d^n = 0 \qquad (7)$$

However, with sponsored jobs, it becomes trickier concerning the type of worker. Some foreign-graduate-hiring firms pay the same wage to both foreign and domestic workers, choosing to absorb the VSC into their general operating costs, so that the visa costs would reflect in the wages of both domestic and foreign workers. We take those firms into account, and when taking a general firm population approach, the visa sponsorship cost for a foreign worker becomes

$$B_f^s = \pi\tau \qquad (8)$$

where $\pi \in (0.5, 1)$ is an exogenous parameter denoting the fraction of the firm VSC that foreign workers absorb. As such, the visa sponsorship cost for a domestic worker is

$$B_d^s = (1 - \pi)\tau \qquad (9)$$

Given $\pi \in (0.5, 1)$, it follows that $B_f^s > B_f^s$, such that it is always more expensive to sponsor a foreign rather than a domestic worker.

Moving on to the value of vacancies, the respective flow value of a sponsored and non-sponsored vacancies are

$$rV^s = -k + q(\theta)\left[\gamma\left(rJ_f^s - V^s\right) + (1 - \gamma)\max(rJ_d^s - V^s, 0)\right] \qquad (10)$$

and

$$rV^n = -k + q(\theta)(1 - \gamma)(rJ_d^n - V^n) \qquad (11)$$

where $k > 0$ is the flow cost of maintain a vacancy, and equation (10) captures the fact that both foreign and domestic jobseekers can work a sponsored job. As with rU_d, $\max(rJ_d^s - V^s, 0)$ captures the fact that is must be *worthwhile* for a sponsored job to hire domestic workers.

2.1.4 Wage Determination

The wage for each job is determined by a Nash bargaining solution, such that a match should maximize the weighted product of the workers and firms respective match surplus (S_i^j). This bargaining solution is given by $\left(J_i^j - V^j\right)^{1-\beta}\left(W_i^j - rU_i\right)^{\beta}$, subject to the respective flow values given by rJ_i^j and rW_i^j. $\beta \in (0,1)$ is the measure of a worker's bargaining power, determined exogenously as by Pissarides (2000). As such, we take the first-order condition with respect to w_i

$$(1 - \beta)\frac{dJ_i^j}{dw_i}\left(W_i^j - rU_i\right) = \beta\frac{dW_i^j}{dw_i}\left(J_i^j - V^j\right)$$

which yield us

$$\left(W_i^j - rU_i\right) = \beta S_i^j \qquad (12)$$

and

$$\left(J_i^j - V^j\right) = (1-\beta)S_i^j \qquad (13)$$

as our surplus sharing equations, implying that fraction β of the match surplus goes to the worker, while the rest $(1-\beta)$ goes to the firm. Now, to more specifically denote match surplus S_i^j, setting $V^j = 0$ (free-entry condition, explained later) and substituting equations (4) and (5) into (1), total match surplus is given by

$$S_i^j = \frac{y_i - B_i^j - rU_i}{r+\lambda} \qquad (14)$$

The above equation demonstrates that match surplus is negatively affected by visa sponsorship costs B_i^j as well as the worker reservation value rU_i. What is more interesting to see is the agent who bears the burden of the visa sponsorship cost. Under a flexible wage structure, by substituting equation (14) into (5) and utilizing (13), we get

$$w_i = rU_i + \beta(y_i - B_i^j - rU_i) \qquad (15)$$

demonstrating that firms shift the burden of B_i^j by the fraction β, the relative worker bargaining power, through a wage cut.

2.1.5 Foreign Minimum Salary Requirement Policy

The UK government takes an immigration policy approach such that only graduates with a salary above a determined minimum can stay and work. This is meant to decrease the number of foreign graduates competing for UK graduate jobs, as well as limit the foreign graduate pool to the most productive workers, using wages as a proxy for productivity.

We use data from the UK Higher Education Statistics Agency (HESA) on 2017/18 graduates, which surveys graduates 15 months after their graduation on employment status. It includes 369,395 observations, out of which 45,225 are non-EU students, 23,075 EU students, and the rest are UK students. We only examine entries from full-time undergraduate students who have completed their university course. Furthermore, since it is summary data with salary range benchmarks, we assume that wages are uniformly distributed between those salary brackets (see appendix A.12 for further explanation).

We attempt to capture the effects of this policy by making ρ, the fraction of immigrant graduate workers, and y_f, average foreign worker productivity, a function of the MSR policy, where $\overline{w_f}$ is the minimum foreign wage.

To do so, we first assume that foreign and domestic graduate productivity is inherently equal, such that $y_f = y_d$ when $\overline{w_f} = 0$. We take wages as a proxy for productivity. In our model, y_d is the mean of the total domestic wage data (we combine wage data for both UK and EU graduates), such that

$$y_d = \frac{\sum_{i=1}^{N} x_i}{N} \qquad (16)$$

and then normalize it to one such that $y_d = 1$. On the other hand, y_f is determined by taking the same wage data but taking the mean of the wages *above* the foreign minimum wage, and then taken as a fraction of y_d, such that

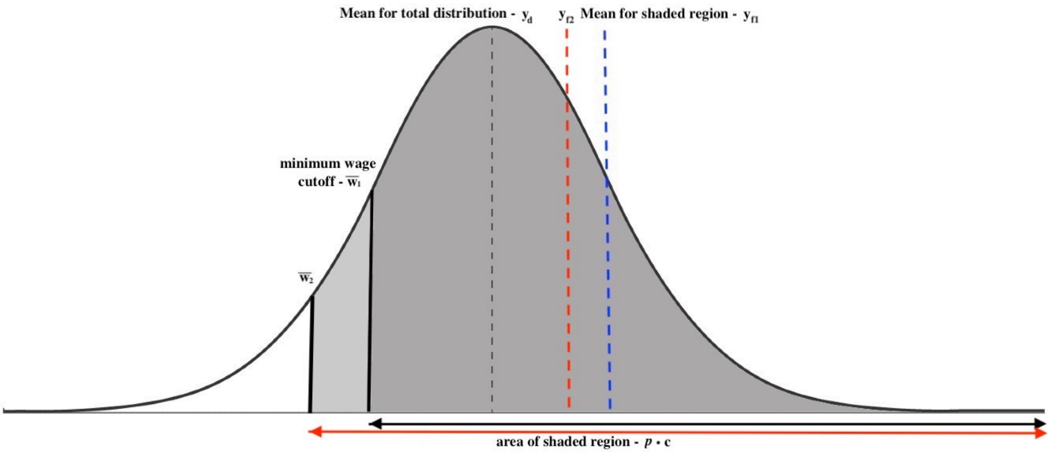
$$y_f = \frac{\sum_{i=1}^{\widehat{N}} \widehat{x_i}}{\widehat{N}} \cdot \frac{1}{y_d} \;\text{ for }\; \widehat{x_i} \geq \overline{w_f} \qquad (17)$$

where $\widehat{N}$ is the total number of observations of wages $\widehat{x_i}$ above $\overline{w_f}$.

With regards to ρ, we assume that all foreign graduates want to stay and work in the UK. While this is a sweeping assumption, it does have some truth as living standards tend to be much higher in the UK than in most non-EU countries and the primary focus is to demonstrate the basic relationship between the two. As such, we take ρ as the *cumulative density function* of the total domestic wage distribution, multiplied by the initial fraction of foreign to domestic graduates, c, such that

$$\rho = c \cdot \frac{\widehat{N}}{N} \qquad (18)$$

where $\widehat{N}$ is the total number of observations of wages $\widehat{x_i} \geq \overline{w_f}$ and N is the total number of wage observations. The above concepts can be demonstrated by this graphic below



where a hypothetical shift in MSR from $\overline{w_1}$ to $\overline{w_2}$ causes y_f to decrease from y_{f1} to y_{f2} but ρ to increase by the additional shaded (light grey) area multiplied by c.

2.2 Labour Market Equilibrium

There are two possible equilibriums that emerge from this model. The first is a 'pooled equilibrium', where it is beneficial for domestic workers to accept both types of jobs. The second is an 'ex-post segmented' equilibrium, where domestic workers only take non-sponsored jobs. We will focus on the first equilibrium since it allows us to demonstrate the competition for sponsored vacancies between foreign and domestic graduates and illustrate crowding out.

The pooled equilibrium is a vector of endogenous variables $\{\phi, \gamma, \theta, u\}$ which satisfy: (1) two steady flow state conditions and (2) two free entry conditions.

2.2.1 Steady Flow State Conditions

The basis of the steady flow state conditions is that unemployment stabilizes in the steady-state and that job destruction is equal to job creation. As such, it follows that for foreign graduates it is

$$\theta q(\theta)\phi\gamma u = \lambda(\rho - \gamma u) \qquad (19)$$

where $\theta q(\theta)\phi$ is the effective probability of contacting a sponsored vacancy, γu is the aggregate measure of unemployed foreign graduates, $(\rho - \gamma u)$ the aggregate measure of foreign graduates in employment, and λ is the job separation rate.

For domestic graduates, the steady flow condition is

$$\theta q(\theta)(1-\gamma)u = \lambda[(1-\rho) - (1-\gamma)u] \qquad (20)$$

where noticeably ϕ is absent since domestic graduate can work both type of jobs.

To find our unemployment equation, we solve for u using equations (19) and (20), such that (see appendix A.1)

$$u = \frac{\lambda(1-\rho)}{(\theta q(\theta) + \lambda)(1-\gamma)} \qquad (21)$$

We can further find ϕ, by taking our equation (21) and substituting into (19) such that (see appendix A.2)

$$\phi = \frac{\theta q(\theta)(1-\gamma)\rho + \lambda(\rho - \gamma)}{\theta q(\theta)\gamma(1-\rho)} \qquad (22)$$

We can go a step further with the equation (21) to derive separate unemployment equations for foreign and domestic graduates, such that (see appendix A.3)

$$u_f = \frac{\gamma}{\rho}u = \frac{\lambda}{\theta q(\theta)\phi + \lambda} \qquad (23)$$

and

$$u_d = \frac{(1-\gamma)}{(1-\rho)}u = \frac{\lambda}{\theta q(\theta) + \lambda} \qquad (24)$$

The unemployment rate u, as well as the subsequent u_d and u_f and share of sponsored vacancies in the graduate labour market ϕ are now stated as functions of θ and γ as well as dependent on our MSR policy through ρ.

2.2.2 Free Entry Conditions

The premise behind free entry is the value of posting a vacancy is zero. The intuition is that since the decision to post a vacancy costs nothing and is a positive NPV project, meant firms start opening new vacancies until the rent from them is driven to zero: $V^s = 0$ and $V^n = 0$. Utilizing this assumption and substituting into (10) and (11), as well as following our wage bargaining equation, we get

$$(1-\beta)\left[\gamma S_f^s + (1-\gamma)S_d^s\right] = \frac{k}{q(\theta)} \qquad (25)$$

and

$$(1-\beta)(1-\gamma)S_d^n = \frac{k}{q(\theta)} \qquad (26)$$

We can take this equation a step further and as in Onwordi (2016), imply an *equal-value* condition, such that the value of posting a sponsored vacancy is equal to a non-sponsored one: $V^s = V^n$. As such, we get

$$\gamma S_f^s = (1-\gamma)[S_d^n - S_d^s] \qquad (27)$$

Using the above equal value condition, and equations (2) and (3) as well as wage bargaining, we can characterize our unemployment flow value equations, such that (See appendix A.4 and A.5 respectively)

$$rU_f = \frac{b_f(r+\lambda) + \theta q(\theta)\phi\beta[y_f - B_f^s]}{r + \lambda + \theta q(\theta)\beta\phi} \qquad (28)$$

and

$$rU_d = \frac{b_d(r+\lambda) + \theta q(\theta)\beta[y_d - \phi B_d^s]}{r + \lambda + \theta q(\theta)\beta} \qquad (29)$$

What is interesting about these flow values is that visa sponsorship costs clearly have an impact on both reservation unemployment values to the extent that they impact the expected capital gain from taking on a job. While it is intuitive that visa transaction costs would affect an unemployed foreign graduate, it also affects a domestic graduate. Since a domestic graduate is able to work both types of jobs, the expected loss from the visa transaction cost is given by the probability of finding a job multiplied by ϕB_d^s.

Now, knowing our unemployment flow equations, we can write our final equations to get θ and γ. Using equation equal value condition (27) alongside (14) and (28), we get the following (see appendix A.6)

$$\frac{(1-\gamma)B_d^s}{(r+\lambda)} = \frac{\gamma\left(y_f - B_f^s - b_f\right)}{r + \lambda + \theta q(\theta)\beta\phi} \qquad (30)$$

It represents that the weighted discounted cost of sponsoring a domestic graduate visa must equal to the discounted profit of a filled foreign job. This intuitively makes sense since if setting $\tau = 0$, γ would decrease to zero since $y_f - b_f \geq y_d - b_d$, causing the payoff from foreign graduates to be larger and thus drive demand for them until their unemployment becomes zero.

Using equations (29) and (25), we get (see appendix A.7)

$$\frac{(1-\beta)\{\gamma(y_f - b_f) - (1-\gamma)(y_d - b_d) - [(1-\gamma)B_d^s + \gamma B_f^s]\}}{r + \lambda + \theta q(\theta)\beta} = \frac{k}{q(\theta)} \qquad (31)$$

The equation above (30) is reminiscent of the standard job creation condition in literature, such as in Pissarides (2000). It tells that the discounted weight profit of a filled job minus the weighted visa costs must equal the per capita cost of advertising a vacancy. A change in the average cost of posting a vacancy (RHS) in relation to the expected gain (LHS) must be either offset by a policy change (lowering visa transaction costs) or via the vacancy creation rate (change in $\theta q(\theta)$ or $q(\theta)$) to restore equilibrium.

2.2.3 Pooled Equilibrium Summary

For clarity, our model equations for pooled equilibrium are repeated below:

$$u = \frac{\lambda(1-\rho)}{(\theta q(\theta) + \lambda)(1-\gamma)} \qquad (21)$$

$$\phi = \frac{\theta q(\theta)(1-\gamma)\rho + \lambda(\rho - \gamma)}{\theta q(\theta)\gamma(1-\rho)} \qquad (22)$$

$$u_f = \frac{\lambda}{\theta q(\theta)\phi + \lambda} \qquad (23)$$

$$u_d = \frac{\lambda}{\theta q(\theta) + \lambda} \qquad (24)$$

$$\frac{(1-\gamma)B_d^s}{(r+\lambda)} = \frac{\gamma(y_f - B_f^s - b_f)}{r + \lambda + \theta q(\theta)\beta\phi} \qquad (30)$$

$$\frac{(1-\beta)[\gamma(y_f - B_f^s - b_f) + (1-\gamma)(y_d - B_d^s - b_d)]}{r + \lambda + \theta q(\theta)\beta} = \frac{k}{q(\theta)} \qquad (31)$$

Our model is fully characterized by 9 exogenous structural parameters: $y_d, b_d, b_f, r, \lambda, \beta, \pi, c, k$; four policy instruments: α, τ as well as y_f, ρ determined through $\overline{w_f}$; and six unknowns: $\gamma, \phi, \theta, u, u_f, u_d$ given above. Our solution to the model equilibrium is recursive; place equation (22) into (39), and solve for γ and θ for given value of exogenous parameters using equations (30) and (31), yielding a unique solution for γ and θ given conditions $0 \leq \gamma \leq 1$ and $\theta \geq 0$. Finally, using γ and θ, subsequently solve for ϕ, u, u_f, and u_d.

2.2.4 Existence of Pooled Equilibrium

An essential condition for the existence of the pooled equilibrium is that the surplus of a match between a domestic graduate and sponsored vacancy must be nonnegative; $S_d^s \geq 0$. Given our surplus wage bargaining rule where $\beta \in (0,1)$, $S_i^j \geq 0$ would imply that $W_d^s \geq rU_d$, meaning that a domestic worker would prefer to work a sponsored rather than be unemployed, and $J_d^s \geq V^s$, implying that a firm would prefer to hire a domestic graduate rather than leave the vacancy open. Our $S_d^s \geq 0$ condition can be written (see appendix A.8) as

$$(r+\lambda)(y_d - B_d^s - b_d) \geq \beta\theta q(\theta)(1-\phi)B_d^s \qquad (31)$$

Besides that, for a pooled equilibrium to exist, it must be that $0 < \phi < 1$ to avoid a corner solution, such that

$$\frac{[\theta q(\theta) + \lambda]\rho}{\rho + \lambda} > \gamma > \rho \qquad (32)$$

(see appendix A.9) where our parameter conditions must satisfy the above via $\gamma, \theta q(\theta)$, and ρ.

3 Quantitative Evaluation

This section will include using numerical examples to showcase the quantitative effect of the policy instruments. We will begin by calibrating the model via specifying values for the exogenous parameters that best aim to resemble the UK graduate labour market and then conduct quantitative comparative statistics to showcase how changes in policy affect the broader graduate labour market.

3.1 Model Calibration

In this section will assign values to exogenous parameters in our model. To begin, we conventionally assume that worker bargaining power β is symmetric; $\beta = 0.5$, such as in Pisarrides (2000). We also equate search match elasticity $\mu = \beta$ to satisfy the *Hosios condition*; $\mu = \beta = 0.5$. More specifically, the search and match model has job search externalities, wherein an additional unemployed jobseeker causes positive externalities for firms with vacancies, and negative externalities for other jobseekers. These externalities give rise to search inefficiencies. However, by equating each agent's share of the job match surplus, β, to the respective contributions in matching, the two opposite externalities offset each other (Hosios, 1990).

We follow UK research Onwordi (2016) to set $b_f = 0.1$, and we set $b_d = 0.15$. For our cost of vacancy k, we use Onwordi (2016) to set $k = 0.5$. We take Papoutskai (2017) 12-month UK job separation rate at $\lambda = 0.056$. Using HESA Graduate Outcomes 2017/2018 data, we set the initial fraction of foreign to domestic graduates at $c = 0.31$. It is difficult to determine π, the fraction of the firm VSC that foreign workers absorb, given the lack of data. For simplicity we assume $\pi = 0.70$, satisfying our condition $\pi \in (0.5, 1)$.

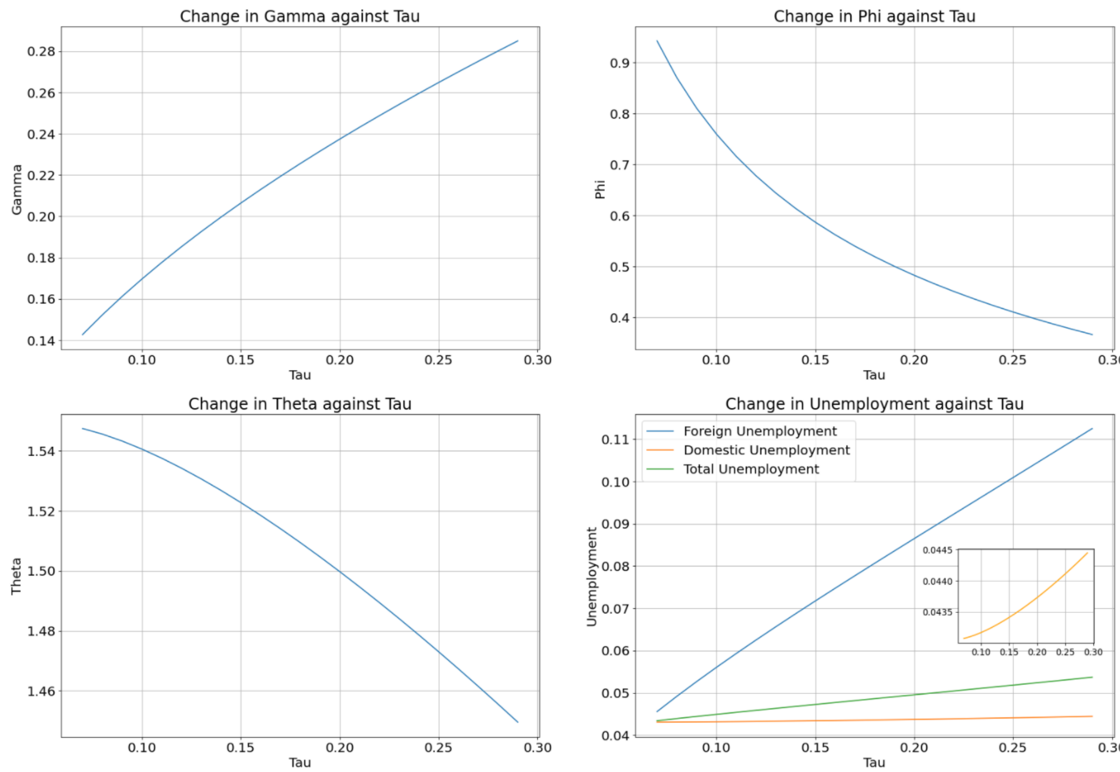
It is extremely difficult to calculate visa sponsorship cost per applicant, τ, given the lack of data and massive variability among firms. We roughly derive $\tau = 0.13$ (see appendix A.10). For our foreign minimum wage policy, $\overline{w_f}$, is set to be at the base level $\overline{w_f} = 25{,}600$ (Home Office, *Skilled Worker Eligibility*, 2022). We determine y_f and ρ using equations (16) and (17) and the HESA Graduate Outcomes data. For $\overline{w_f} = 25{,}600$, we respectively get $y_f = 1.253$ and $\rho = 0.136$. The table in the appendix A.11 summarizes the calibration.

3.2 Comparative Statistics

In this section, we will examine how changes in our specific policy parameters affect the graduate labour market. Using our model, we keep constant our structural parameters while changing a specific policy parameter to showcase its effect.

3.2.1 Examining Visa Cost Transactions

We aim to assess the impact of visa sponsorship costs τ on the graduate labour market. As such, for these values and those outlined in our model calibration, our results are:



An increase in visa transaction costs causes γ to increase, $\frac{\partial \gamma}{\partial \tau} > 0$, given that foreign graduates bear most of the burden of the visa cost increase, thus causing them to be less appealing to hire relative to domestic graduates. Moreover, we see that also reflect in a decrease in ϕ, $\frac{\partial \phi}{\partial \tau} < 0$, as non-sponsored relative to sponsored vacancies become more profitable. Interestingly, we witness a considerable impact on foreign graduate unemployment as well as a minuscule domestic graduate increase. As explained with γ, foreign graduates are worse of; $\frac{\partial u_f}{\partial \tau} > \frac{\partial u_d}{\partial \tau} > 0$.. Through a decrease in expected job payoff, labour market demand decreases resulting in vacancy destruction, where $\frac{\partial \theta}{\partial \tau} < 0$. The destruction is skewed towards more visa-sponsoring vacancies since firms position themselves to increase the probability of matching with a domestic graduate as opposed to non-EU, given that match payoffs with them are worse affected. Our findings stand in line with Onwordi (2016) and Ortega (2000), wherein a reduction in visa sponsorship cost does lead to a Pareto improving outcome.

3.2.2 Examining Foreign Minimum Wage Policy

We aim to see whether the increase in foreign graduate productivity y_f is enough to offset the decrease in foreign graduate population ρ via our foreign minimum wage mechanism subject to equations (16) and (17). We also aim to see for what value $\overline{w_f}$ is productivity maximized, first by defining average productivity y as

$$y = \rho y_f + (1 - \rho) y_d \qquad (33)$$

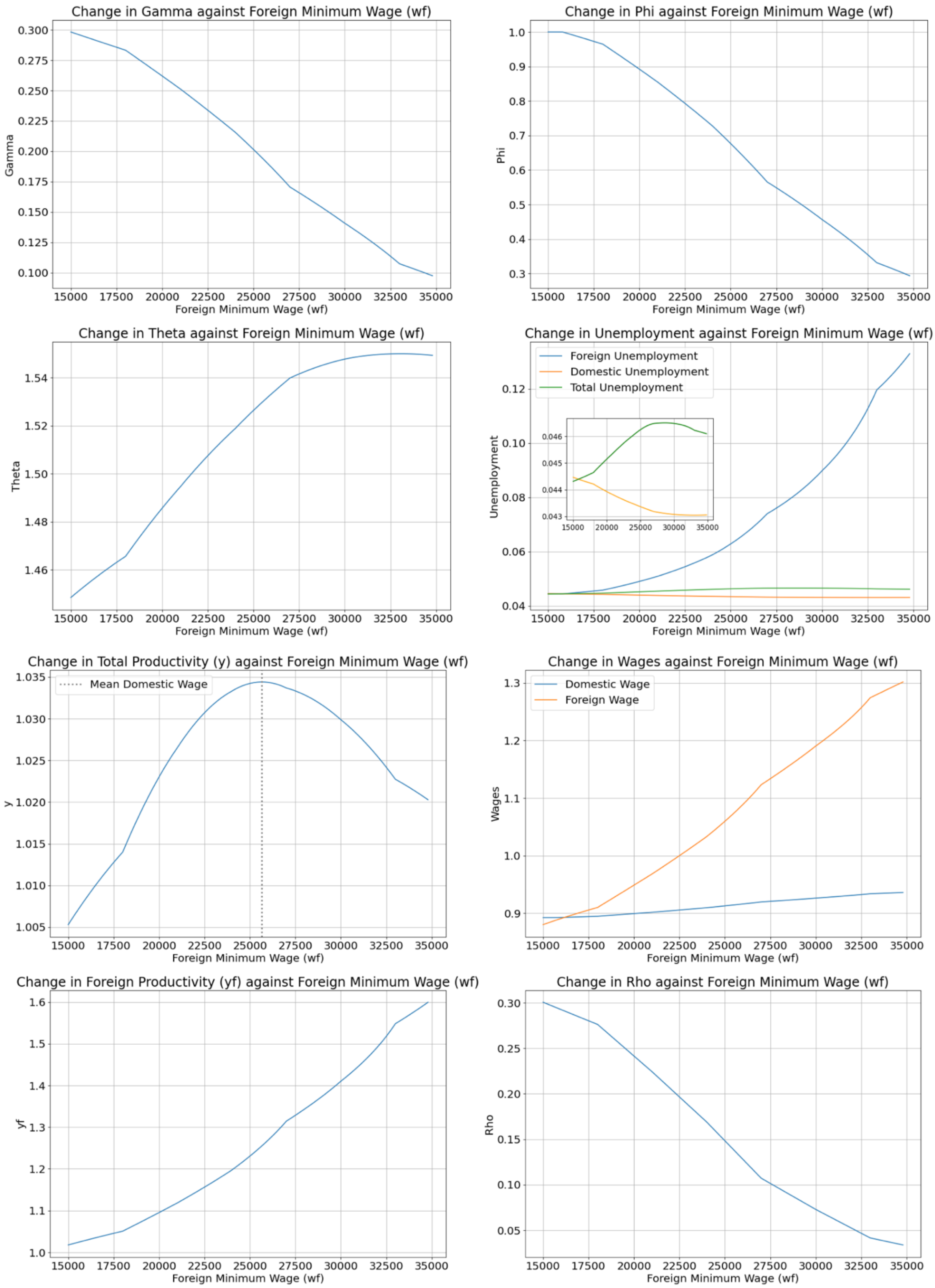
Furthermore, also wish to examine how wages move in conjunction with unemployment. Using equation (15), we derive the following wages equations

$$w_f = \beta(y_f - B_f^s) + (1 - \beta)\frac{b_f(r + \lambda) + \theta q(\theta)\phi\beta(y_f - B_f^s)}{r + \lambda + \theta q(\theta)\beta\phi} \qquad (34)$$

and

$$w_d = \beta(y_d - \phi B_d^s) + (1 - \beta)\frac{b_d(r + \lambda) + \theta q(\theta)\beta(y_d - \phi B_d^s)}{r + \lambda + \theta q(\theta)\beta} \qquad (35)$$

We set $\tau = 0.13$ and for the values outlined in model calibration, our results are:



Increasing the minimum wage requirement results in more productive non-EU graduates but a significantly smaller eligible population. Surprisingly pleasant, we see that equating $\overline{w_f}$ to the mean domestic wage maximizes

y. Our results show that gamma decreases with FMWP, $\frac{\partial \gamma}{\partial \overline{w_f}} < 0$, unsurprisingly as a smaller fraction of more productive foreign workers are left. On a similar note, ϕ is also significantly decreasing against MSR, $\frac{\partial \phi}{\partial \overline{w_f}} < 0$, since the gain in foreign productivity y_f, and by extension, the firm's share of the match surplus $(1-\beta)S_f^s$, does not outweigh the smaller foreign graduate population ρ and the associated probability of a sponsored job match becomes significantly lower. Labour market tightness θ slightly gains with MSR, $\frac{\partial \theta}{\partial \overline{w_f}} > 0$, as labour demand increases with the productivity boost and decreased competition.

Most importantly, we witness a minuscule change in domestic unemployment with regards to MSR, with a change of $\overline{w_f}$ from £15,000 to £35,000 resulting in less than a 0.2% decrease. On the other hand, the same FMWP change cause more than 6% increase in foreign graduate unemployment; $\frac{\partial u_f}{\partial \overline{w_f}} > \frac{\partial u_d}{\partial \overline{w_f}} > 0$. The explanation is that even with significantly higher productivity, foreign graduates' job finding rate decreases significantly with a lower fraction of sponsored vacancies ϕ, thus leading to higher unemployment.

This drastic increase in foreign unemployment is followed by a significant increase in foreign wages, given that the more productive foreign graduate earn a higher wage. Wages for domestic graduates do increase, albeit at a rather insignificant rate. This helps explain the high non-EU wages present in the data; 59% of non-EU graduates earn more than £27,000 against 34% and 43% for UK and EU graduates respectively (HESA, 2020).

All in all, while the crowding-out effect is present, the MSR significantly increases non-EU unemployment while causing only a slight decrease in domestic graduate unemployment. Furthermore, for our calculated value $\tau = 0.13$, our model predicts $u_d = 0.0433$ and $u_f = 0.0656$ as opposed to 3.55%[1] and 6% in the data respectively (HESA, 2020). Our model slightly overestimates both graduate and foreign unemployment.

4 Conclusion

The findings of this paper indicate that a reduction in visa sponsorship costs leads to lower unemployment for both domestic and non-EU graduates. This is achieved through an increase in labour demand driven by a higher job match payoff. The more drastic decrease in non-EU compared to domestic unemployment is due to an additional increase in the fraction of sponsored vacancies. Furthermore, this paper finds that increasing the minimum salary threshold for non-EU graduates does slightly decrease domestic graduate unemployment, albeit at a much higher increase for non-EU students. Even as their productivity increases, due to the sharp decrease in sponsored vacancies caused by a smaller non-EU graduate population, the job-finding rates for non-EU graduates fall dramatically.

The assumptions in this paper were made to investigate the job competition between domestic and non-EU university graduates but ignored the reality that the competition for graduate jobs also includes non-graduates. A

[1] Since we consider domestic workers as both UK and EU graduates, we take unemployment of both and weigh by the number of graduates

possible expansion of the model would be to include non-graduates to better reflect the labour market. Moreover, it was assumed that all non-EU graduates would seek employment in the UK as their first choice, disregarding the labour market state of their respective home countries. Expanding the model to include representative outside vacancies and firm options for foreign graduates would better reflect the competition for labour between countries.

5 Bibliography

Borjas, G.J. 1994. The Economics of Immigration. *Journal of Economic Literature* 32(4), pp. 1667–1717.

Gopal, Anita. "Visa and Immigration Trends: A Comparative Examination of International Student Mobility in Canada, Australia, the United Kingdom, and the United States." *Strategic Enrollment Management Quarterly*, vol. 4, no. 3, 2016, pp. 130–141., doi:10.1002/sem3.20091.

Great Britain. Home Office:

Premium customer service for employers (2014). [Online] Available at: https://www.gov.uk/guidance/employer-sponsorship-join-the-premium-customer-service-scheme [Accessed: 18 February 2022].

Second report on statistics being collected under the exit checks programme (2017). [Online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/639621/second-report-on-statistics-being-collected-under-exit-checks.pdf [Accessed: 22 March 2022].

Immigration Statistics (2021). [Online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/987779/sponsorship-summary-mar-2021-tables.ods [Accessed: 22 March 2022].

Apply for your License (2022). [Online] Available at: https://www.gov.uk/uk-visa-sponsorship-employers/apply-for-your-licence [Accessed: 22 March 2022].

Immigration Skill Charge (2022). [Online] Available at: https://www.gov.uk/uk-visa-sponsorship-employers/immigration-skills-charge [Accessed: 22 March 2022].

Hall, R.E. 2012. The 2010 Nobel Prize in Economics : How the DMP Model Explains Current High Unemployment [Online] Available at: https://web.stanford.edu/~rehall/HallTalkNobelLunch.pdf [Accessed: 11 March 2022].

HESA. "Higher Education Graduate Outcomes Statistics: UK, 2017/18 - Summary." *Higher Education Statistics Agency (HESA*, 2020, www.hesa.ac.uk/news/18-06-2020/sb257-higher-education-graduate-outcomes-statistics.

Hosios, A.J. 1990. On the Efficiency of Matching and Related Models of Search and Unemployment. *The Review of Economic Studies* 57(2), p. 279.

ICEF. "Measuring the Economic Impact of Foreign Students in the UK and the Country's Competitive Position in International Recruitment." 13 Sept. 2021, monitor.icef.com/2021/09/measuring-the-economic-impact-of-foreign-students-in-the-uk-and-the-countrys-competitive-position-in-international-recruitment/.

Onwordi, G.E. 2016. Labour Market Policies and Unemployment in the Presence of Search & Matching Frictions. dissertation. University of Dundee.

Ortega, J. 2000. Pareto-Improving Immigration in an Economy with Equilibrium Unemployment. *The Economic Journal* 110(460), pp. 92–112.

Papoutsaki, D. 2017. Job Separation Rates of Immigrants and Natives in the UK during the Great Recession. *International Journal of Manpower* 38(7), pp. 1036–1054.

Pissarides, C.A. 2000. *Equilibrium Unemployment Theory*. Cambridge, MA: The MIT Press.

Yashiv, E. 2007. Labor Search and Matching in Macroeconomics. *SSRN Electronic Journal*.

6 Appendix

A.1 Finding u equation (21)
Our equation (21) can be written as

$$u = \frac{\lambda[(1-\rho) - (1-\gamma)u]}{\theta q(\theta)(1-\gamma)}$$

We can simply if that

$$\Rightarrow u + \frac{\lambda(1-\gamma)u}{\theta q(\theta)(1-\gamma)} = \frac{\lambda(1-\rho)}{\theta q(\theta)(1-\gamma)}$$

$$\Rightarrow u\left(1 + \frac{\lambda}{\theta q(\theta)}\right) = \frac{\lambda(1-\rho)}{\theta q(\theta)(1-\gamma)}$$

$$\Rightarrow u = \frac{\lambda(1-\rho)}{\theta q(\theta)(1-\gamma)} \div \left(\frac{\theta q(\theta) + \lambda}{\theta q(\theta)}\right)$$

Following derivation above we get

$$\Rightarrow u = \frac{\lambda(1-\rho)}{(\theta q(\theta) + \lambda)(1-\gamma)}$$

A.2 Finding ϕ equation (22)
From equation (19) we get

$$\phi = \frac{\lambda(\rho - \gamma u)}{\theta q(\theta)\gamma u}$$

$$= \frac{\lambda\rho}{\theta q(\theta)\gamma u} - \frac{\lambda}{\theta q(\theta)\gamma}$$

Substituting our equation (21) for u, we get

$$\phi = \frac{\lambda\rho}{\theta q(\theta)\gamma} \cdot \frac{(\theta q(\theta) + \lambda)(1-\gamma)}{\lambda(1-\rho)} - \frac{\lambda}{\theta q(\theta)\gamma}$$

$$= \frac{\theta q(\theta)(1-\gamma)\rho + \lambda\rho(1-\gamma) - \lambda(1-\rho)\gamma}{\theta q(\theta)\gamma(1-\rho)}$$

Simplifying that, we finally get

$$\phi = \frac{\theta q(\theta)(1-\gamma)\rho + \lambda(\rho - \gamma)}{\theta q(\theta)\gamma(1-\rho)}$$

A.3 Finding u_f equation (23)

$$u_f = \frac{\gamma}{\rho}u = \frac{\lambda\gamma(1-\rho)}{(\theta q(\theta) + \lambda)(1-\gamma)\rho}$$

$$= \frac{\lambda\gamma(1-\rho)}{\theta q(\theta)(1-\gamma)\rho + \lambda(1-\gamma)\rho}$$

$$= \frac{\lambda\gamma(1-\rho)}{\theta q(\theta)(1-\gamma)\rho + \lambda(p-\gamma) + \lambda\gamma(1-p)}$$

$$= \lambda \div \left(\frac{\theta q(\theta)(1-\gamma)\rho + \lambda(p-\gamma)}{\gamma(1-\rho)} + \lambda\right)$$

$$= \lambda \div (\theta q(\theta)\phi + \lambda)$$

$$= \frac{\lambda}{\theta q(\theta)\phi + \lambda}$$

A.4 Finding rU_f equation (28)
Our equation (2) states that
$$rU_f = b_f + \phi\theta q(\theta)\left(W_f^n - U_f\right)$$

Using equation (14) and wage bargaining rule, we get
$$rU_f = b_f + \phi\theta q(\theta)\beta\left(\frac{y_f - B_f^s - rU_f}{r+\lambda}\right)$$
$$\Rightarrow rU_f + \frac{\phi\theta q(\theta)\beta rU_f}{r+\lambda} = b_f + \phi\theta q(\theta)\beta\left(\frac{y_f - B_f^s}{r+\lambda}\right)$$
$$\Rightarrow rU_f\left(\frac{\phi\theta q(\theta)\beta + r + \lambda}{r+\lambda}\right) = \frac{b_f(r+\lambda) + \phi\theta q(\theta)\beta[y_f - B_f^s]}{r+\lambda}$$
$$\Rightarrow rU_f = \frac{b_f(r+\lambda) + \theta q(\theta)\phi\beta[y_f - B_f^s]}{r+\lambda+\theta q(\theta)\beta\phi}$$

A.5 Finding rU_d equation (29)
Our equation (3) states that
$$rU_d = b_d + \theta q(\theta)\{\phi \max(W_d^n - U_d, 0) + (1-\phi)(W_d^s - U_d)\}$$

Using equation (14) and wage bargaining rule, as well as assuming it is beneficial for a domestic worker to work a sponsored job, we get:
$$rU_d = b_d + \theta q(\theta)\beta\{\phi S_d^s + (1-\phi)S_d^n\}$$
$$= b_d + \theta q(\theta)\beta\left(\frac{y_d - \phi B_d^s - rU_f}{r+\lambda}\right)$$

Following similar logic as with rU_f, we get
$$rU_d = \frac{b_d(r+\lambda) + \theta q(\theta)\beta[y_d - \phi B_d^s]}{r+\lambda+\theta q(\theta)\beta}$$

A.6 Finding penultimate equilibrium equation (30)
Our equality condition (27) is given by
$$\gamma S_f^s = (1-\gamma)[S_d^n - S_d^s]$$

Using equation (14), we can expand it to
$$\gamma\left(\frac{y_f - B_f^s - rU_f}{r+\lambda}\right) = (1-\gamma)\left[\frac{y_d - rU_d}{r+\lambda} - \frac{y_d - B_d^s - rU_d}{r+\lambda}\right]$$
$$\Rightarrow \gamma\left(y_f - B_f^s - rU_f\right) = (1-\gamma)B_d^s$$

Substituting equation (28) into this, we get
$$(1-\gamma)B_d^s = \gamma\left(y_f - B_f^s - \frac{b_f(r+\lambda) + \theta q(\theta)\phi\beta[y_f - B_f^s]}{r+\lambda+\theta q(\theta)\beta\phi}\right)$$
$$= \gamma\left(\frac{(y_f - B_f^s)(r+\lambda+\theta q(\theta)\beta\phi) - b_f(r+\lambda) + \theta q(\theta)\phi\beta\left[y_f - B_f^s\right])}{r+\lambda+\theta q(\theta)\beta\phi}\right)$$
$$= \gamma\left(\frac{(r+\lambda)\left(y_f - B_f^s - b_f\right)}{r+\lambda+\theta q(\theta)\beta\phi}\right)$$
$$\Rightarrow \frac{(1-\gamma)B_d^s}{(r+\lambda)} = \frac{\gamma\left(y_f - B_f^s - b_f\right)}{r+\lambda+\theta q(\theta)\beta\phi}$$

A.7 Finding final equilibrium equation (31)
We take our penultimate equation (30)
$$(1-\gamma)B_d^s = \gamma\frac{(r+\lambda)(y_f - B_f^s - b_f)}{r+\lambda+\theta q(\theta)\beta\phi}$$

$$\Rightarrow (1-\gamma)(r+\lambda+\theta q(\theta)\beta\phi)B_d^s = \gamma(r+\lambda)(y_f - B_f^s - b_f)$$

Add $(1-\gamma)(r+\lambda)(y_f - B_f^s - b_f)$ to both sides

$$\Rightarrow (1-\gamma)\left[(r+\lambda+\theta q(\theta)\beta\phi)B_d^s + (r+\lambda)\left(y_f - B_f^s - b_f\right)\right] = (r+\lambda)(y_f - B_f^s - b_f)$$

$$\Rightarrow \theta q(\theta)\beta\phi B_d^s + (r+\lambda)\left(y_f + B_d^s - B_f^s - b_f\right) = \frac{(r+\lambda)(y_f - B_f^s - b_f)}{(1-\gamma)}$$

$$\Rightarrow \theta q(\theta)\beta\phi B_d^s = \frac{(r+\lambda)\left[\left(y_f - B_f^s - b_f\right) - (1-\gamma)\left(y_f + B_d^s - B_f^s - b_f\right)\right]}{(1-\gamma)} \qquad (1A)$$

Let's leave this equation above for now, and take our equation (26)

$$(1-\beta)(1-\gamma)S_d^n = \frac{k}{q(\theta)}$$

This would imply

$$\Rightarrow (1-\beta)(1-\gamma)\left(\frac{y_d - rU_d}{r+\lambda}\right) = \frac{k}{q(\theta)}$$

$$\Rightarrow y_d - rU_d = \frac{(r+\lambda)k}{q(\theta)(1-\beta)(1-\gamma)}$$

Substituting equation (29) into this, we get

$$y_d - \frac{b_d(r+\lambda) + \theta q(\theta)\beta[y_d - \phi B_d^s]}{r+\lambda+\theta q(\theta)\beta} = \frac{(r+\lambda)k}{q(\theta)(1-\beta)(1-\gamma)}$$

$$\Rightarrow (r+\lambda+\theta q(\theta)\beta)y_d - b_d(r+\lambda) - \theta q(\theta)\beta[y_d - \phi B_d^s] = \frac{(r+\lambda)(r+\lambda+\theta q(\theta)\beta)k}{q(\theta)(1-\beta)(1-\gamma)}$$

$$\Rightarrow (r+\lambda)(y_d - b_d) + \theta q(\theta)\beta\phi B_d^s = \frac{(r+\lambda)(r+\lambda+\theta q(\theta)\beta)k}{q(\theta)(1-\beta)(1-\gamma)}$$

$$\Rightarrow \theta q(\theta)\phi B_d^s = \frac{(r+\lambda)(r+\lambda+\theta q(\theta)\beta)k}{q(\theta)(1-\beta)(1-\gamma)} - (r+\lambda)(y_d - b_d) \qquad (1B)$$

We equate the equation above $(1B)$ to $(1A)$, to get

$$\frac{(r+\lambda)\left[\left(y_f - B_f^s - b_f\right) - (1-\gamma)\left(y_f + B_d^s - B_f^s - b_f\right)\right]}{(1-\gamma)} = \frac{(r+\lambda)(r+\lambda+\theta q(\theta)\beta)k}{q(\theta)(1-\beta)(1-\gamma)} - (r+\lambda)(y_d - b_d)$$

$$\Rightarrow \frac{(r+\lambda)\left[\left(y_f - B_f^s - b_f\right) - (1-\gamma)\left(y_f + B_d^s - B_f^s - b_f\right) + (1-\gamma)(y_d - b_d)\right]}{(1-\gamma)} = \frac{(r+\lambda)(r+\lambda+\theta q(\theta)\beta)k}{q(\theta)(1-\beta)(1-\gamma)}$$

$$\Rightarrow \left(y_f - B_f^s - b_f\right) - (1-\gamma)\left(y_f + B_d^s - B_f^s - b_f - y_d + b_d\right) = \frac{(r+\lambda+\theta q(\theta)\beta)k}{q(\theta)(1-\beta)}$$

$$\Rightarrow \gamma(y_f - B_f^s - b_f) + (1-\gamma)\left(y_d - B_d^s - b_d\right) = \frac{(r+\lambda+\theta q(\theta)\beta)k}{q(\theta)(1-\beta)}$$

$$\Rightarrow \frac{(1-\beta)\left[\gamma(y_f - B_f^s - b_f) + (1-\gamma)\left(y_d - B_d^s - b_d\right)\right]}{r+\lambda+\theta q(\theta)\beta} = \frac{k}{q(\theta)}$$

A.8 Finding $S_i^j \geq 0$ equation (31)

$S_i^j \geq 0$

$\Rightarrow (\,y_d - B_d^s - rU_d) \geq 0$

$$\left(y_d - B_d^s - \frac{b_d(r+\lambda) + \theta q(\theta)\beta[y_d - \phi B_d^s]}{r+\lambda+\theta q(\theta)\beta} \right) \geq 0$$

$(r+\lambda)(y_d - B_d^s - b_d) + \theta q(\theta)\beta[\phi B_d^s - B_d^s] \geq 0$

$(r+\lambda)(y_d - B_d^s - b_d) - \theta q(\theta)\beta[B_d^s - \phi B_d^s] \geq 0$

$\Rightarrow (r+\lambda)(y_d - B_d^s - b_d) \geq \theta q(\theta)\beta(1-\phi)B_d^s$

A.9 Finding conditions for $0 < \phi < 1$ equation (32)

For $\phi < 1$

if $(1-\phi) > 0$ then $\phi < 1$

$$\therefore (1-\phi) = \frac{\theta q(\theta)\gamma(1-\rho) - \theta q(\theta)(1-\gamma)\rho - \lambda(\rho-\gamma)}{\theta q(\theta)\gamma(1-\rho)} < 0$$

since $\theta q(\theta)\gamma(1-\rho)$ is strictly positive

$\Rightarrow \theta q(\theta)\gamma(1-\rho) - \theta q(\theta)(1-\gamma)\rho - \lambda(\rho-\gamma) > 0$

$\Rightarrow \theta q(\theta)(\gamma-\rho) - \lambda(\rho-\gamma) > 0$

$\Rightarrow \theta q(\theta)(\gamma-\rho) + \lambda(\gamma-\rho) > 0$

$(\gamma-\rho)(\theta q(\theta)+\lambda) > 0$

since $(\theta q(\theta)+\lambda)$ is strictly positive

$\Rightarrow (\gamma-\rho) > 0$

$\Rightarrow \gamma > \rho$

For $0 < \phi$

$\phi > 0 \Rightarrow \theta q(\theta)(1-\gamma)\rho + \lambda(\rho-\gamma) > 0$

$\Rightarrow (\theta q(\theta)+\lambda)\rho - (\rho+\lambda)\gamma > 0$

$$\Rightarrow \frac{(\theta q(\theta)+\lambda)\rho}{(\rho+\lambda)} > \gamma$$

As such, putting $0 < \phi$ and $\phi < 1$ together, we get

$$\frac{[\theta q(\theta)+\lambda]\rho}{(\rho+\lambda)} > \gamma > \rho$$

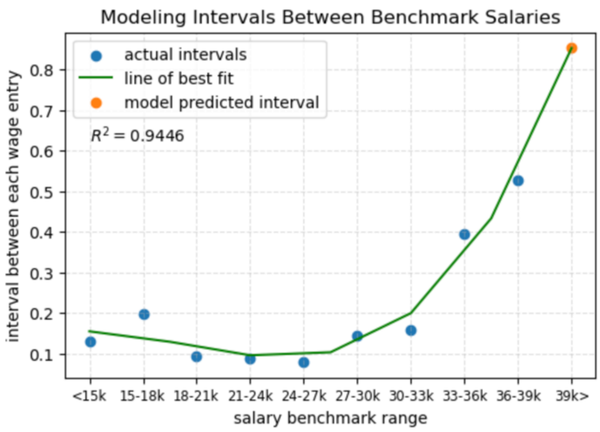
A.10 Deriving τ for calibration

The Home Office 'Premium Sponsor Service' for Skilled Worker (previously Tier 2), which consists of numerous services, but most importantly a dedicated account manager with tailored advice. This costs £8,000 for small sponsors (Home Office, *Premium customer service for employers*, 2014). We assume large sponsors have their own personal department staff who roughly have the same costs. The load on a typical account manager for our sake is 1.96 applicants per business, derived by taking dividing the total number of tier 2 applicants in 2019 (60,559) by the total number of businesses with sponsorship license (30,730) (Home Office, *Immigration Statistics*, 2021). Moreover, the certificate of sponsorship, which every firm who can sponsor a visa needs to have regardless of the number of applicants, is £1,476 (Home Office, *Apply for your License,* 2022). Furthermore, the annual Immigration Skills Charge is £1,000 (Home Office, *Immigration Skill Charge,* 2022). As such, we first add $\frac{8{,}000}{1.96} + 1{,}476 + 1000 = 6{,}558$. We then proceed to normalize it with regards to $y_d = 1$. For simplicity, we assume $y_d = \frac{w_d}{\beta}$, where w_d is the mean domestic graduate salary £25,600 (HESA, 2020) and $\beta = 0.5$. As such, we get $6{,}558 \div \frac{25{,}600}{0.5} \approx 0.13$. Thus, we get $\tau = 0.13$.

A.11 Baseline Model Calibration

Parameters	Value	Source
β	0.5	Pissarides (2000)
μ	μ=β=0.5	Hosios (1990)
b_d	0.15	See text
b_f	0.10	Onwordi (2016)
r	0.02	See text
k	0.5	Onwordi (2016)
λ	0.056	Papoutskai (2017)
τ	0.13	See text
π	0.7	See text
ρ	0.136	$\overline{w_f} = 25,600$, See text
c	0.31	See text
y_d	1	See text
y_f	1.253	$\overline{w_f} = 25,600$, See text

A.12 Explanation of Cleaned Dataset Derivation



	wages
count	205270.00
mean	25659.27
std	7339.28
min	14020.13
25%	20397.01
50%	24610.21
75%	29535.22
max	55735.38

We used the HESA Graduate Outcomes 2017/2018 dataset to calibrate for MSR. In order to use in our Python model, we derived a new dataset with just wages from the HESA dataset. Since it was summary data, the dataset only included distribution of wages alongside salary benchmarks (see x-axis of plot above). We assumed that wages in between those ranges were uniformly distributed. As such we derived interval increases by subtracting taking the higher end of the range against the lower end and dividing by the total number of observations. For example, for salaries in between £15,000-18,000, there were ~31,600 observations. As such, we took $\frac{18-15}{31{,}600} \approx 0.096$. We then plotted wages such that it began from £15,000 and increased by £0.096 with each new entry.

Nonetheless, there were issues at the tail ends; specifically, wages below £15,000 and above £39,000. We could not use the approach above since those benchmarks had no range. As such, for wages below £15,000, we derived that given the data was for full-time employment, it being categorized approximately at minimally 30 hours a week, at 52 weeks a year multiplied by £9 minimum wage, that would be £14,040. This gave as an interval range. For wages above £39,000, we used a 3rd degree polynomial regression to predict the next interval. The above plot demonstrates our line of best fit and values. As such, we derived our cleaned dataset.