Labour Market Monopsony Power and the Dynamic Gains to Openness Reforms*

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Abstract

We quantify the impact of trade and FDI liberalisation episodes within a dynamic general equilibrium framework with firm heterogeneity and monopsonistic labour markets. Firms make standard extensive margin investment choices into exporting and multinational statuses. The labour market features firm-level upward-sloping supply curves, wage-setting power and love of variety in employment. These features interact with roundabout production and the variable-fixed cost tradeoff of outward activity. We calibrate the model to U.S. micro data and study the effect of reductions in tariffs and outward FDI taxes, examining steady state and transitional effects. Compared with a standard model with perfectly elastic firm-level labour supply, we find that the model where firms face upward-sloping labour supply curves gives substantially different quantitative predictions and transition dynamics; for instance, it yields welfare gains that are over five times larger after bilateral trade liberalisation. Decomposition exercises show that substantial differences remain, even when shutting-down combinations of features of the monopsony environment.

Keywords: Monopsonistic labour market; Trade liberalisation; Love of variety in employment; Dynamics; Foreign direct investment; Corporate taxation

JEL codes: F12, F13, F16, F23, F40, H25

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1 Introduction

A standard assumption in international trade research is perfectly competitive labour markets. However, growing evidence supports the idea that firms possess monopsony power (see Naidu, Posner and Weyl, 2018 and Yeh, Macaluso and Hershbein, 2022), and recent papers have begun to adopt imperfect labour markets within trade models (MacKenzie, 2019, Jha and Rodriguez-Lopez, 2021, Egger et al., 2022). Contributing to this emerging research, in this paper we incorporate monopsonistic labour markets into a standard dynamic quantitative model of trade, to study the welfare implications of liberalising open economy policy instruments.[1] We firstly consider a standard import tariff. We then consider an outward tax on FDI profits — the policy motivation being several recent unilateral and multilateral reforms from around the world to the tax treatment of multinationals' profits.[2]

Our modelling of imperfection in the labour market parallels the modelling of monopolistic competition in the goods markets. A representative worker endogenously chooses their labour supply. However, the worker's disutility for labour is modelled in such a way that they get lower disutility if they spread their labour supply over a number of firms. This leads to each firm facing an upward-sloping labour supply (USLS) curve, giving rise to monopsony power. This contrasts with the perfect labour markets scenario, whereby firm-level labour supply is infinitely elastic at the prevailing common market wage.

Other than introducing imperfection in the labour market, the model is a standard dynamic general equilibrium framework with stochastic firm productivity and endogenous entry/exit. Firm dynamics arise due to time-varying firm-level productivity shocks. Firms are monopolistically competitive in the product market and labour is the only factor of production. They endogenously select into one of three production modes — domestic, exporter, multinational — based on their state vector for the period. The fixed cost set up follows papers such as Alessandria and Choi (2007, 2014a,b), Alessandria, Choi and Ruhl (2021) and Ruhl and Willis (2017), where firms pay a one-off sunk cost to establish a new operating segment and then pay fixed period-by-period costs to maintain it (and receive new productivity shocks) thereafter. The exporting-FDI tradeoff combines elements of Helpman, Melitz and Yeaple (2004) and Arkolakis et al. (2018) by including fixed and variables costs of exporting and FDI. In particular, not only do exporters incur an iceberg shipping cost, there are productivity losses associated with the operations of a foreign subsidiary as well. We discipline these parameters using data on the cross-section of U.S. firms.

With regard to trade liberalisation, we set our benchmark calibration at 10% tariffs and assume the labour market to be monopsonistic. We then perform counterfactual exercises for reducing the tariff to zero, both unilaterally and bilaterally. We compare these outcomes against a standard perfect labour markets case, where the initial tariff (which turns out to be 8%) is calibrated such that the ratio of tariff revenues to aggregate final output is the same

[1] As well as being interesting in its own right, dynamic analysis has been shown to be crucial for accurate quantification of the welfare effects of openness reforms, (see Alessandria, Choi and Ruhl, 2021 and Spencer, 2022).

[2] An example of a multilateral reform is the OECD/G20 Inclusive Framework on Base Erosion and Profit Shifting agreement of 2021. A recent unilateral change was removal of the U.S. repatriation tax as in the Tax Cuts and Jobs Act of 2017.

as in the monopsonistic labour market benchmark.[3] We analyse the welfare effects by comparing the steady states, while also taking the transition gains and losses into account. The key insight from the quantitative exercise is that the welfare gains in consumption equivalent variation from a bilateral trade liberalisation are much larger in the monopsonistic labour market case (5%) compared to the perfectly elastic labour supply benchmark (1%). Then again, with the unilateral liberalisation the gains are larger with monopsonistic labour market, but in this case the bulk of the gains go to the non-liberalising country (5%) compared with the liberalising country (1.2%). With perfect labour markets, the liberalising country experiences a small welfare loss.[4] The main source of asymmetric gain is the terms of trade losses for the liberalising country and the corresponding gains for the non-liberalising country.

The key intuition behind the larger gains from trade with imperfect labour markets relates to the fact that upward-sloping labour supply gives increasing firm-level marginal cost structures. This contrasts with perfect markets, where marginal cost is constant. Increasing marginal cost disincentivises exporting at the intensive margin, leaving space for a stronger response at the extensive margin. Not only does the mass of exporters increase significantly, the mass of producing firms in each country increases substantially as well. The latter, in turn, has a feedback effect on labour supply through a love of variety in employment (LOVE) channel, which magnifies the gains from trade.[5] Importantly however, even when we shut-down the employer variety channel, the gains from trade are significantly larger with imperfect markets (2.6%) compared to perfect markets (1%). The same forces are at work in the case of unilateral liberalisation, except that the terms of trade effect tilts the gains in favour of the trading partner.

Looking at FDI, we set the baseline rate of FDI profit taxes to 2%, yielding the profit tax to final output ratio of 0.1%, which is held constant for comparability across the exercises. Again, the welfare gains from bilaterally eliminating FDI profit taxes are larger (1%) when the labour market is monopsonistic compared to the perfect labour market case (0.1%). Interestingly, when we shut down LOVE, a bilateral lowering of the taxes on outward FDI reduces welfare. This follows primarily because the increased presence of multinationals has an adverse effect on entry, leading to a large decline in the mass of entrants and the mass of varieties available for use in the production of aggregate final goods. The mass of producing firms increases, which drives increased labour supply when LOVE is present, but not so when this channel is shut-down. Removing this source of welfare gains makes the overall effect of FDI tax liberalisation welfare reducing. In a perverse way, labour market power induces firms to go multinational, rather than taking the exporting route for selling in the foreign market. Facing an upward-sloping labour supply, going multinational allows firms to pay lower wages in both locations and raises the possibility of there being too many

[3]The benchmark monopsonistic calibration implies a tariff revenue to aggregate final output ratio of 0.7%.

[4]There is a welfare loss of 0.2% for the liberalising country while the gains for the non-liberalising country are 1.3%.

[5]The worker's utility function exhibits love of variety in employment (LOVE), parallel to the love of variety in consumption. We provide microfoundations for this utility function from a set-up where workers draw their match-specific productivity from a distribution and they choose their employer as well as hours worked.

multinationals, leading to potential welfare losses. In this setting, a tax on multinational profits could increase welfare.

Unlike the case of trade liberalisation, a unilateral elimination of FDI profit taxes by Home benefits Home but hurts Foreign. Quantitatively, the effects of unilateral FDI liberalisation are several orders of magnitude larger with the monopsonistic labour market. When Home reduces the taxation of Home-based multinationals, it increases the value of being a Home-based multinational firm. This leads to more entry and firm creation in Home, with more firms entering into FDI status. The latter effect is amplified by the upward-sloping labour supply curve, which tilts the decision in favor of FDI over exporting. Not only do Foreign-based multinationals not benefit directly from a tax cut in Home, they also face higher wages in Home, hence more of them prefer to export rather than undertake FDI. A consequence is that the mass of firms operating in Home increases significantly while the mass of firms operating in Foreign decreases. Given the love of variety for employers, this is a strong source of welfare gain for Home and a source of welfare loss for Foreign. Shutting down LOVE with unilateral FDI liberalisation reduces the gains for Home and losses for Foreign. However, their magnitudes still remain significantly higher (at least twice as large) than with perfect labour markets.

We also quantify the effect of firms' exercise of their labour market power — through wage markdowns (WMD) — on the gains to openness. We shut this feature down by keeping upward-sloping labour supply in the firms' environment, but having them act as wage-takers rather than wage-setters. Specifically, a wage-taking firm pays an equilibrium wage where its labour demand intersects its labour supply. We show that the bulk of the effect of trade liberalisation still obtains as long as firms face an upward-sloping labour supply, so that the exercise of market power contributes only a little quantitatively. This result changes however in the FDI liberalisation exercises, where the presence of wage-setting power is very much significant quantitatively.

Our setup facilitates the study of short-run transitional effects, subsequent to these policy changes. To avoid discussing too many cases, we restrict the transition dynamics to our benchmark monopsonistic competition case with all features (USLS, LOVE, WMD) present. In the case of bilateral tariff liberalisation, we find that there is a short term drop in consumption to finance extra firms when the labour market is monopsonistic. In contrast, consumption overshoots with perfect markets, a result echoing the findings of Alessandria, Choi and Ruhl (2021). In addition, ignoring the welfare effects during transition overstates the gains from tariff reforms in the monopsony case and understates them in the perfect labour market case. Comparing the transitions of unilateral and bilateral tariff liberalisations in the presence of monopsony, we find that the world economy takes longer to converge in the former case. This is mainly driven by the slower adjustment of firms at the extensive margin in the trading partner of the country undertaking unilateral tariff liberalisation.

Looking at the transition effects of FDI tax liberalisation, we generally find that the transition is much longer compared to the case of trade liberalisation. Although the most productive firms transition to multinational status immediately, it takes much longer for firms with intermediate levels of productivity. This follows since it is generally optimal for these firms to transit via exporting (a regularity in the data that we match in our calibration). Moreover, the transition times in the case of bilateral FDI reforms do not depend on the structure of the labour market. This is because the FDI taxes are levied on firm profits, and hence wage bills become tax deductible. As a consequence, FDI taxes do not affect the intensive margin decisions of firms conditional on their status. Tariffs, on the other hand, distort sales and hence affect the intensive margin decisions. Finally, the transition effects of unilateral FDI tax liberalisation tend to be more volatile in the case of monopsony compared to a perfect labour market. For example, in the liberalising country the impact expansion in the measure of entrants is four times larger than its steady state expansion in the monopsony case while in the perfect labour market case it is twice as large.

To sum up, our main finding is that, compared to the standard perfect labour market case, a tariff liberalisation provides much larger welfare gains when labour markets are monopsonistic. The welfare implications of FDI liberalisation are crucially tied to the employer variety effect. In the presence of the employer variety effect, the gains from FDI liberalisation are also larger when labour markets are monopsonistic. However, the absence of the employer variety effect, while retaining upward-sloping labour supply, creates the possibility of there being too many multinationals. While recent studies have started to incorporate imperfect labor markets in trade models, to the best of our knowledge, our paper is the first attempt to study its implications for FDI liberalisation.

2 Related Literature

MacKenzie (2019) constructs a static model where upward-sloping labour supply curves arise from idiosyncratic productivity matches between firms and workers. This setup gives rise to love of employer variety, but he rules-out this effect by assuming a fixed number of firms. The firms face oligopoly in the product market with endogeous markups and oligopsony in the factor market with endogenous markdowns; he performs a quantitative analysis using data from India. He finds that trade liberalisation has a larger effect on markups in the product market than on markdowns in the labour market. In our framework, the markups and markdowns are constant but the mass of firms is endogenous and much of the impact of trade and FDI liberalisation occur through the extensive margin.

Jha and Rodriguez-Lopez (2021) construct a theoretical model where monopsony power in the labour market arises because of workers' idiosyncratic preferences for employers. This also gives rise to love for employer variety. They show how trade liberalisation could provide additional gains through the employer variety channel when monopsony power is high but detract from welfare gains when monopsony power is low. The current paper differs along several dimensions. Labour supply is endogenous in our framework, which opens an additional channel through which trade liberalisation affects welfare. While Jha and Rodriguez-Lopez (2021) provide a theoretical model and derive steady-state results under Pareto distribution of productivity, in this paper we perform a quantitative exercise and evaluate welfare effects in both steady state and during transition. Quantification in the present paper involves recalibrating fixed and variable cost parameters to hold the implied moments constant across the imperfect and perfect scenarios, prior to running liberalisation exercises. The qualitative study of Jha and Rodriguez-Lopez (2021) instead holds these parameters constant across the labour market scenarios. Finally, we also allow firms to undertake FDI and study the implications of FDI tax liberalisation.

Egger et al. (2022) incorporate a monopsonistic labour market in a model of trade with heterogeneous firms. They do not allow firms to engage in horizontal FDI as in our current model, but do allow firms to offshore inputs from abroad. Just as an upward-sloping labour supply curve incentivises firms to engage in horizontal FDI compared to exporting in our setup, in their framework firms are induced to offshore input production. They find that trade in goods is welfare improving but offshoring can be welfare reducing because it allows firms to exercise their labour market power by reducing the size of their domestic operations. Our results on the negative welfare implications of a cut in FDI taxes in the absence of employer variety effect, echoes qualitatively their finding of adverse welfare effects of offshoring. We push the analysis further by quantifying the size of this effect, through developing a dynamic model that can be disciplined with firm micro data.

Dhyne, Kikkawa, Komatsu, Mogstad and Tintelnot (2022) study the labor market effects of foreign demand shocks. They model imperfect labor markets along the lines of Jha and Rodriguez-Lopez (2021), in the context of a network model, allowing firms to have fixed overhead labor costs. The combination of upward sloping labor supply curves and fixed overhead labor cost generates larger effects of trade shocks than a model with a competitive labor market and no fixed overhead labor cost. They abstract from dynamics, FDI and consider a small open economy setting.

Our theoretical model shares some features of the Berger, Herkenhoff and Mongey (2022) model, where labour supply is endogenous. They abstract, however, from welfare effects of employer variety, as they use an oligopsony model with a fixed number of firms. Their focus is on estimating and quantifying the welfare effects of labour market power on the levels of aggregate variables in a closed economy setting. They find a significant welfare loss from labour market power compared to the efficient allocation.

Jha and Rodriguez-Lopez (2022) also use a similar model to study the effects of minimum wages when workers care about employer variety. Their theoretical model quantifies the welfare effects of minimum wages through changes in the mass of employers.

The modelling of FDI in a quantitative open economy framework is similar to Spencer (2022), who studies the implications of corporate tax reforms targeted at multinational firms in the presence of financial frictions but competitive labour markets. We abstract away from financial frictions in the current paper but introduce a monopsonistic labour market. Similarly to our results, Spencer (2022) finds that openness reforms have a larger quantitative impact in the presence of frictional markets.

A growing number of empirical studies provide evidence for finitely-elastic labour supply at the firm-level. Naidu et al. (2018) survey the literature and provide a range of 1 to 5 for the labour supply elasticities facing firms. Berger, Herkenhoff and Mongey (2022) estimate firm-level labour supply elasticities ranging from 0.76 (for a firm that controls an entire local labour market) to 3.74 for the smallest firms. Webber (2015) uses the U.S. Census's Longitudinal Employer-Household Dynamics (LEHD) data and obtains a mean labour supply elasticity of 1.08, whereas Yeh, Macaluso and Hershbein (2022) find a mean value of 1.88;

the latter is the number we use in our quantitative exercise. A consequence of a finitely-elastic labour supply is that firms have market power and they markdown wages below the marginal product of labour. Yeh, Macaluso and Hershbein (2022) estimate the markdowns directly using the output elasticity and revenue share of labour. They find the markdowns to be substantial and increasing since the early 2000s. Our quantitative exercises show that labour market power can significantly affect the welfare effects of trade and FDI reforms.

3 Model Environment

Our model consists of two symmetric counties, referred to as Home (H) and Foreign (F). There are four types of agents in each country: households, intermediate producers, final producers and governments. Labour in each country is the only variable input into production; this factor is immobile across countries. There are flows of trade in intermediate good varieties across countries, as well as horizontal FDI. We adopt the notation convention that variables with a $*$ superscript correspond to activities in F, while those without correspond to those in H. In the exposition that follows, we focus on agents from the H economy, the setup for those from F can be defined similarly. Aggregate and firm-level variables are denoted with capital and lower-case letters, respectively. Time is discrete and indexed by subscript t.

3.1 Households and Monopsonistic Labour Markets

A representative household faces a budget constraint of the form

$$P_t C_t = W_t N_t + \Pi_t + T_t \tag{1}$$

where P_t is the CPI, C_t is consumption of final goods, W_t is an index of wages and N_t is a labour supply index (defined below), Π_t is aggregate profits (net of fixed costs) and T_t are lump-sum tax rebates from the government.[6] We assume that the household owns all of the equity of the firms incorporated in their country of residence.[7] The household preferences are given by

$$U_t = \sum_{t=0}^{\infty} \beta^t \left[C_t - \frac{N_t^{1+\frac{1}{\phi}}}{1+\frac{1}{\phi}} \right] \tag{2}$$

where $\phi \geq 0$ is the Frisch elasticity of labour supply and $\beta \in [0,1]$ is the discount factor.[8] In Appendix A we provide microfoundations for the above utility function in a setting where

[6]Since our model is dynamic, firms will generate positive profits in equilibrium due to the presence of discounting.

[7]Note also that the household implicitly makes a decision each period in the number of shares to hold in the domestically-incorporated firms. Given that there is only one household, in equilibrium they hold all of the equity. As such, we abstract from writing this part of the problem to keep the exposition simple.

[8]We assume household risk neutrality to keep the interpretation of transition results transparent: here dynamics arise due entirely to the supply-side of the economy. Accounting for risk aversion and foreign asset accumulation would affect the demand-side, leading to more non-linearities along the transition path. This will give more scope for differences in the predictions of the models with imperfect and perfect labour markets.

workers draw firm-specific productivity from a Fréchet distribution. They choose which firm to work for and how many hours to work based on the draw of their firm-specific productivities and wage offers.

Varieties of intermediate goods producers are indexed by ω. The household supplies labour to firms producing in its country of residence; the mass of such firms is defined as

$$\Omega_t^P = \Omega_t + \Omega_t^M$$

where the P superscript in Ω_t^P stands for "producing". Variable Ω_t is the mass of operative firms incorporated in H, while Ω_t^M is the mass of multinational firms incorporated in F. That is — the household supplies its labour to both domestic firms and to the H subsidiaries of multinationals from abroad. We define the labour supply index as

$$N_t = (\Omega_t^P)^{\frac{\eta}{1+\theta}} \left(\int_{\omega \in \Omega_t^P} n_t(\omega)^{\frac{1+\theta}{\theta}} d\omega \right)^{\frac{\theta}{1+\theta}} \tag{3}$$

where $\theta > \phi$ is the elasticity of substitution across jobs from different employers and $\eta \in [0, 1]$. A low value of θ indicates a high degree of monopsony power in the labour market — due to low substitutability across jobs — whereas the $\theta \to \infty$ case corresponds to the standard perfectly elastic labour supply scenario. The above specification captures love of variety in employment (LOVE). To see this clearly, we introduce the distinction between the labour supply index in (3) and the aggregate supply of labour hours, defined as $\int_{\omega \in \Omega_t^P} n_t(\omega) d\omega$. While it is the former that matters for welfare, it is the latter that matters for aggregate production. To illustrate the effect of LOVE, suppose there are Ω^P identical firms, so that $n(\omega) = n$ is the same across firms and $N = (\Omega^P)^{\frac{\theta+\eta}{1+\theta}} n$. For a constant amount of supplied labour hours, $L = \Omega^P n$, note that the labour-supply index can be written as $N = L/(\Omega^P)^{\frac{1-\eta}{1+\theta}}$. Hence, the disutility from supplying the same amount of labour hours is lower the larger the Ω^P as long as $0 \leq \eta < 1$.

The standard Dixit-Stiglitz love of variety utility function is based on the idea of product differentiation. This utility function is microfounded by a random utility framework as in Anderson, De Palma and Thisse (1992) or Gabaix, Laibson, Li, Li, Resnick and de Vries (2016) where the idiosyncratic preferences of consumers give rise to market power in the goods market. Love of variety utility functions and market power go hand in hand in the product market. The analogue of product differentiation in the labour market is job differentiation. One could generate market power in the labor market using a framework where workers have idiosyncratic preferences for non-wage characteristics of jobs, as in Jha and Rodriguez-Lopez (2021) or Card, Cardoso, Heining and Kline (2018). These models capture job differentiation which arises due to the heterogeneity in the location of firms and non-wage amenities that they offer. In contrast to the product market, in the labour market, there is an additional reason for job differentiation. Since no two workers are alike in terms of their skill or productivity, job differentiation across firms allows workers to find roles that best match their skills.

In our microfoundation in Appendix A, we use idiosyncratic productivity rather than idiosyncratic tastes to generate market power.[9] More importantly, both these approaches exhibit LOVE, which captures the idea that if many firms are offering differentiated jobs, workers would find better matches either along the productivity dimension or non-wage characteristics.[10] Despite anecdotal support, the empirical relevance of this channel is not well established yet. As such, we conduct our quantitative exercises with and without this channel. The parameter η governs the degree of LOVE preferences; a value of $\eta = 0$ gives full love of variety for employers, while $\eta = 1$ eliminates the effect. We set $\eta = 0$ in our baseline analysis but also conduct quantification where $\eta = 1$, finding significant differences from predictions with perfect labour markets in both cases.[11] While some papers in macroeconomics (e.g. Deb, Eeckhout, Patel and Warren, 2022 and De Loecker, Eeckhout and Mongey, 2021) suppress love of variety in consumption and labour supply through normalization, in others, this feature plays a key role. In Bilbiie, Ghironi and Melitz (2012), love of variety on the consumption side is central, through firm count fluctuations at business cycle frequencies. It also plays a crucial role in Bilbiie, Ghironi and Melitz (2019) where inefficiencies in product variety arise due to different values placed on a variety by producers and consumers.

3.2 Final Goods Firms

A representative final goods producer aggregates over the intermediate goods varieties that are utilised domestically. As will be discussed later, the final good is utilised for both consumption and fixed costs. We define the mass of varieties utilised as

$$\Omega_t^U = \Omega_t + \Omega_t^{X*} + \Omega_t^M$$

where the U in Ω_t^U stands for "utilised" and Ω_t^{X*} is the mass of exporters sending goods from F to H. Final goods producers use technology

$$A_t = \left(\int_{\omega \in \Omega_t^U} q_t(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}} \tag{4}$$

[9] MacKenzie (2019) also derives labour supply from a set up where workers draw their firm specific productivity from a Fréchet distribution. We add the choice of hours in this setting. In the multi-sector models of Kim and Vogel (2021) and Galle, Rodríguez-Clare and Yi (2022) workers get a draw of sector specific productivity. Similar to our set up, in Kim and Vogel (2021) workers also optimally choose the hours worked.

[10] An important non-wage characteristic that is intimately linked to LOVE is commuting time: if a shock causes some firms to close, a worker that reallocates to a new job — even if keeping the same wage — will be worse off if the switch comes with an increase in commuting time. As an example, Dustmann, Lindner, Schönberg, Umkehrer and vom Berge (2022) find that a nationwide minimum wage policy in Germany reduced the number of small establishments, causing a reallocation of workers towards larger higher-paying establishments at the expense of a 10% increase in commuting time. The recent literature on working from home (WFH) provides the most direct evidence on the importance of commuting time for workers' welfare. Barrero et al. (2022), for example, find that willingness to pay for WFH increases with commuting time. Using a nonparametric specification, they mention that "the willingness to pay to WFH two to three days per week exceeds 2 percent of pay for someone with a round-trip commute of more than one hour relative to an observationally similar person who commutes less than 20 minutes per day."

[11] The microfoundation provided in Appendix A is for the $\eta = 0$ case. $\eta = 1$ case is to neutralise the love of variety for employers. Deb, Eeckhout, Patel and Warren (2022) use a similar structure to neutralise the love of variety for employers.

where $q_t(\omega)$ denotes the input of intermediate goods of variety ω and $\sigma > 1$ is the elasticity of substitution across varieties. As in Alessandria, Choi and Ruhl (2021), we introduce a parameter $\widehat{\tau}^X \geq 1$ as a tariff levied by the H Government on imported goods from F. This tariff is borne by the final goods firms at the point they purchase imported varieties from abroad.

3.3 Intermediate Goods Firms

Intermediate firms operate under a dynamic Helpman, Melitz and Yeaple (2004) structure with fixed and sunk costs associated with maintaining and upgrading their statuses, respectively. An incumbent's state variable will change over time and it will always have the option to exit the industry. As such, we describe the environment for incumbent and new entrant firms in turn. To economise on notation, we omit variety-level notation in what follows.

3.3.1 Incumbents

Incumbent firms seek to maximise the discounted value of expected dividends they pay to their shareholders

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t d_t \tag{5}$$

where the discount factor β is that of the household given above, d_t is the dividend in period t and the expectation operator is with respect to their idiosyncratic shocks. These firms produce using a constant returns to scale technology

$$y_t = z_t n_t \tag{6}$$

where y_t is output, z_t is the firm's idiosyncratic productivity level and n_t is its employment of labour. The productivity level evolves over time through process

$$\log(z_t) = \rho_z \log(z_{t-1}) + \epsilon_t, \quad \epsilon_t \sim N(0, \sigma_z^2) \tag{7}$$

where $\rho_z \in [0, 1)$ is a persistence parameter, ϵ_t is a shock with normal distribution about a zero mean with variance σ_z^2. As shorthand, we will refer to the conditional process defined by (7) by $Q(z_t|z_{t-1})$. We assume, to keep the state space small, that the same productivity process applies to production in F should this H firm choose to become a multinational. Time-varying productivity in (7) is what drives non-trivial transition dynamics in our model after a reform.

Firms make a choice of how much labour to hire, subject to the optimal labour supply choices of households (to be described in Section 4). A firm with operations in H must offer a wage to induce the desired supply of labour from the H household. A multinational will make the same considerations when making their labour choice in F.

Incumbents make a choice about their operations at the extensive margin. They choose a status each period s_t, which can be either to exit (E), operate as a domestic firm (D), an exporter (X) or a multinational (M).[12] A domestic firm sells its goods only to the market of its country of incorporation. An exporter also sells to the final goods producer abroad, from its domestic production. A multinational establishes a local subsidiary abroad, employing in the local workforce, for production of goods sold in the local market.

As in papers such as Alessandria and Choi (2007), Alessandria, Choi and Ruhl (2021) and Ruhl and Willis (2017), firms pay a one-off sunk cost to establish a new operating segment. They then pay fixed period-by-period costs to maintain it (and receive new productivity shocks) thereafter. Post-entry, all firms incur fixed cost f^C (the C is shorthand for "continuation") each period they remain active. A firm changing its status to $s_{t+1} \in \{X, M\}$ from status $s_t \in \{D, X, M\}$ with $s_{t+1} \neq s_t$, incurs sunk cost $f_t^{s_{t+1}, s_t}$. That is, the sunk costs are allowed to vary with the firm's current status. A firm that maintains a status of $s_{t+1} \in \{X, M\}$, having incurred the associated sunk cost previously ($s_{t+1} = s_t$), pays period-by-period cost $f^{s_{t+1}, C}$. Notice also the time subscript on $f_t^{s_{t+1}, s_t}$; we allow these four possible sunk costs ($f_t^{X,D}, f_t^{M,D}, f_t^{X,M}, f_t^{M,X}$) to exhibit some randomness to generate dispersion for technical reasons. We then denote the vector of a firm's fixed costs as f_t and the probability distribution they follow by $H(f_t)$.[13] As in Jha and Rodriguez-Lopez (2021), these fixed costs are all denoted in terms of final goods (of their country of incorporation), given the non-competitive labour market. As such, our model economy features roundabout production in fixed costs, as in Caliendo and Parro (2015).

Firms that export or undertake FDI are also subject to variable cost inefficiencies. We denote $\tau^X \geq 1$ as the standard physical iceberg trade cost incurred by an exporter. As in Arkolakis, Ramondo, Rodríguez-Clare and Yeaple (2018), we also define parameter $\tau^M \geq 1$ as a productivity loss associated with the operations of a multinational's foreign subsidiary.[14] For both of these variable costs, a firm must produce τ^s output, for $s \in \{X, M\}$, in order to sell 1 unit of output to the relevant final goods producer. Finally, incumbent firms who generate profits through multinational activity are taxed by the government of their country of incorporation on such profits at rate $\widehat{\tau}^M \in [0, 1]$. Note the difference in the treatment of the distortions levied by the Government across imports and FDI. The tariff rate is on the sale value of imported goods, while the FDI tax is levied on corporate profits of multinationals abroad. We follow this approach to map the policies closely to the data.[15] Note that these distortions will have fundamentally different effects on firm decisions. The tariff distorts the exporting firm's demand curve, potentially affecting both the extensive and intensive margins. This differs from the FDI tax, which solely affects the extensive margin choice,

[12]Note that although firms make the choice of s_t each period, the calibration of the fixed costs will be done to match the persistence of statuses in the data.

[13]Specifically, we assume that $f_t^{s_{t+1}, s_t} \sim LN(\widehat{f}^{s_{t+1} s_t}, \sigma_f^2)$ where $\widehat{f}_t^{s_{t+1}, s_t}$ is the mean and σ_f^2 is the variance of a log-normal distribution for $s_{t+1} \in \{X, M\}$ and $s_t \in \{D, X, M\}$ with $s_{t+1} \neq s_t$. These costs are drawn iid overtime. Note that σ_f^2 is the same for all four sunk costs. This cost structure allows for better convergence properties of the quantitative exercises. In practice, this amounts to introducing another parameter σ_f that must be disciplined with data.

[14]As in Arkolakis et al. (2018), we will use these two variable costs to match sales intensities in the data.

[15]The outward tax on FDI can be thought of as resembling the repatriation tax levied by the U.S. Government prior to the Tax Cuts and Jobs Act (TCJA) or as a minimum tax, such as the 15% agreement reached by the OECD, implementable by the end of 2023.

given that labour expenses are tax deductible.

We summarise the timing of the incumbent's problem below.

1. Enter the period with state vector (z_{t-1}, s_t).
2. Draw new productivity shock z_t from distribution in equation (7).
3. Make static production choices in accordance with s_t and newly-drawn z_t.
4. Draw sunk cost shocks.
5. Make new discrete choice $s_{t+1} \in \{E, D, X, M\}$.

3.3.2 Entrants

Variables and parameters pertaining to new entrant firms will be denoted with T superscripts. These firms create a new variety upon startup. An entrant pays a sunk cost to incorporate their firm, which we denote by f^T. Their initial status is as a domestic firm $s_{t+1} = D$. They draw their initial productivity shock from the unconditional productivity distribution denoted as $Q^T(z)$. They then operate as incumbent firms thereafter. We denote the mass of these new entrants by M_t^T.

3.4 Government

The Government acts passively. They raise taxes exogenously and re-distribute the proceeds to the household. The expression for aggregate tax collections is given as

$$T_t = (\widehat{\tau}^X - 1)I_t + \widehat{\tau}^M \Pi_t^{M*} \tag{8}$$

where the first term represents collected tariff revenues on the value of imports I_t, and the second is proceeds from taxing the H multinationals' profits Π_t^{M*}.

4 Model Equilibrium

This section details the optimisation problems agents in the model solve, as well as characterising their solution. We take the price of the final good in H as the numéraire, meaning that $P_t = 1 \; \forall t$. Note however that we keep P_t in the notation that follows so the equations can be easily translated to those of F.

4.1 Households

The household's problem amounts to choosing the amount to work in each firm $n_t(\omega)$, for a given period, to maximise its utility. This objective is obtained from equations (1) and (2) as

$$\max_{n_t(\omega)} \; \frac{1}{P_t} \left\{ \int_{\omega \in \Omega_t^P} n_t(\omega) w_t(\omega) d\omega + \Pi_t + T_t \right\} - \frac{N_t^{1+\frac{1}{\phi}}}{1 + \frac{1}{\phi}},$$

which is maximised subject to equation (3). Variable $w_t(\omega)$ denotes the wage offered by the firm of variety ω. Notice that the household takes aggregate profits and government distributions as given. Their choice trades-off more income from working, the first term inside the brackets, with more disutility from labour supply, the last term in their objective. Their optimal choice yields a variety-level labour supply condition

$$n_t(\omega) = B_t w_t(\omega)^{\theta} \tag{9}$$

where $B_t = 1/(P_t^{\theta}(\Omega_t^P)^{\eta} N_t^{\frac{\theta-\phi}{\phi}})$. Equation (9) says that the labour supplied to the firm of variety ω depends on a shifter-term comprised of aggregates and a term that is increasing in the wage the firm offers. This gives rise to an upward sloping labour supply (USLS hereafter) curve facing intermediate good firms. That is, firms have market power in the labour market and they mark down wages below the marginal product of labour as shown in the firms' optimisation exercise in Appendix B.

We then define an index over firm-level wages

$$W_t = (\Omega_t^P)^{\frac{-\eta}{1+\theta}} \left(\int_{\omega \in \Omega_t^P} w_t(\omega)^{1+\theta} d\omega \right)^{\frac{1}{1+\theta}}. \tag{10}$$

Using the definitions in equations (3) and (10) in conjunction with (9) yields the relationship

$$N_t = \left(\frac{W_t}{P_t} \right)^{\phi} \tag{11}$$

which can be interpreted as a standard aggregate-level labour supply condition. One can also write the budget constraint as $P_t C_t = W_t^{1+\phi}/P_t^{\phi} + \Pi_t + T_t$ and re-express $B_t = 1/(P_t^{\phi}(\Omega_t^P)^{\eta} W_t^{\theta-\phi})$.

4.2 Final Goods Firms

The firm chooses inputs of intermediate goods to maximise their profits

$$\max_{q_t(\omega)} \; P_t A_t - \int_{\Omega_t + \Omega_t^M} p_t(\omega) q_t(\omega) d\omega - \int_{\Omega_t^{*X}} \widehat{\tau}^X p_t(\omega) q_t(\omega) d\omega$$

subject to technology as in (4) and the CPI P_t is taken as given. Variable $p_t(\omega)$ denotes the price specific to intermediate variety ω. This problem yields demand curves of the form

$$\begin{aligned} q_t(\omega) &= A_t P_t^{\sigma} p_t(\omega)^{-\sigma} && \forall \omega \in \Omega_t + \Omega_t^M \\ q_t(\omega) &= A_t P_t^{\sigma} [\widehat{\tau}^X p_t(\omega)]^{-\sigma} && \forall \omega \in \Omega_t^{*X} \end{aligned} \tag{12}$$

where notice that the final goods producer internalises the effect of the tariff as an increase in the variety's effective price. See then from the definition of (4) with (12) that

$$A_t = \left(\int_{\omega \in \Omega_t + \Omega_t^M} \left\{ A_t P_t^{\sigma} p_t(\omega)^{-\sigma} \right\}^{\frac{\sigma-1}{\sigma}} d\omega + \int_{\omega \in \Omega_t^{*X}} \left\{ A_t P_t^{\sigma} (\widehat{\tau}^X)^{-\sigma} p_t(\omega)^{-\sigma} \right\}^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}$$

$$\Rightarrow P_t = \left(\int_{\omega \in \Omega_t + \Omega_t^M} p_t(\omega)^{1-\sigma} d\omega + \int_{\omega \in \Omega_t^{*X}} (\widehat{\tau}^X)^{1-\sigma} p_t(\omega)^{1-\sigma} d\omega \right)^{\frac{1}{1-\sigma}},$$

which serves as our definition of the CPI.

4.3 Intermediate Goods Firms

We now present the recursive formulations of the incumbent and entrant's problems. We leave time subscripts on functions and variables given the transition analysis in the quantitative results.

4.3.1 Incumbents

The value function for an incumbent firm with state (z_t, s_t) is given by

$$\begin{aligned} v_t(z_t, s_t) = &\mathbb{1}_{s_t=D}\pi_t(z_t, D) + \mathbb{1}_{s_t=X}\pi_t(z_t, X) + \mathbb{1}_{s_t=M}(1-\widehat{\tau}^M)\pi_t(z_t, M) \\ &+ \mathbb{E}_t \max_{s_{t+1}\in\{E,D,X,M\}} \widetilde{v}_t(z_t, f_t, s_{t+1}) \end{aligned} \tag{13}$$

where $\pi_t(z_t, s_t)$ is the period profits given current status $s_t \in \{D, X, M\}$; these all depend on the firm's new z_t draw. Operator $\mathbb{1}_a$ is an indicator for when the argument a is true. The term $\widetilde{v}_t(z_t, f_t, s_{t+1})$ is the continuation value of the firm, conditional on choosing a status s_{t+1}. Notice that this function depends on the draws of the firms' sunk costs, captured by vector f_t. See also that the expectation operator is with respect to the sunk cost shocks given that $v_t(z_t, s_t)$ is at the beginning of the period, right after drawing the new z_t. We denote the policy function for the optimal status choice by $s_{t+1}(z_t, f_t, s_t)$. The conditional value from exiting is given simply by $\widetilde{v}_t(z_t, f_t, E) = 0$; the firm ceases to exist. A non-exit choice ($s_{t+1} \in \{D, X, M\}$) yields conditional value

$$\widetilde{v}_t(z_t, f_t, s_{t+1}) = -f_t(s_{t+1}, s_t) + \beta\mathbb{E}_t[v_{t+1}(z_{t+1}, s_{t+1})] \tag{14}$$

where $f_t(s_{t+1}, s_t)$ represents the entry in vector f_t for a firm moving from status $s_t \in \{D, X, M\}$ to s_{t+1}. Equation (14) says that the firm pays the corresponding fixed cost combination for their choice, based on their current status and drawn sunk cost shocks, then receives the corresponding expected discounted continuation value. The expression for period profits is then given by

$$\begin{aligned} \pi_t(z_t, s_t) = \max_{\{k_t(z_t,s_t)\}} &p_t(z_t, s_t)q_t(z_t, s_t) + \mathbb{1}_{s_t=X}\left[p_t^*(z_t, X)q_t^*(z_t, X)\right] - w_t(z_t, s_t)n_t(z_t, s_t) \\ &+ \mathbb{1}_{s_t=M}\left[p_t^*(z_t, M)q_t^*(z_t, M) - w_t^*(z_t, M)n_t^*(z_t, M)\right]. \end{aligned} \tag{15}$$

where $k_t(z_t, s_t)$ is an array of static control variables, which depend on the firm's status. Note that the maximisation in (15) is done subject to firms' technology (6), the household's labour supply (9) and the final goods demand (12), where the number of constraints varies based-on the firm's status.

The first expression on the right-side of equation (15) is the sales the firm generates domestically. The second term represents the extra sales income it receives, should it choose to export some of its output. The third term is the wage bill the firm incurs domestically. Note that the first and third terms will differ potentially between a domestic firm and exporting firm, holding z_t constant, due to the upward-sloping labour supply curve. The fourth term in

(15) is the profits from overseas operations, should the firm have multinational status. The array $k_t(z_t, s_t)$ consists of $p_t(z_t, s_t), q_t(z_t, s_t), w_t(z_t, s_t), n_t(z_t, s_t)$ for all three statuses, with the addition of $p_t^*(z_t, s_t), q_t^*(z_t, s_t)$ for $s_t \in \{X, M\}$ and also $w_t^*(z_t, s_t), n_t^*(z_t, s_t)$ for $s_t = M$. We defer expressions for optimal controls to Appendix B.

4.3.2 Entrants

An entrant receives value function $v_t^T \geq 0$ of the form

$$v_t^T = -f^T + \beta \mathbb{E}_t^T[v_{t+1}(z_{t+1}, D)] \tag{16}$$

where notice that the expectation is with respect to the entrants' draw from the unconditional distribution of productivity. The entrant incurs the fixed cost at time t and then receives the discounted expected expected value from being an incumbent with domestic status. This value must be weakly positive for a positive mass of entrants to exist; this mass is zero otherwise.

4.4 Cross-Sectional Measure

We track the cross-section of firms in each country along the state space (z_t, s_t). Denote the corresponding cross-section of firms at the start of period t, after drawing shock z_t but before the sunk cost shocks are drawn, by $\mu_t(z_t, s_t)$. The law of motion for this measure is given as follows

$$\begin{aligned} \mu_{t+1}(z_{t+1}, s_{t+1}) = & \sum_{s_t \in \{D,X,M\}} \int_{z_t} \int_{f_t} \mathbb{1}_{s_{t+1}=s_{t+1}(z_t,f_t,s_t)} Q(z_{t+1}|z_t) H(f_t) \mu_t(dz_t, ds_t) \\ & + M_t^T \mathbb{1}_{s_{t+1}=D} Q^T(z_{t+1}) \end{aligned} \tag{17}$$

for any arbitrary z_t, z_{t+1} and $s_t, s_{t+1} \in \{D, X, M\}$. Equation (17) says that the incumbent firms draw from the sunk cost probability process $H(f_t)$, upon which their status choice $s_{t+1}(z_t, f_t, s_t)$ is conditional. They then draw a new productivity shock z_{t+1} at the start of period $t+1$. We then integrate and sum over all possible z_t, f_t and s_t values that can lead to arbitrary state (z_{t+1}, s_{t+1}) at $t+1$ to obtain $\mu_{t+1}(z_{t+1}, s_{t+1})$. The mass of entrants M_t^T each enter at status $s_{t+1} = D$ by design and draw their initial shock from unconditional distribution $Q^T(z_{t+1})$.

4.5 Equilibrium Definition

We define equilibrium in terms of an infinite sequence of equilibrium objects for H

$$\{\{v_t(z_t, s_t), \mu_t(z_t, s_t), k_t(z_t, s_t)\}_{(z_t,s_t)}, \{s_{t+1}(z_t, f_t, s_t)\}_{(z_t,f_t,s_t)}, A_t, P_t, W_t, N_t, \Pi_t, C_t, F_t, T_t\}_{t=0}^{\infty}, \tag{18}$$

which we denote as Γ. Infinite sequence Γ is such that the following conditions hold.

1. The household optimises its labour-leisure choice taking W_t, Π_t and T_t as given.

2. The value function $v_t(z_t, s_t)$ and set of policy functions for control variables $k_t(z_t, s_t)$, $s_{t+1}(z_t, f_t, s_t)$ solve firm problem (13) with all aggregate objects taken as given.
3. Cross-sectional measure $\mu_t(z_t, s_t)$ satisfies the law of motion given in equation (17).
4. The free entry condition holds: $v_t^T = 0$ where value to entry is given by equation (16).
5. Aggregate objects can be found using the cross-sectional measure $\mu_t(z_t, s_t)$. Market clearing in the final goods market gives

$$A_t = C_t + F_t$$

where A_t is given by equation (4), C_t is given by the household budget constraint in equation (1) and F_t is aggregate fixed costs used by H firms. Aggregate object Π_t is aggregate profits and T_t is aggregate tax collections.
6. The government budget constraint holds as in equation (8), giving T_t.
7. The labour market clearing condition holds, meaning that aggregate labour demand given in (11), equals supply as defined in equation (3), with the aggregate wage index given by equation (10).

The conditions for F are defined similarly with infinite sequence denoted by Γ^*. Note the conditions in H and F all hold simultaneously in any equilibrium.

4.6 Discussion of Model Features

Compared to the existing quantitative studies of the effects of trade liberalisation (e.g. Alessandria and Choi, 2007, Alessandria et al., 2021) or FDI liberalisation (e.g. Spencer, 2022) our framework introduces some new features, which have welfare implications. Our model includes two non-standard features: the first is upward-sloping firm-level labour supply (USLS) curves, giving rise to labour market power. The second is love of variety in employment (LOVE), which leads to welfare consequences when there are changes in the mass of local employers. Since labour supply is endogenous and the consumption good is supplied competitively, wage markdowns (WMD) resulting from labour market power act as a tax on labour (or a subsidy to leisure), which distorts labour supply downwards. However, LOVE implies that the market does not provide an optimal number of firms if firms are wage takers in the labour market. Labour market power in this setting is efficiency enhancing.[16] With endogenous labour supply and LOVE, labour market power has an offsetting effect: it distorts labour supply but alleviates the distortion in the provision of employer variety.

To elucidate these new features, we provide a simplified static version of the model for the closed economy case in Appendix C. Here we show that the decentralised equilibrium — with firms exercising labour market power — is efficient when labour supply is exogenous. In this set up, if firms act as wage takers in the labour market, the decentralised equilibrium is inefficient. When labour supply is endogenous, the exercise of labour market power has offsetting effects on labour supply. Wage-taking behaviour by firms avoids distorting labour supply, but does not provide the optimal mass of firms in the presence of LOVE. Overall,

[16] This is similar to the role of monopolistic competition in providing the optimal variety when utility function exhibits love of variety on the consumption side.

in the presence of LOVE, the exercise of monopsony power results in higher welfare than in the case of wage taking behaviour. On the other hand, in the absence of LOVE, the results are flipped: the exercise of monopsony power becomes purely distorting and wage taking behaviour by firms increases welfare. Our decomposition of the welfare effects in the quantitative exercises below will be informed by this discussion.

5 Calibration

In this section, we detail the choices of parameters used in the numerical solution. We consider several variations on the model and parameter space, with a view towards decomposing the effects of the non-standard features discussed above. While USLS curves give rise to labour market power, resulting in wage markdowns (WMD), we examine the implications of USLS in the absence of WMD by making firms wage-takers. When firms are wage-takers, they still face a finitely elastic labour supply curve, yet they do not internalise their impact on the wage.[17] Loosely-speaking, one can think of firms here as being myopic with respect to their labour market power. In general, firm-level employment and wages will both be higher when firms are wage-takers than wage-setters, all else equal. Recall that the parameter η controls LOVE in the labour supply aggregator index (3). Through considering varying combinations of the wage-setter and wage-taker scenarios, with parameterisations where $\eta = 0$ and $\eta = 1$, we can isolate the quantitative impact of each of WMD, LOVE, and USLS.

In performing our policy exercises, we firstly study tariff reduction in the context of calibrations where FDI is prohibitively costly. We do this with a view to first quantify imperfect labour markets' effect on the domestic-foreign engagement margin. We then secondly move to incorporate the export-FDI substitution margin in the context of the multinational tax reforms. For the purpose of studying trade liberalisations, we start with the following five sets of calibrated parameters.

- Calibration 1 (C1): the baseline model where FDI is prohibitively costly ($\widehat{f}^{M,D} = \widehat{f}^{M,X} = f^{M,C} \to \infty$). Firms are wage-setters, $\theta < \infty$ and $\eta = 0$. Model contains WMD, LOVE and USLS.
- Calibration 2 (C2): the same setup as C1, except firms are wage-takers. Model contains LOVE and USLS.
- Calibration 3 (C3): the same setup as C1, except $\eta = 1$. Model contains WMD and USLS.
- Calibration 4 (C4): as in C1, $\theta < \infty$, but firms are wage-takers and $\eta = 1$. Model contains only USLS.
- Calibration 5 (C5): FDI is still prohibitively costly, but $\theta \to \infty$. Model contains none of WMD, LOVE or USLS.

Note that each time we change the structure of the model and parameterisations for θ and η, we re-calibrate so that the behaviour of firms in the model matches a common set of moments

[17] We give the alternative expressions for optimal employment and firm-level wages in Appendix B.

in the data.[18] One crucial object that we always calibrate internally is the magnitude of the tariff policy instrument, to hold the ratio of tariff revenue collections to output constant across parameterisations.

There are several comparisons one can make across these five calibrations to infer the effects of each of WMD, LOVE, and USLS. Notice that there are sometimes multiple comparisons that can quantify the effect of one single feature. Moreover, given the non-linear nature of the model, two comparisons to examine the same feature can offer different quantitative conclusions. The effect of WMD can be inferred from comparing C1 to C2 or C3 to C4. The effect of LOVE comes from comparing C1 to C3 or C2 to C4. The effect of USLS can be deduced from comparing C4 to C5. We then also calibrate 5 sets of model variants and parameters where FDI has a finite cost and is feasible ($\widehat{f}^{M,D}, \widehat{f}^{M,X}, f^{M,C} < \infty$), but otherwise with the same specifications as C1–C5; we refer to these as C6–C10, respectively. These calibrations with FDI will be used to infer the effect of FDI liberalisation episodes.

Note that the two countries are taken to be symmetric across all calibrations. To keep the computational burden low and to ensure proper identification, we have two sets of parameters. One set are for parameters chosen outside the model, directly from the data and previous studies in the literature. The second set consists of parameters calibrated inside the model to ensure consistency of firm-level model moments with the data.

Parameter	**Symbol**	**Value**	**Source**
Discount factor	β	0.98	Literature
Frisch elasticity	ϕ	0.20	Literature
Elasticity of labour supply	θ	1.88	Literature
Elasticity of substitution	σ	5.00	Literature
Exporting tariff in C1	$\widehat{\tau}^X$	1.10	Literature
Persistence of productivity	ρ_z	0.66	Compustat
Variability of productivity	σ_z	0.22	Compustat

Table 1: Parameters calibrated outside the model.

Table 1 shows the parameter values selected outside the model as well as their source. The discount factor is taken to be consistent with real interest rates in recent years. This is also the value used in several papers studying firm dynamics (e.g. see Corbae and D'Erasmo, 2021). We take the Frisch elasticity as the lower bound of those considered in Berger, Herkenhoff and Mongey (2022).[19] We take the elasticity of the firm-level labour supply to be 1.88, the mean firm-level empirical estimate from Yeh, Macaluso and Hershbein (2022).[20]

[18]Given that our focus is on quantification of the labour market frictions' effect on a policy *change*, it is necessary to hold the starting point constant. By re-calibrating, we ensure that firms' behaviour in the pre-reform economy is always the same. Some examples of the many other papers taking this approach are Costinot and Rodríguez-Clare (2014), Atkeson and Burstein (2010), Simonovska and Waugh (2014) and Brooks and Dovis (2020). For a more qualitative discussion on how comparative statics on θ affect the gains from trade, absent re-calibration, see Jha and Rodriguez-Lopez (2021).

[19]The authors find that the welfare losses of labour market power are increasing in the Frisch elasticity. As such, this value will give more conservative estimates of the friction's effect on openness reforms. We also perform robustness on this parameter in Appendix E.

[20]There is a large spread in empirical estimates of this elasticity; this value sits within this range. For a

We take the elasticity of substitution across varieties in final goods aggregation as 5 as in Alessandria, Choi and Ruhl (2021); similarly in Calibration 1 we use a 10% tariff rate.

The parameters for the firm productivity process are estimated from firm-level data in Compustat over the period 1979–2018. We use the estimation method in Cooper and Haltiwanger (2006) to this end, yielding estimates of 0.66 for the persistence parameter and 0.22 for the variability parameter. We then discretise the productivity process into a Markov process using the method of Tauchen (1986).

We then calibrate 12 parameters inside the model using simulated method of moments. Table 2 shows each parameter, and the value it assumes under each of the calibrations C1–C10, as well as the target moment that identifies it. We calibrate the parameters in each case to minimise the squared difference of the model moments from their data analogues.

We now briefly turn to describe the identification of the parameters. It is important to note that, since this is a general equilibrium model, there is not a one-to-one mapping of any given parameter to a data moment. But rather, a change in one parameter will likely impact several moments. But we choose target moments that will shed the most light on the parameter of interest. Since it is difficult to disentangle parameters f^C and f^T in the data, we follow standard practice in firm dynamics papers, by setting f^T to normalise the wage rate to one (e.g. see Hopenhayn and Rogerson, 1993). Since wages are heterogeneous in our setting, we set the wage index, W_t, specified in equation (10) equal to 1. We draw upon the summary statistics regarding foreign engagement statuses of establishments from Boehm, Flaaen and Pandalai-Nayar (2020). This study works with U.S. census data and summarises key moments relating to employment and establishment counts. They classify observations as pertaining to domestic, exporting, importing, U.S. multinational and foreign multinational establishments.[21] The specific moments we borrow are transition probabilities across statuses, to identify the mean of the corresponding sunk cost draws. We then take the fractions of exporters and multinationals to identify the associated period-by-period fixed costs. A higher variability in the sunk cost distribution gives larger spread in the productivity of firms upgrading to X or M status. As such, we identify this parameter by matching the exit rate of exporting firms.

The fixed continuation cost for all firms to maintain their headquarters, f^C, targets the economy-wide exit rate from the Business Dynamics Statistics (BDS) dataset. We calibrate the physical iceberg costs for X and M statuses by matching the average export intensity (15%) and the foreign sales intensity (30%) from Compustat, respectively.[22] Lastly, consider

comprehensive discussion of the empirical literature, see Jha and Rodriguez-Lopez (2021).

[21] One issue with using these data is that ours is a model of firms, rather than establishments. We treat these establishment moments as an approximation for the transitions experienced by firms across statuses. Previous versions of this paper have instead calibrated directly to firm-level transitions using Compustat segment information and the procedure of Fillat and Garetto (2015). Since Compustat pertains to large, publicly-listed firms, transitions are much rarer than in the population of firms at large, while also over-representing multinationals in the stationary equilibrium (compared with Bernard, Jensen and Schott, 2009). Aggregate insights from comparing across the different calibrations are largely robust to which approach is used.

[22] Note that one could alternatively calibrate to the aggregate FDI sales intensity using the Bureau of Economic Analysis (BEA) data on multinational firms. This number is very close to the 30% we obtain from

the policy instruments. Recall that we set the export tariff in C1 to be 10%. We then compute the aggregate tax collections to final output ratio for the economy under C1, which is found to be around 0.7%. We then use this moment as a target, to identify the tariff rate ($\widehat{\tau}^X$) in C2–C5, with a view towards keeping the size of the tariff reduction constant across these quantitative exercises. We fix this tariff rate at 10% throughout C6–C10. Using a similar approach, we set the FDI tax rate to 2% in C6, compute the corresponding ratio of FDI taxes collected to final output (0.1%) and then again identify $\widehat{\tau}^M$ through treating this as a target in C7–C10. This 2% number is set to roughly match the magnitude of the rise in effective global taxes proposed in the Made in America Tax Plan.[23] All of the data and model moments across the calibrations are presented in Table 3.

6 Quantitative Exercises

We proceed by running two sets of quantitative exercises. First we run a tariff reduction exercise, where $\widehat{\tau}^X$ is set to 1, in the context of C1–C5. We then do an FDI tax liberalisation, where $\widehat{\tau}^M$ is set to zero, using C6–C10. Comparing across the five calibrations, for a given liberalisation exercise, allows for inference of the quantitative effect of each feature of labour market power on policy reform predictions.

For both the trade and FDI exercises, the design is as follows. We take the calibrated economy to be the steady state at time $t = 0$. At time $t = 1$, the government(s) announce the policy rate change and that it will last indefinitely. We then map the full transition dynamics to the new steady state equilibrium. We solve for the transition using a standard shooting-type algorithm, similarly to Spencer (2022).[24]

In thinking about the two sets of exercises, we consider both bilateral and unilateral reforms. Bilateral reforms involve both countries implementing the same policy change simultaneously. Unilateral reforms involve only country H changing its policy parameter. To prevent excessive length in our analysis, when studying the transition after a unilateral tariff reform, we limit the discussion to C1 and C5 (and correspondingly C6 and C10 for the unilateral FDI reform).

Lastly, the results of this section are generated with a Frisch elasticity of $\phi = 0.2$. As such, liberalisation episodes can lead to predictions of variation in the level of labour market participation. We also perform robustness exercises where we instead set $\phi = 0$. We defer the numerical results to Appendix E and note that quantitative significance of imperfect labour markets is preserved, while the qualitative insights remain unaffected.

Compustat.

[23]This Plan proposed to increase the global minimum tax to the domestic 21% rate. Tørsløv, Wier and Zucman (2023) estimate the global effective corporate tax rate of U.S. firms to be 19%. As such, this proposed minimum tax change would give around a 2% increase in the tax burden of multinationals. See https://home.treasury.gov/system/files/136/MadeInAmericaTaxPlan_Report.pdf for more details on the policy proposal.

[24]More details on the computational algorithms are deferred to Appendix D.

Parameter		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	Target
						Calibration						
Sunk cost of entry	f^T	0.329	0.290	0.433	0.301	0.482	0.328	0.282	0.424	0.296	0.490	Unit wage
Sunk cost (D,X)	$\widehat{f}^{X,D}$	0.026	0.022	0.030	0.021	0.085	0.068	0.058	0.043	0.039	0.159	Transition (D,X)
Fixed cost X	$f^{X,C}$	0.014	0.012	0.017	0.012	0.029	0.011	0.009	0.018	0.011	0.028	Fraction X
Sunk cost stddev	σ_f	0.300	0.500	1.300	1.200	1.000	1.020	1.020	1.020	0.600	1.040	Transition (X,E)
Fixed cost	f^C	0.181	0.153	0.229	0.159	0.165	0.181	0.154	0.232	0.161	0.163	Exit rate
Physical iceberg X	τ^X	1.350	1.350	1.350	1.350	1.385	1.350	1.350	1.350	1.350	1.350	Export intensity
Export tariff	$\widehat{\tau}^X$	1.100	1.100	1.100	1.100	1.080	1.100	1.100	1.100	1.100	1.100	Taxes/output C1
Sunk cost (X,M)	$\widehat{f}^{M,X}$						0.083	0.041	0.144	0.066	0.092	Transition (X,M)
Sunk cost (M,X)	$\widehat{f}^{X,M}$						0.052	0.053	0.033	0.034	0.092	Transition (M,X)
Fixed cost M	$f^{M,C}$						0.086	0.072	0.116	0.077	0.088	Fraction M
Physical iceberg M	τ^M						1.650	1.653	1.653	1.653	1.230	FDI sales intensity
FDI tax	$\widehat{\tau}^M$						0.020	0.050	0.020	0.050	0.030	FDI taxes/output C6

Table 2: Parameters calibrated inside the model. Fixed costs are expressed as a fraction of total final output.

Moment	Data	C1	C2	C3	C4	C5	Data	C6	C7	C8	C9	C10	Source
							Calibration						
Fraction X	0.360	0.351	0.352	0.370	0.343	0.344	0.290	0.285	0.313	0.305	0.302	0.296	Census
Transition (D,X)	0.054	0.063	0.064	0.072	0.063	0.062	0.054	0.036	0.045	0.050	0.048	0.039	Census
Transition (X,E)	0.054	0.033	0.033	0.034	0.033	0.033	0.053	0.052	0.053	0.055	0.063	0.052	Census
Exit rate	0.080	0.079	0.079	0.079	0.079	0.079	0.080	0.076	0.075	0.079	0.079	0.075	Census
Export intensity	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	Compustat
Taxes/output $\widehat{\tau}^X$	0.007	0.007	0.007	0.007	0.007	0.007							C1
Transition (X,M)							0.008	0.016	0.022	0.014	0.024	0.018	Census
Transition (M,X)							0.019	0.018	0.012	0.010	0.021	0.019	Census
Fraction M							0.055	0.048	0.044	0.040	0.041	0.049	Census
FDI sales intensity							0.300	0.300	0.300	0.300	0.300	0.300	Compustat
FDI taxes/output $\widehat{\tau}^M$							0.001	0.001	0.001	0.001	0.001	0.001	C6

Table 3: Data moments and model counterparts. Note that we report separate data moments for C1–C5, which are conditional on firms that do not transition to multinational status.

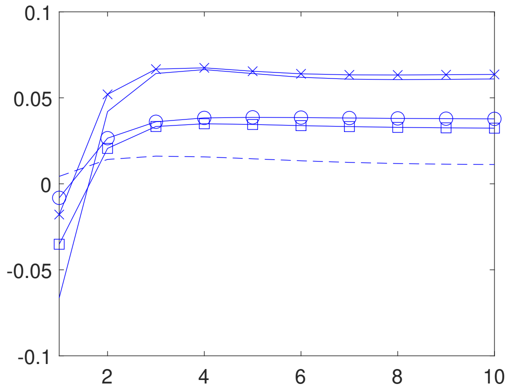
6.1 Trade Liberalisation

We begin with a discussion of the bilateral tariff reduction. We firstly compare the results of C1 with C5, to induce the effect of imperfectly competitive labour markets as a whole, then proceed to decompose the effect across the three features WMD, LOVE, and USLS. Table 4 depicts the steady state trade tariff reduction results for both bilateral and unilateral reforms across C1–C5. Figure 1 depicts the transition paths for variables in response to the bilateral reform, while Figure 2 gives those for the unilateral exercise.

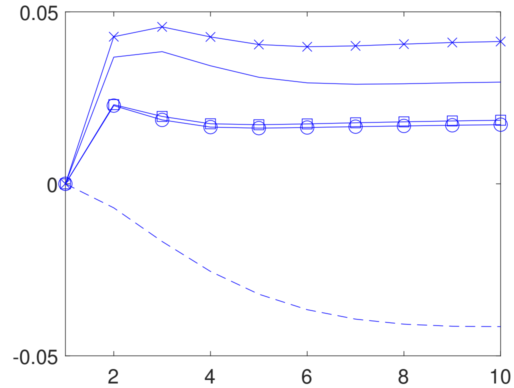
6.1.1 Bilateral Trade Liberalisation

Considering firstly the bilateral exercise, C1 and C5 offer starkly different cross-sectional predictions. Firms face contrasting cost structure trade-offs across the two scenarios. C1 brings increasing marginal costs and low exporting fixed and sunk costs, as opposed to constant marginal cost and high export fixed and sunk costs in C5 (see Table 2). As such, many firms are close to the domestic-exporter boundary in C1, giving a significantly larger jump in the measure of exporters on impact. This holds true in both the absolute sense and relative to the final steady state change in the measure — around 70% of this change is realised at $t = 1$ in C1 versus around 40% in C5. This spills-over to affect entry along the transition, on account of two channels. Firstly, the stronger exporter extensive margin response in C1 means more variety in final goods, driving down the sunk cost of entry, due to roundabout production. Secondly, when a firm upgrades to export in C1, it moves further along its marginal cost curve (due to the firm facing an upward-sloping labour supply). Such firms reduce their scale of production for the local market, leaving more space for newly-created firms. With the jump in export activity, the measure of entrants booms for the first few years of the transition in C1, before settling to a higher steady state. Since variable costs for goods sold locally and abroad are separable in C5, no such contraction in firm domestic supply ensues following the reform. Moreover a muted exporting extensive margin means weaker roundabout production amplification. Instead, with the greater need for resources for export sunk costs, the entry measure drops immediately to its new and lower steady state along the transition of C5.

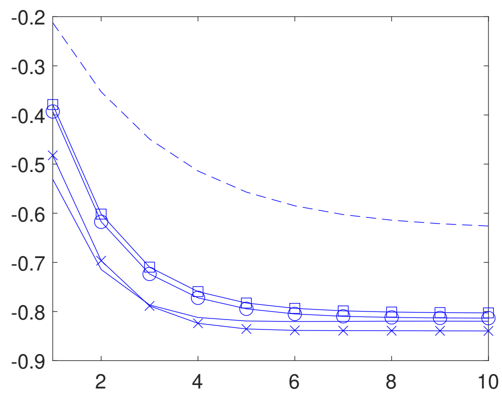
The contrasting effects between C1 and C5 at the cross-section yield different behaviours at the household level. In terms of welfare, utility is influenced positively by consumption and negatively by labour supply. The changes to the population of firms in C1 give an increase in the measure of firms in each country. This translates into an 44% increase in the steady state measure of new varieties in production of the final good and a 3% rise in the measure of employers. This latter effect amplifies the welfare gains in C1. In terms of consumption, the households have three sources of income — labour earnings, profits (net of fixed costs) and tax revenue rebates. In C1, the creation of new firms and exporting branches requires a large injection of funds from the household, giving a short-term drop in consumption of more than 5% in the first period of the transition. Instead in C5, consumption over-shoots the new steady state along the transition, as the drop in entry and overall firm mass releases more resources. The trajectory for consumption in C5 mirrors the overshooting result from the baseline exercises of Alessandria, Choi and Ruhl (2021); labour market power breaks this result.



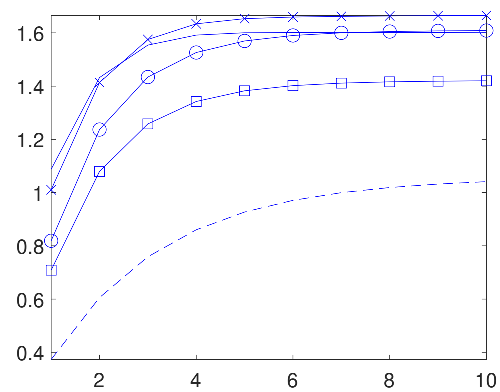
(a) Consumption



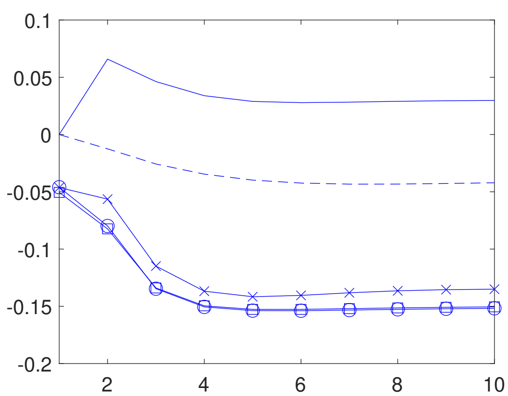
(b) Total firm mass



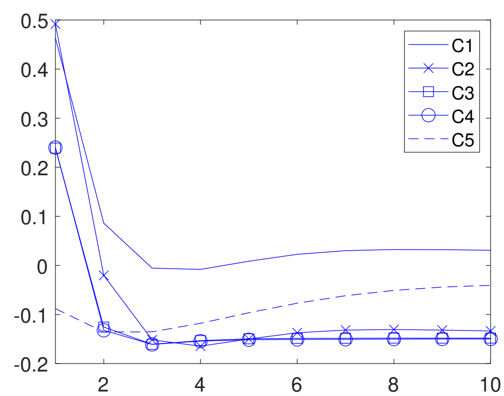
(c) Domestic firm mass



(d) Exporter firm mass



(e) Exit firm mass



(f) Entrant firm mass

Figure 1: Transition to bilateral reduction in import tariffs. Horizontal axes represent years and vertical axis are percentage deviations from calibrated steady state (prior to multiplication by 100). Legend is displayed in final panel and applies to all within the figure.

	Calibration 1: WMD,LOVE,USLS			Calibration 2: LOVE, USLS			Calibration 3: WMD, USLS			Calibration 4: USLS			Calibration 5: None		
	Bi.	**Uni.**		**Bi.**	**Uni.**		**Bi.**	**Uni.**		**Bi.**	**Uni.**		**Bi.**	**Uni.**	
Steady state	**H/F**	**H**	**F**	**H/F**	**H**	**F**	**H/F**	**H**	**F**	**H/F**	**H**	**F**	**H/F**	**H**	**F**
Welfare	0.050	0.012	0.050	0.052	0.015	0.043	0.026	0.008	0.040	0.030	0.011	0.037	0.008	-0.002	0.013
Consumption	0.061	0.016	0.055	0.064	0.019	0.049	0.033	0.012	0.045	0.038	0.017	0.041	0.011	-0.001	0.015
Disutility	0.071	0.026	0.037	0.072	0.027	0.037	0.045	0.026	0.028	0.046	0.035	0.027	0.019	0.007	0.010
Measure D	-0.820	-0.734	-0.698	-0.840	-0.764	-0.731	-0.804	-0.732	-0.707	-0.815	-0.735	-0.708	-0.638	-0.421	-0.402
Measure X	1.603	1.336	1.301	1.666	1.414	1.383	1.417	1.253	1.222	1.607	1.416	1.373	1.061	0.688	0.667
Measure T	0.030	-0.008	0.004	-0.135	-0.153	-0.138	-0.152	-0.152	-0.145	-0.152	-0.149	-0.143	-0.042	-0.033	-0.027
Measure all	0.030	-0.008	0.003	0.042	0.002	0.013	0.017	0.001	0.006	0.016	0.003	0.005	-0.042	-0.032	-0.027
Measure P	0.030	-0.008	0.003	0.042	0.002	0.013	0.017	0.001	0.006	0.016	0.003	0.005	-0.042	-0.032	-0.027
Measure U	0.438	0.341	0.349	0.464	0.369	0.377	0.395	0.339	0.342	0.422	0.363	0.365	0.245	0.155	0.158
Profits	0.165	0.082	0.132	0.130	0.049	0.105	0.096	0.039	0.082	0.109	-0.099	0.126	0.072	0.037	0.071
Taxes	-1.000	-1.000	1.527	-1.000	-1.000	1.588	-1.000	-1.000	1.455	-1.000	-1.000	1.610	-1.000	-1.000	0.644
W index	0.059	0.022	0.080	0.060	0.023	0.081	0.037	0.020	0.073	0.038	0.021	0.074	0.016	0.006	0.048
P index	0.000	0.000	0.048	0.000	0.000	0.048	0.000	0.000	0.049	0.000	0.000	0.049	0.000	0.000	0.040
Transition															
Welfare	0.047	0.011	0.048	0.050			0.023			0.029			0.009	-0.002	0.013

Table 4: Numerical results from trade liberalisation exercises. Numbers above the dividing line compare steady states, while those below consider the full transition dynamics. Numbers are percentage deviations from calibrated steady state (prior to multiplication by 100). Measure all is the mass of all firms originating from the country in consideration. Measure P denotes object Ω^P (the mass of producing firms in the relevant country), while measure U is object Ω^U (the mass of varieties utilised in production of the aggregate final good). Unilateral transition numbers for C2, C3 and C4 are omitted in the interest of brevity.

Our transitional welfare results show that treatment of the labour market has implications for policy inferences based entirely on steady state analysis. The lifetime welfare gains in consumption equivalent variation are 5% in C1, compared with 0.8% in C5. Not accounting for the transition leads one to over-state the gains to this reform by around 6% in C1, while it under-states them by around 12% in C5. These inferential differences for welfare are important when one imagines that policymakers are likely to be somewhat short-sighted.

We now study the quantitative effect of wage markdowns (WMD), starting by comparing the bilateral exercise of C1 to C2. In this comparison, the remaining two features (LOVE and USLS) are present and held constant. Table 4 shows remarkably similar steady state numbers for most variables across C1 and C2. This follows from a relatively low export intensity at 15%; the long-run interaction of the cost structure differences with the option to export is small. Given the offsetting effects of labour market power on welfare discussed in Section 4.6, this is not surprising. However, Figure 1 reveals some noticeable differences along the transition. The transition path for the total firm mass sits higher in the absence of WMD, bringing more varieties in final goods and employment, giving slightly higher welfare gains in C2. Although total varieties rises in both calibrations, the reasoning differs, as can be seen from divergent transition responses in the measures of entrants and exiting firms. The ratio of the sunk cost of entry to fixed cost of operation (f^T/f^C) is smaller in C1 than C2 — the value of entry is lower relative to incumbency in the former than the latter. As such, entrants stand to benefit more from the lower fixed costs coming with love of final goods variety, in the presence of WMD. This drives a larger and more persistent rise in entry in C1, which raises the measure of exits. In contrast, entry rises temporarily in C2, before falling below the initial steady state, in tandem with a fall in exit. These differences culminate in an impact drop in consumption, which is over twice as large in C1 than C2, again highlighting the importance of dynamic analysis in studying this friction.

A second quantification of the importance of wage markdowns (WMD) comes from the comparison of C3 to C4. Here, the only feature present in both calibrations is firm upward-sloping labour supply curves (USLS). The lifetime welfare impact (including the transition) is larger with this comparison now — the absence of friction WMD offers gains 26% larger in C4 than C3, (compared with 6% larger in C2 than C1). Similarly to the comparison of C1 to C2, the measure of varieties in final goods rises by more in the absence of WMD. This follows from a notably larger expansion in the measure of exporters in C4 than C3, at all points along the transition path. Moreover, without LOVE, labour supply is less responsive to the heightened demand for resources from the tariff reduction, giving a larger wage response in C4. Lastly, notice that similar insights are gained from comparing consumption's path across C3 and C4 as with C1 versus C2. Both converge to roughly the same steady state, but the contraction on impact is four times smaller in the absence of WMD. Although more resources are required, all else held constant, for the stronger expansion in exporters in C4, externalities from roundabout production mitigate the required funding injection from the household. To understand the larger welfare gains from trade liberalisation in the absence of WMD in the C3-C4 comparison compared to C1-C2, recall from Section 4.6 that in the absence of LOVE, labour market power is distorting. The distorting effect of WMD in C3 reduces the gains from trade liberalisation.

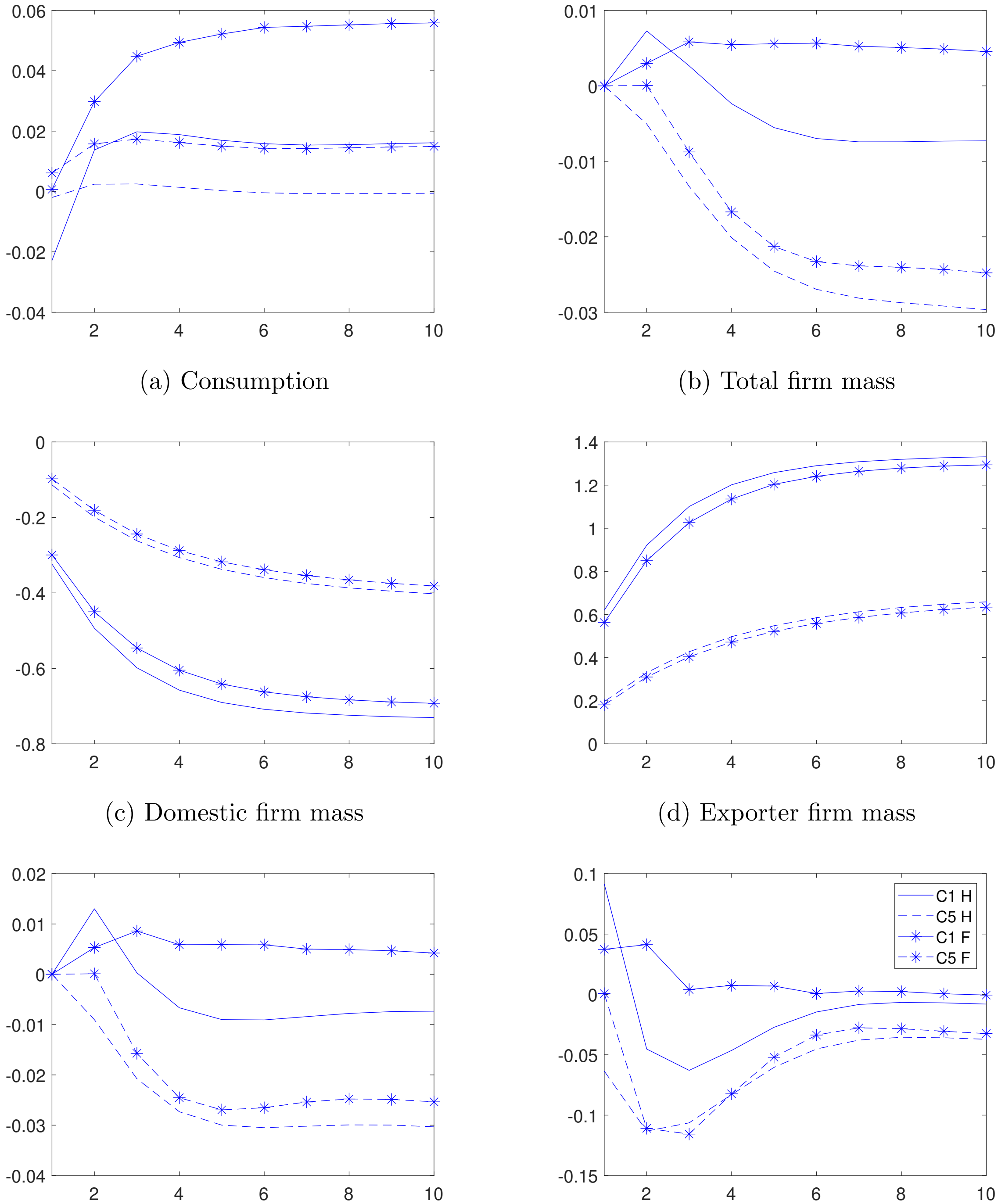
We now look to study the effect of love of variety in employment (LOVE) on bilateral trade liberalisation estimates, firstly comparing C1 to C3. Both WMD and USLS are present and held constant in this comparison. Examining the transition paths, note that labour supply's long-run expansion is 60% larger in C1 than C3. Moreover the expansion in C1 is faster, jumping to around 90% of its long-run value by the period subsequent to reform, in comparison with 77% in C3. The increasing needs of expanding firms triggered by the reform, can be met more easily with the creation of more labour resources, given the reduction in labour supply disutility that follows from the presence of LOVE. This feature facilitates a stronger short-run expansion in both the measures of exporters and entrants in C1 than C3. The overall measure of firms settles with an expansion that is roughly 77% larger in the presence of LOVE. This yields a steady state expansion in final goods variety around 11% larger in C1 than C3, as well as wage effects that are 60% larger, culminating in lifetime welfare gains that are roughly double in C1 than C3. Comparing C2 to C4 yields roughly similar quantitative inferences regarding the importance of LOVE, a result consistent with the earlier finding that WMD plays a minor role from a welfare perspective. On the whole, C1-C3 comparison reveals larger gains from trade liberalisation in the presence of LOVE when firms markdown wages than in the C2-C4 comparison when they behave as wage takers. This interaction effect can again be attributed to the fact that in the presence of LOVE, WMD alleviates a distortion as first mentioned in Section 4.6.

Lastly, within the context of the bilateral trade liberalisation, we quantify the impact of firm-level upward-sloping labour supply curves (USLS). Here we make the comparison between C4 and C5; this analysis shuts down WMD and LOVE in both calibrations. USLS drives a significantly higher transition path for the exporter mass in C4 than C5; the impact response is twice as large and the steady state effect is 50% larger. Moreover the entry measure rises by around 25% on impact in C4, in contrast with a drop of 10% in C5. USLS is the only feature of imperfect labour markets that is required to break the over-shooting of consumption along the transition path. In spite of this, stronger expansionary effects lead to lifetime welfare gains that are around 3 times larger in the presence of USLS.

Taking stock, the results so far show that imperfect labour markets significantly raise the gains from bilateral trade liberalisation. The decomposition exercises show that this is primarily coming from LOVE and USLS of our environment. Importantly though, even if we neutralize the love of variety on the employer side, the gains from trade liberalisation are significantly larger in the presence of an upward-sloping labour supply.

In summary, in Table 5 we provide two possible decompositions of the lifetime welfare gain differences between C1 and C5 for the bilateral trade reform.[25] The difference in predicted lifetime welfare gains across C1 and C5 is substantial. Wage markdowns play a minor quantitative role (less than 16% of the difference), with the remainder roughly split across love of employer variety and upward-sloping firm-level labour supply.

[25] Note this table contains the same information as the transition welfare line in Table 4, but expressed as differences in welfare gains across calibrations.



(a) Consumption

(b) Total firm mass

(c) Domestic firm mass

(d) Exporter firm mass

(e) Exit firm mass

(f) Entrant firm mass

Figure 2: Transition to unilateral reduction in import tariff. Horizontal axes represent years and vertical axis are percentage deviations from calibrated steady state (prior to multiplication by 100). Legend is displayed in final panel and applies to all within the figure.

	Trade 1	**Trade 2**	**FDI 1**	**FDI 2**
Wage Markdowns (WMD)	-0.003	-0.006	-0.010	0.024
Love of Variety in Employment (LOVE)	0.021	0.024	0.049	0.015
Upward-Sloping Labour Supply (USLS)	0.020	0.020	-0.031	-0.031
Welfare gains difference	0.038	0.038	0.008	0.008

Table 5: Decomposition of bilateral reform lifetime (transition) welfare gains. Trade 1 uses the decomposition of WMD as (C1-C2), LOVE as (C2-C4) and USLS as (C4-C5). Trade 2 uses decomposition WMD as (C3-C4), LOVE as (C1-C3) and USLS as (C4-C5). FDI 1 and 2 to the analogous decomposition for C6 through C10. Difference is (C1-C5) for trade and (C6-C10) for FDI. All numbers are percentage point differences.

6.1.2 Unilateral Trade Liberalisation

We now briefly give some discussion to the unilateral trade liberalisation results. We proceed by first giving some intuition for the effects of this reform that apply to most of the variables in C1–C5. We next compare the full transition of C1 for the unilateral reform to that of the bilateral. We then compare the unilateral transition results of C1 to C5. We conclude with a discussion of the decomposition for WMD, LOVE, and USLS in relation to the unilateral reform, focusing only on the steady state in the interest of brevity.

We now describe the economics behind the differences of variables across H and F when H unilaterally liberalises. As H removes its tariff, its final goods producers substitute towards imported varieties. The increased demand for goods produced by F in H improves F's terms of trade which is reflected in the greater increase in average wage and the wage index, W, in F than in H. Since trade is balanced in our framework, these terms of trade effects necessitate that the rise in the quantity of imports into H must be smaller than for that into F. Notice also that the measure of exporters always responds more strongly in H; this is accompanied with a weaker response at the intensive margin for H. See also that tax revenues are all lost in H, while they increase in F. These effects culminate in the welfare effects always being lower in H than in F.

We now briefly compare the transitions of the unilateral and bilateral exercises for C1. The world economy takes longer to converge to its new steady state with the unilateral exercise than with the bilateral — most variables had settled within three or four years in the latter. This difference is driven by the transition in the F price index in the former case. The rise in H demand for F exports gives a boom in this index of around 5.3% on impact; this effect is highly persistent; it takes over 10 years to converge to its new steady sate. Recall that upgrading exporters place upward-pressure on their marginal cost of production. The higher F price index softens this effect for F firms. As such, their contraction in size is slower than in the bilateral exercise. The ensuing release of domestic resources, which allows for more marginal F domestic firms to upgrade to export, takes longer. Moreover, the F price effect increases the price of sunk costs for entry, eroding F entrant value gains. These effects on the F cross-section culminate in a longer adjustment of consumption of the F household, the demand from which spills-over to shape the speed of adjustment to H firms' behaviour.

Next compare the transition paths of the unilateral exercise across C1 and C5. The most striking result here is that this reform looks adverse from a normative perspective for H in C5, giving the opposite policy inference to C1. The measure of H exporters rises by 20% on impact, leading to a one year drop in consumption of 0.2% in C5. The measure of H entrants contracts quickly in the years after the reform, releasing resources, giving a temporary boom in H consumption above its initial steady state for years 2 through 5. From year 6 onwards, H consumption again drops in C5, eventually settling at a new and lower steady state. Since F still levies its tariffs on H exporters, the value gains to H firms of the reform are small. This gives small H labour income gains that are offset by lost tariff revenues in the long run in C5, with lifetime welfare losses of 0.2%.

Consider now the steady state decomposition for the unilateral exercise, first studying the effect of wage markdowns (WMD). Notice that the welfare effects are larger for H in the absence of markdowns, while those for F are smaller, for both sets of comparisons (C1 vs C2 and C3 vs C4). Without WMD, a larger fraction of the household's real income comes from labour earnings (around 95% with WMD and 98% without) and less from real profits (4% with WMD and 1% without), pre-reform. Similarly to the bilateral exercise, the rise in each of the three components of real household income is larger across the board for H and F without WMD. However since real labour income grows slowest of the three sources, its larger representation in consumption leads to smaller welfare gains in F. The H welfare gains are larger without WMD since the terms of trade effect makes their goods relatively cheaper. Also note that similar to the bilateral trade liberalisation case, WMD causes a larger reduction in welfare gains in H in C3 relative to C4 (in the absence of LOVE) than in C2 relative to C1 (in the presence of LOVE). This again is due to the distortionary effect of WMD in the absence of LOVE but a compensatory effect in the presence of LOVE as discussed in Section 4.6.

Next we explore the role of love of employer variety (LOVE) in shaping unilateral gains. Table 4 shows that this feature plays a smaller quantitative role here compared to what it did with the bilateral exercise, where C1 offered steady state gains that were almost double those in C3. The measure of employers contracts in H with the unilateral reform for C1, while it increases slightly for F. The latter effect in F gives some mild amplification, where the welfare gains are 0.4 percentage points (40%) lower for H and 1 percentage point lower for F (25%) in C3. Similar insights follow when studying the second comparison (C2 vs C4) for the unilateral episode.

Finally, we study the effect of upward-sloping firm-level labour supply (USLS) in the unilateral reform, comparing C4 with C5. The welfare losses to H are reversed, while welfare gains to F are almost 3 times larger in the presence of USLS. The combination of increasing marginal costs and roundabout production yields an extensive margin effect for X, which is over twice as strong for both countries, in C4 than C5. This drives a wage effect that is over 3 times stronger for H and over 50% larger for F in the presence of USLS.

6.2 FDI Liberalisation

We now turn to incorporate horizontal FDI into the model. This option allows firms to escape their local upward-sloping labour supply curves. As such, it seems natural to anticipate that this will have significant quantitative implications for WMD, LOVE, and USLS. We consider reducing the outward FDI tax rate to zero. We first discuss the implications of a bilateral reduction of FDI taxes followed by a discussion of unilateral tax reduction.

6.2.1 Bilateral FDI Liberalisation

Table 6 presents the numerical results from the exercises. Figure 3 illustrates the transition from the bilateral exercise. As with the trade liberalisation analysis, we start with a comparison of C6 to C10 to infer imperfect labour markets' overall effect on the policy predictions. We then decompose the effects of WMD, LOVE, and USLS through a series of comparisons.

Firstly, comparing across C6 and C10 for the bilateral episode, the time paths for most firm measures are qualitatively the same, with some amplification in the former. The exception is the measure of exporters — this booms temporarily above the initial steady state in C6 before declining — which drops immediately in C10. A stronger rise in the option value of FDI in C6 spills-over to do the same to that of exporting, given that firms upgrade to the former status after transiting through the latter (see Table 3). Although the total firm mass declines in both C6 and C10, this effect is outweighed — with regard to the measure of employers — by the rise in multinationals, being a source of welfare gains with labour market power. The weaker response in FDI and stronger contraction in exporters in C10 also leads to a drop in the measure of varieties for consumption. These effects culminate in large differences in welfare predictions, with a lifetime gain of 1% in C6 versus 0.2% in C10. There are two notable similarities along the transition though. First, a strong drop on impact in the measure of domestic and entrant firms gives over-shooting of consumption in both C6 and C10. In addition, the time to converge to the new steady state is around ten years, which contrasts with around 5 years for the bilateral trade episode, again due to most firms transiting to M status through X.

We now move to the decomposition exercise in the context of the bilateral FDI reform. The headline result of this decomposition is that, in contrast with the trade exercise, wage markdowns (WMD) play a crucially important role in shaping the macroeconomic effects of the FDI reform. The firm-level economics are as follows. Firms that upgrade from exporter to multinational status escape their local increasing marginal cost structure. When these firms are unable to internalise their wage-setting power, they sit further along this cost structure prior to upgrading, making the option to escape it more valuable. Moreover, multinationals are much larger and more profitable than exporters in the calibrated steady states. For instance, in C6, the employment size premium of multinationals over domestic firms is 106%, as opposed to a 6% premium for exporters in C1. Given this larger scale, FDI completely changes the landscape for quantification of this friction's effect on reform predictions.

	Calibration 6: WMD,LOVE,USLS			Calibration 7: LOVE, USLS			Calibration 8: WMD, USLS			Calibration 9: USLS			Calibration 10: None		
	Bi.	**Uni.**		**Bi.**	**Uni.**		**Bi.**	**Uni.**		**Bi.**	**Uni.**		**Bi.**	**Uni.**	
Steady state	**H/F**	**H**	**F**	**H/F**	**H**	**F**	**H/F**	**H**	**F**	**H/F**	**H**	**F**	**H/F**	**H**	**F**
Welfare	0.010	0.043	-0.026	0.020	0.057	-0.029	-0.005	0.014	-0.017	-0.031	0.018	-0.063	0.001	0.007	-0.005
Consumption	0.011	0.048	-0.030	0.023	0.067	-0.034	-0.007	0.015	-0.020	-0.037	0.023	-0.075	0.002	0.008	-0.006
Disutility	0.006	0.036	-0.028	0.022	0.060	-0.030	-0.012	0.006	-0.017	-0.039	0.028	-0.074	0.002	0.006	-0.004
Measure D	-0.123	-0.043	-0.268	-0.273	-0.178	-0.341	-0.130	-0.022	-0.148	-0.344	-0.195	-0.351	-0.035	0.019	-0.055
Measure X	-0.024	-0.085	0.361	-0.116	-0.135	0.269	0.021	-0.065	0.180	-0.071	-0.172	0.180	-0.122	-0.130	0.000
Measure M	1.345	2.150	-0.277	3.837	5.878	-0.561	1.123	1.271	-0.181	3.600	5.685	-0.507	0.906	1.085	-0.122
Measure T	-0.024	0.057	-0.113	-0.092	0.063	-0.249	-0.034	0.016	-0.050	-0.154	0.051	-0.198	-0.009	0.036	-0.044
Measure all	-0.024	0.051	-0.089	-0.045	0.099	-0.160	-0.034	0.017	-0.050	-0.102	0.051	-0.197	-0.014	0.028	-0.042
Measure P	0.039	0.147	0.015	0.117	0.341	0.093	0.011	0.065	0.001	0.043	0.271	0.033	0.029	0.077	0.011
Measure U	0.026	0.098	-0.007	0.064	0.231	0.040	0.013	0.036	-0.014	0.017	0.171	-0.014	-0.004	0.032	-0.020
Profits	0.151	0.269	-0.038	0.306	0.567	-0.158	0.114	0.181	-0.063	0.265	0.393	-0.178	0.097	0.153	-0.044
Taxes	-0.185	0.213	-0.157	-0.303	0.118	-0.263	-0.145	0.026	-0.105	-0.257	0.057	-0.271	-0.272	-0.148	-0.136
W index	0.005	0.030	-0.012	0.018	0.050	-0.005	-0.009	0.007	-0.008	-0.033	0.013	-0.041	0.002	0.005	0.003
P index	0.000	0.000	0.012	0.000	0.000	0.021	0.000	0.000	0.006	0.000	0.000	0.021	0.000	0.000	0.007
Transition															
Welfare	0.010	0.037	-0.020	0.020			-0.005			-0.029			0.002	0.005	-0.005

Table 6: Numerical results from FDI liberalisation exercises. Numbers above the dividing line compare steady states, while those below consider the full transition dynamics. Numbers are percentage deviations from calibrated steady state (prior to multiplication by 100). Measure all is the mass of all firms originating from the country in consideration. Measure P denotes object Ω^P (the mass of producing firms in the relevant country), while measure U is object Ω^U (the mass of varieties utilised in production of the aggregate final good). Unilateral transition numbers for C2, C3 and C4 are omitted in the interest of brevity.

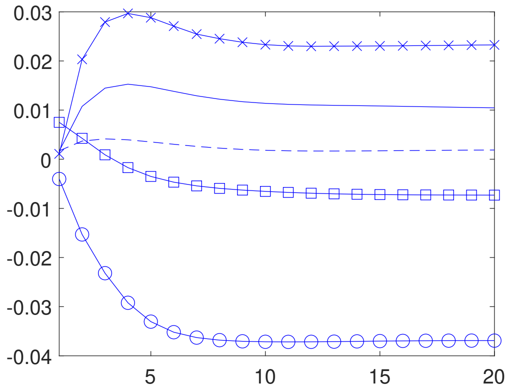
Consider a comparison of the C6 and C7 transitions for the firm cross-section in Figure 3. The long-run multinational elasticity is considerably larger without WMD. Moreover, the expansion in this measure is much more rapid: the measure jumps to 23% of its new steady state value on impact in C6, in contrast with 32% in C7. This spills-over to give more extreme movements in the remaining statuses. The exporter measure starts with a larger deviation and ends with a smaller one in C7 than C6. Cross-sectional changes are strong, as reflected by the domestic and entrant measures over-shooting their new steady state from beneath in C7.

Now consider the second quantification of WMD through comparing C8 to C9 for the bilateral reform. Recall that in this context, the only feature present in each case is the upward-sloping labour supply (USLS). A surprising point to notice here is that the bilateral tax liberalisation is welfare-reducing in each of these specifications. The key insight here comes from the iceberg cost of FDI, which we use to match the FDI sales intensity of 30% in the data.[26] This parameter can be thought of as a productivity loss associated with activities like local compliance costs for overseas subsidiaries' operations. In C6-C9, this parameter assumes a large value of 1.7, meaning a foreign subsidiary is a little below 40% less productive than its parent. As such, an increase in FDI activity brings with it considerable wasted labour resources through this cost. This wastage is only sufficiently problematic to make FDI negative, in the normative sense, when the love of variety for employment (LOVE) is shut-down, as in C8 and C9. In C6 and C7, more FDI gives lower disutility of labour supply, to the extent that these iceberg losses are offset and welfare gains are realised. Lastly, on this point, notice that welfare gains are positive in C10 since the calibrated FDI iceberg cost is much lower at around 1.2. The welfare loss from increased FDI echoes the findings of the qualitative study of Egger et al. (2022), where offshoring of inputs by firms to escape moving up the rising labour supply curve causes welfare losses. Our framework is more general, in that their model suppresses LOVE through a normalisation.

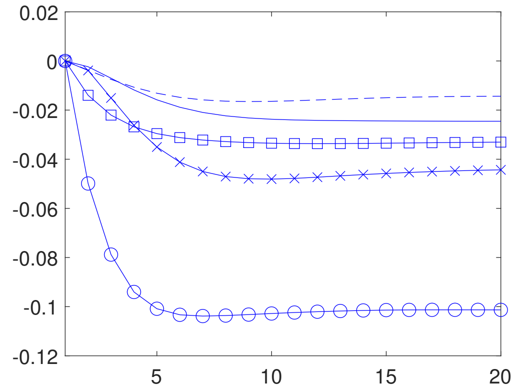
The comparison of C8 to C9 again reveals a stronger incentive for multinational firm creation in the absence of WMD, both in the steady state and along the transition. Since the physical iceberg cost of FDI is the same across the two scenarios, this effect translates into bigger welfare losses in C9. The trade-off at the individual firm level is that upgrading to FDI relieves the pressure of their domestically increasing marginal costs of production, at the expense of efficiency losses. The fact that firms continue to make the choice to upgrade indicates the power associated with USLS. With more multinational activity in C9 comes a stronger adverse impact on the value of new firm creation, giving a drop in entry that is over three times larger on impact than in C8. As more upgrading firms move further back down their labour supply curves, so does labour income received by households, driving the normative implications of this comparison. While wage markdowns lowered welfare gains in comparing C6 to C7, they raise them in C8 vs C9, highlighting the significant non-linearities that materialise when we study this issue in a model with FDI.

Now consider a comparison of C6 to C8 to shed some more light on the role of love of variety in employment (LOVE) on the bilateral FDI reform. In C6, the creation of new multina-

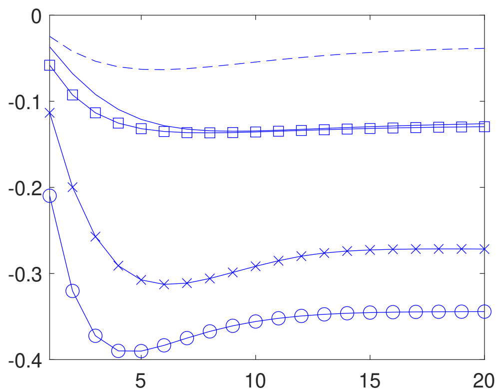
[26] Welfare gains are realised from this reform if one re-calibrates C8 and C9 without targeting this FDI sales intensity in the data.



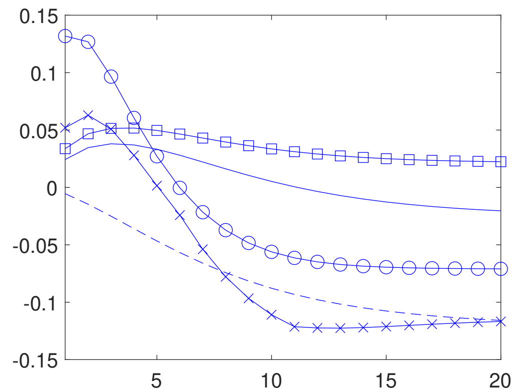
(a) Consumption



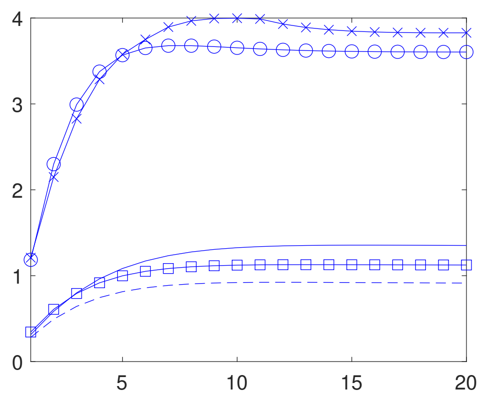
(b) Total firm mass



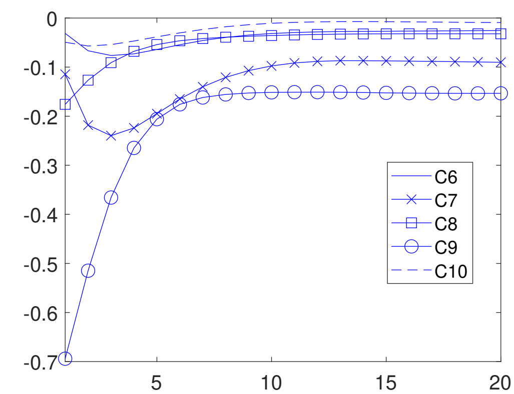
(c) Domestic firm mass



(d) Exporter firm mass



(e) Multinational firm mass



(f) Entrant firm mass

Figure 3: Transition to bilateral reduction in FDI taxes. Horizontal axes represent years and vertical axis are percentage deviations from calibrated steady state (prior to multiplication by 100). Legend is displayed in final panel and applies to all within the figure.

tionals raises employer variety by 4% in the steady state, making labour more responsive to higher need for resources. This contrasts with C8, where labour supply contracts, disincentivising the creation of new firms and mitigating that for multinationals. As a consequence, the steady-state welfare increases by 1% in C6 but decreases by 0.5% in C8. Some stark differences arise between C6 and C8 along the transition path; the trajectories of the measures of entrants and consumption are almost mirror images of each other. A stronger short-term boom in consumption in C8 leads-into the new lower steady state. This short-term effect offsets some of the losses caused by the reform, raising the lifetime welfare effect by 0.15% over the steady state. The stronger incentive to escape increasing marginal costs, in the absence of WMD, drive larger quantitative differences when inferring the effect of LOVE through comparing C7 with C9. This widens the gap in predicted welfare effects to 5 percentage points as a result of LOVE (welfare increases by 2% in the presence of LOVE in C7 and decreases by 3% in C9 in the absence of LOVE).

We lastly compare C9 to C10 to get quantitative insights into the role of upward-sloping labour supply curves (USLS) in shaping the effects of bilateral FDI liberalisation. As firms flood into multinational status in C9 to relieve their cost structures, they send the total measure of firms onto a steep downward-trajectory. The measure of entrants drops by 14 times more on impact in C9 than C10, resulting in a total firm measure over 10% below its initial steady state in the long run. The rush of firms into an expensive, yet socially unproductive, mode of operation in C9 is then reflected in the time path for consumption. This variable drops on impact and continues to do so thereafter — the only case across C6–C10 to display such a pattern. The bilateral liberalisation has a small positive effect on welfare of 0.2% in C10, while bringing considerable losses of nearly 3% in C9.

The bilateral FDI exercise stands in stark contrast with the trade exercise previously explored. Here, all three features WMD, LOVE, and USLS have a quantitatively significant role in shaping macroeconomic effects of reforms. Wage markdowns now serve an intuitive role of limiting the extensive margin: this can move welfare effects in either direction, depending on FDI's normative implications. Love of employer variety then amplifies the gains as firms substitute their local export production for establishment of new foreign subsidiaries. Lastly, increasing labour supply curves, through hindering the ability of firms to turn a profit, also have a somewhat intuitive effect of greatly reducing the gains to openness. These welfare effects are again summarised through a pair of decomposition exercises in Table 5.

6.2.2 Unilateral FDI Liberalisation

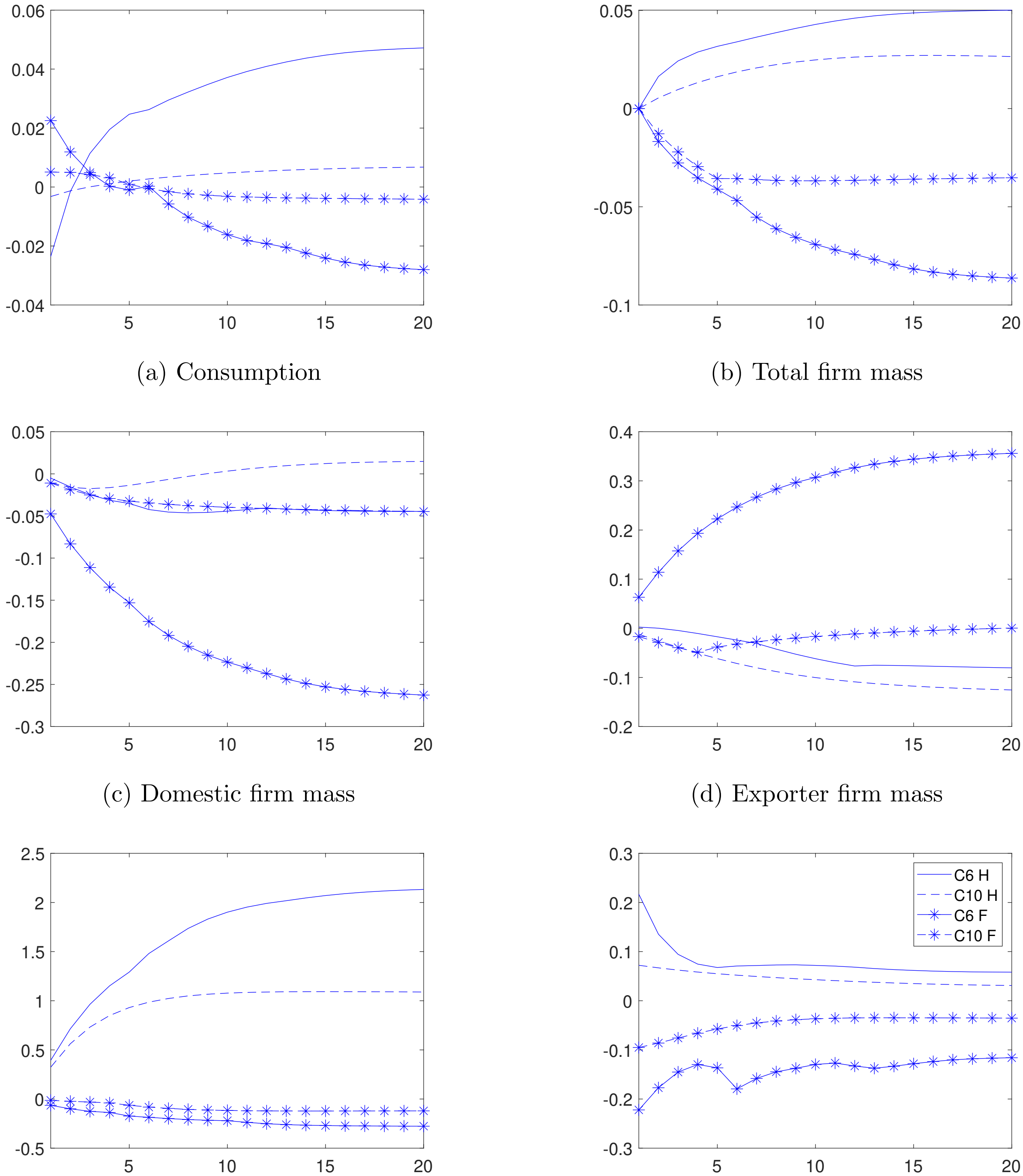
Our final set of comparisons comes from exploring the role of unilateral FDI reforms. Figure 4 gives the transitions for C6 and C10 for the unilateral reform. The pattern arising from Table 6 and Figure 4 is that the unilateral FDI reform is never mutually beneficial, in contrast with the unilateral trade episode; the liberalising country now benefits at the other's expense. Responses of firms from the liberalising country H significantly reduce the value of F firms' activities on two fronts. On the F front, these large H multinationals rapidly consume F labour resources, displacing smaller domestic firms as well as lowering the value to entry. On the H front, this re-shuffling of the global competitive landscape increases the value of establishing an H firm. This raises the costs of labour in H, which serves to displace the subsidiaries of F firms in H. The wage index in F drops in almost all model specifications, while the opposite happens for H.

Comparing C6 with C10, notice that the absolute difference between H welfare gains and F welfare losses is much larger in the presence of imperfectly competitive labour markets. The difference in C10 is close to zero, as opposed to almost 6 percentage points in C6. This significant amplification comes since, in forcing F multinationals to downgrade their status to exporters, these F firms are forced back onto a single labour supply curve for their total world production. Moreover this effect in C6 is extremely powerful — notice that the mass of F multinationals drops by 7% on impact and continues contracting until 28% of such firms are displaced. This contrasts with C10, where the initial response is a drop of 1%, before the measure slowly declines, eventually reaching a level 12% below its initial steady state.

There are substantial differences between the predictions of C6 and C10 along the transition from the unilateral FDI reform. First, consider the time paths of cross-sectional variables relating to H. The measures of H domestic firms move along opposite trajectories in C6 and C10. Resources are substituted from domestic firms to exporters in C6, while the opposite happens in C10. The impact expansion in the measure of entrants is around four times larger than its steady state expansion in C6, in contrast with two times larger in C10. The reduction in F multinationals and entrants tend to be stronger in C6 than C10 along the transition. The stronger release in resources from F firms gives a short-term boom in F consumption that is four times larger on impact in C6 than C10, before giving a long-term contraction around five times larger.

Now we briefly decompose the effects of WMD, LOVE, and USLS on the steady state unilateral reform differences. While H gains more in the absence of WMD, F suffers more. The larger losses to F are relatively small when comparing C6 to C7, but become extremely pronounced in C8 vs C9, where their losses are over three times larger. The difference is due to the presence of LOVE in C6-C7 and its absence in C8-C9. In the absence of LOVE, there is no offsetting employer variety effect, as resources are reallocated away from F firms and towards wasteful H multinationals, with high iceberg productivity losses. Note also that the net effect of this unilateral reform is negative in the context of C8 and profoundly negative in C9. In studying employer variety's impact, a significantly lower extensive margin effect on the measure of H multinationals in C8, yields a much lower spread in the welfare effects between H and F than in C6. However, the rise in the measure of M firms from H is relatively similar across C7 and C9. This drives a much more severe welfare loss in F in C9, giving a spread in welfare effects that is roughly the same as in C7. Lastly, in comparing C9 with C10, upward-sloping labour supply (USLS) gives amplification of roughly double the welfare gains in H, since closing F multinationals releases more resources for H firms. However, the amplification of losses in F are profound — over twelve times the losses in C10 are suffered in C9.

In sum, the unilateral FDI liberalisation exercises show that the liberalising country always gains while the partner always loses. While this is also true in a set up with a perfectly competitive labour market (C10), the magnitudes are much larger in the imperfectly competitive set up (C6-C9). Adding up the gains and losses of the two countries involved, there is a small net gain in the competitive labour market case (C10) but a significantly larger net gain in



(a) Consumption

(b) Total firm mass

(c) Domestic firm mass

(d) Exporter firm mass

(e) Multinational firm mass

(f) Entrant firm mass

Figure 4: Transition to unilateral reduction in FDI tax. Horizontal axes represent years and vertical axis are percentage deviations from calibrated steady state (prior to multiplication by 100). Legend is displayed in final panel and applies to all within the figure.

our baseline imperfect labour market case (C6). However, the decomposition exercises reveal that the overall gains are contingent on the presence of LOVE. In the absence of LOVE, there are net losses, and these are much larger in magnitude if firms facing upward sloping labour supply do not exercise labour market power (C9).

We close the analysis here by stating that, given the dramatic impact it has on firm cost structures, the option to undertake FDI has quantitative implications for WMD, LOVE, and USLS that differ substantially from the trade exercises. All three features are significant here, highlighting the importance of considering FDI in any rigorous quantification of imperfect competition in labour markets on the gains to openness. Including this option also interacts with inferences in the short-run versus the long-run, further underlining the importance of a dynamic structure when thinking about this particular issue.

6.3 Robustness on the Frisch Elasticity

In our theoretical model, ϕ captured the Frisch elasticity of labour supply and in our quantitative exercises we set this parameter to 0.2. In Appendix E we provide results upon setting $\phi = 0$. Table A-1 and A-2 show the parameter values and moments used for each of the series of calibration exercises, respectively. Table A-3 shows the steady state quantitative results for the trade liberalisation exercise (labelled as C11–C15), while Table A-4 shows those for the FDI exercise (called C16–C20). We abstract from providing transition results in the interest of brevity.

The results generally show that the qualitative inferences made in the main body of the paper still hold in the face of the lower Frisch elasticity. The quantitative differences between the imperfect and perfect labour markets cases, however, become smaller. That said, the magnitudes are still noticeably significant. For instance, the bilateral trade liberalisation in C11 yields welfare gains that are over four times larger than C15. The bilateral FDI episode gives gains that are eight times larger in C16 than C20.

One point worth emphasising: notice that LOVE still has a quantitative effect in studying the liberalisation episodes with $\phi = 0$. See that the aggregate labour supply index will be fixed at unity always when $\phi = 0$ from (11). In a similar discussion to that in Section 3.1, consider Ω^P identical firms with $n(\omega) = n \; \forall \omega$. For a given supply of aggregate labour hours $L = \Omega^P n$, see that we can write $1 = L/(\Omega^P)^{\frac{1-\eta}{1+\theta}}$ meaning $L = (\Omega^P)^{\frac{1-\eta}{1+\theta}}$. When we shut-down LOVE, we can write $L = 1$, which contrasts with $L = (\Omega^P)^{\frac{1}{1+\theta}}$ when $\eta = 0$. As such, the supply of labour hours is variable when we preserve LOVE with $\phi = 0$, but fixed when $\eta = 1$. Consequently, a larger expansion follows the tariff reforms in the presence of LOVE (C11 vs C13 or C12 vs C14), similarly for the FDI reforms (C16 vs C18 or C17 vs C19). It is worth pointing out that $\phi = 0.2$ that we chose in our baseline exercises is on the lower side compared to the estimates in the literature. A higher value of ϕ will produce even larger quantitative differences between the imperfect and perfect labour market cases.

7 Concluding Remarks

This paper takes a first step towards rigorous quantification of the effect of imperfect labour markets on open economy reforms. We take a standard dynamic model with heterogeneous firms that draw idiosyncratic shocks and embed the feature of monopsonistic employers. Parameters are disciplined with cross-sectional data on the firm distribution. We evaluate both trade tariff reductions and tax reforms on the profits of multinational firms. The model is sufficiently parsimonious to facilitate the study of these reforms along the transition path. Productive firms have a strong incentive to undertake horizontal FDI in this model, as it allows for lower variable production costs.

Our main finding is that, compared to the benchmark competitive labour market case, a tariff liberalisation provides much larger welfare gains when labour markets are monopsonistic. Since our imperfect labour market model exhibits love of employer variety, we verify that the larger welfare effects of tariff liberalisation in the imperfectly competitive labour market survive, even when we shut down this feature. The welfare implications of FDI liberalisation are crucially tied to the employer variety effect. In the presence of love of employer variety, the gains from FDI liberalisation are also larger compared to a competitive labour market. However, abstracting from the employer variety effect in combination with labour market power creates the possibility of there being too many multinationals.

This paper leaves space for many interesting extensions. Our model exhibits constant markups in the product market and constant markdowns in the labour market. A fruitful extension would be to study these open economy reforms in a setting with variable markups and markdowns. Trottner (2023) constructs a model with variable markups, markdowns, and endogenous number of firms, however, he does not explore the implications of openness reforms in that setting. Extending our framework to a multi-country setting would allow for comparison with a large body of other works in the quantitative trade area. Including vertical FDI could lead to a variety of new insights, as this friction likely affects the organisation of supply chains in a significant way. Generally, these advances would require moving to a calibration exercise with an asymmetric country setup, which could also facilitate discussion about inequality, both within and across countries. Given the implications for both policy and our scientific understanding of institutional features of the labour market, it is hoped that our work paves the way for many more studies in the area.

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Appendices

A Microfoundation for Utility Function

In what follows, we drop all time subscripts and focus on H, where $P = 1$. Assume that the utility function of a representative worker for working at firm ω which pays a wage per unit of labour of $w(\omega)$ is given by

$$U(\omega) = \max_{h(\omega)} \varepsilon(\omega)h(\omega)w(\omega) - \frac{\phi}{1+\phi}h(\omega)^{\frac{1+\phi}{\phi}} \tag{A-1}$$

where $\varepsilon(\omega)$ is the productivity (or efficiency units of labour) for the worker from working at firm ω and $h(\omega)$ is the hours worked. $\varepsilon(\omega)$ is drawn for each firm ω from a Frechet Distribution with distribution function

$$H(\varepsilon(\omega)) = e^{-\varepsilon(\omega)^{-\sigma}},\ \sigma > 1.$$

Given the utility function in (A-1), if a worker decides to work for firm ω, then the hours worked, $h(\omega)$, is simply

$$h(\omega) = (\varepsilon(\omega)w(\omega))^{\phi}. \tag{A-2}$$

Therefore, the utility from working at firm ω is

$$U(\omega) = \frac{1}{1+\phi}(\varepsilon(\omega)w(\omega))^{1+\phi}. \tag{A-3}$$

Now, in order for a worker to work at firm ω rather than any other firm k, the following must be true: $U(\omega) > \max\limits_{\{k\}} U(k)$. Given the Frechet distribution and iid draws of $\varepsilon(k)$, the probability of a worker working at firm ω is

$$P(\omega) \equiv \text{Prob}\left(U(\omega) > \max_{\{k\}} U(k)\right) = \int_0^\infty \bigcap_k \text{Prob}\left(\varepsilon(k) < \varepsilon(\omega)\left(\frac{w(\omega)}{w(k)}\right)\right) dH(\varepsilon(\omega))$$

hence

$$P(\omega) = \int_0^\infty e^{-\varepsilon(\omega)^{-\sigma}\sum_{k\neq\omega}\left(\frac{w(k)}{w(\omega)}\right)^{\sigma}} e^{-\varepsilon(\omega)^{-\sigma}}\varepsilon(\omega)^{-\sigma-1}d\varepsilon(\omega). \tag{A-4}$$

Re-write (A-4) as

$$P(\omega) = \sigma\int_0^\infty e^{-\varepsilon(\omega)^{-\sigma}\sum_{k}\left(\frac{w(k)}{w(\omega)}\right)^{\sigma}} \varepsilon(\omega)^{-\sigma-1}d\varepsilon(\omega). \tag{A-5}$$

Use the notation $\Upsilon = \sum_k \left(\frac{w(k)}{w(\omega)}\right)^{\sigma}$ gives (A-5) as

$$P(\omega) = \frac{\sigma}{\sigma\Upsilon}\ e^{-\varepsilon(\omega)^{-\sigma}W}\Big|_0^\infty = \frac{1}{\Upsilon} = \frac{w(\omega)^{\sigma}}{\sum_k w(k)^{\sigma}} \tag{A-6}$$

Also, note that in deriving the expressions (A-6) and (A-9) we have used a discrete number of firms, however, Ben-Akiva, Litinas and Tsunokawa (1985) have shown that extending the analysis to a continuum of choices implies that $P(\omega) = w(\omega)^{\sigma}/\int w(k)^{\sigma}dk$.

Now the total labour supplied by a worker to firm ω in efficiency units is $h'(\omega) = \varepsilon(\omega)h(\omega)$. From (A-2) this is equal to $w(\omega)^{\phi}\varepsilon(\omega)^{1+\phi}$. Therefore, $Eh' = w(\omega)^{\phi}E\left(\varepsilon(\omega)^{1+\phi}\middle|U(\omega) > \max_{\{k\}} U(k)\right)$. Next, we calculate $E\left(\varepsilon(\omega)^{1+\phi}\middle|U(\omega) > \max_{\{k\}} U(k)\right)$ as follows.

$$E\left(\varepsilon(\omega)^{1+\phi}\middle|U(\omega) > \max_{\{k\}} U(k)\right) = \frac{\sigma}{P(\omega)}\int_0^{\infty} \varepsilon(\omega)^{1+\phi}e^{-\varepsilon(\omega)^{-\sigma}\Upsilon}\varepsilon(\omega)^{-\sigma-1}d\varepsilon(\omega) \tag{A-7}$$

Next, use $t = \varepsilon(\omega)^{-\sigma}\Upsilon$. Hence $dt = -\sigma\varepsilon(\omega)^{-\sigma-1}\Upsilon d\varepsilon(\omega)$ and (A-7) becomes

$$E\left(\varepsilon(\omega)^{1+\phi}\middle|U(\omega) > \max_{\{k\}} U(k)\right) = \frac{\sigma}{P(\omega)}\int_0^{\infty} e^{-t}\frac{\varepsilon(\omega)^{-\sigma+\phi}}{\sigma\varepsilon(\omega)^{-\sigma-1}\Upsilon}dt.$$

The equality above uses the fact that $t = \varepsilon(\omega)^{-\sigma}\Upsilon$ implies that when $\varepsilon(\omega) \to 0$, $t \to \infty$ and when $\varepsilon(\omega) \to \infty$, $t \to 0$, hence the integration limits flip. Next note that $t = \varepsilon(\omega)^{-\sigma}\Upsilon$ implies that $\varepsilon(\omega) = (\Upsilon/t)^{\frac{1}{\sigma}}$ and $P(\omega) = 1/\Upsilon$. Therefore,

$$E\left(\varepsilon(\omega)^{1+\phi}\middle|U(\omega) > \max_{\{k\}} U(k)\right) = \Upsilon^{\frac{1+\phi}{\sigma}}\int_0^{\infty} e^{-t}t^{-\frac{1+\phi}{\sigma}}dt = \Upsilon^{\frac{1+\phi}{\sigma}}\Gamma\left(1 - \frac{1+\phi}{\sigma}\right) \tag{A-8}$$

where Γ is the gamma function.

If there are $\overline{L}$ workers, then the labour supply function facing firm ω offering a wage $w(\omega)$ is

$$n(\omega) = \overline{L}P(\omega)E\left(\varepsilon(\omega)^{1+\phi}\middle|U(\omega) > \max_{\{k\}} U(k)\right) = \frac{w(\omega)^{\phi}\Upsilon^{\frac{1+\phi}{\sigma}}}{\Upsilon}\Gamma\left(1 - \frac{1+\phi}{\sigma}\right)\overline{L}.$$

Simplify above to obtain

$$n(\omega) = \frac{w(\omega)^{\sigma-1}}{\left(\sum_k w(k)^{\sigma}\right)^{\frac{\sigma-1-\phi}{\sigma}}}\Gamma\left(1 - \frac{1+\phi}{\sigma}\right)\overline{L}.$$

Now, if we denote $\sigma - 1$ by θ, then the above becomes

$$n(\omega) = \frac{w(\omega)^{\theta}}{\left(\sum_k w(k)^{1+\theta}\right)^{\frac{\theta-\phi}{1+\theta}}}\Gamma\left(\frac{\theta-\phi}{1+\theta}\right)\overline{L}$$

Using the equivalence to the continuous case established in Ben-Akiva, Litinas and Tsunokawa (1985), $\left(\sum_k w(k)^{1+\theta}\right)^{\frac{\theta-\phi}{1+\theta}} \approx \left(\int w(k)^{1+\theta}dk\right)^{\frac{\theta-\phi}{1+\theta}}$, the above is same as (9) in the text with $\eta = 0$ upon using the normalisation $\Gamma\left(\frac{\theta-\phi}{1+\theta}\right)\overline{L} = 1$ to reduce rotational clutter.

Next, the welfare of an agent who has received a productivity shock $\varepsilon(\omega)$ and works for firm ω is given in (A-3). However, a worker works for firm ω iff $U(\omega) > \max_{\{k\}} U(k)$. Therefore, the expected maximized utility from working for firm ω upon using (A-8) is

$$\begin{aligned} EU(\omega) &= \frac{1}{1+\phi}w(\omega)^{1+\phi}E\left(\varepsilon(\omega)^{1+\phi}\middle|U(\omega) > \max_{\{k\}} U(k)\right) \\ &= \frac{1}{1+\phi}w(\omega)^{1+\phi}\Upsilon^{\frac{1+\phi}{\sigma}}\Gamma\left(\frac{\sigma-1-\phi}{\sigma}\right) \end{aligned}$$

Upon using the expression for Υ re-write the above as

$$EU(\omega) = \frac{1}{1+\phi}\left(\sum_k w(k)^{1+\theta}\right)^{\frac{1+\phi}{1+\theta}} \Gamma\left(\frac{\theta-\phi}{1+\theta}\right) \tag{A-9}$$

In the continuous case $\left(\sum_k w(k)^{1+\theta}\right)^{\frac{1+\phi}{1+\theta}} \approx \left(\int w(k)^{1+\theta}dk\right)^{\frac{1+\phi}{1+\theta}} = W^{1+\phi}$, where the last equality follows from the definition of W in equation (10) in the text. Therefore,

$$EU(\omega) = \frac{1}{1+\phi}W^{1+\phi}\Gamma\left(\frac{\theta-\phi}{1+\theta}\right) \tag{A-10}$$

Next, verify that the expression for welfare in the text,

$$\int_{\omega\in\Omega^P} n(\omega)w(\omega)d\omega - \frac{N_t^{1+\frac{1}{\phi}}}{1+\frac{1}{\phi}},$$

upon using (9) and (11) becomes $\frac{1}{1+\phi}W^{1+\phi}$ which differs from (A-10) by the constant $\Gamma\left((\theta-\phi)/(1+\theta)\right)$.

B Optimal Controls for Firm Problem

We present the optimal static controls for firms separately for the cases whereby firms have wage-setting power and when they are wage-takers. Note that firms exercise their wage-setting power in C1, C3, C6 and C8. The remainder have firms as wage-takers.

With Wage-Setting Power

In what follows, we derive the optimal control variables contained in array $k_t(z_t, s_t)$ for each firm status. To simplify the notation, the firm's state will be denoted $\varphi_t = (z_t, s_t)$ in what follows. In the case of a domestic firm, we reduce their choice of $k_t(\varphi_t)$ to a wage choice problem of the form

$$\pi_t(z_t, D) = \max_{w_t(\varphi_t)} p_t(\varphi_t)q_t(\varphi_t) - w_t(\varphi_t)n_t(\varphi_t)$$

subject to constraints

$$\begin{aligned}
q_t(\varphi_t) &= A_t P_t^{\sigma} p_t(\varphi_t)^{-\sigma} \\
y_t(\varphi_t) &= z_t n_t(\varphi_t) \\
y_t(\varphi_t) &= q_t(\varphi_t) \\
n_t(\varphi_t) &= B_t w_t(\varphi_t)^{\theta}
\end{aligned}$$

which are the demand curve from the H final goods producer, the domestic production function, market clearing condition and labour supply function. Note that these constraints imply four variables: $q_t(\varphi_t)$, $y_t(\varphi_t)$, $n_t(\varphi_t)$ and $p_t(\varphi_t)$. Using these constraints and then maximising over the H wage gives solution

$$w_t(\varphi_t) = \left(\frac{1+\theta}{\theta}\right)^{-\frac{\sigma}{\theta+\sigma}} \left(\frac{\sigma}{\sigma-1}\right)^{-\frac{\sigma}{\theta+\sigma}} \left(\frac{A_t P_t^{\sigma}}{B_t}\right)^{\frac{1}{\theta+\sigma}} z_t^{\frac{\sigma-1}{\theta+\sigma}}.$$

In the case of an exporting firm, it chooses $k_t(\varphi_t)$ through solving the problem

$$\pi_t(z_t, X) = \max_{n_t^D(\varphi_t), n_t^X(\varphi_t)} p_t(\varphi_t)q_t(\varphi_t) + p_t^*(\varphi_t)q_t^*(\varphi_t) - w_t(\varphi_t)n_t(\varphi_t)$$

where it is written in terms of the labour for domestic and export production $n_t^D(\varphi_t)$ and $n_t^X(\varphi_t)$. The problem is subject to constraints

$$\begin{aligned}
q_t(\varphi_t) &= A_t P_t^{\sigma} p_t(\varphi_t)^{-\sigma} \\
q_t^*(\varphi_t) &= A_t^* P_t^{*\sigma} \widehat{\tau}^{X*(-\sigma)} p_t^*(\varphi_t)^{-\sigma} \\
y_t(\varphi_t) &= z_t n_t^D(\varphi_t) \\
y_t^*(\varphi_t) &= z_t n_t^X(\varphi_t) \\
y_t(\varphi_t) &= q_t(\varphi_t) \\
y_t^*(\varphi_t) &= \tau^X q_t^*(\varphi_t) \\
n_t(\varphi_t) &= B_t w_t(\varphi_t)^{\theta} \\
n_t(\varphi_t) &= n_t^D(\varphi_t) + n_t^X(\varphi_t)
\end{aligned}$$

where recall that τ^X is a physical iceberg cost of production, while $\widehat{\tau}^{X*}$ is the tariff levied by the F government. See that these 8 constraints give 8 unknowns: $p_t(\varphi_t)$, $q_t(\varphi_t)$, $p_t^*(\varphi_t)$, $q_t^*(\varphi_t)$, $y_t(\varphi_t)$, $y_t^*(\varphi_t)$, $n_t(\varphi_t)$ and $w_t(\varphi_t)$. We then take FOCs with respect to $n_t^D(\varphi_t)$ and $n_t^X(\varphi_t)$. This yields

$$\begin{aligned}
n_t^X(\varphi_t) =& n_t^D(\varphi_t) \frac{A_t^* P_t^{*\sigma} \widehat{\tau}^{X*(-\sigma)}}{A_t P_t^{\sigma}} \tau^{X(1-\sigma)} \\
n_t^D(\varphi_t) =& \left(1 + \frac{A_t^* P_t^{*\sigma} \widehat{\tau}^{X*(-\sigma)}}{A_t P_t^{\sigma}} \tau^{X(1-\sigma)}\right)^{\frac{-\sigma}{\theta+\sigma}} \left(\frac{\sigma-1}{\sigma}\right)^{\frac{\theta\sigma}{\theta+\sigma}} \left(\frac{1}{A_t P_t^{\sigma}}\right)^{-\frac{\theta}{\theta+\sigma}} \times \\
& \left(\frac{\theta}{1+\theta}\right)^{\frac{\theta\sigma}{\theta+\sigma}} B_t^{\frac{\sigma}{\theta+\sigma}} z_t^{\frac{(\sigma-1)\theta}{\theta+\sigma}}
\end{aligned}$$

In the case of a multinational firm, its choice of controls is reduced to the problem

$$\pi_t(z_t, M) = \max_{n_t(\varphi_t), n_t^{M*}(\varphi_t)} p_t(\varphi_t)q_t(\varphi_t) + p_t^*(\varphi_t)q_t^*(\varphi_t) - w_t(\varphi_t)n_t(\varphi_t) - w_t^*(\varphi_t)n_t^{M*}(\varphi_t)$$

subject to the constraints

$$\begin{aligned}
q_t(\varphi_t) &= A_t P_t^{\sigma} p_t(\varphi_t)^{-\sigma} \\
q_t^*(\varphi_t) &= A_t^* P_t^{*\sigma} p_t^*(\varphi_t)^{-\sigma} \\
y_t(\varphi_t) &= z_t n_t(\varphi_t) \\
y_t^*(\varphi_t) &= z_t n_t^{M*}(\varphi_t) \\
y_t(\varphi_t) &= q_t(\varphi_t) \\
y_t^*(\varphi_t) &= \tau^M q_t^*(\varphi_t) \\
n_t(\varphi_t) &= B_t w_t(\varphi_t)^{\theta} \\
n_t^{M*}(\varphi_t) &= B_t^* w_t^*(\varphi_t)^{\theta}
\end{aligned}$$

where recall $\tau^M > 1$ is an iceberg productivity loss from producing in the foreign subsidiary. Notice that again the optimisation will be over variables $n_t(\varphi_t)$ and $n_t^{M*}(\varphi_t)$, while the 8 constraints imply 8 other variables: $q_t(\varphi_t)$, $p_t(\varphi_t)$, $q_t^*(\varphi_t)$, $p_t^*(\varphi_t)$, $y_t(\varphi_t)$, $y_t^*(\varphi_t)$, $w_t(\varphi_t)$ and $w_t^*(\varphi_t)$. This problem yields solution

$$\begin{aligned}
n_t(\varphi_t) &= \left(\frac{\sigma-1}{\sigma}\right)^{\frac{\sigma\theta}{\sigma+\theta}} \left(\frac{1}{A_t P_t^{\sigma}}\right)^{-\frac{\theta}{\sigma+\theta}} \left(\frac{\theta}{1+\theta}\right)^{\frac{\sigma\theta}{\sigma+\theta}} B_t^{\frac{\sigma}{\sigma+\theta}} z^{\frac{\theta(\sigma-1)}{\sigma+\theta}} \\
n_t^{M*}(\varphi_t) &= \left(\frac{\sigma-1}{\sigma}\right)^{\frac{\sigma\theta}{\sigma+\theta}} \left(\frac{1}{A_t^* P_t^{*\sigma}}\right)^{-\frac{\theta}{\sigma+\theta}} \left(\frac{\theta}{1+\theta}\right)^{\frac{\sigma\theta}{\sigma+\theta}} (B_t^*)^{\frac{\sigma}{\sigma+\theta}} \left(\frac{z}{\tau^M}\right)^{\frac{\theta(\sigma-1)}{\sigma+\theta}}.
\end{aligned}$$

Without Wage-Setting Power

In this setup, firms make their choices with the wage taken as fixed when they take their first order conditions (FOCs). The wages they pay are then found ex-post, to reconcile the optimal employment choice with the firm's individual labour supply curve from the household problem. The problem for a domestic firm is

$$\pi_t(\varphi_t, D) = \max_{q_t(\varphi_t), n_t(\varphi_t)} \; p_t(\varphi_t) q_t(\varphi_t) - w_t n_t(\varphi_t)$$

where

$$\begin{aligned}
q_t(\varphi_t) &= A_t P_t^{\sigma} p_t(\varphi_t)^{-\sigma} \\
y_t(\varphi_t) &= z_t n_t(\varphi_t) \\
y_t(\varphi_t) &= q_t(\varphi_t).
\end{aligned}$$

Combining the constraints with the objective yields FOCs

$$\begin{aligned}
q_t(\varphi_t) &= \left(\frac{w_t}{z_t}\right)^{-\sigma} \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} A_t P_t^{\sigma} \\
n_t(\varphi_t) &= \frac{q_t(\varphi_t)}{z_t}.
\end{aligned}$$

Note that the firm-level labour supply curve can be inverted to obtain expression

$$w_t(\varphi_t) = \left(\frac{q_t(\varphi_t)/z_t}{B_t} \right)^{\frac{1}{\theta}}.$$

Combining this expression with the optimal output and employment choices then yields

$$\begin{aligned} q_t(\varphi_t) &= \left(\frac{1}{z_t}\right)^{\frac{-\sigma(\theta+1)}{\theta+\sigma}} \left(\frac{1}{B_t}\right)^{\frac{-\sigma}{\theta+\sigma}} [A_t P_t^\sigma]^{\frac{\theta}{\theta+\sigma}} \left(\frac{\sigma}{\sigma-1}\right)^{\frac{-\theta\sigma}{\theta+\sigma}} \\ n_t(\varphi_t) &= \left(\frac{1}{z_t}\right)^{\frac{\theta(1-\sigma)}{\theta+\sigma}} \left(\frac{1}{B_t}\right)^{\frac{-\sigma}{\theta+\sigma}} [A_t P_t^\sigma]^{\frac{\theta}{\theta+\sigma}} \left(\frac{\sigma}{\sigma-1}\right)^{\frac{-\theta\sigma}{\theta+\sigma}} \end{aligned}$$

and consistent wages of the form

$$w_t(\varphi_t) = \left\{ \left(\frac{1}{z_t}\right)^{\frac{\theta(1-\sigma)}{\theta+\sigma}} \left(\frac{1}{B_t}\right)^{\frac{\theta}{\theta+\sigma}} [A_t P_t^\sigma]^{\frac{\theta}{\theta+\sigma}} \left(\frac{\sigma}{\sigma-1}\right)^{\frac{-\theta\sigma}{\theta+\sigma}} \right\}^{\frac{1}{\theta}}.$$

The problem of an exporter can then be written as

$$\pi_t(\varphi_t, X) = \max_{q_t(\varphi_t), q_t^*(\varphi_t), n_t(\varphi_t)} \; p_t(\varphi_t) q_t(\varphi_t) + p_t^*(\varphi_t) q_t^*(\varphi_t) - w_t n_t(\varphi_t)$$

where

$$\begin{aligned} q_t(\varphi_t) &= A_t P_t^\sigma p_t(\varphi_t)^{-\sigma} \\ q_t^*(\varphi_t) &= A_t^*(P_t^*)^\sigma (\widehat{\tau}^X)^{-\sigma} (p_t^*(\varphi_t))^{-\sigma} \\ y_t(\varphi_t) &= z_t n_t(\varphi_t) \\ y_t(\varphi_t) &= q_t(\varphi_t) + \tau^X q_t^*(\varphi_t). \end{aligned}$$

Combining constraints with the objective and taking FOCs then yields

$$\begin{aligned} q_t(\varphi_t) &= \left(\frac{w_t(\varphi_t)}{z_t}\right)^{-\sigma} \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} A_t P_t^\sigma \\ q_t^*(\varphi_t) &= \left(\frac{w_t(\varphi_t)\tau^X}{z_t}\right)^{-\sigma} \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} A_t^*(P_t^*)^\sigma (\widehat{\tau}^{X*})^{-\sigma} \\ n_t(\varphi_t) &= \frac{q_t(\varphi_t) + \tau^X q_t^*(\varphi_t)}{z_t}. \end{aligned}$$

Hence the wage consistent with this behaviour is

$$w_t(\varphi_t) = \left(\frac{1}{B_t} \left\{ \left(\frac{1}{z_t}\right)^{1-\sigma} \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} A_t P_t^\sigma + \left(\frac{1}{z_t}\right)^{1-\sigma} \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} A_t^*(P_t^*)^\sigma (\widehat{\tau}^{X*})^{-\sigma} (\tau^X)^{1-\sigma} \right\} \right)^{\frac{1}{\theta+\sigma}}$$

Finally, the problem of a multinational is written as

$$\pi_t(\varphi_t, M) = \max_{q_t(\varphi_t), q_t^*(\varphi_t), n_t(\varphi_t), n_t^*(\varphi_t)} \; p_t(\varphi_t) q_t(\varphi_t) + p_t^*(\varphi_t) q_t^*(\varphi_t) - w_t n_t(\varphi_t) - w_t^* n_t^*(\varphi_t)$$

where

$$
\begin{aligned}
q_t(\varphi_t) &= A_t P_t^{\sigma} p_t(\varphi_t)^{-\sigma} \\
q_t^*(\varphi_t) &= A_t^*(P_t^*)^{\sigma}(p_t^*(\varphi_t))^{-\sigma} \\
y_t(\varphi_t) &= z_t n_t(\varphi_t) \\
y_t^*(\varphi_t) &= z_t n_t^*(\varphi_t) \\
y_t(\varphi_t) &= q_t(\varphi_t) \\
y_t^*(\varphi_t) &= \tau^M q_t^*(\varphi_t).
\end{aligned}
$$

Combining and taking FOCs gives

$$
\begin{aligned}
q_t(\varphi_t) &= \left(\frac{w_t(\varphi_t)}{z_t}\right)^{-\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} A_t P_t^{\sigma} \\
q_t^*(\varphi_t) &= \left(\frac{w_t^*(\varphi_t)\tau^M}{z_t}\right)^{-\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} A_t^*(P_t^*)^{\sigma},
\end{aligned}
$$

which are combined with labour supply curves in each country to yield final expressions

$$
\begin{aligned}
q_t(\varphi_t) &= \left(\frac{1}{z_t}\right)^{\frac{-\sigma(\theta+1)}{\theta+\sigma}}\left(\frac{1}{B_t}\right)^{\frac{-\sigma}{\theta+\sigma}}\left[A_t P_t^{\sigma}\right]^{\frac{\theta}{\theta+\sigma}}\left(\frac{\sigma}{\sigma-1}\right)^{\frac{-\theta\sigma}{\theta+\sigma}} \\
q_t^*(\varphi_t) &= \left(\frac{\tau^M}{z_t}\right)^{\frac{-\sigma(\theta+1)}{\theta+\sigma}}\left(\frac{1}{B_t^*}\right)^{\frac{-\sigma}{\theta+\sigma}}\left[A_t^*(P_t^*)^{\sigma}\right]^{\frac{\theta}{\theta+\sigma}}\left(\frac{\sigma}{\sigma-1}\right)^{\frac{-\theta\sigma}{\theta+\sigma}}.
\end{aligned}
$$

C Static Autarky Model

The Model

The economy produces a single final good that is chosen as the numéraire.

$$
A = \left(\int_{\omega\in\Omega} q(\omega)^{\frac{\sigma-1}{\sigma}} d\omega\right)^{\frac{\sigma}{\sigma-1}},
$$

where $q(\omega)$ is the intermediate good of variety ω, Ω is the measure of intermediate varieties available for purchase, and $\sigma > 1$ denotes the elasticity of substitution between intermediate-good varieties. This final good is used for consumption by workers. The demand for variety ω is then given by $q(\omega) = A\left[\frac{p(\omega)}{P}\right]^{-\sigma}$, where $p(\omega)$ is the price of variety ω, and $P = \left[\int_{\omega\in\Omega} p(\omega)^{1-\sigma} d\omega\right]^{\frac{1}{1-\sigma}}$ is the price of the final good, and with our choice of numeraire, $P = 1$.

Preferences are given by

$$
U \equiv C - \frac{N^{1+\frac{1}{\phi}}}{1+\frac{1}{\phi}}, \tag{A-11}
$$

where C is the consumption of the final good, N is the labour-supply index, and ϕ is the Frisch elasticity of labour supply. The labour-supply index is defined as

$$N = \Omega^{\frac{\eta}{1+\theta}} \left(\int_{\omega \in \Omega} n(\omega)^{\frac{1+\theta}{\theta}} d\omega \right)^{\frac{\theta}{1+\theta}}, \tag{A-12}$$

where η is the parameter that controls LOVE. $\eta = 0$ will have full LOVE as in our baseline model. $\eta = 1$ will get rid of LOVE so that in the homogeneous firm case this will yield $N = \Omega n$.

The labour supply curve can be determined as follows.

$$\underset{n(\omega)}{Max} \int w(\omega) n(\omega) - \frac{N^{1+\frac{1}{\phi}}}{1+\frac{1}{\phi}}$$

the above yields

$$n(\omega) = \Omega^{-\eta} N^{\frac{\phi-\theta}{\phi}} w(\omega)^{\theta} \equiv B w(\omega)^{\theta}$$

Define the wage index W in this case as

$$W = \Omega^{-\frac{\eta}{1+\theta}} \left(\int w(\omega)^{1+\theta} \right)^{\frac{1}{1+\theta}}$$

Next, verify that

$$\begin{aligned} N &= \Omega^{\frac{\eta}{1+\theta}} \left(\int_{\omega \in \Omega} n(\omega)^{\frac{1+\theta}{\theta}} d\omega \right)^{\frac{\theta}{1+\theta}} = \Omega^{\frac{-\eta\theta}{1+\theta}} N^{\frac{\phi-\theta}{\phi}} \left(\int_{\omega \in \Omega} w(\omega)^{1+\theta} d\omega \right)^{\frac{\theta}{1+\theta}} \\ N^{\frac{\theta}{\phi}} &= \Omega^{\frac{-\eta\theta}{1+\theta}} \left(\int_{\omega \in \Omega} w(\omega)^{1+\theta} d\omega \right)^{\frac{\theta}{1+\theta}} = W^{\theta}. \end{aligned}$$

Therefore,

$$W = N^{\frac{1}{\phi}}$$

and

$$\int w(\omega) n(\omega) = \Omega^{-\eta} N^{\frac{\phi-\theta}{\phi}} \int w(\omega)^{1+\theta} = \Omega^{-\eta} N^{\frac{\phi-\theta}{\phi}} W^{1+\theta} \Omega^{\eta} = N^{\frac{\phi-\theta}{\phi}} W^{1+\theta} = WN$$

And hence, welfare is

$$Welf = \frac{W^{1+\phi}}{1+\phi}. \tag{A-13}$$

Decentralized Equilibrium with firms exercising labour market power

Since firms are homogeneous, we can assume the fixed cost to be in terms of labour. The profit of a firm in this case is

$$\max_{l} \left\{ p\varphi(n-f) - wn \right\},$$

where n is the total labour hired by the firm of which $n-f$ is used in variable production and f is used for fixed operations. Demand is $q = Ap^{-\sigma}$. or $p = A^{\frac{1}{\sigma}}q^{-\frac{1}{\sigma}}$, and labour supply facing firms is $w = \left(\frac{n}{B}\right)^{\frac{1}{\theta}}$. Therefore, the above maximization exercise can be written as

$$\max_n \left\{ A^{\frac{1}{\sigma}}\varphi^{\frac{\sigma-1}{\sigma}}(n-f)^{\frac{\sigma-1}{\sigma}} - \left(\frac{n}{B}\right)^{\frac{1}{\theta}} n \right\}$$

The f.o.c is

$$\frac{\sigma-1}{\sigma}A^{\frac{1}{\sigma}}\varphi^{\frac{\sigma-1}{\sigma}}(n-f)^{\frac{-1}{\sigma}} = \frac{1+\theta}{\theta}\left(\frac{l}{B}\right)^{\frac{1}{\theta}} \tag{A-14}$$

The zero profit condition is

$$A^{\frac{1}{\sigma}}\varphi^{\frac{\sigma-1}{\sigma}}(n-f)^{\frac{\sigma-1}{\sigma}} = \left(\frac{n}{B}\right)^{\frac{1}{\theta}} n \tag{A-15}$$

From (A-14) and (A-15) obtain the following expression for the optimal amount of labour hired by a firm.

$$n_d = \frac{\sigma(1+\theta)}{\sigma+\theta} f \tag{A-16}$$

The equation for labour supply is $n = Bw^{\theta}$ where $B = \Omega^{-\eta}W^{\phi-\theta}$. Since $W = \Omega^{-\frac{\eta}{1+\theta}}\left(\int w(\omega)^{1+\theta}\right)^{\frac{1}{1+\theta}}$, in the homogeneous firm case we get $W = \Omega^{\frac{1-\eta}{1+\theta}}w$. And hence $B = \Omega^{\frac{(1-\eta)(\phi-\theta)}{1+\theta}-\eta}w^{\phi-\theta}$.Therefore, labour supply for a firm is $\Omega^{\frac{(1-\eta)(\phi-\theta)-\eta(1+\theta)}{1+\theta}}w^{\phi}$. Hence labour supply equals labour demand implies the following.

$$\Omega^{\frac{(1-\eta)(\phi-\theta)-\eta(1+\theta)}{1+\theta}}w^{\phi} = \frac{\sigma(1+\theta)}{\sigma+\theta} f$$

And the aggregate price equation is

$$\Omega^{\frac{1}{1-\sigma}}\frac{\sigma(1+\theta)}{(\sigma-1)\theta}\frac{w}{\varphi} = 1$$

Use the above 2 to solve for Ω and w_d which are given by

$$\Omega_d^{\frac{(1-\eta)(\theta-\phi)+\eta(1+\theta)}{1+\theta}-\frac{\phi}{\sigma-1}} = \frac{((\sigma-1)\theta)^{\phi}(\sigma+\theta)\varphi^{\phi}}{(\sigma(1+\theta))^{1+\phi} f} \tag{A-17}$$

$$w_d = \Omega_d^{\frac{1}{\sigma-1}}\frac{(\sigma-1)\theta}{\sigma(1+\theta)}\varphi \tag{A-18}$$

And hence the expression for wage index is given by

$$W_d = \Omega^{\frac{1-\eta}{1+\theta}}w_d = \Omega_d^{\frac{1}{\sigma-1}+\frac{1-\eta}{1+\theta}}\frac{(\sigma-1)\theta}{\sigma(1+\theta)}\varphi \tag{A-19}$$

When firms do not exercise market power in the labour market

$$\max_n \left\{ A^{\frac{1}{\sigma}} \varphi^{\frac{\sigma-1}{\sigma}} (n-f)^{\frac{\sigma-1}{\sigma}} - \left(\frac{n}{B}\right)^{\frac{1}{\theta}} n \right\}$$

The f.o.c is

$$\frac{\sigma-1}{\sigma} A^{\frac{1}{\sigma}} \varphi^{\frac{\sigma-1}{\sigma}} (n-f)^{\frac{-1}{\sigma}} = w$$

The zero profit in this case is

$$A^{\frac{1}{\sigma}} \varphi^{\frac{\sigma-1}{\sigma}} (n-f)^{\frac{\sigma-1}{\sigma}} = wn$$

From the above 2 obtain

$$n_c = \sigma f$$

The labour supply is same as before. Hence labour supply equals labour demand implies the following.

$$\Omega^{\frac{(1-\eta)(\phi-\theta)-\eta(1+\theta)}{1+\theta}} w^{\phi} = \sigma f$$

And the aggregate price equation is

$$\Omega^{\frac{1}{1-\sigma}} \frac{\sigma}{(\sigma-1)} \frac{w}{\varphi} = 1$$

Use the above 2 to solve for Ω and w and obtain .

$$\Omega_c^{\frac{(1-\eta)(\theta-\phi)+\eta(1+\theta)}{1+\theta} - \frac{\phi}{\sigma-1}} = \frac{(\sigma-1)^{\phi}}{\sigma^{1+\phi} f} \varphi^{\phi} \tag{A-20}$$

$$w_c = \Omega^{\frac{1}{\sigma-1}} \frac{\sigma-1}{\sigma} \varphi \tag{A-21}$$

And the expression for wage index is

$$W_c = \Omega_c^{\frac{1-\eta}{1+\theta}} w_c = \Omega_c^{\frac{1}{\sigma-1}+\frac{1-\eta}{1+\theta}} \frac{(\sigma-1)}{\sigma} \varphi \tag{A-22}$$

Planner's problem

The planner chooses Ω and n to maximize

$$\underset{n,\Omega}{Max} \left\{ \Omega^{\frac{\sigma}{\sigma-1}} \varphi (n-f) - \frac{\left(\Omega^{\frac{\theta+\eta}{1+\theta}} n\right)^{1+\frac{1}{\phi}}}{1+\frac{1}{\phi}} \right\}$$

The f.o.c are

$$\Omega^{\frac{\sigma}{\sigma-1}} \varphi = \left(\Omega^{\frac{\theta+\eta}{1+\theta}}\right)^{1+\frac{1}{\phi}} n^{\frac{1}{\phi}} \tag{A-23}$$

$$\frac{\sigma}{\sigma-1} \Omega^{\frac{1}{\sigma-1}} \varphi (n-f) = \frac{\theta+\eta}{1+\theta} n^{1+\frac{1}{\phi}} \Omega^{\frac{\theta+\eta}{(1+\theta)\phi}+\frac{\theta+\eta}{1+\theta}-1} \tag{A-24}$$

Solve the above two to get the following expressions for n and Ω.

$$n_p = \frac{\sigma(1+\theta)}{\sigma+\theta-\eta(\sigma-1)} f \tag{A-25}$$

$$\Omega_p^{\frac{(\theta-\phi)(\sigma-1)-(1+\theta)\phi+\eta(1+\phi)(\sigma-1)}{(1+\theta)(\sigma-1)}} = \frac{\sigma+\theta-\eta(\sigma-1)}{\sigma(1+\theta)} \frac{\varphi^{\phi}}{f} \tag{A-26}$$

Upon using the first f.o.c. write welfare as

$$Welf_p = \left(\Omega_p^{\frac{\theta+\eta}{1+\theta}} n_p\right)^{1+\frac{1}{\phi}} \left(\frac{(\theta+\eta)(\sigma-1)}{\sigma(1+\theta)} - \frac{\phi}{1+\phi}\right) \tag{A-27}$$

To compare the welfare in the $\phi \to 0$ case, using (A-23) substitute out n_p in the above and obtain

$$Welf_p = \Omega^{\left(\frac{\sigma}{\sigma-1}-\frac{\theta+\eta}{1+\theta}\right)(1+\phi)} \varphi^{1+\phi} \left(\frac{(\theta+\eta)(\sigma-1)}{\sigma(1+\theta)} - \frac{\phi}{1+\phi}\right) \tag{A-28}$$

Comparison of planner, monopsony, and wage taking firms cases

Baseline case: $\eta = 0$

In this case the key equations are

$$\begin{aligned}
n_p &= \frac{\sigma(1+\theta)}{\sigma+\theta} f; \Omega_p^{\frac{(\theta-\phi)}{1+\theta}-\frac{\phi}{\sigma-1}} = \frac{\sigma+\theta}{\sigma(1+\theta)} \frac{\varphi^{\phi}}{f} \\
n_d &= \frac{\sigma(1+\theta)}{\sigma+\theta} f; \Omega_d^{\frac{(\theta-\phi)}{1+\theta}-\frac{\phi}{\sigma-1}} = \frac{((\sigma-1)\theta)^{\phi}(\sigma+\theta)\varphi^{\phi}}{(\sigma(1+\theta))^{1+\phi} f} \\
n_c &= \sigma f; \Omega_c^{\frac{(\theta-\phi)}{1+\theta}-\frac{\phi}{\sigma-1}} = \frac{(\sigma-1)^{\phi}}{\sigma^{1+\phi} f} \varphi^{\phi}
\end{aligned}$$

Easily verify that $n_p = n_d < n_c$. That is the per firm employment is higher in the wage taking case than in the other two cases. However, note that the exercise of monopsony power in the labour market doesn't distort per firm employment. Next, let us look at the case of $\phi \to 0$. Note that per firm employment remains unchanged. However, the masses of firms are different.

When $\phi \to 0$ In this case, N becomes exogenous. The expressions for masses of firms are given by

$$\Omega_p = \Omega_d = \left(\frac{\sigma+\theta}{\sigma(1+\theta)} \frac{1}{f}\right)^{\frac{1+\theta}{\theta}} > \left(\frac{1}{\sigma f}\right)^{\frac{1+\theta}{\theta}} = \Omega_c$$

That is, the mass of firms is optimal (coincides with the planner's problem) when the labour market is monoposonistically competitive. However, the mass of firms is less than optimal if firms do not exercise labour market power. The expression for welfare in the planner's case is obtained from (A-28) by setting $\eta = 0$ and $\phi = 0$ and is given by

$$Welf_p = \left(\frac{\theta(\sigma-1)}{\sigma(1+\theta)}\right) \Omega_p^{\frac{\sigma+\theta}{(\sigma-1)(1+\theta)}} \varphi.$$

which corresponds to the welfare in the decentralized case with firms exercising monopsony power (verify from (A-13) and A-19)). That is the exercise of monopsony power allows the decentralized equilibrium to achieve optimality when $\phi = 0$. If firms do not exercise market power, then the expression for welfare in the decentralized equilibrium is obtained by setting $\eta = 0$ in (A-22) which is

$$Welf_c = \frac{(\sigma-1)}{\sigma}\Omega_c^{\frac{\sigma+\theta}{(\sigma-1)(1+\theta)}}\varphi.$$

Therefore,

$$\frac{Welf_p}{Welf_c} = \frac{\theta}{1+\theta}\left(\frac{\sigma+\theta}{1+\theta}\right)^{\frac{\sigma+\theta}{(\sigma-1)\theta}} > 1$$

The inequality above follows from the fact that the ratio is decreasing in θ, goes to ∞ as $\theta \to 0$ and goes to 1 as $\theta \to \infty$.

Therefore, we have verified that when N is exogenous, monopsonistically competitive labour market along with monopolistically competitive product market achieves efficiency in the presence of LOVE. Just as in the presence of love of variety in consumption a monopolistically competitive product market achieves efficiency, in the presence of LOVE, a monopsonistically competitive labour market achieves efficiency. If firms are wage takers, the decentralized equilibrium is inefficient.

When $\phi > 0$ Getting back to the $\phi > 0$ case, let us compare the masses of firms in the 3 cases. The expressions for Ω_i are given by

$$\begin{aligned}
\Omega_p^{\frac{(\theta-\phi)}{1+\theta}-\frac{\phi}{\sigma-1}} &= \frac{\sigma+\theta}{\sigma(1+\theta)}\frac{\varphi^\phi}{f} \\
\Omega_d^{\frac{(\theta-\phi)}{1+\theta}-\frac{\phi}{\sigma-1}} &= \frac{((\sigma-1)\theta)^\phi(\sigma+\theta)\varphi^\phi}{(\sigma(1+\theta))^{1+\phi}f} \\
\Omega_c^{\frac{(\theta-\phi)}{1+\theta}-\frac{\phi}{\sigma-1}} &= \frac{(\sigma-1)^\phi}{\sigma^{1+\phi}}\frac{\varphi^\phi}{f}
\end{aligned}$$

Note that we require $\phi < \frac{(\sigma-1)\theta}{\sigma+\theta}$ to get sensible results, which we assume to be the case. It is clear from above that $\Omega_p \neq \Omega_d \neq \Omega_c$. $\Omega_p \neq \Omega_d$ implies that the exercise of monopsony power doesn't lead to an efficient decentralized outcome anymore. The reason is that while the exercise of monopsony power leads to the correct mass of firms with exogenous labour supply, the resulting wage markdown causes a distortion in the labour supply by taxing labour and implicitly subsidizing leisure. If firms are wage takers, the distortion in labour supply is avoided, however, the presence of LOVE means that the mass of firms is sub-optimal in this case. So, the decentralized equilibrium with and without monopsony power is inefficient. Comparing the expressions for welfare in the wage markdown and wage taker cases, we find that

$$\frac{Welf_d}{Welf_c} = \left(\frac{\theta}{1+\theta}\right)^{\frac{(\sigma-1)\theta}{(\sigma-1)\theta-\phi(\sigma+\theta)}}\left(\frac{\sigma+\theta}{1+\theta}\right)^{\frac{\theta+\sigma}{(\sigma-1)\theta-\phi(\sigma+\theta)}}$$

The above expression is greater than one when $\phi \to \frac{(\sigma-1)\theta}{\sigma+\theta}$, decreasing in θ and goes to 1 as $\theta \to \infty$. Therefore, welfare is higher when firms exercise labour market power. Below we verify that this result is overturned in the absence of LOVE.

When $\eta = 1$

$$
\begin{aligned}
n_p &= \sigma f; \Omega_p^{1-\frac{\phi}{\sigma-1}} = \frac{\varphi^\phi}{\sigma f} \\
n_d &= \frac{\sigma(1+\theta)}{\sigma+\theta} f; \Omega_d^{1-\frac{\phi}{\sigma-1}} = \frac{((\sigma-1)\theta)^\phi (\sigma+\theta)\varphi^\phi}{(\sigma(1+\theta))^{1+\phi} f} \\
n_c &= \sigma f; \Omega_c^{1-\frac{\phi}{\sigma-1}} = \left(\frac{\sigma-1}{\sigma}\right)^\phi \frac{\varphi^\phi}{\sigma f}
\end{aligned}
$$

Observe that now $n_p = n_c > n_d$. That is, monopsony causes a distortion in per firm employment while wage taking firms choose the optimal level of employment.

When $\phi \to 0$ Again, looking at the case of zero Frisch elasticity, note that

$$\Omega_p = \Omega_c = \frac{1}{\sigma f} < \frac{(\sigma+\theta)}{(\sigma(1+\theta)) f} = \Omega_d$$

That is, the exercise of labour market power results in too many varieties/firms and sub-optimal employment per firm. Therefore, monopsony power is distortionary in this case and if firms are wage takers, the resulting outcome is efficient. The expressions for welfare are given by

$$Welf_p = \left(\frac{\sigma-1}{\sigma}\right) \Omega_p^{\frac{1}{\sigma-1}} \varphi = Welf_c; Welf_d = \Omega_d^{\frac{1}{\sigma-1}} \frac{(\sigma-1)\theta}{\sigma(1+\theta)} \varphi$$

Next, using the expressions for Ω_p and Ω_d obtain

$$\frac{Welf_p}{Welf_d} = \frac{(1+\theta)}{\theta} \left(\frac{1+\theta}{\sigma+\theta}\right)^{\frac{1}{\sigma-1}} > 1$$

The inequality above follows from the fact that the ratio is decreasing in θ, goes to ∞ as $\theta \to 0$ and goes to 1 as $\theta \to \infty$.

So, we have shown that when $\phi \to 0$, the exercise of monopsony power in the labour market results in an efficient outcome in the presence of LOVE but is distortionary in the absence of LOVE. In the latter case, if firms were wage takers, the decentralized outcome would be efficient.

When $\phi > 0$ Now let us look at the masses of firms in the 3 cases.

$$\Omega_p^{1-\frac{\phi}{\sigma-1}} = \frac{\varphi^\phi}{\sigma f}; \Omega_c^{1-\frac{\phi}{\sigma-1}} = \left(\frac{\sigma-1}{\sigma}\right)^\phi \frac{\varphi^\phi}{\sigma f}; \Omega_d^{1-\frac{\phi}{\sigma-1}} = \left(\frac{(\sigma-1)\theta}{\sigma}\right)^\phi \frac{(\sigma+\theta)}{(1+\theta)^{1+\phi}} \frac{\varphi^\phi}{\sigma f}$$

It is clear that $\Omega_p \neq \Omega_d \neq \Omega_c$.

$$\frac{Welf_d}{Welf_c} = \left(\frac{\sigma+\theta}{1+\theta}\right)^{\frac{1}{\sigma-1-\phi}} \left(\frac{\theta}{1+\theta}\right)^{\frac{\sigma-1}{\sigma-1-\phi}} < 1$$

The inequality above follows from the fact that the expression above goes to 1 as $\theta \to \infty$ and it is increasing in θ. Therefore, monopsony causes greater distortion than the case of wage taking firms. This is because monopsony distorts labour supply while wage taking by firms doesn't. As mentioned earlier, in the presence of labour supply margin, monopolistic competition in the product market is distorting, and therefore, even if firms are wage takers in the labour market, the decentralized equilibrium doesn't achieve efficiency.

D Computational Algorithms

Steady State

Calibrated Steady State

For the computation of the steady state in the calibration step (note that aggregate objects are stationary and so their time subscripts are omitted):

1. Fix the W and W^* indices to unity (we will adjust the fixed costs of entry to make this consistent with free entry later). In what follows, variables with hats will denote conjectures in the computations. Conjecture objects $\widehat{A}$, $\widehat{A}^*$, $\widehat{\Omega}^P$ and $\widehat{\Omega}^{P*}$ — the demand shifters for final output in H, F, the mass of producing firms in H and F, respectively. Recall that the final good in H is the numéraire and since the two countries are symmetric, it follows that $P = P^* = 1$.
2. Solve the incumbent firm's Bellman equation (13). This step yields their value function as well policy functions for price, employment, discrete choice and wage policy functions. All these objects are functions of the firm's state space. Solve this part of the problem using value function iteration.
3. Solve the entrant's problem (16) using the value function obtained from step 2 and assuming the fixed entry cost $f^T = 0$ (this is a free parameter given the fixed W above). After obtaining entry value v^T, set $f^T = v^T$.
4. Find the steady state cross-sectional distribution of H and F firms: normalising to have a unit measure of each set of firms. Do this by firstly re-writing the cross-sectional law of motion in equation (17) in matrix notation as

$$\mu_t = \zeta_t \mu_t + M_t^T G^T \tag{A-29}$$

where μ_t the vector of the measure of firms across the state space and ζ_t is a Markov transition matrix that depends on the productivity process for incumbents, their equilibrium discrete choices and the stochastic process for the sunk cost draws. We can then find the invariant stationary distribution through inverting the steady state version of equation (A-29) as $\widetilde{\mu} = \widetilde{M}^T(I-\zeta)^{-1}G^T$. Here I is the identity matrix, $\widetilde{\mu}$ is the stationary distribution and $\widetilde{M}^T$ is the measure of entrants that normalises the overall firm measure to unity (giving the stationary distribution).

5. Find variable averages implied by the stationary distribution found in step 4.
6. Find the measures of firms using the linearity of the stationary measure such that the definition of the wage indices hold in each country as given in equation (10). Recall that these indices are set equal to unity as per the normalisation above. Note that this step utilises the average employment levels found using the stationary distribution, in step 5.
7. Aggregate using the variable averages and firm measures, found in step 6.
8. Compute the following metrics of distance

$$\begin{aligned} \Delta^A &= |\widehat{A} - A| \\ \Delta^{A*} &= |\widehat{A}^* - A^*| \\ \Delta^{MP} &= |\widehat{\Omega}^P - \Omega^P| \\ \Delta^{MP*} &= |\widehat{\Omega}^{P*} - \Omega^{P*}|. \end{aligned} \tag{A-30}$$

See that the first two objects in the set of equations in (A-30) represent the distance of the conjectured demand shifter from the supply of final goods implied from the previous step in H and F, respectively. The second two equations give the distance of the conjectured masses of producers from those implied in H and F, respectively. If $\max(\Delta^A, \Delta^{A*}, \Delta^{MP}, \Delta^{MP*})$ is sufficiently small, then stop. Otherwise update the conjectures $\widehat{A}$, $\widehat{A}^*$, $\widehat{\Omega}^P$ and $\widehat{\Omega}^{P*}$, return to step 2 above and repeat until convergence. Once converged, compute the list of equilibrium objects in equation (18) for this calibrated steady state. Label this list of objects Γ_0.

Counterfactual Steady State

When running a counterfactual, use the following procedure:

A Conjecture objects $\widehat{A}, \widehat{A}^*, \widehat{P}^*, \widehat{W}$, $\widehat{W}^*$, $\widehat{\Omega}^P$ and $\widehat{\Omega}^{P*}$. Notice that now we now need to solve endogenously for the price of final goods in F and the two wage indices.

B As in step 2 in the calibration procedure, solve the incumbent firm's Bellman equation using value function iteration.

C Solve the entrant's problem (16) using the value function obtained from step B and the fixed cost of entry implied by step 3 of the calibration procedure.

D As in step 4 of the calibration procedure, find the stationary cross-section of firms.

E As in step 5 of the calibration procedure, find the averages of variables using the stationary distribution.

F Similarly to step 6 of the calibration procedure, find the measures of firms implied by the current wage index conjectures $\widehat{W}$ and $\widehat{W}^*$.

G As in step 7 of the calibration procedure, aggregate using the measures of firms found in step F.

H Compute the metrics of distance of (A-30) in the calibration procedure, as well as

$$\Delta^{P*} = |\widehat{A}^* - C^* - L^*|$$
$$\Delta^{W} = |v^T|$$
$$\Delta^{W*} = |v^{T*}|$$

where the top equation is the difference between the conjectured final output in F and aggregate demand, while the second and third are the distances of the free entry conditions from holding. If $\max(\Delta^A, \Delta^{A*}, \Delta^{MP}, \Delta^{MP*}, \Delta^{P*}, \Delta^W, \Delta^{W*})$ is sufficiently small, then stop. Otherwise update the conjectured objects $\widehat{A}, \widehat{A}^*, \widehat{\Omega}^P, \widehat{\Omega}^{P*}, \widehat{P}^*, \widehat{W}, \widehat{W}^*$, return to step B and repeat until convergence. Once stopped, compute the list of objects in (18) for this steady state, label this list $\Gamma_{\widehat{\mathcal{T}}}$

Transition Dynamics

One uses the economies given by Γ_0 and Γ_1 as boundary conditions for the simulation, which starts at time $t = 1$. After having solved for the two steady states, follow the procedure below.

a Conjecture the length of time to convergence, label this number $\widehat{\mathcal{T}} \in \mathbb{N}$.

b Conjecture time paths for aggregate variables $\{\widehat{\Gamma}_t\}_{t=1}^{\widehat{\mathcal{T}}-1}$ where

$$\widehat{\Gamma}_t \equiv (\widehat{A}_t, \widehat{A}_t^*, \widehat{P}_t^*, \widehat{W}_t, \widehat{W}_t^*, \widehat{\Omega}_t^P, \widehat{\Omega}_t^{P*}, \widehat{M}_t^T, \widehat{M}_t^{T*}).$$

Notice that now we need to also conjecture the masses of entrants in each country.

c Take $v_{\widehat{\mathcal{T}}}(z, s)$ to be the endpoint for the H incumbent value function. This serves as the continuation value for the final period of the transition. Iterate backwards on the firm Bellman equation (13) to the initial period. This gives a sequence $\{v_t(z, s)\}_{t=1}^{\widehat{\mathcal{T}}-1}$. Do the same for the F firms.

d Using the sequence $\{v_t(z, s)\}_{t=1}^{\widehat{\mathcal{T}}-1}$, iterate backwards on the entrant Bellman equation (16). This gives a sequence of entry values $\{v_t^T\}_{t=1}^{\widehat{\mathcal{T}}-1}$. Do the same for F firms.

e Using the policy functions found in c and d, as well as μ_0 from list Γ_0 as a starting point, iterate forwards on the law of motion (A-29) to obtain a sequence of cross-sectional measures $\{\mu_t(z, s)\}_{t=1}^{\widehat{\mathcal{T}}-1}$. Do the same for the F firms.

f Compute the following sequence of distance metrics $\{\Delta_t\}_{t=1}^{\widehat{\mathcal{T}}-1}$

$$\Delta_t = (\Delta_t^A, \Delta_t^{A*}, \Delta_t^{P*}, \Delta_t^W, \Delta_t^{W*}, \Delta_t^{MP}, \Delta_t^{MP*}, \Delta_t^M, \Delta_t^{M*})$$

where

$$
\begin{aligned}
\Delta_t^A &= |\widehat{A}_t - A_t| \\
\Delta_t^{A*} &= |\widehat{A}_t^* - A_t^*| \\
\Delta_t^{P*} &= |\widehat{A}_t^* - C_t^* - F_t^*| \\
\Delta_t^W &= |\widehat{W}_t - W_t| \\
\Delta_t^{W*} &= |\widehat{W}_t^* - W_t^*| \\
\Delta_t^{MP} &= |\widehat{\Omega}_t^P - \Omega_t^P| \\
\Delta_t^{MP*} &= |\widehat{\Omega}_t^{P*} - \Omega_t^{P*}| \\
\Delta_t^M &= |v_t^T| \\
\Delta_t^{M*} &= |v_t^{T*}|
\end{aligned}
$$

are the time-varying versions of distance metrics defined for the steady states. Note we also consider Δ_t^W and Δ_t^{W*} along the transition since we no longer normalise the cross-sectional measure. If $\max_t\{\max \Delta_t\}_{t=1}^{\widehat{\mathcal{T}}-1}$ is sufficiently small then stop. Otherwise, update the sequences of $\{\widehat{\Gamma}_t\}_{t=1}^{\widehat{\mathcal{T}}-1}$, return to step c and repeat.

g Check to see if the system has converged by time $\widehat{\mathcal{T}}$. If not, update your guess of $\widehat{\mathcal{T}}$, return to step b and repeat until convergence.

E Robustness on the Frisch Elasticity

		Calibration										
Parameter		**C11**	**C12**	**C13**	**C14**	**C15**	**C16**	**C17**	**C18**	**C19**	**C20**	**Target**
Sunk cost of entry	f^T	0.329	0.290	0.413	0.291	0.482	0.328	0.282	0.405	0.294	0.490	Unit wage
Sunk cost (D, X)	$\widehat{f}^{X,D}$	0.026	0.022	0.029	0.021	0.085	0.068	0.058	0.048	0.040	0.159	Transition (D, X)
Fixed cost X	$f^{X,C}$	0.014	0.012	0.017	0.012	0.029	0.011	0.009	0.016	0.011	0.028	Fraction X
Sunk cost stddev	σ_f	0.300	0.500	1.700	1.200	1.000	1.020	1.020	1.050	0.620	1.040	Transition (X, E)
Fixed cost	f^C	0.181	0.153	0.219	0.159	0.165	0.181	0.154	0.221	0.160	0.163	Exit rate
Physical iceberg X	τ^X	1.350	1.350	1.350	1.350	1.385	1.350	1.350	1.350	1.350	1.350	Export intensity
Export tariff	$\widehat{\tau}^X$	1.100	1.100	1.100	1.100	1.080	1.100	1.100	1.100	1.100	1.100	Taxes/output C1
Sunk cost (X, M)	$\widehat{f}^{M,X}$						0.083	0.041	0.140	0.064	0.092	Transition (X, M)
Sunk cost (M, X)	$\widehat{f}^{X,M}$						0.052	0.053	0.033	0.034	0.092	Transition (M, X)
Fixed cost M	$f^{M,C}$						0.086	0.072	0.107	0.075	0.088	Fraction M
Physical iceberg M	τ^M						1.650	1.653	1.653	1.653	1.230	FDI sales intensity
FDI tax	$\widehat{\tau}^M$						0.020	0.050	0.020	0.050	0.030	FDI taxes/output C6

Table A-1: Parameters calibrated inside model with $\phi = 0$. Fixed costs expressed as fraction of final output.

					Calibration								
Moment	**Data**	**C11**	**C12**	**C13**	**C14**	**C15**	**Data**	**C16**	**C17**	**C18**	**C19**	**C20**	**Source**
Fraction X	0.360	0.351	0.352	0.357	0.343	0.351	0.290	0.285	0.313	0.285	0.291	0.296	Census
Transition (D, X)	0.054	0.063	0.064	0.068	0.063	0.064	0.054	0.036	0.045	0.040	0.048	0.039	Census
Transition (X, E)	0.053	0.033	0.033	0.034	0.033	0.033	0.053	0.052	0.053	0.062	0.063	0.052	Census
Exit rate	0.080	0.079	0.079	0.079	0.079	0.079	0.080	0.076	0.075	0.079	0.079	0.075	Census
Export intensity	0.150	0.158	0.158	0.158	0.158	0.156	0.150	0.158	0.158	0.158	0.158	0.158	Compustat
Taxes/output $\widehat{\tau}^X$	0.007	0.007	0.007	0.007	0.007	0.007							C1
Transition (X, M)							0.008	0.016	0.021	0.013	0.022	0.019	Census
Transition (M, X)							0.019	0.018	0.012	0.009	0.022	0.019	Census
Fraction M							0.055	0.048	0.044	0.041	0.044	0.049	Census
FDI sales intensity							0.300	0.302	0.301	0.301	0.301	0.304	Compustat
FDI taxes/output $\widehat{\tau}^M$							0.001	0.001	0.001	0.001	0.001	0.001	C6

Table A-2: Data and model moments for robustness with $\phi = 0$. Note that we report separate data moments for C1–C5, which are conditional on firms that do not transition to multinational status.

	Calibration 11 WMD,LOVE,USLS			Calibration 12 LOVE, USLS			Calibration 13 WMD, USLS			Calibration 14 USLS			Calibration 15 None		
	Bi.	**Uni.**		**Bi.**	**Uni.**		**Bi.**	**Uni.**		**Bi.**	**Uni.**		**Bi.**	**Uni.**	
Steady state	$\boldsymbol{H/F}$	$\boldsymbol{H}$	$\boldsymbol{F}$	$\boldsymbol{H/F}$	$\boldsymbol{H}$	$\boldsymbol{F}$	$\boldsymbol{H/F}$	$\boldsymbol{H}$	$\boldsymbol{F}$	$\boldsymbol{H/F}$	$\boldsymbol{H}$	$\boldsymbol{F}$	$\boldsymbol{H/F}$	$\boldsymbol{H}$	$\boldsymbol{F}$
Welfare	0.031	0.005	0.040	0.034	0.008	0.034	0.024	0.007	0.039	0.027	0.015	0.037	0.007	-0.003	0.013
Consumption	0.031	0.005	0.040	0.034	0.008	0.034	0.024	0.007	0.039	0.027	0.015	0.037	0.007	-0.003	0.013
Measure D	-0.825	-0.736	-0.702	-0.844	-0.767	-0.735	-0.797	-0.728	-0.705	-0.816	-0.691	-0.662	-0.639	-0.422	-0.404
Measure X	1.530	1.309	1.267	1.591	1.387	1.348	1.452	1.298	1.265	1.579	1.297	1.251	1.053	0.685	0.664
Measure E	0.001	-0.019	-0.011	-0.159	-0.161	-0.151	-0.159	-0.156	-0.150	-0.162	-0.009	-0.006	-0.045	-0.034	-0.030
Measure all	0.001	-0.019	-0.011	0.012	-0.009	-0.002	0.007	-0.004	-0.001	0.005	-0.009	-0.006	-0.046	-0.034	-0.029
Measure P	0.001	-0.019	-0.011	0.012	-0.009	-0.002	0.007	-0.004	-0.001	0.005	-0.009	-0.006	-0.046	-0.034	-0.029
Measure U	0.398	0.326	0.332	0.423	0.354	0.359	0.387	0.339	0.341	0.407	0.324	0.327	0.240	0.153	0.156
Profits	0.128	0.068	0.116	0.098	0.036	0.091	0.097	0.045	0.092	0.087	0.067	0.112	0.068	0.031	0.070
Taxes	-1.000	-1.000	1.496	-1.000	-1.000	1.553	-1.000	-1.000	1.484	-1.000	-1.000	1.526	-1.000	-1.000	0.644
W index	0.041	0.015	0.071	0.042	0.016	0.071	0.034	0.019	0.072	0.035	0.023	0.076	0.015	0.005	0.048
P index	0.000	0.000	0.049	0.000	0.000	0.049	0.000	0.000	0.050	0.000	0.000	0.049	0.000	0.000	0.040

Table A-3: Robustness on steady state trade liberalisation exercises with $\phi = 0$. Numbers are percentage deviations from calibrated steady state (prior to multiplication by 100). Measure all is the mass of all firms originating from the country in consideration. Measure P denotes object Ω^P (the mass of producing firms in the relevant country), while measure U is object Ω^U (the mass of varieties utilised in production of the aggregate final good).

	Calibration 16 WMD,LOVE,USLS			Calibration 17 LOVE, USLS			Calibration 18 WMD, USLS			Calibration 19 USLS			Calibration 20 None		
	Bi.	**Uni.**		**Bi.**	**Uni.**		**Bi.**	**Uni.**		**Bi.**	**Uni.**		**Bi.**	**Uni.**	
Steady state	H/F	H	F	H/F	H	F	H/F	H	F	H/F	H	F	H/F	H	F
Welfare	0.008	0.031	-0.016	0.014	0.039	-0.020	-0.007	0.014	-0.020	-0.030	0.018	-0.057	0.001	0.007	-0.005
Consumption	0.008	0.031	-0.016	0.014	0.039	-0.020	-0.007	0.014	-0.020	-0.030	0.018	-0.057	0.001	0.007	-0.005
Measure D	-0.125	-0.069	-0.243	-0.280	-0.204	-0.301	-0.175	-0.038	-0.155	-0.341	-0.227	-0.329	-0.036	0.018	-0.054
Measure X	-0.027	-0.072	0.352	-0.124	-0.162	0.228	0.052	-0.084	0.192	-0.080	-0.110	0.220	-0.122	-0.131	0.001
Measure M	1.340	2.003	-0.192	3.792	5.660	-0.394	1.480	1.578	-0.154	3.544	5.172	-0.422	0.906	1.080	-0.122
Measure E	-0.027	0.035	-0.094	-0.101	0.029	-0.224	-0.042	0.015	-0.056	-0.147	-0.006	-0.174	-0.009	0.035	-0.042
Measure all	-0.026	0.030	-0.071	-0.053	0.065	-0.140	-0.042	0.015	-0.056	-0.097	0.042	-0.174	-0.015	0.026	-0.041
Measure P	0.037	0.121	0.024	0.107	0.299	0.103	0.018	0.077	0.008	0.055	0.255	0.049	0.028	0.076	0.012
Measure U	0.023	0.080	0.004	0.054	0.192	0.042	0.025	0.042	-0.012	0.025	0.176	0.014	-0.005	0.030	-0.020
Profits	0.145	0.232	-0.012	0.292	0.515	-0.138	0.136	0.174	-0.046	0.289	0.521	-0.175	0.093	0.148	-0.044
Taxes	-0.185	0.185	-0.120	-0.303	0.066	-0.263	-0.117	0.052	-0.130	-0.275	0.087	-0.232	-0.272	-0.148	-0.136
W index	0.004	0.020	-0.007	0.013	0.033	-0.004	-0.012	0.007	-0.012	-0.032	0.011	-0.042	0.002	0.005	0.003
P index	0.000	0.000	0.008	0.000	0.000	0.013	0.000	0.000	0.005	0.000	0.000	0.012	0.000	0.000	0.006

Table A-4: Robustness on steady state FDI liberalisation exercises with $\phi = 0$. Numbers are percentage deviations from calibrated steady state (prior to multiplication by 100). Measure all is the mass of all firms originating from the country in consideration. Measure P denotes object Ω^P (the mass of producing firms in the relevant country), while measure U is object Ω^U (the mass of varieties utilised in production of the aggregate final good).