Policy Effects of International Taxation on Firm Dynamics and Capital Structure*

Adam Hal Spencer†

September 29, 2021

Abstract

This paper develops a quantitative open economy framework with dynamics, firm heterogeneity and financial frictions to study the impact of corporate tax reforms targeted at multinationals. The model quantifies their impact on firm selection, production and welfare. Firms draw idiosyncratic shocks, invest in capital, choose optimal financing and select endogenously into selling abroad, through exporting or FDI. I apply this framework to the removal of the U.S. repatriation tax as in the Tax Cuts and Jobs Act. The reform's impact trades-off two selection effects — more offshoring versus greater U.S. business dynamism. The reform leads to higher U.S. welfare at little cost to the Treasury. A series of exercises illustrate that the novel features of this framework have significant quantitative implications. The reform gives starkly different cross-sectional predictions and lower welfare gains when financial frictions are removed and it is welfare reducing in a static counterpart of the model.

Keywords: Dynamics, Financial Frictions, Corporate Tax, Firm Heterogeneity, Foreign Direct Investment, Repatriation Tax

JEL codes: E62, F23, G32, H25, L11

I Introduction

The activities of multinational firms account for almost one-third of world GDP and about one-fourth of employment (OECD, 2018a).

Multinational firms are large, profitable and have widespread influence over goods and factor markets. Consequently, their tax treatment often receives special attention from policymakers. In June 2021, the G7 agreed on a global minimum corporate rate to minimise tax evasion by multinationals (G7, 2021). The 2021 Made in America Tax Plan made a proposal to mitigate U.S. firms' offshoring activities (Treasury, 2021). The 2017 Tax Cuts and Jobs Act (TCJA) sought to reduce the tax burden on U.S. multinationals, to increase their competitiveness (Speaker's Office, 2017). Cuts to the U.K. corporate tax rate in 2015 took place with an objective of attracting FDI from abroad (HM Government, 2013). How do these tax reforms targeted at multinationals affect the domestic macroeconomy?

This paper develops a new modelling framework that can be used to evaluate these types of reforms quantitatively. Their real impact in the model is shaped by general equilibrium effects and how they change the behaviour of firms across the entire cross-section. A tax reform targeting FDI firms affects large multinationals differently from small. It spills-over to impact non-multinational incumbents and new startups through adjustments to market conditions. Heterogeneous investment responses can aggregate to have a significant impact on the macroeconomy.

The model emphasises two key ingredients for accurately capturing these heterogeneous investment sensitivities — dynamics and financial frictions. The environment features investment at the extensive and intensive margins, bringing inter-temporal considerations and capital accumulation to the forefront of firm decision-making. It gives a distribution of foreign engagement statuses and firm sizes. This motivates the inclusion of financial frictions, as they have differential effects on firms, based on their place in the size distribution (Hennessy & Whited, 2007). After developing this general framework, I test its predictions using a brief comparison with the data on an aspect of the 2004 American Jobs Creation Act that revoked a tax credit from U.S. exporters. I then utilise the framework to quantify the impact of a recent tax policy episode targeted at multinationals — the removal of the U.S. *repatriation tax* — an aspect of the TCJA.

The primitive element of firm heterogeneity in the quantitative framework is idiosyncratic

1

productivity shocks that are drawn from a persistent distribution. Firms are monopolistically competitive and produce using a constant returns technology in capital and labour in each location that they have a presence. Firms select endogenously into different modes of production based on their state vector for the period. They can either exit the industry, operate as a purely domestic firm, an exporter, a multinational or an offshoring multinational. Those of the latter three modes have access to a foreign market.

The fixed cost setup follows the structure of Alessandria & Choi (2007, 2014b) and Alessandria, Choi, & Ruhl (2021). Firms pay a one-off sunk cost in the period they create a new operating segment and then smaller period-by-period fixed continuation costs in each subsequent. The exporting-FDI tradeoff follows the structure of Helpman, Melitz, & Yeaple (2004) with variable iceberg transport costs for exporting versus higher fixed costs for FDI. Offshoring multinationals produce all their output abroad to take advantage of lower input costs, exporting some of their goods back to their home market. Each period there is an endogenous measure of new entrant firms into the model, who incur a fixed sunk cost to establish and operate as domestics in their first period of incumbency.

The model allows for rich structure in the external financing of firms. The financial frictions incorporated are standard in the corporate finance literature: debt tax shields, a collateral constraint and costly equity issuance. Firms have two potential financing instruments. Firstly, they can issue one-period debt securities, which are collateralised by the liquidation values of their domestic and overseas capital stocks. Secondly, they can issue new equity, which incurs a premium that increases in the size of the issuance.[1] Optimal capital structure balances the tax advantage of borrowing with current and future expected financing costs. The latter effect instils precautionary concerns in firms, as excessive borrowing can lead to future equity issuance in the event of a cashflow shortfall. Even when a firm issues equity in the current period, in which case more borrowing directly offsets the size of the corresponding premium, its collateral constraint will generally be slack for precautionary reasons. The average domestic firm that issues new equity optimally leaves 24% excess capacity in their borrowing constraint. In turn, these apprehensions restrain firms along both margins of their investment.

The model is solved numerically with parameters disciplined by data to capture the firm

---

[1]This cost function is designed to capture direct costs (such as underwriting fees) associated with issuing new equity, in addition to indirect costs such as value losses associated with differential firm valuations between insiders and outside investors. For more discussion see Hennessy & Whited (2007).

lifecycle, interactions between multinationals and the rest of the cross-section, as well as investment and financial decisions. Firm-level leverage and equity issuance statistics are matched to identify the magnitude of financial frictions, while physical capital investment data are used to calibrate adjustment costs. Fixed costs are identified by matching transition probabilities across all the operational statuses. The initial productivity distribution pins-down the firm lifecycle.

I apply the general framework to a part of the TCJA, which was aimed specifically at U.S. multinationals. The repatriation tax was a rate that the U.S. Government levied on the overseas earnings of U.S.-incorporated firms prior to the Act — it was removed effective January 1st 2018. When a U.S. firm generates earnings in a foreign country, it pays corporate taxes to the local tax authority. Prior to the TCJA, it would also pay taxes to the U.S. Government on these earnings when they were remitted back to the U.S. parent, or repatriated.[2] The rate paid was equal to the difference between the U.S. statutory rate of 35% and the rate the firm had already paid to the foreign government. Foreign corporate taxes are still levied, but U.S. taxes on these overseas earnings of U.S. firms are no longer incurred post-TCJA.

How did removing the repatriation tax impact the U.S. economy? There are two broad channels associated with the reform in my framework. The first is an offshoring channel, which was feared by the Act's opponents (Bernstein, 2017). This involves a horizontal switching-effect, where more U.S. multinational activity is incentivised at the expense of export activity. This serves to depress the domestic labour market. The second channel is a firm value creation effect. The lower tax burden incentivises more creation of multinationals and capital accumulation through foreign subsidiaries, expanding productive capacity and profits. Higher option value for FDI drives a business dynamism effect, where more U.S. startups put upward-pressure on the domestic wage and spur investment. There is empirical evidence supporting the rise in U.S. multinational activity in the post-TCJA data — real U.S. FDI outflows increased by 36% in 2018 relative to the previous three year average.[3]

---

[2]This deferrability option applied to earnings generated through firms' core business activities — around 90% of those made by U.S. firms abroad. Those that it doesn't apply to include dividends, royalties and interest; I abstract from these types of earnings in my analysis.

[3]This number is found using the BEA series (BEA, 2021) "balance of payments and direct investment position data: U.S. direct investment abroad, financial outflow transactions without current-cost adjustment". I take the "all countries total" figure and exclude tax havens as defined in Tørsløv, Wier, & Zucman (2018) and the top 6 countries by U.S. cash holdings reported by Faulkender, Hankins, & Petersen (2019) to abstract from tax planning considerations. This ultimately excludes Belgium, Ireland, Luxembourg,

These two competing channels make this policy the ideal application in the context of the numerical laboratory this paper develops — which effect dominates is ultimately a quantitative question.

Baseline estimates suggest that removing the repatriation tax was a favourable policy initiative. It leads to significant selection effects in the U.S. firm cross-section. Steady state results suggest that the fraction of exporters drops by 1.1 percentage points (pp) post-reform, while that for multinationals rises by 0.4pp. The rise in entry value drives an increase in the measure of new startups of 0.24%, as well as a rise in the domestic capital stock, which culminate in higher output of 0.4%. Since many of these positive domestic effects are taxable by the U.S. Government, the reform brings only a slight decrease in revenues (inclusive of the transition) of 0.38% in net present value terms. Higher profitability and a more favourable labour market induce a rise in U.S. welfare of 0.26% in consumption equivalent variation.

Subsequent to the policy exercises, I turn to assess the quantitative significance of features of the model. Dynamics have a significant impact on the results. A static model analogue predicts a larger offshoring effect of the repatriation tax's removal — the fraction of multinationals and exporters rise and fall respectively by 5.3pp. This pushes-down wages, leads to a 5% drop in U.S. tax collections and a 1.2% welfare loss. These starkly contrasting predictions follow from markedly different optimal repatriation taxes across the two models. In the static analogue, the optimal rate is 41%, as bolstering the terms of trade is a primary means of maximising welfare. Moving to a zero tax shifts the economy further from this optimal rate. This contrasts with the baseline model where dynamics make capital accumulation concerns paramount — its optimal steady state tax is much lower at 5%.

Financial frictions have a significant impact on the results. The costly equity issuance feature tames an excessive expansion effect created by the tax's removal. When a firm establishes a foreign subsidiary, it typically needs to raise new equity to cover the fixed and variable investments. This triggers the issuance premium, increasing the marginal cost of investment and limiting the new subsidiary's scale. Precautionary concerns compound this effect; new multinationals hold-back for fear of future issuance to maintain their operations. With the tax reform, subsidiaries' scale expansion is modest, leaving space for more action

Netherlands, Switzerland, Malta, Other Western Hemisphere, Hong Kong, United Kingdom and Singapore. CPI data are taken from BLS series CUSR0000SA0L1E (BLS, 2021). Real flows are expressed in 2015 U.S. dollars, (using the January index for each year).

at the extensive margin. A re-calibrated version of the model with costless equity issuance sees radically different cross-sectional predictions, which move the opposite way.[4] A larger intensive margin expansion causes a decrease in the prevalence of multinationals and an increase in exporters, bringing more variable inefficiencies with the latter. The surviving multinationals face less competition in the foreign market, making them much more profitable, giving larger gains to the option value of FDI. This leads to larger entry value gains and a diversion of more resources towards less productive startups. These inefficiencies culminate in smaller welfare gains of the reform — 0.06% in contrast with 0.26% in the baseline.

This paper contributes to several different literatures. The first relates to trade, multinationals and policy reforms; a small subset of these papers study reforms targeted at multinationals. McGrattan & Prescott (2009), Burstein & Monge-Naranjo (2009) and Ramondo (2014) consider the gains from opening-up to FDI from foreign firms. Ramondo & Rodriguez-Clare (2013) study the interaction of openness to FDI and trade simultaneously. Models in the quantitative trade literature are typically static; of those that incorporate dynamics, the emphasis has mostly been on the export margin. Examples include Alessandria, Choi, & Ruhl (2021), Ruhl & Willis (2017), Alvarez (2017), Atkeson & Burstein (2010), Fitzgerald, Haller, & Yedid-Levi (2016), Brooks & Dovis (2019) and Ravikumar, Santacreu, & Sposi (2019). An exception is McGrattan (2012), who studies FDI openness reforms along the dynamic transition path, but in a model with representative agents. Ramondo & Rodriguez-Clare (2013) find that including FDI in a calibrated model can substantially increase the gains from policy reforms relative to one with trade only. I contribute to this literature by bringing policy, FDI decisions, heterogeneity and dynamics together.

A second area this work speaks to is the literature in structural corporate finance. My framework nests the closed economy general equilibrium model with heterogeneity and financial frictions of Gomes (2001), while also disentangling debt and equity financing as in Hennessy & Whited (2007). Gourio & Miao (2009) conduct quantitative exercises with respect to dividend tax reforms using a calibrated model of heterogeneous firms and financial frictions. Some prominent papers in the literature include Nikolov & Whited (2014), Riddick & Whited (2009) and Li, Whited, & Wu (2016). Studies in this area

---

[4]Note that the firm lifecycle is held fixed across the two models — both that for a new entrant firm and that for a new multinational subsidiary.

5

typically have a closed economy partial equilibrium setup. An exception is Fillat & Garetto (2015), who document and then rationalise the regularity that multinationals typically have higher returns using a sunk-cost model of FDI. I contribute to this literature by studying capital structure decisions in a general equilibrium open economy framework.

A third related literature is that studying the impact of the repatriation tax specifically on U.S. firm behaviour. There are a small number of papers that study the issue in the context of partial equilibrium models. Gu (2017) studies the tax's impact on firm cash holdings. Curtis, Garın, & Mehkari (2017) think about news shocks surrounding the tax to get at anticipatory effects. Albertus, Glover, & Levine (2018) study how the tax and agency conflicts affect the overseas investment of incumbent U.S. multinationals. Papers with an empirical focus include Arena & Kutner (2015), who look at similar reforms to removing the repatriation tax, in the context of British and Japanese firms. Foley, Hartzell, Titman, & Twite (2007) and Harford, Wang, & Zhang (2017) broadly look at the impact of the repatriation tax on cash holdings of U.S. firms. My novelty in this context is that I investigate the impact of this reform on the incentives for the creation of new multinationals and U.S firms more generally — effects that so far have been largely ignored.

The remainder of this paper is organised as follows. Section II describes the environment of the quantitative model. Section III details its equilibrium. Section IV outlines the calibration procedure. Section V presents results of the model's policy applications. Section VI quantifies the impact of certain features of the model. Section VII concludes.

II   Model Environment

The model is dynamic and in discrete time; time periods are indexed by a subscript $t \in \mathbb{Z}^+ \cap \{0\}$. The world is comprised of two asymmetric countries: Home (H) and Foreign (F). All uncertainty in the model is idiosyncratic at the firm-level. Goods for consumption made by Home firms are referred to as H goods, while those originating from abroad are called F goods. Households in each country have preference for both types of goods, fostering trade. The notation is such that variables with superscript H (F) correspond to activities of H (F) firms. Additional $*$ superscripts are for activities that take place in F. For example, C_t^c and C_t^{c*} are aggregate consumption of $c \in \{H, F\}$ goods by the Home and Foreign households respectively. There are six agents in the model in total: households, firms and

6

government fiscal authorities in each country. Aggregate variables are denoted by capital letters, while firm-level variables are in lowercase.

i World Markets

There are nine markets throughout the world in total, each of which is described in table 1. The mobility of goods and factors are taken to be either perfectly mobile, immobile or imperfectly mobile across the two countries. Given the paper's focus is on the U.S. domestic macroeconomy, the model has an asymmetric country setup where F proxies for the rest of the world. The latter represents the total outside opportunities for U.S. firms. To this end, I take a relatively agnostic stance on the behaviour of F agents. In particular, I take F-incorporated firms to be representative, keeping the focus of the model on the rich setup of the Home firms. In addition, I assume that many of the market prices in F are unaffected by U.S. firms on average, taking them to be exogenous.[5]

Market	Mobility	Price	Price Determination
Global investment goods	Perfectly mobile	Λ_t	Exogenous
H labour	Immobile	W_t	Endogenous
F labour	Immobile	W_t^*	Exogenous
H consumption goods in H	Imperfectly mobile	$P_t^H = 1$	Numéraire
F consumption goods in H	Imperfectly mobile	P_t^F	Exogenous
H consumption goods in F	Imperfectly mobile	P_t^{H*}	Endogenous
F consumption goods in F	Imperfectly mobile	P_t^{F*}	Exogenous
H riskless bonds	Immobile	R_t	Endogenous
H firm shares	Immobile	$\psi_t(\omega)$	Endogenous

Table 1: World markets and prices

Investment goods are assumed to be perfectly mobile across the two countries with one single integrated global investment goods market.[6] These investment goods are supplied perfectly elastically at the prevailing market price. They are purchased by H firms, who then augment their own capital stock, after which they receive all associated future benefits.

---

[5]The data lend some support to this assumption. U.S. multinationals are spread across a great multitude of countries. For instance, as of 2017, there were around 28 countries that had 100,000 or more people employed by U.S. multinationals

[6]Previous versions of the paper have assumed these goods instead to be imperfectly mobile or totally immobile. The qualitative results were robust to these assumptions.

7

Consistent with empirical evidence, both varieties of consumption goods are imperfectly mobile, where trade can take place subject to iceberg transport costs, (to be discussed in more detail shortly).[7] The aggregate price fetched for H goods in the Home market is taken to be the numéraire. The aggregate price of H goods in Foreign is found endogenously, thereby ensuring that general equilibrium price changes discipline the magnitude of the effect of any reforms that lead to an expansion in the supply to this market. The prices of Foreign goods in each market are taken to be exogenous.

Labour markets are totally segmented across the two countries so that meaningful welfare statements can be made. The Home wage is found endogenously, while that in F is exogenous. There are two financial markets in the Home country — that for shares in the equity of H firms and another for riskless bonds — both have endogenous prices. I assume that only the H household can hold these assets, noting that this simplifies the analysis while also being a reasonable approximation to the data.[8]

ii Households

ii.1 Home Households

A representative H household has a lifetime utility function of the form

$$\sum_{t=0}^{\infty} \chi^t \frac{C_t^{1-\gamma}}{1-\gamma} \tag{1}$$

where $\chi \in [0,1]$ is their discount factor and γ their coefficient of relative risk aversion. The C_t variable is an aggregator across H and F goods of the form

$$C_t = (C_t^H)^\lambda (C_t^F)^{1-\lambda}$$

where λ is the expenditure share on H goods. Recall that F goods are assumed to be homogeneous, while the H goods are over a set of differentiated varieties. The set of available H goods varieties is denoted by Ω_t, while individual varieties are indexed by $\omega \in$

---

[7]See Frankel (1985) or Obstfeld & Rogoff (2000), who note that intermediate goods are more mobile than final goods.

[8]The fraction of U.S. financial securities owned by foreigners is in the minority — around 20% in 2018 (Treasury (2019)).

8

Ω_t. Consumption and the price of variety ω are denoted by $c_t^H(\omega)$ and $p_t^H(\omega)$ respectively. This then gives aggregation of the form

$$C_t^H = \left(\int_{\omega \in \Omega_t} c_t^H(\omega)^\rho d\omega \right)^{\frac{1}{\rho}}$$

where $\rho \in [0,1]$ governs the elasticity of substitution of the differentiated varieties: $\sigma = 1/(1-\rho)$. The aggregate price index for H goods can then be written as

$$P_t^H = \left(\int_{\omega \in \Omega_t} p_t^H(\omega)^{1-\sigma} d\omega \right)^{\frac{1}{1-\sigma}}.$$

The household's budget constraint is given by

$$C_t^H + P_t^F C_t^F + \frac{B_{t+1}}{1 + R_{t+1}} + \int_{\omega \in \Omega_t} a_{t+1}(\omega)\psi_t(\omega)d\omega =$$

$$B_t + \int_{\omega \in \Omega_t} a_t(\omega)[\psi_t(\omega) + d_t(\omega)]d\omega + (1 - \tau^W)W_t + \Lambda_t I_t + G_t. \qquad (2)$$

They supply their unit endowment of labour inelastically for a wage of W_t, which is subject to tax rate $\tau^W \in [0,1]$. They save through shares in the H firms, where $a_{t+1}(\omega)$ denotes their choice of the number of shares in producer of variety ω to take into period $t + 1$. Variable $\psi_t(\omega)$ is the price per share and $d_t(\omega)$ is the dividend. They provide investment to firms I_t. They save through B_{t+1} riskless bonds, which are purchased at a discount $1/(1 + R_{t+1})$ and return B_{t+1} next period. They also receive lump-sum distributions from the H Government, denoted by G_t.

ii.2   Foreign Households

Given the paper's focus on the H economy, I take relatively agnostic stance on the behaviour of the F household. Its aggregate demand for H goods is an exogenous function of the price, with form as in Costantini & Melitz (2008)

$$C_t^{H*} = A^* \left(P_t^{H*} \right)^{1-\eta^*} \qquad (3)$$

9

where A^* and η^* are constants. These aggregates are then spread across all the different varieties as

$$C_t^{H*} = \left(\int_{\omega^* \in \Omega_t^*} c_t^{H*}(\omega^*)^\rho d\omega^* \right)^{\frac{1}{\rho}}$$

$$P_t^{H*} = \left(\int_{\omega^* \in \Omega_t^*} p_t^{H*}(\omega^*)^{1-\sigma} d\omega^* \right)^{\frac{1}{1-\sigma}}$$

where Ω_t^* denotes the set of varieties supplied to the F market. The F household is assumed to supply labour in the F market at the prevailing wage rate W_t^*.

iii   Firms

iii.1   Home Firms

In this section the environment for H firms is described; note that variety-level notation will be omitted for ease of exposition.

States and Choices

Here I briefly introduce the state and choice variables of incumbent and newly-entered H firms; these variables will be described in more detail in later subsections. After an incumbent enters period t and draws its stochastic shocks, it's left with a state vector of the form $\varphi_t = (k_t, k_t^*, b_t, \theta_t, s_{t-1})$ where k_t is its capital stock in H, k_t^* is that in F, b_t is its debt obligation, θ_t is its productivity level and s_{t-1} is its previous extensive margin status. The extensive margin pertains to whether it sells its output to just the H market or both this and the F market, in addition to its mode of servicing F (exporting or FDI) if applicable.

Conditional on this state, an incumbent then makes a series of choices. The first choice is its period extensive margin status s_t. It then makes a series of static choices denoted by $z_t = (n_t, n_t^*, p_t, p_t^*, q_t, q_t^*)$, where n_t (n_t^*) is variable labour hired in H (F), p_t (p_t^*) is its output price in H (F) and q_t (q_t^*) is its output level in H (F). Finally it makes a series of inter-temporal choices denoted by $y_{t+1} = (k_{t+1}, k_{t+1}^*, b_{t+1})$, where k_{t+1} is its period $t+1$ capital stock in H, k_{t+1}^* is that in F and b_{t+1} is the amount of borrowings through riskless bonds (net of cash), repayable with interest in $t+1$.

10

All variables pertaining to new entrants have T superscripts. New entrant firms are all ex-ante identical, meaning they make the same choices at establishment. They make intertemporal choices denoted by $y_{t+1}^T = (k_{t+1}^T, b_{t+1}^T)$, which are their investment in an H capital stock and their initial borrowings respectively.

Objective Function

The H firms have the standard objective of optimising to maximise the expected discounted value of dividends that go to their shareholders (the H households)

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \Delta_t d_t$$

where $\Delta_t \in [0,1]$ is the firm's time-varying discount factor. The expectation operator is taken with respect to the firm's idiosyncratic future stochastic variables. The discount factor Δ_t corresponds to the stochastic discount factor of the H household, given by

$$\Delta_t = \chi^t \left(\frac{C_t}{C_0} \right)^{-\gamma}$$

where notice that in general $\Delta_t \neq \chi^t$ unless the model is in steady state.

Operational Statuses: Extensive Margin Investment

In the spirit of Helpman, Melitz, & Yeaple (2004), H firms have the option to select into different modes of servicing the H and F markets. They make a discrete choice each period, which will depend on their state vector, of what status to assume.[9] The possible statuses for firms are

1. Exit the industry (E),

2. Operate as a pure domestic (D),

3. Operate as an exporter (X),

4. Operate as a multinational (M),

---

[9]Although the firms make their discrete choice each period, dependence of this choice on their entire state vector introduces persistence of their status across periods. See the model equilibrium section for more details.

5. Operate as an offshoring multinational (MO).[10]

A firm that exits the industry will liquidate its assets, repay its debts, pay a final dividend to its shareholders and then cease to exist thereafter. A domestic firm produces in H and sells to the household in H only. The remaining three statuses correspond to firms, which are able to produce and service both the H and F markets, but differ in terms of their locations of production. An exporting firm undertakes all of its production in H and sells part of its output to the H household, with the remainder to the F household. The output that is shipped to F incurs an iceberg transport cost, denoted by $d_{HF} \geq 1$.

A multinational services the H market by producing and selling in H and services the F market through FDI — producing through its subsidiary in F. An offshoring multinational undertakes all of its production in F and then exports some of its goods back to H for sale in the H market. To ensure transitions from new entrant to MO status aren't too fast, only firms with current period M status can offshore their production. Note also that the offshoring option brings with it iceberg transport costs on the goods shipped-back to H, denoted by $d_{FH} \geq 1$.

Organisational Structures, Fixed Costs and Liquidations

Firms incur fixed costs associated with their extensive margin operational statuses described above. I follow the setup of a large up-front sunk, followed by period-by-period smaller fixed cost framework of papers such as Alessandria & Choi (2007, 2014b) and Alessandria, Choi, & Ruhl (2021). The total value of fixed cost payments, denoted generally as $f_t(s_{t-1}, s_t)$ for $s_t, s_{t-1} \in \{D, X, M, MO\}$, depend on the firm's choice of status s_t as well as its previous status s_{t-1}. The total value of fixed cost payments associated with each combination of statuses are spelled-out explicitly in table 7 in appendix A.

A firm pays a large up-front sunk fixed cost associated with establishing a new segment in its organisational structure: hereafter referred to as an establishment cost. The new segment commences operations in the period immediately after the payment of its establishment cost; it takes one period to become operational. Each period thereafter when production takes place through this segment, a smaller period-by-period fixed cost is incurred: hereafter referred to as a fixed continuation cost. Both establishment and continuation fixed

---

[10]In previous versions of the paper, corporate tax inversions were also permitted, where an H firm was able to re-incorporate as a F firm for an additional fixed cost. Inclusion of this additional status has no bearing on the results and so is omitted in this version; further details are deferred to appendix D.

costs are denoted in terms of labour units of the country, in which they are incurred. I assume that continuation costs are operating expenses and hence tax-deductible by the relevant fiscal authority. Table 2 depicts the organisational structures of all H firm statuses in the model.

Status	H Segments	F Segments
D	Headquarters	–
X	Headquarters	–
	Export segment	–
M	Headquarters	Subsidiary
MO	Headquarters	Subsidiary
		Export segment

Table 2: Organisational structures for each firm status.

Firms of each status have headquarters (HQ) in H. HQ is always responsible for the oversight over the organisation and the choices it makes. Specifically, the firm's operating and financing decisions, in addition to choices regarding dividend distributions to its shareholders. HQ is established when a new firm is created, the fixed establishment cost of which is denoted by f^{HQ}. Each period after a firm's inception, a continuation fixed cost denoted by $f^{HQ,C}$ is incurred regardless of status. Both of these costs are in H labour units.

When production takes place in H, (for statuses D, X, M), all production takes place through the firm's HQ at no additional fixed cost. Similarly to Kasahara & Lapham (2013), I assume that the establishment costs of transitioning to X or M depends on s_{t-1}. The idea is that a firm transitioning from s_{t-1} to s_t with $s_t, s_{t-1} \in \{X, M, MO\}$ where $s_t \neq s_{t-1}$ has experience servicing F that makes it cheaper for them to transition than a firm coming from D status.

A firm that chooses to export some of their output to F is required to establish an export segment in its organisational structure: this segment is responsible for physically sending goods abroad. Establishment of the export segment incurs an establishment cost of $f^X(s_{t-1})$ and a continuation cost of $f^{X,C}$, (both in H labour units), each period of operation thereafter.

A multinational firm pays an establishment cost for its F subsidiary of $f^M(s_{t-1})$, denoted in H labour units, with the interpretation of domestic due diligence costs associated with building a physical presence in F. A continuation cost of $f^{M*,C}$ is incurred from the next

13

period onwards when operations commence and is denoted in F labour units. Finally an offshoring multinational still has its overall operations overseen by HQ in H, but all of its production takes place in F. An establishment cost of f^{MO*} is paid in F labour units to build its export segment in F, which sends goods back to H. A continuation cost of $f^{MO*,C}$ is paid period-by-period in F labour units when operating.

Certain firm transitions bring with them liquidations of capital stocks associated with closing segments, the proceeds from which are denoted by $l_t(k_t, k_t^*)$. Downsizing from $s_{t-1} \in \{M, MO\}$ to $s_t \in \{D, X\}$ will involve liquidation of the F capital stock in the downsizing period, for cash flow of $\Lambda_t \xi^* k_t^*$.[11] Firms upgrading to $s_t = MO$ have choice regarding the timing of liquidation of their H capital stock — either in the period that their F export segment comes online or immediately when changing their status. Firms choosing the former can thus continue production through HQ during their transitional period. Firms upgrading from $s_{t-1} = X$ to $s_t = M$ have the same option to continue exporting in the transition while waiting for their F subsidiary to become operational. Once the F subsidiary comes online, the export segment is closed.

Technology

Firms produce using a constant returns to scale production technology in each country; capital and labour are inputs. Recall that firms own their capital stocks. A firm with D or X status has a capital stock only in H, while a firm with M status has one in each of H and F and an MO firm has only an F capital stock.

Firms face stochastic productivity shocks that are subject to purely idiosyncratic risk. This shock is assumed common to all segments within a firm to keep the state space small. The productivity level follows a persistent process of the form

$$\log(\theta_t) = \rho_\theta \log(\theta_{t-1}) + \sigma_\theta \epsilon_t, \ \ \epsilon_t \sim N(0,1) \tag{4}$$

where $0 < \rho_\theta < 1$ and $\sigma_\theta > 0$ measures volatility. I assume the factor share $\alpha \in [0,1]$ is the same across technologies used by H firms in both countries; the production function in H

---

[11]I make this assumption to keep the definition of what constitutes a multinational firm clear. Notice that a firm with multinational status can also choose endogenously to reduce its F capital stock close to zero while keeping F subsidiary operational. Such a firm would still be considered to be a multinational.

14

is of the form

$$q_t = \theta_t k_t^{\alpha} n_t^{1-\alpha}$$

with that in F being defined similarly. Capital in H and F depreciate at the same rate $\delta \in [0,1]$. A firm's law of motion for capital in H is

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

where i_t denotes investment; that in F is defined in the same way. Capital adjustment costs take the form of those in Clementi & Palazzo (2019) — these are incurred when firms invest outside the range of capital replacement (i.e. $i_t \in [0, \delta k_t]$ for H).[12] Formally, the adjustment cost in H is given by

$$\phi_t(k_t, i_t) = \{\mathbb{1}_{i_t > \delta k_t} + \mathbb{1}_{i_t < 0}\} \frac{\phi}{2} \left(\frac{i_t}{k_t}\right)^2 k_t$$

where $\phi > 0$. Adjustment costs for the F capital stock are denoted by $\phi_t^*(k_t^*, i_t^*)$, which are defined similarly.

External Financing

HQ can raise two types of external financing in H: new equity and riskless debt.[13] This setup follows the work of Hennessy & Whited (2005) and earlier work by Gomes (2001). There are three financial frictions that work together to give determinate capital structure — a collateral constraint, debt tax shields and costly equity issuance.

The firm's choice of net debt is collateralised by the liquidation value of its capital stocks in H and F as

$$b_{t+1} \leq l_{t+1}(k_{t+1}, k_{t+1}^*)$$

where $l_{t+1}(k_{t+1}, k_{t+1}^*) = \Lambda_{t+1} \left(\xi k_{t+1} + \xi^* k_{t+1}^*\right)$. This constraint says that the firm's bor-

---

[12]While keeping with the type of convex adjustment costs posited by Cooper & Haltiwanger (2006), Clementi & Palazzo (2019) show that this functional form better fits Compustat data.

[13]I assume the subsidiary can't raise external financing in F. The contrary would increases the size of the state space and require rich data on internal capital markets to discipline the model. I view this is not particularly restrictive though since HQ is always able to send the subsidiary additional funds.

15

rowing can be no larger than what creditors would be able to seize in the case where their assets are liquidated. Note that some prominent U.S. firms followed a tax-minimisation strategy, prior to the reform, of undertaking an *effective* repatriation. This involves deferring repatriation and borrowing domestically against accumulated overseas earnings (see Gangar & Robinson (2014)). When $\xi^* > 0$, multinationals in the model can adopt such strategies.[14]

The firms borrow at a discount in accordance with the H economy riskless rate. Upon choosing their optimal borrowings, they receive $b_{t+1}/(1 + R_{t+1})$ in period t, repaying b_{t+1} in $t+1$, implying interest of $b_{t+1}(1 - 1/[1 + R_{t+1}])$. Each unit of interest paid by the firm comes with a tax deduction proportional to the H domestic corporate tax rate τ^Π, giving a total debt tax shield of $b_{t+1}(1 - 1/(1 + R_{t+1}))\tau^\Pi$, receivable at $t+1$.

The costly equity issuance friction says that raising funds from equityholders comes at a premium above using internal funds, capturing flotation costs and value losses associated with signalling (Hennessy & Whited (2005)). Denote the pre-equity issuance dividend paid by the firm as e_t; when this variable is positive, cash is paid to shareholders, while its negative signifies a new equity issuance. In the event that $e_t < 0$, the premium incurred is of the form

$$\zeta_t(e_t) = \zeta^0 + \zeta^1|e_t| \tag{5}$$

for parameters $\zeta^0, \zeta^1 > 0$. This then results in a dividend net of equity issuance costs of $d_t = e_t - \zeta_t(e_t)$. The frictions present in the model give an optimal internal capital structure. Consider a firm that has a severe funding shortfall at t and needs to issue new equity. The firm is incentivised to use debt financing — both because it brings a tax benefit and because it displaces the funding requirement of the equity issuance. The firm shouldn't necessarily borrow to the extent that its constraint binds though. The premium of the equity issuance is confined to period t. However, higher borrowing has implications for the firm's financing needs in period $t+1$: increasing b_{t+1} raises the probability of future equity issuance and such issuance's size. The optimal amount of borrowing trades-off these two forces.

Exit and Entry

---

[14]I explore the quantitative implications of allowing these strategies in section VI.iii.

16

There are two forms of exit, which take place amongst H firms. The first is exogenous — each firm faces some probability of exiting the industry through a death shock as in Ghironi & Melitz (2005). These probabilities are denoted as $\kappa(s_t) \in [0,1]$ for $s_t \in \{D, X, M, MO\}$. Should a firm be hit by this death shock, it receives the value associated with exiting given its current state and ceases to exist thereafter. The second type of exit is endogenous — should a firm's state induce a particularly low value associated with an operational status, it can choose to leave voluntarily.

I denote the overall measure of firms as M_t. I refer to this and the measure of varieties interchangeably. There is an endogenous measure of potential entrants into the industry in period t, denoted by $M_t^T > 0$. These firms pay the fixed establishment cost for their headquarters in H and then decide how much to invest in their H capital stock, which is financed by collateralised riskless debt and new equity issuance. The new equity they issue is subject to the issuance premium given in (5).[15] The entrants' borrowing is collateralised by the liquidation value of their initial investment, $l_{t+1}^T(k_{t+1}^T) = \Lambda_{t+1}\xi k_{t+1}^T$. These new firms then wait until period $t + 1$ to commence their operations. When starting period $t + 1$, these firms draw their initial productivity from a distribution denoted by $\Theta^T(\theta)$, which is related to the ergodic distribution of the productivity process in (4). They then act as incumbent firms thereafter.

iii.2   Foreign Firms

F firms are taken to have a much simpler setup than those from H. There is a single representative firm incorporated in F. It uses a constant returns to scale production function in F labour to produce goods:

$$Q_t^{F*} = N_t^{F*}$$

where Q_t^{F*} denotes their aggregate production and N_t^{F*} denotes the aggregate amount of labour employed. Sale of F goods to the H household take place through exporting, which incurs the iceberg cost $d_{FH} \geq 1$. The owners of the F firm are assumed to be the F

---

[15]I interpret this as the cost associated with the initial public offering (IPO) of the firm's equity on the stock exchange. This follows the approach of Corbae & D'Erasmo (2021).

17

household. The F firm's profit maximisation problem leads to the following relationships

$$P_t^F = d_{FH}W_t^*$$
$$P_t^{F*} = W_t^*.$$

iv   Government

Governments in each country are assumed to be passive with exogenously given tax rates on their different sources of income.

iv.1   Home Government

The H Government collects taxes and distributes the proceeds to the H household in a lump sum fashion as in Corbae & D'Erasmo (2021). Rebating collections in this way ensures that policy changes that lead to revenue changes are properly internalised in the model from a welfare perspective.[16] The tax rates levied are on corporate profits generated in H, labour earnings made by the H household and repatriated overseas earnings generated by H multinationals, denoted by τ^Π, τ^W and $\tau^{\Pi,U}$ respectively. Recall that the lump sum transfers to the household are denoted by G_t; its budget constraint is given by

$$G_t = \tau^\Pi \Pi_t + \tau^W W_t + \tau^{\Pi,U} U_t^+$$

where Π_t denotes aggregate profits generated in H net of firm tax deductions and U_t^+ denotes aggregate repatriated overseas earnings of H multinationals.

iv.2   Foreign Government

In keeping with the agnostic setup for agents in F, the F Government simply collects taxes on corporate profits made in their jurisdiction; the rate is denoted by $\tau^{\Pi*}$. This is then distributed to the F household lump-sum as $G_t^* = \tau^{\Pi*}\Pi_t^*$ where G_t^* denotes the transfer and Π_t^* denotes profits made in F.

---

[16]Thinking about public debt accumulation could also be an interesting avenue for future research.

v   Timing

At the beginning of period t:

(1) Incumbents enter the period with state vector $(k_t, k_t^*, b_t, \theta_{t-1}, s_{t-1})$.

(2) Incumbents draw their new productivity shock θ_t and exogenous death shock.

(3) An incumbent exits the industry if impacted by the death shock. If it survives, the firm makes its extensive margin decision s_t.

(4) Incumbents make their static decisions z_t and then their intensive-margin dynamic decisions y_{t+1}.

(5) Entrants pay a fixed cost f^{HQ} to establish their headquarters and enter the industry.

(6) Entrants make their intensive margin decisions and act as incumbents from $t + 1$ onwards.

(7) Households choose savings and consumption given their budget constraint.

III   Model Equilibrium

In this section, I describe the optimal behaviour of agents in the model and definition of the equilibrium. I keep time subscripts on all variables to allow for analysis of transitions between steady states in policy exercises.

i   Households

i.1   Home Households

The household maximises objective (1) subject to budget constraint (2), yielding Euler equations

$$\psi_t(\omega) = \chi \left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} \mathbb{E}_t \left[\psi_{t+1}(\omega) + d_{t+1}(\omega) \right]$$

$$\frac{1}{1 + R_{t+1}} = \chi \left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} \tag{6}$$

for shares and bonds respectively. Note that the expectation in the condition for shares is with respect to the firm's idiosyncratic shocks. In steady state, the Euler equation for bonds implies a relationship between the riskless rate and household discount factor of

$$\chi = \frac{1}{1+R} \tag{7}$$

These equations are all consistent with the discount rate used by the H firms. In steady state, one can think of an H firm as discounting its future net dividends using a discount rate of R, while out of steady state, it uses a time-varying discount rate of R_{t+1}, (to be discussed below).

ii Firms

ii.1 Home Firms

Incumbent Recursive Formulation

In this section, I briefly sketch the form of the recursive structure for Home firms. I defer a more detailed discussion of the explicit functional forms to appendix C. Denote the value to an incumbent as $v_t(\varphi_t)$ where recall $\varphi_t = (k_t, k_t^*, b_t, \theta_t, s_{t-1})$ is the post-shock state vector at t. The firm makes its discrete choice of the status that offers the highest conditional value $\widehat{v}(\varphi_t, s_t)$

$$v_t(\varphi_t) = \max_{s_t \in S(s_{t-1})} \widehat{v}_t(\varphi_t, s_t)$$

where $S(s_{t-1})$ denotes the set of choices available to the firm given their current status. Note that $S(s_{t-1}) = \{E, D, X, M\}$ if $s_{t-1} \in \{D, X\}$ and $S(s_{t-1}) = \{E, D, X, M, MO\}$ if $s_{t-1} \in \{M, MO\}$ given the assumptions on offshoring.

In what follows, I'll economise on notation by dropping the explicit dependence of variables on their arguments, excepting the value functions. The conditional value from exiting can be written as

$$\widehat{v}_t(\varphi_t, E) = l_t - b_t \tag{8}$$

where recall $l_t = \Lambda_t(\xi k_t + \xi^* k_t^*)$ is the value the firm receives from liquidating its capital

20

stocks. Note that firms exiting both exogenously and endogenously receive the value given in (8). A general Bellman equation is now presented for firms making choices that involve continuation. The conditional value for a choice $s_t \in \{D, X, M, MO\}$ is

$$\widehat{v}_t(\varphi_t, s_t) = \max_{z_t, y_{t+1}} d_t + \beta_{t+1}\mathbb{E}_t[v_{t+1}(\varphi_{t+1})]$$

$$d_t = e_t - \mathbb{1}_{e_t < 0}\zeta_t$$

subject to its collateral constraint $b_{t+1} \leq l_{t+1}$. The conditional value is comprised of a period dividend, d_t, in addition to a discounted expected continuation value, $\beta_{t+1}\mathbb{E}_t[v(\varphi_{t+1})]$, which depends on the $t+1$ state implied by the firm's choices at t. The firm's discount factor is given by the ratio of the household stochastic discount factors, $\beta_{t+1} = \Delta_{t+1}/\Delta_t$. The expectation is with respect to the firm's idiosyncratic productivity and death shocks. The period dividend is net of the equity issuance premium, ζ_t, in the case where the pre-issuance dividend, e_t, is negative.

The general form of the dividend, pre-equity issuance premium, for a continuing firm is

$$e_t = \mathbb{1}_{s_t \in \{D, X, M\}} \left\{ (1 - \tau^\Pi)\pi_t - \Lambda_t i_t - \Lambda_t \phi_t \right\} + \frac{b_{t+1}}{1 + R_{t+1}} - b_t + b_t \left\{ 1 - \frac{1}{1 + R_t} \right\}\tau^\Pi$$

$$- f_t + l_t + \mathbb{1}_{s_t \in \{M, MO\}} \left\{ \mathbb{1}_{u_t < 0} + \mathbb{1}_{u_t \geq 0} \left(\frac{1 - \tau^{\Pi, U} - \tau^{\Pi*}}{1 - \tau^{\Pi*}} \right) \right\} u_t. \quad (9)$$

Firms that have production taking place in H generate some profits from their operating activities net of H corporate taxes, $(1 - \tau^\Pi)\pi_t$. Additionally, they reinvest in their H capital stock, $\Lambda_t i_t$, as well as bearing the associated adjustment costs $\Lambda_t \phi_t$. Irrespective of status, borrowing activities affect the cashflow to the firm's shareholders. HQ receives proceeds from the firm's new borrowing, repays its previous debt and receives its debt tax shields. The firm's fixed cost payments are a cash outflow while its liquidation proceeds are a cash inflow.

The final expression in equation (9) pertains to firms with an operational presence in F — they receive net repatriations, u_t, from their subsidiaries. Note that this variable is modelled as a dividend from the subsidiary to HQ and can be either positive or negative. Negative values are funding injections in the subsidiary and are not subject to taxes. Positive values are earnings repatriations to HQ and subject to the repatriation tax through the term $(1 - \tau^{\Pi, U} - \tau^{\Pi*})/(1 - \tau^{\Pi*})$. The denominator of this term ensures that the tax is

21

levied on the pre-tax F earnings of the firm. The formal expression for net repatriations is

$$u_t = (1 - \tau^{\Pi*})\pi_t^* - \Lambda_t i_t^* - \Lambda_t \phi_t^*.$$

This expression says that the subsidiary's profits net of F corporate taxes, $(1 - \tau^{\Pi*})\pi_t^*$, can either be repatriated or reinvested in the F capital stock, $\Lambda_t i_t^*$. Note that an offshoring multinational's profits of π_t^* will include those it generates from selling their goods in F as well as those from exporting goods back to H. The overseas reinvestment also comes with an adjustment cost, $\Lambda_t \phi_t^*$.

Entrant Home Firm Recursive Formulation

A newly-created firm has an unconditional value of entry given by

$$v_t^T = \max_{y_{t+1}^T} d_t^T + \beta_{t+1}\mathbb{E}^T[v_{t+1}(\varphi_{t+1})] \tag{10}$$
$$d_t^T = e_t^T - \zeta_t^T - W_t f^{HQ}$$
$$e_t^T = -k_{t+1}^T + \frac{b_{t+1}^T}{1 + R_{t+1}}$$

subject to its collateral constraint $b_{t+1}^T \leq l_{t+1}^T$. The value is comprised of an initial equity injection, d_t^T, as well as a discounted expected continuation value, $\beta_{t+1}\mathbb{E}^T[v_{t+1}(\varphi_{t+1})]$. Notice that the expectation is unconditional and with regard to a truncated version of the ergodic distribution implied by (4). I denote the probability mass removed from the top of the support and dispersed amongst its remainder by $\nu_\ominus^T$. Variable ζ_t^T denotes the IPO costs. The initial capital investment is financed by the firm's initial borrowing and equity issuance.

iii   National Accounts

As in Alvarez (2017), I rule-out accumulation of financial assets between H and F.[17] This setup keeps the model parsimonious while also keeping with the narrative of the F economy

---

[17]Some recent papers studying dynamics in models of trade, (e.g. Alessandria, Choi, & Ruhl (2021) and Ravikumar, Santacreu, & Sposi (2019)) allow for bonds to be traded between countries with short-run trade imbalances. These papers typically find that the overall effects associated with trade reform tend to be larger in size than in a static context. Given the expansionary nature of removing the repatriation tax, it is likely that the quantitative results of the policy exercise that follow are a lower bound.

serving as a general equilibrium disciplining device for H outward tax reforms. The current account balance for H is given by

$$CA_t = X_t - IM_t + U_t^+,$$

which is comprised of exports X_t, less imports IM_t plus earnings repatriations from abroad U_t^+. The financial account balance is given by

$$FA_t = U_t^-$$

where U_t^- is aggregate investment abroad by H multinationals. Each period it must be that $CA_t = FA_t$, giving that the total value of imports equals the total value of exports plus net FDI flows.

iv Recursive Equilibrium

I defer the full-length definition of the recursive equilibrium to appendix E. An abridged version is as follows

    a. Agents are optimising,

    b. All markets are clearing,

    c. Both governments are on their budget constraints,

    d. There is an endogenous cross-sectional measure of H firms,

    e. The free entry condition holds for H entrants,

    f. The national accounts balance.

The cross-sectional measure is defined over the state space of the H firms. The free entry condition states that the value to entry into the industry is equal to zero: $v_t^T = 0$ in equation (10).

IV   Calibration

In this section, I detail choices of parameters used in the baseline quantitative exercise. One period in the model is taken to be one year. There are two sets of parameters used. Those in the first are selected outside of the model to keep the computational burden of the calibration low, while the second set are calibrated within the model to target moments in the data.

Name	Symbol	Value	Data Source
Steady state riskless rate	R	0.02	Literature
Household discount factor	χ	0.98	$1/(1+R)$
Elasticity of substitution	σ	4.00	Literature
Coefficient of relative risk aversion	γ	2.00	Literature
Household H consumption share	λ	0.85	World Bank (2021)
F demand elasticity	η^*	1.50	Literature
F wage	W^*	1.00	Normalisation
Investment goods price	Λ	1.00	Normalisation
Capital share production function	α	0.33	Literature
Labour share production function	$1-\alpha$	0.67	Constant returns
Depreciation rate	δ	0.13	Compustat (S&P, 2021)
Technology persistence	ρ_θ	0.74	Compustat (S&P, 2021)
Technology volatility	σ_θ	0.20	Literature
H corporate tax rate	τ^Π	0.35	Statutory rate
F corporate tax rate	$\tau^{\Pi*}$	0.27	BEA (2021)
H repatriation tax rate	$\tau^{\Pi,U}$	0.08	Statutory rate
H labour income tax rate	τ^W	0.32	OECD (2018b)

Table 3: Parameters matched/selected outside the model

Table 3 shows the values of all the parameters chosen outside of the model. I give a brief discussion here of the sources of these data, with more details deferred to appendix J. The steady state riskless rate is taken from Hennessy & Whited (2007); this rate is broadly consistent with treasury real long term rates in the last couple of decades.[18] I take the capital share in the constant returns to scale production function to be one-third. The depreciation rate is taken to match the average rate in Compustat of 0.13.

The H household consumption share, λ, is taken to be the 2017 share of imports of goods

---

[18]See   https://www.treasury.gov/resource-center/data-chart-center/interest-rates/Pages/
TextView.aspx?data=reallongtermrateAll for Treasury's estimates of historical real long term rates.

and services relative to GDP for the U.S. I set $\rho = 0.75$, which implies an elasticity of substitution across varieties of goods of 4 as in Costantini & Melitz (2008). Also from this paper I take the F demand curve elasticity, η^*, to be 1.5. The coefficient of relative risk aversion, γ, is from Alessandria, Choi, & Ruhl (2021).

To estimate the persistence of productivity, ρ_θ, I use the Olley & Pakes (1996) method with Compustat data for U.S. firms, giving a value of 0.74. This value coincides with that used in Gu (2017) and is close to others used in the literature. I use a value of 0.2 for the productivity volatility, σ_θ. This value is consistent with other studies of firm dynamics (e.g. Corbae & D'Erasmo (2021)) and studies of firm-level productivity volatility more generally (see Comin & Mulani (2006), Comin & Philippon (2006)).

I set the H domestic corporate tax rate, τ^Π, to be the pre-TCJA statutory rate of 35%. I explicitly exclude tax haven nations from the calculation of the F corporate rate, $\tau^{\Pi*}$. This rate is set to 27%, the average across the top ten non-excluded countries for U.S. multinational presence in terms of employment, as per the 2017 BEA activities of multinationals data (BEA, 2021). Note that this rate almost coincides with the 26% used by Gu (2017). The difference in the corporate rates gives a repatriation tax, $\tau^{\Pi,U}$, of 8%. Finally the H labour tax, τ^W, is taken from the OECD (2018b), which states that the average single worker in the U.S. faced a tax wedge of around 32%

Table 4 lists the parameters calibrated inside the model and the moments that identify them. Table 5 gives the data and model moments as well as the source of the former. Due to the model's complexity, the parameters affect the moments in a way that's non-linear. As such there is no perfect mapping between the parameters and targets, but the latter are chosen to be reflective of the former. Specifics surrounding the baseline calibration procedure are deferred to appendix F.

I match the economy-wide entry/exit rate as reported in papers such as Tian (2018) and Decker, Haltiwanger, Jarmin, & Miranda (2016). The firm transitions and fractions are taken from Compustat segment data, constructed using the method of Fillat & Garetto (2015); these transition probabilities are conditional on survival.[19] The productivity advantages come from TFP estimates from Compustat.

I set the upper-bound of the support for the entrants' productivity draws, ν_Θ^T, to discipline

---

[19]Their paper studies only manufacturing firms over 1979–2009. If I restrict my sample in the same way, I get roughly the same moments they present.

25

Name	Symbol	Value	Moment Targeted
Establishment cost of entry	f^{HQ}	0.01	Unit wage
Continuation cost for HQ	$f^{HQ,C}$	0.07	Entry/exit rate
Establishment cost D to X	$f^X(D)$	0.28	Transition (D, s_t), $s_t \in \{X, M\}$
Establishment cost M to X	$f^X(M)$	0.07	Transition (M, X)
Continuation cost of X	$f^{X,C}$	0.07	Transition (X, X)
Establishment cost of D to M	$f^M(D)$	0.48	Fraction M
Establishment cost of X to M	$f^M(X)$	0.17	Transition (X, M)
Continuation cost of M	$f^{M,C}$	0.12	Transition (M, M)
Death probability for D	$\kappa(D)$	0.10	M productivity premium
Death probability for $s_t \neq D$	$\kappa(s_t)$	0.00	Normalisation
Entrant top productivity scaling	ν_Θ^T	0.07	Mean firm growth ages 1–5
Iceberg cost H to F	d_{HF}	1.45	Mean export sales intensity
Iceberg cost F to H	d_{FH}	1.45	d_{HF}
Adjustment cost	ϕ	0.15	Mean investment rate
Liquidation fraction H	ξ	0.30	Mean leverage
Liquidation fraction F	ξ^*	0.30	ξ
Equity premium constant	ζ_0	0.01	Fraction of equity issuance
Equity premium proportional	ζ_1	0.31	Mean issuance to market cap
F demand scaling	A^*	0.54	Unit demand

Table 4: Parameters calibrated inside the model

the lifecycle of a new entrant. I match the average annual growth rate of a firm over the ages 1–5; the source is from Haltiwanger, Jarmin, & Miranda (2013) (see their figure 4B). The average export sales intensity, (gross) investment rate and leverage ratio (debt net of cash) are taken from Compustat. Carlson, Fisher, & Giammarino (2010) study seasoned equity offerings (SEO) in the context of the SDC database. I use their figures regarding the frequency and size of SEOs (relative to market capitalisation) to pin-down the equity issuance cost parameters.[20]

Given the long time-span of the data, I briefly give discussion of how the Compustat targets change over time. I break the series at 2005 and compare the moments based on the prior years to the full sample; the former are in table 13 in appendix L.[21] Movements of M down

---

[20]Carlson, Fisher, & Giammarino (2010) report 5,740 SEOs over the period 1980 to 2005. I then impute the frequency of around 4% by noting that there are 134,992 firm-year observations in Compustat over the same period.

[21]I choose 2005 given the empirical validation exercise in section V.i relates to a policy reform effective 2005 onwards.

Moment	Data	Model	Data Source
Entry/exit rate	0.11	0.11	Literature
Transition $(D, s_t), s_t \in \{X, M\}$	0.04	0.04	Compustat
Transition (M, X)	$3 * 10^{-3}$	$4 * 10^{-3}$	Compustat
Transition (X, X)	0.86	0.88	Compustat
Transition (X, M)	0.07	0.08	Compustat
Transition (M, M)	0.97	0.98	Compustat
Fraction M	0.35	0.36	Compustat
Fraction X*	0.08	0.14	Compustat
X productivity premium*	0.26	0.23	Compustat
M productivity premium	0.36	0.38	Compustat
M capital premium*	2.06	1.98	Compustat
Mean annual firm growth ages 1–5			
Employees	0.12	0.12	Literature
Capital		0.14	
Mean export sales intensity	0.15	0.17	Compustat
Aggregate affiliate sales intensity*	0.38	0.43	BEA
Mean investment rate	0.07	0.08	Compustat
Mean leverage	0.13	0.14	Compustat
Fraction of firms issuing equity	0.04	0.03	SDC & Literature
Mean equity iss. to market cap.	0.21	0.25	SDC & Literature

Table 5: Moments. Notes: all moments that come from Compustat condition on firms being from the U.S. I classify as such when the foreign incorporation and headquarters codes indicate so. Numbers are all prior to multiplication by 100. Moments with (*) are untargeted in the calibration. The aggregate affiliate sales intensity is defined as aggregate earnings by multinational affiliates over aggregate earnings by affiliates plus parents.

to X drop when going from the pre-2005 to full sample, giving an increase in the former's fraction by 4% and a decrease in the latter's of 3%. In spite of the compositional shift, the average export intensity remains relatively constant. A downward trend in firm leverage gives a 1% lower average in the full sample. Otherwise the moments look quite similar across the two.

V   Policy Applications

This section conducts two policy experiments. Given the calibration, H will be referred to as the U.S. in what follows. The first subsection undertakes an empirical validation

exercise, which seeks to confront the cross-sectional predictions of the model with data. In particular, it compares responses of firms' propensity to export to tax policy changes. After instilling confidence in the model's predictive power, the second subsection moves to study the main policy episode of the paper — removal of the U.S. repatriation tax — referred to hereafter as the baseline exercise.

i   Empirical Validation: Removal of U.S. Exporter Tax Credits

Do firms really respond to tax incentives when it comes to servicing overseas markets? If so, by how much? Can the model match these responses? This section answers these questions in the context of a 2004 reform to the tax treatment of exporters in the U.S. I focus on this reform rather than the TCJA itself, due to many confounding events around the time of the latter, such as other aspects of reform to the U.S. tax code and the trade war with China.

Beginning in 1971, the U.S. Government allowed firms exporting from the U.S. to shield 15% of the associated corporate taxes through paper transactions. The most recent name for this provision was a tax exemption on extra-territorial income (ETI).[22] In 1997, the E.U. announced its intention to file a WTO complaint, arguing that it resembled an illegal export subsidy. In response, the U.S. Government passed the Extra-Territorial Income Exclusion Act (ETIEA) of 2000, which made some changes to the firms that qualify for the exemption. The ETIEA was ultimately rejected by the E.U. The American Jobs Creation Act of 2004 saw the exemption removed, making export income subject to the same tax rate as domestic income thereafter.

I study the exemption's removal in 2004 and its impact on the propensity for U.S. firms to serve foreign markets as exporters.[23] The empirical strategy is a difference-in-difference design using Compustat fundamentals and segment data, where U.S. firms are the treatment and foreign-based firms are the control group. I briefly describe the data work here, more details are deferred to appendix J. Using the procedure of Fillat & Garetto (2015), I identify firms as either domestics, exporters or multinationals based on their reporting of geographical segments. I then classify a firm as based in the U.S. when both their head-

---

[22]Over the period 1984–2000, exporters were able to process their export sales income through so-called Foreign Sales Corporations.

[23]Note that the reform also had implications for multinationals that simultaneously exported from the U.S. I don't have such firms in my model though, so I focus on pure exporters to keep the inferences clean.

Downloaded from https://academic.oup.com/restud/advance-article/doi/10.1093/restud/rdab071/6395374 by University of Nottingham user on 26 October 2021

quarters and foreign incorporation codes so indicate. The process leaves me with 86% U.S. firms and 14% foreign firms over the period 1979–2017. Figure 3 verifies the absence of pre-trends in the years leading-up to 2005.

I focus on the year of the exemption's removal (2004) and the first year of its effectiveness (2005). The regression design is of a linear probability form for $t \in \{2004, 2005\}$ as follows

$$x_{it} = \alpha_0 + \alpha_1 h_i + \alpha_2 g_t + \alpha_3 h_i g_t + \varepsilon_{it} \tag{11}$$

where x_{it} is a dummy variable that equals 1 when firm i has exporter status at time t and 0 otherwise, h_i is in indicator for a firm being based in the U.S. and g_t is a dummy for if year t is post-reform. The parameters are $\alpha_0, \alpha_1, \alpha_2, \alpha_3 \in \mathbb{R}$ and ε_{it} is a residual. The key parameter of interest is α_3, which indicates the change in the probability of a U.S. firm being an exporter after the exemption is repealed.

Details regarding this exercise are given in appendix L. The regression results for specification (11) are presented in table 12. The column listed for year t' in the table runs the regression for $t \in \{t' - 1, t'\}$, where $t' \neq 2005$ are placebo regressions. The results for 2005 indicate that the reform leads to a decrease in the probability of a U.S. firm being an exporter by 1.1%. Removing the exemption leads to lower returns to exporting, meaning fewer firms that can profitably incur the associated fixed establishment cost.

I re-calibrate the model to the pre-2005 data with the assumption that a firm's export profits — it's export sales less a fraction of its overall operating expenses — are only subject to 85% of the U.S. corporate tax rate.[24] The calibration details are given in table 13. The tax exemption is then removed, where now all exporter profits are subject to the U.S. statutory rate, with steady states then being compared. The transition probability from D to X drops, as does the persistence of the X status, leading to a 1.8% drop in the fraction of X firms from 11% to 9.2%. The slight over-statement in the model is likely a result of grandfathering provisions some firms received in the early years of its removal (see Boyd, Kaplan, & Bracuti (2010)). The model also agrees qualitatively with previous studies on this episode. Desai & Hines Jr (2008) studied the U.S. exporter stock price reaction to the 1997 complaint, which led to the ETIEA, finding there to be a decrease. Alessandria & Choi (2014a) consider the reform in a sunk-cost model of exporting and

---

[24]I take the stance that the fraction of X firms' costs attributable to the sales to F is given by the ratio of export production (inclusive of iceberg costs) out of total production, $d_{HF} q_t^* / (q_t + d_{HF} q_t^*)$.

find that it likely reduced export growth by around 10%. This exercise indicates that the model gives cross-sectional predictions to targeted tax reforms that match the data and previous studies. I now utilise the model to study the impact of a reform, whose effect is not so easily inferred using a purely empirical strategy.

ii   Baseline Exercise: Removal of the U.S. Repatriation Tax

The design of the baseline exercise is as follows. At $t = 0$, the economy is in its calibrated steady state. At time $t = 1$, the U.S. Government announces and enacts the removal of the repatriation tax indefinitely. The exercise then maps the transition dynamics to the new steady state — this transition takes around 9 years. Table 6 presents the changes in variables across the pre-reform and post-reform steady states and transition welfare.
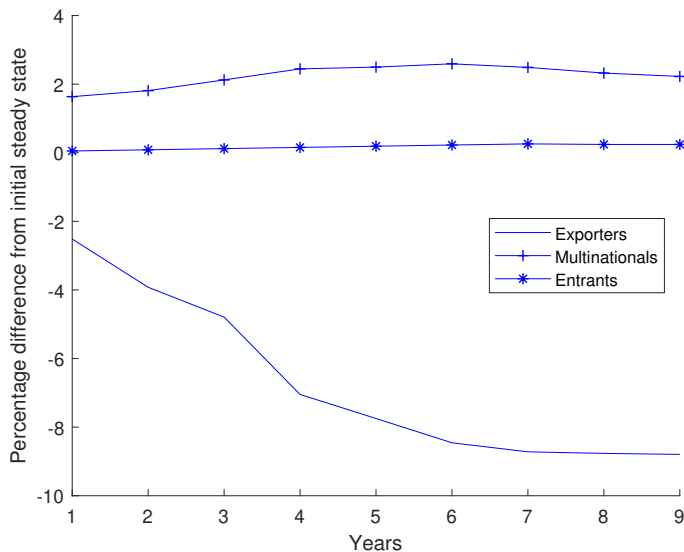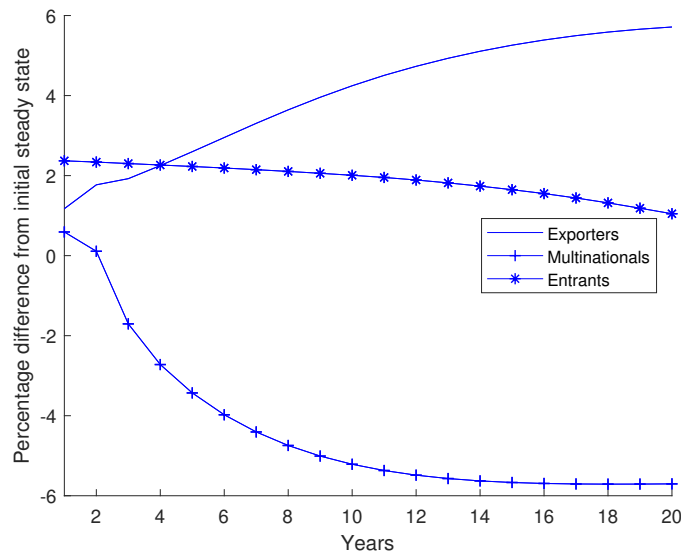
Figure 1: Measures of firm statuses. Notes: all numbers are expressed as percentage deviations from their initial steady state value. All numbers are after multiplication by 100.

The reform creates value for incumbents and induces a re-shuffling of the firm cross-section away from exporting and towards FDI. A firm engaging in FDI faces a lower tax bill than an exporter shipping the same quantity. Figure 1a depicts the transition paths for the measures of exporters, multinationals and entrants. On impact, the measures of exporters and multinationals change by -2.5% and 1.6% respectively. This initial response is driven

30

by small yet productive domestic and exporting incumbent firms that stand to benefit from the tax savings, without needing to significantly downsize their U.S. operations.

The policy change creates more value for startups. The large instantaneous cross-sectional response increases competition for resources, dampening these value gains and leading to a modest initial rise in the measure of entrants by 0.05%. Further adjustment ensues in the years that follow. Larger incumbent non-multinational firms gradually decrease the size of their U.S. capital stock, before expanding abroad, in order to minimise the associated adjustment costs. This process releases more resources, allowing for a progressive increase in the measure of entrants before assuming a value of 0.24% in the new steady state. This new firm creation bolsters the continued growth in the measure of multinationals, while also contributing to a deterioration in the U.S. terms of trade.

The tax liberalisation fundamentally alters the way U.S. multinationals finance themselves. Similarly to Gu (2017), pre-reform multinational capital structure traded-off repatriation tax costs, investment opportunities and the cost of raising external financing. Distinctly in my framework, recall that multinationals use effective repatriations — borrowing in the U.S. against overseas capital. The *largest* of multinationals would over-accumulate F capital and use their domestic borrowings primarily to pay dividends. With the tax's removal, these firms dis-save overseas capital and reduce domestic leverage concurrently, driving a 5% drop in aggregate borrowings. *Smaller* multinationals would instead use their pre-reform borrowings to defray the cost of equity issuance. With the reform, repatriations become a cheaper financing source in firms' internal capital markets. This allows smaller FDI firms to expand their scale, both domestically and abroad. They bring an increase in domestic capital of 0.1% and the F capital stock by 1.3%. Their financing structure involves initially issuing new debt and equity, then rolling-over the former and repatriating more current period F earnings going forward.

The reform brings an overall U.S. welfare gain, but costs are incurred over the transition. Business dynamism absorbs resources initially. Moreover, tax revenue losses are front-loaded. Higher labour income and domestic profit tax collections help mitigate the losses of export profit and repatriation collections, but these don't become a reliable source of revenue until the new business operations are properly established. Overall, there's a slight decrease in tax collections of 0.38% in net present value terms, causing a drop in household income. Figure 2a shows that consumption drops on impact by 0.05%. It remains below its pre-reform level for a period of two years, eventually yielding a gain

31
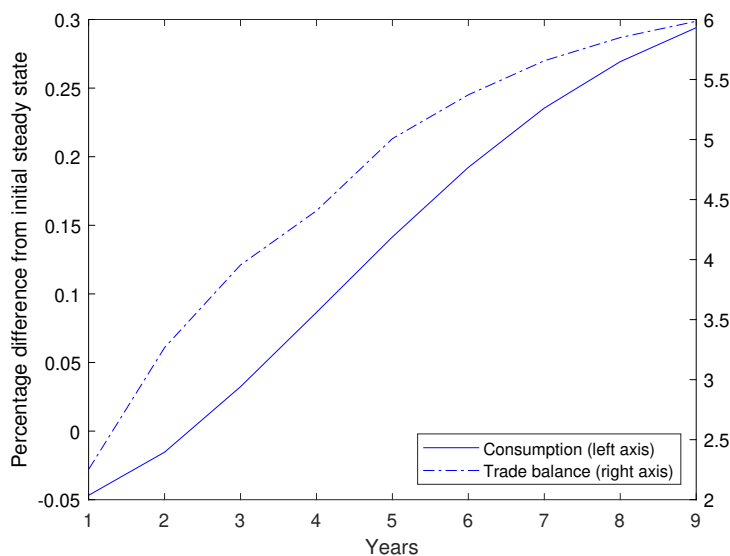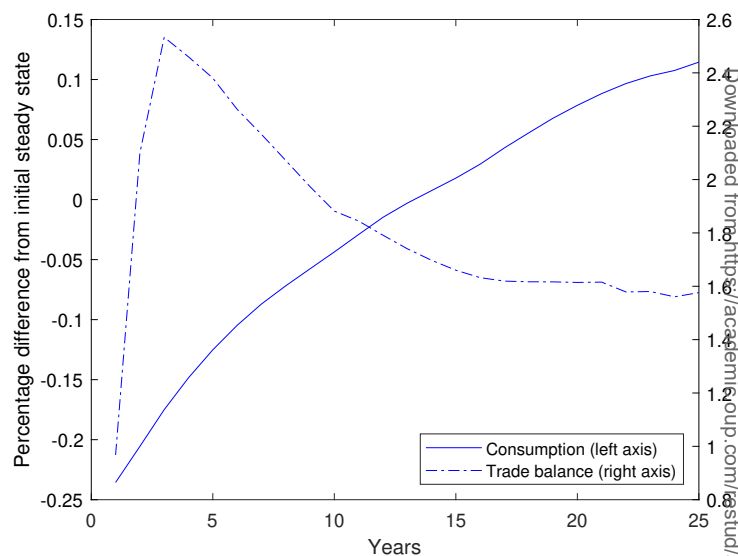
Figure 2: Consumption and the trade balance. Notes: all numbers are expressed as percentage deviations from their initial steady state value. The trade balance is defined as imports of consumption goods less exports of consumption goods. All numbers are after multiplication by 100.

of 0.26% in consumption equivalent variation along the whole transition. This pattern for consumption agrees qualitatively with the trade expansion exercises in the dynamic models of Alvarez (2017) and Ravikumar, Santacreu, & Sposi (2019). The reform overall is a reasonably inexpensive way to generate welfare gains for the U.S. economy.

I also briefly turn to give mention to the changes to corporate taxation in the TCJA more broadly — reducing the corporate rate to 21% while also removing the repatriation tax. Appendix K shows the results. The qualitative effects are similar to the baseline — firm creation gives an expansion in the use of domestic factors of production. The TCJA magnitudes are larger than the baseline since the former gives a 14% break to the full firm tax base, while the latter gives an 8% reduction on a small set of earnings to a subset of firms. However, extrapolating from the model's predictions to the world makes the normative implications of this reform unclear. The model predicts larger welfare gains, but the cost to the Treasury is also much larger — around nine-fold higher than the baseline.[25] Given high levels of U.S. public debt, a richer model of government fiscal activity is needed

[25]These losses are even more substantial in the other model variants discussed in section VI: up to 6.3% in the static analogue.

32

Variable	Baseline	Static	FEIM
Steady state only			
Measure of firms	0.46	-1.81	0.92
Measure of entrants	0.24	0.00	1.10
Fraction of exporters	-1.09	-5.26	0.26
Fraction of multinationals	0.40	5.26	-1.14
Domestic capital	0.09	—	-0.22
Overseas capital	1.32	—	5.43
Dividends	5.12	3.76	22.21
Equity issuance	5.23	3.59	22.60
Debt	-5.39	—	2.04
Price of H goods in F	-1.44	-1.05	-1.45
Repatriations	39.51	1.00	77.21
Tax collections	-0.32	-5.25	-1.60
Wage	0.12	-0.90	0.60
Output	0.41	-0.58	0.28
Measured TFP	0.29	-0.42	-1.75
Consumption/utility	0.29	-1.17	0.12
Inclusive of transition			
Tax collections	-0.38	—	-1.65
Consumption/utility	0.26	—	0.06

Table 6: Results. Notes: numbers above the line compare steady states only, those below include the full transition path. The fractions of exporters and multinationals are presented as percentage point differences between the fractions post and pre-reform. All other variables are percentage differences from the pre-reform value. All numbers are expressed after multiplying by 100.

to properly internalise this reform's revenue impact.[26] In the following section, I focus on the repeal of the repatriation tax in isolation as it generates clear tradeoffs between the different firm statuses, making for more direct comparisons across model variants.

VI   Quantification Exercises

This section explores the roles of features of the model to infer their quantitative significance. The first subsection studies the role of dynamics. The second explores that of the costly equity issuance financial friction. The final subsection considers the effect of several

---

[26]E.g. see https://fred.stlouisfed.org/series/GFDEGDQ188S. Although such considerations have potential to be interesting, they're outside the scope of the current study.

miscellaneous features.

i   The Role of Dynamics

Here I study the effect of removing the repatriation tax in the context of a more standard, static trade model and compare with the baseline. I utilise a version of Helpman, Melitz, & Yeaple (2004) where the only heterogeneity amongst firms comes from productivity. I defer details of the model to to appendix M; the results of the exercise are in the second column of table 6.

The offshoring effect is far more substantial in the static model, with 5.3pp of exporters being exactly displaced by multinationals; the changes were -1.1pp and 0.4pp respectively in the baseline. In a dynamic setting, the past, present and future affect a firm's decision-making — history limits their attainable scale, while residual uncertainty and expected future conditions affect their continuation value. In the static model, a firm's productivity draw and the current market conditions are paramount. This makes them more responsive to changes in the latter than in the dynamic context, such as the tax reform and the price effects that ensue.

The normative assessment of the reform is reversed in the static model. The larger off-shoring effect drives a dramatic reduction in domestic employment for variable production, reducing the wage by 0.9%. Most of the profitability gains are absorbed by multinationals at the peak of the productivity distribution; the terms of trade effect reduces the sizes of the average exporter and multinational by 4% and 5% respectively. This effect completely erodes the value gains to being a startup, leaving their measure unchanged. Given the absence of a deferrability concept, lost repatriation taxes leave a large dent in the U.S. Treasury's bottom-line. When coupled with the larger-scale shifting of profits abroad, this results in exorbitant tax revenue losses of 5.3%. These effects culminate in a U.S. welfare loss of 1.2%.

The welfare reduction in the static model materialises since the reform moves the economy further away from its optimal unilateral repatriation tax of 41%. Utility is bolstered by higher productivity, more varieties of goods and stronger terms of trade. An increase in the tax rate reduces the rate of offshoring, raising the productivity threshold for multinationals. This drives an increase in the terms of trade. However the net effect on the domestic labour market could go in either direction. Higher variable labour needs and exporter fixed costs

34

put upward-pressure on demand, while fewer multinational fixed costs do the opposite. This leads to an ambiguous productivity effect of increasing the tax. As the rate rises, the profitability of multinationals falls at an increasing rate, since the marginal multinational's productivity rises rapidly. Exporter profitability moves in the reverse. The overall effect on the value of U.S. firms and the number of varieties balances these two effects. Moving from the 8% observed to the optimal rate sees the fraction of multinationals fall by 26pp and that for exporters rise by 34pp, leading to a 12% increase in the terms of trade. This translates into gains to the number of varieties of 9% and welfare of 5%.

The optimal steady state unilateral repatriation tax in the dynamic baseline model is around 5%. An additional factor impacting welfare in the dynamic context is firms' productive capacity as facilitated by capital accumulation. This optimal tax rate is revealed to maximise the overall capital stock held by U.S. firms. The non-monotonicity over $[0\%, 8\%]$ follows from a tension between the value gains realised by upgrading incumbents and the gains absorbed by new entrants. Recall that the calibration exercise matched the lifecycle of an entrant through curtailing their average productivity. Consequently, the 3% reduction in moving from the observed to the optimal tax has a significant effect on the profitability of incumbents, without meaningfully affecting the value to entry. This weaker entry effect consumes fewer resources, allowing for more incumbents to upgrade to multinational status, fostering a larger capital stock expansion. In fact, this optimal dynamic tax also maximises the fraction of multinationals in the cross-section — moving to it causes the fraction to rise by 0.85pp, twice that of moving to the zero tax. The capital accumulation effect takes precedence over the prominent contributors to welfare in the static model. The terms of trade fall by 0.59% when moving from observed to the optimal rate in the dynamic context. The measure of varieties rises by 0.24% — half of that from removing the tax completely.

This discussion relates to the more general literature on trade policy. The repatriation tax is levied on the outward activities of firms, drawing a parallel with an export tax in a model without FDI. It can also protect weak firms domestically, in a similar spirit to a tariff. In the static context, papers have shown that large positive interventions of these kinds can be rationalised. For those that use a Melitz (2003) framework, the motives for these interventions are similar to those of the repatriation tax above (selection, variety and terms of trade). For instance, see Demidova & Rodríguez-Clare (2009), Felbermayr, Jung, & Larch (2013), Haaland & Venables (2016) and Costinot, Rodríguez-Clare, & Werning

(2020). The terms of trade effect is particularly important quantitatively in my static context given the considerable variable cost advantage of multinationals over exporters.

A literature points to the idea that optimal trade protections are lower in dynamic models. Larch & Lechthaler (2013) obtain this result in a dynamic selection model, when accounting for transitions and short-sightedness of policymakers. The incumbent-entrant value tradeoff in my 5% dynamic optimal repatriation tax result is reminiscent of a main channel in Alessandria, Choi, & Ruhl (2021). They find that a tariff reduction reduces entry along the transition, which releases more resources, causing a short-run boom in consumption and substitution towards the exporting margin. This results in a similar inference to mine in a unilateral context — the welfare change in a static environment is a poor approximation to that of a dynamic setting. Ravikumar, Santacreu, & Sposi (2019) find the gains from tariff reduction are much larger in a dynamic setting and that the elasticity of gains rises with the size of the deduction. Alvarez (2017) draws similar inferences. The fact that capital is maximised in my baseline model with a small but positive tax highlights the interesting non-linear interactions between firms of different statuses that follow when one accounts for FDI.

ii   The Role of Financial Frictions: Costly Equity Issuance

To quantify the role of the equity issuance premium, in this subsection I re-calibrate the model with the parameters $\zeta_0 = \zeta_1 = 0$ and re-examine the effect of removing the repatriation tax. This model is referred to as the *free* equity issuance model (FEIM) hereafter; the results are presented in column 3 of table 6. The FEIM is calibrated to hold moments the same as the baseline. Importantly, I hold the lifecycle of a new entrant and the lifecycle of a new multinational constant across the FEIM and the baseline. I adjust the average productivity of new entrants to keep their growth rate over years 1–5 the same. I also keep the average foreign sales intensity for a new multinational over years 1–5 of the affiliate's life constant across both models.[27] More details regarding the calibration are in appendix I.

The reform in the FEIM increases concentration in the market for U.S. goods abroad, weakening the competitiveness of U.S. firms and bringing about domestic inefficiencies. Costless equity issuance makes investment cheaper for U.S. firms at the intensive margin

---

[27]The growth rates and intensities for averages over years 1–10 are also much the same.

36

than in the baseline, both in the present and in expectation. Incumbent multinationals exploit this to take advantage of the lower FDI tax burden on a much larger scale. A sweeping capital flight from the U.S. ensues, driving changes in the steady state domestic and overseas stocks of -0.2% and 5.4% respectively. The rise at the intensive margin gradually reduces the measure of multinationals at the extensive margin, (see figure 1b). The displaced multinationals downgrade their statuses to exporters. This brings a first domestic inefficiency — higher variable labour costs from exporting absorb more resources in exchange for less output.

The multinationals that survive are considerably more profitable, driving a second domestic inefficiency — excessive entry. The reform causes the average foreign affiliate sales intensity for an FDI firm to rise in the FEIM, while it causes a decrease in the baseline. As supported by empirical studies, this intensity doesn't change substantially subsequent to an affiliate's establishment, (see Garetto, Oldenski, & Ramondo (2019)).[28] A new multinational jumps to this higher intensity in the FEIM, bringing larger gains to the option value of FDI and entry value than in the baseline. The steady state entry measure rises by 1.1% in the former, in contrast with 0.24% in the latter. However, the average of these startups in the FEIM poses little threat to incumbents given it's calibrated to be less productive than its baseline counterpart. This effect drains resources available for servicing the U.S. household, leading to lower welfare gains of the reform.

The baseline delivers response dynamics that are markedly different to the FEIM. The equity issuance premium raises the marginal cost of investment, limiting the intensive margin expansion abroad, leaving more space at the extensive margin. Former exporters then release more resources domestically. Multinationals' average domestic capital stock expands given the lower cost of financing facilitated by cheaper earnings repatriations. Their stronger domestic presence fosters competitive pressure, giving an increase in domestic firms' average capital stock. This contrasts with the FEIM where fewer variable labour resources are available for domestic firms, reducing their profitability and average capital holdings. Costly equity issuance prevents excessive expansion in both markets in a way that preserves and heightens the competitiveness of U.S. firms.

This friction plays a significant role here due to the unique financial needs specific to multinational firms. The subsidiary receives a large one-time equity injection from the

---

[28]They document that affiliates do not start small relative to their parents and that their growth out of the overall sales share is minimal. There is a jump in the ratio if the affiliate commences export operations.

Downloaded from https://academic.oup.com/restud/advance-article/doi/10.1093/restud/rdab071/6395374 by University of Nottingham user on 26 October 2021

parent at establishment; it then jumps close to its long-run sales intensity. This injection places considerable strain on the parent's financing needs. This contrasts with the lifecycle of a new exporting firm — the export intensity rises gradually over time in the data (e.g. see Alessandria, Choi, & Ruhl (2021)). As such, a new exporter's establishment is far less demanding for the organisation financially. The difference between the baseline and FEIM relates to the spirit of Ramondo & Rodriguez-Clare (2013), who find that the impact of openness reforms can look very different quantitatively in a model that includes FDI. Costly equity issuance shapes the magnitude of openness reforms' effect due to its impact on switching at the extensive margin. This effect can only materialise when one explicitly includes the option to be a multinational in the model.

The presence of the premium leads firms to engage differently with the other two frictions — debt tax shields and the collateral constraint. In the FEIM, firms that borrow always do so to the point where the constraint binds to capitalise on the tax deductions. When the F capital stock expands following the reform, so too does the amount of collateral FDI firms can borrow against. This contributes to the bigger jump in multinational value in the FEIM, increasing the steady state aggregate debt by 2%, amplifying the excessive entry and other domestic inefficiencies that ensue. In contrast, firms' constraints in the baseline will generally be slack. A firm forced to issue new equity will typically issue debt simultaneously to minimise the size of the premium; they'll do this sparingly though for fear of catalysing future financial hardship. The effects of the reform manifest themselves in the changes of the average slackness of firms that issue new equity.[29] That for a multinational falls from 8.9% to 7.7% across steady states, as they exploit more tax shields and use repatriations for any induced shortfall in future. However, the greater competitive pressure drives more financial conservatism on the part of domestics and exporters; their slackness rises from 23.8% to 28.7% and 6.4% to 10.4% respectively.

The transitional costs to welfare are larger and persist longer in the FEIM, as shown in figure 2b. The measures of all statuses rise on impact, as firms speculate on the possibility of a successful overseas expansion, before attrition starts to dominate. More transfers in the short-run from the household to firms ensue than in the baseline, where the effect is more gradual. The larger re-shuffling of the cross-section interacts with capital adjustment costs, extending the transition's time frame. A bigger profit-shifting effect in the FEIM sees a net present value decrease in U.S. tax collections of 1.65% — over 4 times larger

---

[29]Formally this is represented by $1 - b_{t+1}/l_{t+1}$ for when $e_t < 0$.

than the baseline. The cumulative effect of these changes is an increase in consumption equivalent variation of 0.06% in the FEIM, compared with 0.26% in the baseline. This gives a considerable difference in the ratio of overall gains relative to those of the new steady state — around 50% and 91% for the two models respectively. The presence of the equity issuance friction has significant implications for the quantitative exercises, both from positive and normative perspectives.

iii Miscellaneous Features

The Role of the Open Economy

What value is there in thinking about tax reforms with trade and the open economy in mind? How would the outcome differ if we instead gave the largest of firms a tax cut in a closed economy framework? Recall from table 5 that around 35% of firms are multinationals in the baseline. In appendix H, an autarky model analogue is developed where the largest 35% of firms receive differential tax treatment to the rest of the cross-section. They are subject to a weighted average of the U.S. domestic and F corporate rates, where the weights depend on the affiliate sales intensity and repatriation rates of multinationals in the baseline. The counterfactual then gives these large firms a reduction in their tax rate equal to the effective reduction received by multinationals in the baseline when the repatriation tax is removed.

The tax break in the closed economy setting generally gives weaker macro effects than in the open economy. The reform in the former gives a rise in the return to investment at the intensive margin, but misses the additional benefit realised in the latter from the extensive margin. Another way to think of this is that it's harder for firms to find new profitable projects to invest in when the F market doesn't exist, limiting the potential benefits of lower taxes. A smaller rise in profitability follows for both incumbents and entrants, with a modest increase in the steady state measure of firms of 0.1%. Note also that the terms of trade effect is absent, indicating that these extensive margin benefits in the open economy are large. The closed economy reform also induces firms above and close to the size threshold to substitute towards capital and away from labour, offsetting the effects of entry and giving a slightly lower wage. The overall effect is a 0.01% increase in welfare, signalling that the benefits of tax reductions can be under-stated in the absence of open economy considerations.

39

The Role of Deferrability

Why is it necessary to model deferrability, overseas asset accumulation and effective repatriations when evaluating the repatriation tax's removal? Does this modelling approach play any role beyond reducing multinationals' effective tax rate? To answer these questions, I again utilise the static model. Rather than keeping the same parameterisation of the repatriation tax rate across models, (as in table 3), I calibrate it internally such that the fraction of U.S. tax collections it generates is the same as in the baseline. The implied tax rate is 2%. The exercise then removes this tax and compares steady states: the details are presented in appendix N.

The optimal tax rate in this calibration is roughly the same as in section VI.i; the pre-reform steady state is shifted further away from it. This translates into a smaller welfare loss of 0.04% when the tax is removed. Recall that the multinationals, which were the largest in the baseline prior to the reform, over-saved and thus reduce their overseas capital stock with the tax's removal. This frees-up space in the F market for the entry of new multinationals, driving the firm value gains. No such large adjustment happens in the static model of this section; the largest multinationals reap most of the benefit from the tax savings. It follows then that changes in firm statuses at the cross-section are minimal, as is the change in entry value. This drives an output reduction and tax collection losses of almost three times those in the baseline. The tax's removal creates different incentives for incumbents across the two models, giving alternative ensuing market structures and ultimate conclusions.

The Role of Country Asymmetry

How would the results differ in a symmetric country model? In addition to keeping with the home-rest of the world interpretation, the assumption of asymmetry also greatly simplifies the computations of the model. Solving a fully symmetric two country model involves tracking two cross-sectional measures of heterogeneous firms and more than doubling the number of aggregate state variables. To garner some insight into this simplification's role, I solve a fully symmetric version of the static variant of the model. Details of this exercise are deferred to appendix O.

The aggregate results from removing the repatriation tax are generally similar across the symmetric and asymmetric country static models. The predominant difference is at the

cross section — the fraction of firms that change their status from exporter to multinational in the symmetric model is 16% — three times larger than in the asymmetric context. The increase in U.S. FDI is met in F with a rise in the local wage of 0.13%, giving a cost-push rise in the local price of F goods of 0.31%. This drives a substitution of the F household towards U.S. goods, whose consumption rises by 1.8%, in contrast with a 0.2% increase in F goods. This gives further gains to the value of FDI for U.S. firms, amplifying the expansion at the extensive margin. In light of this comparison, a bigger extensive margin effect may give slightly higher welfare effects if the baseline were extended to a symmetric-country setup. But the overall discussion gives some evidence that country asymmetry is a reasonably innocuous assumption.

VII   Concluding Remarks

Tax reforms targeted at multinational firms have been pervasive in recent years. This paper studied the issue of how these reforms affect the domestic macroeconomy. My contributions are twofold. The first is methodological — I develop a dynamic general equilibrium model with firm-level open economy selection effects, capital accumulation and financial frictions. The framework built is widely applicable and can be used to examine the impact of these targeted tax reforms across steady states and the transition path. The second is an applied policy contribution. Parameters of the model are calibrated to the U.S. firm distribution and the baseline exercise estimates the impact of removing the corporate repatriation tax.

The key insight from the U.S. application is that this aspect of the TCJA appears to be positive from a domestic perspective — it is an inexpensive way to generate U.S. welfare gains. The main takeaways from a methodological perspective are that dynamics and financial frictions greatly shape the positive and normative inferences relative to more standard trade models without these features.

This study lends itself to several avenues of future research. Why were some so concerned about the offshoring effects associated with this part of the TCJA? Building-up the labour side of the model with matching frictions might help to answer this question. Corporate tax policy changes can potentially interact with issues surrounding sovereign debt. The U.K. Government recently announced its intention to increase its corporate rate from 19% to 25% from 2022 onwards to make-up for revenue shortfalls (HM Government, 2021). A

richer fiscal policy setup in the model could potentially speak to such interesting issues. It is hoped that the implications of this new framework can be used to assist in future reform discussions, not just in the U.S., but by policymakers worldwide.

Data Availability Statement

The replication package can be found in Zenodo (`https://doi.org/10.5281/zenodo.5500626`) under "Replication package for Policy Effects of International Taxation on Firm Dynamics and Capital Structure".

References

Adda, J., & Cooper, R. W. (2003). *Dynamic economics: quantitative methods and applications*. MIT press.

Albertus, J. F., Glover, B., & Levine, O. (2018). Foreign investment of us multinationals: The effect of tax policy and agency conflicts.

Alessandria, G., & Choi, H. (2007). Do sunk costs of exporting matter for net export dynamics? *The Quarterly Journal of Economics*, *122*(1), 289–336.

Alessandria, G., & Choi, H. (2014a). Do falling iceberg costs explain recent us export growth? *Journal of International Economics*, *94*(2), 311–325.

Alessandria, G., & Choi, H. (2014b). Establishment heterogeneity, exporter dynamics, and the effects of trade liberalization. *Journal of International Economics*, *94*(2), 207–223.

Alessandria, G., Choi, H., & Ruhl, K. J. (2021). Trade adjustment dynamics and the welfare gains from trade. *Journal of International Economics*, *131*, 103458.

Alvarez, F. (2017). Capital accumulation and international trade. *Journal of Monetary Economics*, *91*, 1–18.

Arena, M. P., & Kutner, G. W. (2015). Territorial tax system reform and corporate financial policies. *The Review of Financial Studies*, *28*(8), 2250–2280.

Atkeson, A., & Burstein, A. T. (2010). Innovation, firm dynamics, and international trade. *Journal of political economy*, *118*(3), 433–484.

Babkin, A., Glover, B., & Levine, O. (2017). Are corporate inversions good for shareholders? *Journal of Financial Economics*, *126*(2), 227–251.

Bazdresch, S., Kahn, R. J., & Whited, T. M. (2018). Estimating and testing dynamic corporate finance models. *The Review of Financial Studies*, *31*(1), 322–361.

BEA. (2021). *Data on activities of u.s. multinationals.* Retrieved from `https://www.bea.gov/data/intl-trade-investment/activities-us-multinational-enterprises-mnes`

Bernstein, J. (2017). *Republican tax plan will lead to more offshoring of u.s. jobs and a larger trade deficit.* The Washington Post.

BLS. (2021). *Cpi for all urban consumers (cpi-u).* Retrieved from `https://beta.bls.gov/dataViewer/view/timeseries/CUSR0000SA0L1E`

Boehm, C. E., Flaaen, A., & Pandalai-Nayar, N. (2019). *Multinationals, offshoring and the decline of us manufacturing* (Tech. Rep.). National Bureau of Economic Research.

Boyd, C., Kaplan, J., & Bracuti, A., G. (2010). *Extraterritorial income benefits may still be alive.*

Brooks, W., & Dovis, A. (2019). Credit market frictions and trade liberalizations. *Journal of Monetary Economics*.

Burstein, A. T., & Monge-Naranjo, A. (2009). Foreign know-how, firm control, and the income of developing countries. *The Quarterly Journal of Economics*, *124*(1), 149–195.

Carlson, M., Fisher, A., & Giammarino, R. (2010). Seo risk dynamics. *The Review of Financial Studies*, *23*(11), 4026–4077.

Clementi, G. L., & Palazzo, B. (2019). Investment and the cross-section of equity returns. *The Journal of Finance*, *74*(1), 281–321.

Comin, D., & Mulani, S. (2006). Diverging trends in aggregate and firm volatility. *The Review of Economics and Statistics*, *88*(2), 374–383.

Comin, D., & Philippon, T. (2006). *tthe rise in firm (level volatility: Causes and consequencesunder macroeconomics annual 2005.* Volume.

Cooper, R. W., & Haltiwanger, J. C. (2006). On the nature of capital adjustment costs. *The Review of Economic Studies*, *73*(3), 611–633.

Corbae, D., & D'Erasmo, P. (2021). Reorganization or liquidation: Bankruptcy choice and firm dynamics. *The Review of Economic Studies*.

Costantini, J., & Melitz, M. (2008). The dynamics of firm-level adjustment to trade liberalization. *The organization of firms in a global economy*, *4*, 107–141.

Costinot, A., Rodríguez-Clare, A., & Werning, I. (2020). Micro to macro: Optimal trade policy with firm heterogeneity. *Econometrica*, *88*(6), 2739–2776.

Curtis, C. C., Garın, J., & Mehkari, M. S. (2017). *Repatriation taxes* (Tech. Rep.). Working paper.

Decker, R. A., Haltiwanger, J., Jarmin, R. S., & Miranda, J. (2016). Where has all the skewness gone? the decline in high-growth (young) firms in the us. *European Economic Review*, *86*, 4–23.

Deloitte. (2017). *Corporate tax rates 2013–2017.* Retrieved from `https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=` `&ved=2ahUKEwj99bSe7cHwAhWP3KQKHZhsBd8QFnoECAIQAA&url=https%3A%` `2F%2Fwww2.deloitte.com%2Fcontent%2Fdam%2FDeloitte%2Fglobal%` `2FDocuments%2FTax%2Fdttl-tax-corporate-tax-rates-2013-2017.pdf&usg=` `AOvVaw15RSu4n2wfTVN11JGgP3Uk`

Demidova, S., & Rodríguez-Clare, A. (2009). Trade policy under firm-level heterogeneity in a small economy. *Journal of International Economics*, *78*(1), 100–112.

Desai, M. A., & Hines Jr, J. R. (2002). *Expectations and expatriations: Tracing the causes and consequences of corporate inversions* (Tech. Rep.). National Bureau of Economic Research.

Desai, M. A., & Hines Jr, J. R. (2008). Market reactions to export subsidies. *Journal of International Economics*, *74*(2), 459–474.

Faulkender, M. W., Hankins, K. W., & Petersen, M. A. (2019). Understanding the rise in corporate cash: Precautionary savings or foreign taxes. *The Review of Financial Studies*, *32*(9), 3299–3334.

Felbermayr, G., Jung, B., & Larch, M. (2013). Optimal tariffs, retaliation, and the welfare loss from tariff wars in the melitz model. *Journal of International Economics*, *89*(1), 13–25.

Fillat, J. L., & Garetto, S. (2015). Risk, returns, and multinational production. *The Quarterly Journal of Economics*, *130*(4), 2027–2073.

Fitzgerald, D., Haller, S., & Yedid-Levi, Y. (2016). *How exporters grow* (Tech. Rep.). National Bureau of Economic Research.

Floden, M. (2008a). *Adda cooper markov process discretisation code.* Retrieved from `https://martinfloden.net/files/ar1_processes_matlab_code.zip`

Floden, M. (2008b). A note on the accuracy of markov-chain approximations to highly persistent ar(1) processes. *Economics Letters*, *99*(3), 516-520.

Foley, C. F., Hartzell, J. C., Titman, S., & Twite, G. (2007). Why do firms hold so much cash? a tax-based explanation. *Journal of Financial Economics*, *86*(3), 579–607.

Frankel, J. A. (1985). *International capital mobility and crowding out in the us economy: imperfect integration of financial markets or of goods markets?* National Bureau of Economic Research Cambridge, Mass., USA.

G7. (2021). *G7 finance ministers and central bank governors communiqué.* Retrieved from `https://www.gov.uk/government/publications/g7-finance-ministers-meeting -june-2021-communique/g7-finance-ministers-and-central-bank-governors -communique`

Gangar, S., & Robinson, M. (2014). *Apple sells 12b of bonds to keep cash overseas.* Bloomberg Online. (`https://www.bloomberg.com/news/articles/2014-04-29/apple -returns-to-bond-market-to-scale-biggest-borrowers-ranks`)

Garetto, S., Oldenski, L., & Ramondo, N. (2019). *Multinational expansion in time and space* (Tech. Rep.). National Bureau of Economic Research.

Ghironi, F., & Melitz, M. J. (2005). International trade and macroeconomic dynamics with heterogeneous firms. *The Quarterly Journal of Economics*, *120*(3), 865–915.

Goffe, W. L. (1996). Simann: A global optimization algorithm using simulated annealing. *Studies in Nonlinear Dynamics & Econometrics*, *1*(3). Retrieved from `https://jblevins.org/mirror/amiller/`

Gomes, J. F. (2001). Financing investment. *American Economic Review*, *91*(5), 1263–1285.

Gourio, F., & Miao, J. (2009). *Transitional dynamics of dividend tax reform* (Tech. Rep.). Boston University-Department of Economics.

Gu, T. (2017). Us multinationals and cash holdings. *Journal of Financial Economics*, *125*(2), 344–368.

Haaland, J. I., & Venables, A. J. (2016). Optimal trade policy with monopolistic competition and heterogeneous firms. *Journal of International Economics*, *102*, 85–95.

Haltiwanger, J., Jarmin, R. S., & Miranda, J. (2013). Who creates jobs? small versus large versus young. *Review of Economics and Statistics*, *95*(2), 347–361.

Harford, J., Wang, C., & Zhang, K. (2017). Foreign cash: Taxes, internal capital markets, and agency problems. *The Review of Financial Studies*, *30*(5), 1490–1538.

Helpman, E., Melitz, M. J., & Yeaple, S. R. (2004). Export versus fdi with heterogeneous firms. *American economic review*, *94*(1), 300–316.

Hennessy, C. A., Levy, A., & Whited, T. M. (2007). Testing q theory with financing frictions. *Journal of financial economics*, *83*(3), 691–717.

Hennessy, C. A., & Whited, T. M. (2005). Debt dynamics. *The Journal of Finance*, *60*(3), 1129–1165.

Hennessy, C. A., & Whited, T. M. (2007). How costly is external financing? evidence from a structural estimation. *The Journal of Finance*, *62*(4), 1705–1745.

HM Government. (2013). *A guide to uk taxation.* Retrieved from `https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/183408/A_guide_to_UK_taxation.pdf`

HM Government. (2021). *Corporation tax charge and rates from 1 april 2022 and small profits rate and marginal relief from 1 april 2023.* Retrieved from `https://www.gov.uk/government/publications/corporation-tax-charge-and-rates-from-1-april-2022-and-small-profits-rate-and-marginal-relief-from-1-april-2023/corporation-tax-charge-and-rates-from-1-april-2022-and-small-profits-rate-and-marginal-relief-from-1-april-2023`

Horowitz, J. L. (1998). Bootstrap methods for covariance structures. *Journal of Human Resources*, 39–61.

Kasahara, H., & Lapham, B. (2013). Productivity and the decision to import and export: Theory and evidence. *Journal of international Economics*, *89*(2), 297–316.

Larch, M., & Lechthaler, W. (2013). Whom to send to doha? the shortsighted ones! *Review of Economic Dynamics*, *16*(4), 634–649.

Lentz, R., & Mortensen, D. T. (2008). An empirical model of growth through product innovation. *Econometrica*, *76*(6), 1317–1373.

Li, S., Whited, T. M., & Wu, Y. (2016). Collateral, taxes, and leverage. *The Review of Financial Studies*, *29*(6), 1453–1500.

McGrattan, E. R. (2012). Transition to fdi openness: Reconciling theory and evidence. *Review of Economic Dynamics*, *15*(4), 437–458.

McGrattan, E. R., & Prescott, E. C. (2009). Openness, technology capital, and development. *Journal of Economic Theory*, *144*(6), 2454–2476.

Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, *71*(6), 1695–1725.

Nikolov, B., & Whited, T. M. (2014). Agency conflicts and cash: Estimates from a dynamic model. *The Journal of Finance*, *69*(5), 1883–1921.

Obstfeld, M., & Rogoff, K. (2000). The six major puzzles in international macroeconomics: is there a common cause? *NBER macroeconomics annual*, *15*, 339–390.

OECD. (2018a). *Multinational enterprises in the global economy: Heavily debated but hardly measured.* Retrieved from `https://www.oecd.org/industry/ind/MNEs-in-the-global-economy-policy-note.pdf`

47

OECD. (2018b). *Taxing wages — the united states.* Retrieved from `https://www.oecd.org/unitedstates/taxing-wages-united-states.pdf`

Olley, G. S., & Pakes, A. (1996). The dynamics of productivity in the telecommunications equipment industry. *Econometrica*, *64*(6), 1263.

Ramondo, N. (2014). A quantitative approach to multinational production. *Journal of International Economics*, *93*(1), 108–122.

Ramondo, N., & Rodriguez-Clare, A. (2013). Trade, multinational production, and the gains from openness. *Journal of Political Economy*, *121*(2), 273–322.

Ravikumar, B., Santacreu, A. M., & Sposi, M. (2019). Capital accumulation and dynamic gains from trade. *Journal of International Economics*, *119*, 93–110.

Riddick, L. A., & Whited, T. M. (2009). The corporate propensity to save. *The Journal of Finance*, *64*(4), 1729–1766.

Ruhl, K. J., & Willis, J. L. (2017). New exporter dynamics. *International Economic Review*, *58*(3), 703–726.

S&P. (2021). *Compustat-capital iq.* Retrieved from `https://wrds-www.wharton.upenn.edu/pages/get-data/compustat-capital-iq-standard-poors/`

Speaker's Office. (2017). *President trump: We must create a level playing field.* Speaker's Office Website. (`http://www.speaker.gov/general/president-trump-we-must-create-level-playing-field.`)

Tian, C. (2018). Firm-level entry and exit dynamics over the business cycles. *European Economic Review*, *102*, 298–326.

Tørsløv, T. R., Wier, L. S., & Zucman, G. (2018). *The missing profits of nations* (Tech. Rep.). National Bureau of Economic Research.

Treasury. (2019). *Foreign portfolio holdings of u.s. securities.* Retrieved from `https://ticdata.treasury.gov/Publish/shla2018r.pdf`

Treasury. (2021). *The made in america tax plan.*

World Bank. (2021). *Imports of goods and services (% of gdp).* Retrieved from `https://data.worldbank.org/indicator/NE.IMP.GNFS.ZS?end=2017&mostrecentyeardesc=true&start=1960`

Yasar, M., Raciborski, R., & Poi, B. (2008). Production function estimation in stata using the olley and pakes method. *The Stata Journal*, *8*(2), 221–231.

Status t		Status $t+1$			
		D	**X**	**M**	**MO**
T	*Continuation:*	$(1-\tau^{\Pi})f^{HQ,C}$	$(1-\tau^{\Pi})f^{HQ,C}$	$(1-\tau^{\Pi})f^{HQ,C}$	N/A
	Establishment:	—	$f^X(D)$	$f^M(D)$	N/A
D	*Continuation:*	$(1-\tau^{\Pi})f^{HQ,C}$	$(1-\tau^{\Pi})f^{HQ,C}$	$(1-\tau^{\Pi})f^{HQ,C}$	N/A
	Establishment:	—	$f^X(D)$	$f^M(D)$	N/A
X	*Continuation:*	$(1-\tau^{\Pi})f^{HQ,C}$	$(1-\tau^{\Pi})(f^{HQ,C}+f^{X,C})$	$(1-\tau^{\Pi})(f^{HQ,C}+f^{X,C})$ or $(1-\tau^{\Pi})(f^{HQ,C})$	N/A
	Establishment:	—	—	$f^M(X)$	N/A
M	*Continuation:*	$(1-\tau^{\Pi})f^{HQ,C}$	$(1-\tau^{\Pi})f^{HQ,C}$	$(1-\tau^{\Pi})f^{HQ,C}+(1-\tau^{\Pi*})W_t^* f^{M*,C}$	$(1-\tau^{\Pi})f^{HQ,C}+(1-\tau^{\Pi*})W_t^* f^{M*,C}+W_t^* f^{MO*}$
	Establishment:	—	$f^X(M)$	—	
MO	*Continuation:*	$(1-\tau^{\Pi})f^{HQ,C}$	$(1-\tau^{\Pi})f^{HQ,C}$	$(1-\tau^{\Pi})f^{HQ,C}+(1-\tau^{\Pi*})W_t^* f^{M*,C}+$ or $(1-\tau^{\Pi})f^{HQ,C}+$ $(1-\tau^{\Pi*})W_t^*(f^{M*,C}+f^{MO*,C})$	$(1-\tau^{\Pi})f^{HQ,C}+(1-\tau^{\Pi*})W_t^*(f^{M*,C}+f^{MO*,C})$
	Establishment:	—	$f^X(M)$	—	—

Table 7: Fixed costs for each status $\left(f_t(s_{t-1},s_t)\right)$.

Appendix A   Full List of Fixed Cost Combinations

Table 7 displays the different combinations of fixed costs associated with all the possible statuses and transitions. The fixed establishment and continuation costs are reported separately for each transition.

Appendix B   Static Choices: Optimal Pricing, Quantity and Employment

Domestic Pricing

A domestic firm faces the following static profit maximisation problem

$$\max_{\{p_t, q_t, n_t\}} \quad p_t q_t - W_t n_t$$

subject to

$$q_t = \left(\frac{p_t}{P_t^H} \right)^{-\sigma} C_t^H$$

$$\theta_t (k_t)^{\alpha} (n_t)^{1-\alpha} \geq q_t.$$

The demand curve pins-down the optimal quantity, while the output requirement pins-down the optimal level of employment. Taking the first order condition (FOC) with respect to the price yields the optimal price of

$$p_t = \left\{ \frac{\sigma}{\sigma - 1} \frac{1}{1 - \alpha} \left(\frac{1}{\theta_t \{k_t\}^{\alpha}} \right)^{\frac{1}{1-\alpha}} (C_t^H \{P_t^H\}^{\sigma})^{\frac{\alpha}{1-\alpha}} \right\}^{\frac{1-\alpha}{1-\alpha(1-\sigma)}}. \tag{12}$$

Exporter Pricing

The profit-maximising choices of an exporting firm depend on its previous status, s_{t-1}. In the case where $s_{t-1} = X$, the firm produces goods for both markets and sends goods

51

abroad through its export segment. In this case, their static problem is of the form

$$\max_{\{p_t, q_t, p_t^*, q_t^*, n_t\}} \quad p_t q_t + p_t^* q_t^* - W_t n_t$$

subject to

$$q_t = \left(\frac{p_t}{P_t^H}\right)^{-\sigma} C_t^H$$

$$q_t^* = \left(\frac{p_t^*}{P_t^{H*}}\right)^{-\sigma} C_t^{H*}$$

$$\theta_t (k_t)^\alpha (n_t)^{1-\alpha} \geq q_t + d_{HF} q_t^*.$$

The demand curves for the two countries pin-down the optimal quantities while the optimal labour hiring comes from the output requirement constraint. Notice that the iceberg cost $d_{HF} \geq 1$ features in the production requirement constraint. Two FOCs then pin-down the optimal prices in each market as

$$p_t = \frac{1}{d_{HF}} p_t^* \tag{13}$$

$$p_t = \left\{ \frac{\sigma}{\sigma - 1} \frac{1}{1 - \alpha} \left(\frac{1}{\theta_t \{k_t\}^\alpha}\right)^{\frac{1}{1-\alpha}} \left[\{P_t^H\}^\sigma C_t^H + \{d_{HF}\}^{1-\sigma} \{P_t^{H*}\}^\sigma C_t^{H*} \right]^{\frac{\alpha}{1-\alpha}} \right\}^{\frac{1-\alpha}{1-\alpha(1-\sigma)}}. \tag{14}$$

In contrast, a firm that had status of $s_{t-1} \neq X$ is only choosing to establish its export segment in t, meaning that their production for export has not yet commenced. These firms choose the optimal price of a domestic firm given in (12).

Multinational Pricing

A firm that was a multinational last period $s_{t-1} = M$ solves two separate static profit maximisation problems. The first is with respect to domestic profits

$$\max_{\{p_t, q_t, n_t\}} \quad p_t q_t - W_t n_t$$

52

subject to the same constraints as a domestic firm, with the same solution as for a domestic firm given in (12). The second is with respect to its overseas profits

$$\max_{\{p_t^*, q_t^*, n_t^*\}} \quad p_t^* q_t^* - W_t^* n_t^*$$

subject to

$$q_t^* = \left(\frac{p_t^*}{P_t^{H*}}\right)^{-\sigma} C_t^{H*}$$

$$\theta_t (k_t^*)^\alpha (n_t^*)^{1-\alpha} \geq q_t^*,$$

which yields an optimal pricing solution of the form

$$p_t^* = \left\{ \frac{\sigma}{\sigma-1} \frac{1}{1-\alpha} \left(\frac{1}{\theta_t \{k_t^*\}^\alpha}\right)^{\frac{1}{1-\alpha}} (C_t^{H*} \{P_t^{H*}\}^\sigma)^{\frac{\alpha}{1-\alpha}} \right\}^{\frac{1-\alpha}{1-\alpha(1-\sigma)}}. \qquad (15)$$

Firms with $s_{t-1} = D$ must wait a period to commence operations through their F subsidiary and thus set their H pricing in accordance with (12). A firm with $s_{t-1} = X$ has the option of whether to continue exporting in period t or to cease operations through its export segment. Should it continue to export in t, it's optimal pricing is given by equations (13) and (14), otherwise it only sets the H price through (12). Finally a firm with $s_{t-1} = MO$ has the option of whether or not to continue exporting from its F export segment or not. If it chooses not to do so, it's only sales are to the F household, which have the solution given in (15). If it chooses to continue exporting to H in the transition period, then their static profit maximisation problem is given by

$$\max_{\{p_t, q_t, p_t^*, q_t^*, n_t^*\}} \quad p_t q_t + p_t^* q_t^* - W_t^* n_t^*$$

subject to

$$q_t = \left(\frac{p_t}{P_t^H}\right)^{-\sigma} C_t^H$$

$$q_t^* = \left(\frac{p_t^*}{P_t^{H*}}\right)^{-\sigma} C_t^{H*}$$

$$\theta_t (k_t^*)^\alpha (n_t^*)^{1-\alpha} \geq d_{FH} q_t + q_t^*,$$

53

which gives optimal pricing solutions of the form

$$p_t^* = \frac{1}{d_{FH}} p_t \tag{16}$$

$$p_t^* = \left\{ \frac{\sigma}{\sigma - 1} \frac{1}{1 - \alpha} W_t^* \left(\frac{1}{\theta_t \{k_t^*\}^\alpha} \right)^{\frac{1}{1-\alpha}} \left[(d_{FH})^{1-\sigma} \{P_t^H\}^\sigma C_t^H + \{P_t^{H*}\}^\sigma C_t^{H*} \right]^{\frac{\alpha}{1-\alpha}} \right\}^{\frac{1-\alpha}{1-\alpha(1-\sigma)}}. \tag{17}$$

Offshoring Multinational Pricing

A firm with $s_{t-1} = MO$ solves the problem of a downsizing offshorer, (who continues to export), to multinational in the previous subsection. Their optimal pricing solutions are given by (16) and (17). A firm such that $s_{t-1} = M$ must wait a period before it can use its F export segment to service the H market. As such it can either continue producing through headquarters at H, in which case its pricing decisions are given by (12) and (15). If it chooses not to produce at H while transitioning, it's only pricing decision is given by (15).

Appendix C   Full Recursive Formulation for Each Status

In this appendix, I describe the H firms' full recursive formulation corresponding to each firm status in more detail. A firm that chooses to be a domestic has value given by

$$\widehat{v}_t(\varphi_t, D) = \max_{\{z_t, y_{t+1}\}} d_t + \beta_{t+1}\mathbb{E}_t[v_{t+1}(\varphi_{t+1})]$$

subject to

$$
\begin{aligned}
d_t =& e_t - (\mathbb{1}_{e_t<0})\zeta_t \\
e_t =& (1 - \tau^\Pi)\pi_t - f_t - \Lambda_t i_t - \Lambda_t \phi_t + l_t + \frac{b_{t+1}}{1 + R_{t+1}} - b_t + b_t\left(1 - \frac{1}{1 + R_t}\right)\tau^\Pi \\
\pi_t =& p_t q_t - W_t n_t \\
f_t =& (1 - \tau^\Pi)W_t f^{HQ,C} \\
l_t =& (\mathbb{1}_{s_{t-1}\in\{M,MO\}})\xi\Lambda_t k_t^* \\
i_t =& k_{t+1} - (1 - \delta)k_t \\
b_{t+1} \leq& \xi\Lambda_t k_{t+1}.
\end{aligned}
$$

The domestic firm's period dividend is comprised of its after-tax profits from its sales to the H household where p_t, q_t and n_t are the firm's price, quantity and labour input employed to service the H market. These variables are chosen in a static context to maximise the profits of the firm, (see appendix B). The period dividend involves cash outflows associated with paying fixed costs, variable investment and capital adjustment costs. The firm also re-balances its borrowing for the period, receives its debt tax shields and proceeds from liquidating its F capital stock if it came into the period with some. I assume that an exiting firm pays its headquarters' fixed operation cost for the period and then recoups the value of the expenditure when liquidating its capital stocks. These terms net-out in the exit value function. An exporting firm receives value given by

$$\widehat{v}_t(\varphi_t, X) = \max_{\{z_t, y_{t+1}\}} d_t + \beta_{t+1}\mathbb{E}_t[v_{t+1}(\varphi_{t+1})]$$

subject to

$$d_t = e_t - (\mathbb{1}_{e_t < 0})\zeta_t$$

$$e_t = (1 - \tau^\Pi)\pi_t - f_t - \Lambda_t i_t - \Lambda_t \phi_t + l_t + \frac{b_{t+1}}{1 + R_{t+1}} - b_t + b_t \left(1 - \frac{1}{1 + R_t}\right)\tau^\Pi$$

$$\pi_t = p_t q_t + (\mathbb{1}_{s_{t-1} = X})p_t^* q_t^* - W_t n_t$$

$$f_t = (1 - \tau^\Pi)W_t f^{HQ,C} + (\mathbb{1}_{s_{t-1} = X})(1 - \tau^\Pi)W_t f^{X,C} + (\mathbb{1}_{s_{t-1} \neq X})W_t f^X$$

$$l_t = (\mathbb{1}_{s_{t-1} \in \{M, MO\}})\xi\Lambda_t k_t^*$$

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

$$b_{t+1} \leq \xi\Lambda_t k_{t+1}.$$

where notice that the firm realises some sales revenue $p_t^* q_t^*$ associated with selling to the F household when its export segment is operational, (i.e. $s_{t-1} = X$). These variables are again chosen statically to maximise profits. The fixed cost function includes the export continuation fixed cost again when the segment is operational, otherwise the fixed establishment cost is incurred. A multinational firm has a Bellman equation given by

$$\widehat{v}_t(\varphi_t, M) = \max_{\{z_t, y_{t+1}\}} d_t + \beta_{t+1}\mathbb{E}_t[v_{t+1}(\varphi_{t+1})]$$

56

where

$$d_t = e_t - (\mathbb{1}_{e_t<0})\zeta_t$$

$$e_t = (1-\tau^\Pi)\pi_t + \left\{\mathbb{1}_{u_t<0} + \mathbb{1}_{u_t\geq0}\left(\frac{1-\tau^{\Pi,U}-\tau^{\Pi*}}{1-\tau^{\Pi*}}\right)\right\}u_t$$

$$-f_t - \Lambda_t i_t - \Lambda_t \phi_t + \frac{b_{t+1}}{1+R_{t+1}} - b_t + b_t\left(1-\frac{1}{1+R_t}\right)\tau^\Pi$$

$$\pi_t = p_t q_t + (\mathbb{1}_{s_{t-1}=X}\mathbb{1}_{o_t=1})p_t^* q_t^* - W_t n_t$$

$$u_t = \mathbb{1}_{s_{t-1}\in\{M,MO\}}(1-\tau^{\Pi*})\{p_t^* q_t^* - W_t^* n_t^*\} - \Lambda_t i_t^* - \Lambda_t \phi_t^*$$

$$f_t = (1-\tau^\Pi)W_t f^{HQ,C} + \mathbb{1}_{s_{t-1}=M}(1-\tau^{\Pi,U}-\tau^{\Pi*})W_t^* f^{M*,C} + (\mathbb{1}_{s_{t-1}=X}\mathbb{1}_{o_t=1})W_t f^{X,C}$$

$$+ (\mathbb{1}_{s_{t-1}\neq M})W_t f^M$$

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

$$i_t^* = k_{t+1}^* - (1-\delta)k_t^*$$

$$b_{t+1} \leq \xi\Lambda_t(k_{t+1} + k_{t+1}^*).$$

A multinational firm with $s_{t-1} = X$ makes an additional static choice — whether to continue exporting while it waits for its F subsidiary to become operational. The variable $o_t \in \{0,1\}$ is an indicator function equal to one when such a firm elects to export in the transition. This decision is static and depends on the firm's current state. Further details are in appendix B.

The salient difference of the offshorer's Bellman equation from that of a regular multinational is that the production for sale of goods to the H household takes place through the F subsidiary. Notice then, as a consequence, the profits generated from said production are then taxable by the F Government in the period they're earned. It's not until these earnings are repatriated back to headquarters in H that they are taxed by the H Government. Notice that a firm that was an offshorer at $t-1$ but was a regular multinational at $t-2$ that chose to continue producing in the transitional period will receive liquidation proceeds from its H capital stock. The value to the choice of $s_t = MO$ depends on whether the firm was already an offshorer or just a regular multinational at $t-1$

$$\widehat{v}_t(\varphi_t, MO) = (\mathbb{1}_{s_{t-1}=M})\left(\max_{m\in\{0,1\}} \widetilde{v}_t(\varphi_t, MO, m)\right) + (\mathbb{1}_{s_{t-1}=MO})(\bar{v}_t(\varphi_t, MO))$$

where $\bar{v}_t(\varphi_t, MO)$ is the Bellman equation for a firm that was an offshorer in the previous

period. The variable $m \in \{0, 1\}$ is a control of the firm (which depends on its state φ_t) that equals one when the firm chooses to keep producing through its headquarters in H during the transition period from M to MO and equals zero otherwise. The value function $\widetilde{v}_t(\varphi_t, MO, m)$ denotes the value of the firm's state in period t when choosing to be an offshorer when making choice m when transitioning from M. See that

$$\bar{v}_t(\varphi_t, MO) = \max_{\{z_t, y_{t+1}\}} d_t + \beta_{t+1}\mathbb{E}_t[v_{t+1}(\varphi_{t+1})]$$

where

$$d_t = e_t - \mathbb{1}_{e_t<0}\zeta_t$$

$$e_t = \left\{ \mathbb{1}_{u_t<0} + \mathbb{1}_{u_t\geq 0}\left(\frac{1 - \tau^{\Pi,U} - \tau^{\Pi*}}{1 - \tau^{\Pi*}}\right) \right\} u_t - f_t + \frac{b_{t+1}}{1 + R_{t+1}} - b_t + b_t\left(1 - \frac{1}{1 + R_t}\right)\tau^{\Pi}$$

$$u_t = (1 - \tau^{\Pi*})\left\{ p_t q_t + p_t^* q_t^* - W_t^* n_t^* \right\} - \Lambda_t i_t^* - \Lambda_t \phi_t^*$$

$$f_t = (1 - \tau^{\Pi})W_t f^{HQ,C} + (1 - \tau^{\Pi,U} - \tau^{\Pi*})W_t^*\{f^{M*,C} + f^{MO*,C}\}$$

$$i_t^* = k_{t+1}^* - (1 - \delta)k_t^*$$

$$b_{t+1} \leq \xi^* \Lambda_t k_{t+1}^*.$$

Then when $m = 1$ and the firm continues to produce through headquarters during its transition

$$\widetilde{v}_t(\varphi_t, MO, 1) = \max_{\{z_t, y_{t+1}\}} e_t + \beta_{t+1}\mathbb{E}_t[v_{t+1}(\varphi_{t+1})]$$

58

where

$$e_t = d_t - \mathbb{1}_{d_t<0}\zeta_t$$

$$d_t = (1 - \tau^\Pi)\pi_t - \Lambda_t i_t - \Lambda_t \phi_t - f_t + \left\{ \mathbb{1}_{u_t<0} + \mathbb{1}_{u_t\geq 0} \left(\frac{1 - \tau^{\Pi,U} - \tau^{\Pi*}}{1 - \tau^{\Pi*}} \right) \right\} u_t$$

$$+ \frac{b_{t+1}}{1 + R_{t+1}} - b_t + b_t \left(1 - \frac{1}{1 + R_t} \right) \tau^\Pi$$

$$\pi_t = p_t q_t - W_t n_t$$

$$u_t = (1 - \tau^{\Pi*})\{p_t^* q_t^* - W_t^* n_t^*\} - \Lambda_t i_t^* - \Lambda_t \phi_t^*$$

$$f_t = (1 - \tau^\Pi)W_t f^{HQ,C} + (1 - \tau^{\Pi,U} - \tau^{\Pi*})W_t^* f^{M*,C} + W_t^* f^{MO*}$$

$$i_t^* = k_{t+1}^* - (1 - \delta)k_t^*$$

$$b_{t+1} \leq \xi\Lambda_t(k_{t+1} + k_{t+1}^*).$$

The key departure of this Bellman equation from $\bar{v}_t(\varphi_t, MO)$ is that the firm receives some operating income from its servicing of the H household through production in H. When the firm instead chooses to downsize immediately, their Bellman equation is of the form

$$\widetilde{v}_t(\varphi_t, MO, 0) = \max_{\{z_t, y_{t+1}\}} d_t + \beta_{t+1}\mathbb{E}_t[v_{t+1}(\varphi_{t+1})]$$

where

$$d_t = e_t - \mathbb{1}_{d_t<0}\zeta_t$$

$$e_t = l_t - f_t + \left\{ \mathbb{1}_{u_t<0} + \mathbb{1}_{u_t\geq 0} \left(\frac{1 - \tau^{\Pi,U} - \tau^{\Pi*}}{1 - \tau^{\Pi*}} \right) \right\} u_t + \frac{b_{t+1}}{1 + R_{t+1}} - b_t + b_t \left(1 - \frac{1}{1 + R_t} \right) \tau^\Pi$$

$$u_t = (1 - \tau^{\Pi*})\{p_t^* q_t^* - W_t^* n_t^*\} - \Lambda_t i_t^* - \Lambda_t \phi_t^*$$

$$f_t = (1 - \tau^\Pi)W_t f^{HQ,C} + (1 - \tau^{\Pi,U} - \tau^{\Pi*})W_t^* f^{M*,C} + W_t^* f^{MO*}$$

$$l_t = \xi\Lambda_t k_t$$

$$i_t^* = k_{t+1}^* - (1 - \delta)k_t^*$$

$$b_{t+1} \leq \xi^*\Lambda_t(k_{t+1}^*)$$

where the firm receives proceeds of the liquidation in the form of l_t.

Appendix D   Allowing for Corporate Inversions

One can also easily accommodate corporate inversions in the model. Here, I briefly sketch how they can be accounted for and the quantitative implications that follow. I assume that firms that undertake inversions must have $s_{t-1} \in \{M, MO\}$ — meaning they must already have a segment in F. When modelling this, more assumptions are required regarding the corporate tax system of F. One can simply assume that F has a so-called territorial tax system for its firms, meaning that the F Government levies no repatriation tax or other worldwide taxes on any earnings its firms generate in H.

I model inverting firms as establishing their "paper" headquarters in F, meaning that they become an F firm for taxation purposes. I refer to them as "paper" headquarters as the new overseas parent is typically established in a tax haven nation where the firm has little to no real operations. For example, places like Bermuda and Panama are typical popular destinations, (see Desai & Hines Jr (2002) for a comprehensive list).

I model inverting firms as continuing to use their H headquarters for overall coordination of the entity, with the interpretation of management remaining in the U.S. post-inversion. Inverting firms pay a fixed establishment cost through their subsidiary of f^{HQ*} and then a continuation fixed cost of $f^{HQ*,C}$ in each period thereafter. The benefit associated with an inversion is that the firm is now no longer a U.S. firm for tax purposes. As a consequence, it is no longer subject to the repatriation tax when bringing funds back to H. I assume that the firm's shareholders remain all based in the U.S. post-inversion.[30] Similarly to when a status is upgraded in the model, I assume that there is a one period delay before the firm is officially recognised as being from F for tax purposes.

There are two permissible types of firms post-inversion. Those that were of status M at the time of inversion and those that were of status MO at the time of inversion. The distinction dictates whether some of the firm's production takes place in H or whether all takes place in F. I denote the status of these two types of firms by $s_t \in \{IM, IMO\}$ for the two respective possible types. The firms' overall Bellman equation is augmented for

---

[30]There are complications from an investor's perspective with these transactions. For instance, the act of an inversion makes accumulated capital gains on holding their shares payable immediately. For a careful treatment of these considerations and quantitative analysis, see Babkin, Glover, & Levine (2017). I abstract from such considerations as they're beyond the scope of my research question.

the possibility of inversion as follows

$$v_t(\varphi_t) = \max_{s_t \in S(s_{t-1})} \widehat{v}(\varphi_t, s_t)$$

where see that for $s_{t-1} \in \{T, D, X\}$, $S(s_{t-1}) = \{E, D, X, M\}$ and for $s_{t-1} \in \{M, MO, IM, IMO\}$, $S(s_{t-1}) = \{E, D, X, M, MO, IM, IMO\}$. The Bellman equation for a firm with status $s_t = IM$ is given by

$$\widehat{v}_t(\varphi_t, IM) = \max_{\{z_t, y_{t+1}\}} d_t + \beta_{t+1}\mathbb{E}_t[v_{t+1}(\varphi_{t+1})]$$

where

$$d_t = e_t - (\mathbb{1}_{e_t<0})\zeta_t$$

$$e_t = (1 - \tau^\Pi)\pi_t + \mathbb{1}_{s_{t-1}\in\{IM,IMO\}}u_t + \mathbb{1}_{s_{t-1}\in\{M,MO\}}\left\{\mathbb{1}_{u_t<0} + \mathbb{1}_{u_t\geq0}\left(\frac{1 - \tau^{\Pi,U} - \tau^{\Pi*}}{1 - \tau^{\Pi*}}\right)\right\}u_t$$

$$- f_t - \Lambda_t i_t - \Lambda_t\phi_t + \frac{b_{t+1}}{1 + R_{t+1}} - b_t + b_t\left(1 - \frac{1}{1 + R_t}\right)\tau^\Pi$$

$$\pi_t = p_t q_t - W_t n_t$$

$$u_t = (1 - \tau^{\Pi*})\{p_t^* q_t^* - W_t^* n_t^*\} - \Lambda_t i_t^* - \Lambda_t\phi_t^*$$

$$f_t = (1 - \tau^\Pi)W_t f^{HQ,C} + (1 - \tau^{\Pi*} - \mathbb{1}_{s_{t-1}\in\{M,MO\}}\tau^{\Pi,U})W_t^* f^{M*,C}$$

$$+ (\mathbb{1}_{s_{t-1}\in\{M,MO\}})(1 - \tau^{\Pi*})W_t^* f^{HQ*} + \mathbb{1}_{s_{t-1}\in\{IM,IMO\}}(1 - \tau^{\Pi*})W_t^* f^{HQ*,C}$$

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

$$i_t = k_{t+1}^* - (1 - \delta)k_t^*$$

$$b_{t+1} \leq \xi\Lambda_t(k_{t+1} + k_{t+1}^*).$$

where notice that the tax term $(1 - \tau_t^{\Pi,U} - \tau^{\Pi*})/(1 - \tau^{\Pi*})$ is no longer multiplying the amount of earnings repatriated once the "paper" headquarters is operational. Moreover the repatriation tax is no longer a deduction from the firm's fixed costs of overseas operations. Note also that the static variables — p_t, q_t, n_t, p_t^*, q_t^* and n_t^* are the same as for a regular M status firm in appendix B. In the interest of brevity, I won't display the Bellman equation for a firm with $s_t = IMO$, but note it would be similar to that of a regular offshoring firm but again with repatriation taxes removed.

One can get a sense of the numbers from Boehm, Flaaen, & Pandalai-Nayar (2019), who

61

look at movements of establishments between being U.S multinational and foreign multinational status.[31] The transitions are very small — less than 1% of U.S. multinational establishments switch to foreign status. As such, when the model is calibrated to include such firms, they have a negligible impact on the quantitative results. Notice also that, since these firms do not pay repatriation taxes prior to the reform, they are a drain on U.S. tax revenues. Consequently, the inclusion of these firms qualitatively puts upward-pressure on tax collections when the repatriation tax is removed. Given the negligible quantitative effects, I opt to keep inversions out of the baseline specification for simplicity.

Appendix E   Extended Recursive Equilibrium Definition

Cross-Sectional Measure of Home Firms

The cross-sectional measure of firms over the state space is denoted by $\mu_t(\varphi_t)$ where recall that

$$\varphi_t = (k_t, k_t^*, b_t, \theta_t, s_{t-1}).$$

Denote the policy functions for an incumbent firm, for choices made at time t by $k_{t+1}(\varphi_t)$, $k_{t+1}^*(\varphi_t)$, $b_{t+1}(\varphi_t)$ and $s_t(\varphi_t)$, which are all functions of the current period state. Then denote the policy functions for a new entrant by k_t^T and b_t^T. Notice that all these policy functions have time subscripts given that the quantitative exercise aims to study transitional effects. See then that the cross-sectional measure evolves according to the law of motion given by

$$\mu_{t+1}(\varphi_{t+1}) = \sum_{s \in \{D,X,M,MO\}} \int_{\theta,b,k^*,k} \Gamma[\varphi_t, \varphi_{t+1}] \mu_t(dk, dk^*, db, d\theta, s) + M_t^T \int_\theta \Gamma^T \Theta^T(d\theta) \quad (18)$$

where recall that M_t^T is the measure of new entrants that come into the economy at t, (which are incumbents from $t+1$ onwards). The $\Gamma[\varphi_t, \varphi_{t+1}]$ and Γ^T functions are endogenous transition functions for incumbents and new entrants respectively, which have

---

[31]This is only an approximation since my study is of firms, not establishments.

form given by

$$\Gamma[\varphi_t, \varphi_{t+1}] = \mathbb{1}_{[k=k_{t+1}(\varphi_t)]\wedge[k^*=k^*_{t+1}(\varphi_t)]\wedge[b=b_{t+1}(\varphi_t)]}\Theta(\theta_{t+1}|\theta_t)$$
$$\Gamma^T = \mathbb{1}_{[k=k_t^T]\wedge[b=b_t^T]}\Theta^T(\theta_t)$$

where $\wedge$ is the logical conjunction operator, $\Theta(\theta_{t+1}|\theta_t)$ denotes the conditional productivity process for incumbents in equation (4) and $\Theta^T(\theta_t)$ is the unconditional productivity process for entrants. These transition functions are indicators, which are equal to one when a part of the state space that corresponds with firms' endogenous choices is considered.

Recursive Equilibrium

A recursive equilibrium in this model is defined as a set of sequences

$$\{P_t^H, P_t^{H*}, P_t^F, P_t^{F*}, W_t, W_t^*, \Lambda_t, R_t, \{\psi_t(\omega)\}_{\omega\in\Omega}, M_t^T, \mu_t\}_{t=0}^{\infty} \tag{19}$$

such that the following conditions hold for any arbitrary time period t, (with the above sequences taken as given by agents)

1. H household optimises over consumption and savings.

2. H incumbent firms optimise.

3. H entrant firms optimise and the free entry condition $V_t^T = 0$ holds.

4. μ_t is the measure of H firms across their entire state space.

5. M_t^T is the measure of entering H firms.

6. P_t^H is the equilibrium price (numéraire) of H goods in H with market clearing

$$Q_t^H = C_t^H$$

where Q_t^H denotes supply of H goods to the H market and C_t^H is aggregate consumption of H goods by the H household.

63

7. P_t^{H*} is the equilibrium price (endogenous) of H goods in F with market clearing

$$Q_t^{H*} + X_t^H = C_t^{H*}$$

where Q_t^{H*} is aggregate supply of H goods by H multinationals abroad, X_t^H is aggregate exports of H goods to F and C_t^{H*} is aggregate demand for H goods in F.

8. P_t^F is the equilibrium price (exogenous) of F goods in F with market clearing

$$X_t^F = C_t^F$$

where X_t^F is the exports of F goods to H and C_t^F is aggregate demand for F goods by H households.

9. P_t^{F*} is the equilibrium price (exogenous) of F goods in F with market clearing

$$Q_t^{F*} = C_t^{F*}$$

where Q_t^{F*} is aggregate supply of F goods and C_t^{F*} is aggregate demand for F goods by F households.

10. The wage W_t clears the home labour market with condition

$$1 = N_t^H + F_t^{HQ} + F_t^{HQ,C} + F_t^X + F_t^{X,C} + F_t^M$$

where the labour supply on the left-side of the equation equals one. The total labour demand is made-up of total variable labour demand N_t^H, aggregate entry fixed establishment costs, F_t^{HQ}, aggregate fixed headquarters continuation costs $F_t^{HQ,C}$, aggregate exporting fixed establishment costs F_t^X, aggregate exporting fixed continuation costs $F_t^{X,C}$ and aggregate multinational fixed establishment costs F_t^M.

11. W_t^* is the equilibrium wage (exogenous) in F with market clearing condition

$$L_t^* = N_t^{H*} + N_t^{F*} + F_t^{M*,C} + F_t^{MO*} + F_t^{MO*,C}$$

where L_t^* is the F labour supply, N_t^{H*} is aggregate variable labour demand in F from H firms, N_t^{F*} is aggregate variable labour demand in F by F firms, $F_t^{M*,C}$ is

64

the aggregate multinational fixed continuation cost of H firms, F_t^{MO*} is the aggregate offshoring fixed establishment cost for H firms and $F_t^{MO*,C}$ is aggregate fixed continuation cost for H offshoring firms.

12. Λ_t is the equilibrium price (exogenous) of investment goods, which clears the global investment good market

$$S_t^* = I_t^H + I_t^{H*} + Z_t + AC_t^H + AC_t^{H*}$$

where S_t^* is aggregate supply of investment goods, I_t^H is aggregate demand for variable investment goods in H by H firms, I_t^{H*} is aggregate demand for variable investment goods in F by H firms, Z_t is aggregate equity issuance costs by H firms and AC_t^H and AC_t^{H*} are aggregate adjustment costs incurred by H firms in H and F respectively.

13. R_t is the equilibrium riskless rate (endogenous) for bonds in H, which clears the market with

$$B_t = B_t^S$$

where B_t is savings through riskless bonds by the H household and B_t^S is aggregate borrowing through bonds by H firms.

14. The stock markets for H firms in H clear at prices (endogenous) $\psi_t(\omega)$ with

$$a_t(\omega) = 1$$

where 1 is the normalised number of shares per firm and $a_t(\omega)$ is the number of shares in a given firm that a household optimally chooses to hold.

15. The H Government budget constraint is

$$G_t = \tau^\Pi \Pi_t + \tau^W W_t + \tau^{\Pi,U} U_t^+.$$

16. The F Government budget constraint is

$$G_t^* = \tau^{\Pi*} \Pi_t^*.$$

65

Notice that in the case of a steady state, the aggregate sequences in (19) will be invariant across time. An economy in transition as a result of a policy change will have some of these objects changing until converging to a new steady state.

Appendix F   Calibration Technical Details

There are several parameters to be calibrated inside the model. I discretise the productivity shock into a Markov process using the methodology of Adda & Cooper (2003) using the code accompanying Floden (2008b) from Floden (2008a). The parameters to be calibrated are listed in table 4; denote the vector of these parameters as Ξ. The calibration procedure for the baseline is executed in accordance with the following objective function

$$J(\Xi) = \left[\Psi^{\text{Data}} - \Psi^{\text{Model}}(\Xi) \right]' W \left[\Psi^{\text{Data}} - \Psi^{\text{Model}}(\Xi) \right]$$

where Ψ^{Data} are the targets of some moments in the data, (fixed numbers), $\Psi^{\text{Model}}(\Xi)$ are the set of moments in the model (a function of the parameters) and W is a positive definite weighting matrix. The process utilises the packages accompanying Goffe (1996). I employ the approach of approximating the optimal W from a simplified version of the bootstrapped empirical moment variance-covariance matrix. This is an often used approximation (e.g. see Lentz & Mortensen (2008)); the approach was initially advocated for by Horowitz (1998). Specifically, the diagonal elements of W have the reciprocals of the bootstrapped moment variances. For the few moments I take from other papers, I set their weights to be the average of the others. Off-diagonals I set to be zero.

Appendix G   Computational Algorithms

In what follows I describe the algorithms for solving for the steady state and transition paths in turn.

Stationary Recursive Equilibrium

1. Guess initial values for the aggregate variables required for incumbent H firm optimisation: $C^{H,0}, P^{H*,0}, W^0$ — the aggregate demand from the H market, the price of

H goods in *F* and the *H* wage — the 0 superscripts denote the initial guess. Note in the calibration step that I fix the *H* wage to unity.

2. Find the implied Foreign demand for Home goods using the demand curve in equation (3). Note in the calibration step that I fix the aggregate demand shifter that enters into the firm's problem to one — i.e. $(P^{H*})^\sigma C^{H*} = 1$. I infer the equilibrium price later in the procedure as $P^{H*} = 1/(Q_t^{H*} + X_t^H)^{\frac{1}{\sigma}}$ where the denominator is the aggregate supply of *H* goods to *F* found in step 8 below. The A^* parameter is then inferred by inverting (3) to get $A^* = (Q_t^{H*} + X_t^H)/(P^{H*})^{1-\eta^*}$.

3. Solve the optimisation for an incumbent *H* firm: gives value functions and policy functions.

4. Solve the optimisation problem for an *H* entrant: gives the value to entry and associated policy functions.

5. Find the stationary distribution of *H* firms across their state space: the stationary measure corresponding to a unit measure of firms.

6. Find aggregate variables corresponding to the stationary distribution.

7. Find the stationary measure of firms using linearity of the stationary measure in addition to the market clearing condition for *H* labour, (given the unit labour supply). Notice that this step imposes that the labour market at *H* clears; it yields M and M^T.

8. Find aggregate variables using the equilibrium measure of firms found in step 7.

9. Find the steady state levels of consumption for the *H* household.

10. Construct metrics of distance from each equilibrium condition:

    - $\Delta^T = v^T$ is the value to entry for *H* firms (from step 4),

    - Δ^H is the distance of the conjectured level of demand for *H* goods in *H* ($C^{H,0}$) from the supply (from step 8),

    - Δ^{H*} is the excess demand for *H* goods in *F* (finding supply from step 8 and demand from step 2).

67

If running the calibration, stop when $|\Delta^H|$ is sufficiently small. In general, if

$$\max(|\Delta^T|, |\Delta^H|, |\Delta^{H*}|) \tag{20}$$

is sufficiently close to zero, then stop. Otherwise construct new guesses for the aggregate objects using

$$C^{H,1} = C^{H,0} + \epsilon^H \Delta^H$$
$$W^1 = W^0 + \epsilon^T \Delta^T$$
$$P^{H*,1} = P^{H*,0} + \epsilon^{H*} \Delta^{H*}$$

where $\epsilon^j \in \mathbb{R}$ for $j \in \{H, T, H*\}$ are small parameters chosen for updating of each of the equilibrium objects. Note that if the model is being calibrated, $\epsilon^T = \epsilon^{H*} = 0$. Next set

$$C^{H,0} = C^{H,1}$$
$$W^0 = W^1$$
$$P^{H*,0} = P^{H*,1}.$$

Then return to step 2 and repeat until convergence, (when the object (20) is sufficiently close to zero).

Transition Recursive Equilibrium

The algorithm below describes how to find the transition path between two steady states after a policy change. The policy change is assumed to be announced in period $t = 1$ and be effective thereafter. The initial condition for the model is the pre-reform steady state at time $t = 0$.

A. Conjecture the number of time periods required to converge to the post-reform steady state: call this number $\mathcal{T} \in \mathbb{N}$.

B. Find the pre and post reform steady states using the algorithm described in the

68

previous subsection. This step yields two lists of steady state equilibrium objects

$$\Upsilon_0 = (P_0^H, P_0^{H*}, P_0^F, P_0^{F*}, W_0, W_0^*, \Lambda_0, R_0, \{\psi_0(\omega)\}_{\omega \in \Omega}, M_0^T, \mu_0, v_0, C_0^H, B_0)$$
$$\Upsilon_{\mathcal{T}} = (P_{\mathcal{T}}^H, P_{\mathcal{T}}^{H*}, P_{\mathcal{T}}^F, P_{\mathcal{T}}^{F*}, W_{\mathcal{T}}, W_{\mathcal{T}}^*, \Lambda_{\mathcal{T}}, R_{\mathcal{T}}, \{\psi_{\mathcal{T}}(\omega)\}_{\omega \in \Omega}, M_{\mathcal{T}}^T, \mu_{\mathcal{T}}, v_{\mathcal{T}}, C_{\mathcal{T}}^H, B_{\mathcal{T}})$$

where Υ_0 denotes the set of equilibrium objects for the pre-reform steady state and $\Upsilon_{\mathcal{T}}$ denotes that for the post-reform new steady state. The variables C_0^H and $C_{\mathcal{T}}^H$ denote the aggregate consumption level of the H household pre and post-reform. Variables B_0 and $B_{\mathcal{T}}$ are the optimal H household savings in each steady state and v_0 and $v_{\mathcal{T}}$ are the value functions for incumbent H firms in the pre and post-reform steady states respectively. Notice that $P_0^H = P_{\mathcal{T}}^H$, $P_0^F = P_{\mathcal{T}}^F$, $P_0^{F*} = P_{\mathcal{T}}^{F*}$, $W_0^* = W_{\mathcal{T}}^*$ and $\Lambda_0 = \Lambda_{\mathcal{T}}$ given that these prices are exogenous. Moreover note that $R_0 = R_{\mathcal{T}}$ given the steady state relationship between the riskless rate and discount factor in equation (7).

C. Conjecture sequences of time paths for aggregate variables

$$\{C_t^{H,0}, W_t^0, P_t^{H*,0}, R_{t+1}^0, M_t^{T,0}\}_{t=1}^{\mathcal{T}-1}$$

where the 0 superscript denotes that these are the first guess of the transitional paths of the equilibrium objects. Note that the conjectured sequence of prices $P_t^{H*,0}$ imply a sequence of demand for H goods in F from equation (3).

D. Take $v_{\mathcal{T}}$ to be the endpoint value for the H incumbent firms' value function. Iterate backwards from $t = \mathcal{T} - 1$ to $t = 1$ on the incumbent firms' optimisation problem. Note that the firm one period ahead discount factor at each point in time is $\beta_{t+1} = 1/(1 + R_{t+1}^0)$, (which is time-varying). This step gives a sequence of value functions, $\{v_t\}_{t=1}^{\mathcal{T}-1}$ and policy functions for the H incumbent firms.

E. Using the incumbent firm value functions $\{v_t\}_{t=1}^{\mathcal{T}-1}$ found in the previous step, iterate backwards on the sequence of problems for an H entering firm. This yields a sequence of entrant policy functions and values to entry $\{v_t^T\}_{t=1}^{\mathcal{T}-1}$. Again notice that the discount factor for the entrant is given by a time-varying $\beta_{t+1} = 1/(1 + R_{t+1}^0)$.

F. Iterate forwards on the measure of H firms using μ_0 as the starting point and the law of motion in (18). Notice that these forward iterations make use of the sequence of

69

conjectured entering firm measures, $\{M_t^{T,0}\}_{t=1}^{\mathcal{T}-1}$. This yields a sequence of measures $\{\mu_t\}_{t=1}^{\mathcal{T}-1}$. These measures can then be used to find aggregate variables corresponding to H firms at any given t.

G. Iterate forwards on the H household's problem until convergence using the following procedure:

   i. Use the household's pre-reform level of steady state savings B_0 as an initial condition. Make an initial guess of their consumption in the period of the reform denoted $C_1^{hh,0}$. Note that the 1 subscript denotes period $t = 1$ and the 0 superscript denotes the initial guess for this object. For an arbitrary $t > 1$, denote the resulting level of aggregate H consumption and savings by $C_t^{hh,0}$ and B_{t+1}^0 respectively.

   ii. Find the time t chosen level of borrowing B_{t+1}^0 from the household's budget constraint (2) using aggregate objects found from the sequence of measures $\{\mu_t\}_{t=1}^{\mathcal{T}-1}$.

   iii. Find the time $t + 1$ level of aggregate consumption using the household's Euler equation (6).

   iv. Repeat steps ii. and iii. until reaching the conjectured period of convergence $\mathcal{T}$. Compare the distance of the implied convergence period savings from the Euler equation iteration process with that found in step B. of the overall procedure. Specifically compute a metric of distance from the endpoint as

   $$\Delta^B = B_{\mathcal{T}+1}^0 - B_{\mathcal{T}+1}$$

   If Δ^B is sufficiently small then stop. Otherwise update the reform period guess for aggregate consumption using

   $$C_1^{hh,1} = C_1^{hh,0} + \epsilon^C \Delta^B$$

   for $\epsilon^C \in \mathbb{R}$ as a sufficiently small updating parameter. Set $C_1^{hh,0} = C_1^{hh,1}$ and return to step ii. and repeat the procedure until Δ^B is sufficiently close to zero. The final outcomes of this household forward-shooting procedure are sequences of optimal household savings, denoted by $\{B_{t+1}^0\}_{t=1}^{\mathcal{T}}$ and consumption $\{C_t^{hh,0}\}_{t=0}^{\mathcal{T}-1}$

70

H. Compute metrics of distance from each of the equilibrium objects for each time period t over the transition. Specifically

- $\Delta_t^T = v_t^T$ is the value to entry for H firms (found in step E.),
- Δ_t^H is the distance of the conjectured level of demand for H goods in H (from step C) and the supply (from step F),
- Δ_t^{H*} is excess demand for H goods in F, (supply is from the aggregates from step F. and demand is implied in step C),
- Δ_t^L is the excess demand for H labour, (where supply is unity for each period and demand for labour comes from step F.),
- Δ_t^R is the excess demand for H riskless bonds, (where supply of bonds are the savings from the household problem in step G. and aggregate demand comes from aggregate firm borrowing in step F.).

If

$$\max\left(\{|\Delta_t^T|, |\Delta_t^H|, |\Delta_t^{H*}|, |\Delta_t^L|, |\Delta_t^R|\}_{t=1}^{\mathcal{T}-1}\right)$$

is sufficiently close to zero, then stop and proceed to step I. Otherwise construct new guesses for the aggregate objects using

$$C_t^{H,1} = C_t^{H,0} + v^H \Delta_t^H$$
$$W_t^1 = W_t^0 + v^W \Delta_t^L$$
$$P_t^{H*,1} = P_t^{H*,0} + v^{H*} \Delta_t^{H*}$$
$$R_t^1 = R_t^0 + v^R \Delta_t^R$$
$$M_t^{T,1} = M_t^{T,0} + v^M \Delta_t^T$$

where v^j for $j \in \{H, W, H*, R, M\}$ are very small, appropriately-chosen updating parameters for the aggregate variables. Set $C_t^{H,0} = C_t^{H,1}, W_t^0 = W_t^1, P_t^{H*,0} = P_t^{H*,1}, R_t^0 = R_t^1$ and $M_t^{T,0} = M_t^{T,1}$. Return to step D. and repeat.

I. Check to see if the aggregate variables, (including the overall measure of H firms), have converged continuously to the post-reform steady state by period $\mathcal{T}$. If not, update your guess of how long the convergence takes, $\mathcal{T}$ and return to step C.

71

Appendix H Closed Economy Exercise

This appendix develops a model with a view to understanding the role of the open economy in evaluating tax reforms. I develop a standard single country version of the model with taxes. The quantitative exercise then gives a tax reduction to the group of firms that are the largest, in the amount of the effective reduction that multinationals receive in the baseline exercise from the paper.

Model

The household's problem is the same as the baseline, with the exception that their consumption is no longer divided between two types of goods. The firm faces a state vector of the form

$$\varphi_t = (k_t, b_t, \theta_t)$$

which is made up of their capital stock, debt obligation from last period and their current productivity draw. Their productivity process still follows that specified in equation (4). The firms now make a discrete choice only over whether to operate or not in a given period. An incumbent's recursive formulation is given as follows. With their state vector realised, they face the following discrete choice

$$v_t(\varphi_t) = \max(\widehat{v}_t(\varphi_t), l_t - b_t)$$

where they receive value $\widehat{v}_t(\varphi_t)$ in the case of continuing and their liquidation value $l_t = \xi k_t$ in the case of exit. The value from continuing is

$$\widehat{v}_t(\varphi_t) = \max_{z_t, y_{t+1}} d_t + \beta_{t+1} \mathbb{E}_t[v_{t+1}(\varphi_{t+1})]$$

$$d_t = e_t - \mathbb{1}_{e_t < 0} \zeta_t$$

subject to $b_{t+1} \leq l_{t+1}$. See that $z_t = (n_t, p_t, q_t)$ denotes their static choices, which are employment, price and quantity respectively and $y_{t+1} = (k_{t+1}, b_{t+1})$ are their dynamic choices. The functional form for the equity issuance premium is the same as in equation (5). See that the value function is made of a period dividend (net of equity issuance costs)

72

plus a continuation value. The form of the pre-equity issuance period dividend is

$$e_t = (1 - \tau^\Pi + \tau^{\Pi,K} \mathbb{1}_{k_t \geq \bar{k}}) \pi_t - i_t - \phi_t + \frac{b_{t+1}}{1 + R_{t+1}} - b_t + b_t \left\{ 1 - \frac{1}{1 + R_t} \right\} \tau^\Pi - f_t$$

$$\pi_t = p_t q_t - W_t n_t$$

$$f_t = (1 - \tau^\Pi) W_t f^{HQ,C}$$

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

The key distinction in this setup from a tax perspective is the inclusion of a reduction for firms above a certain size. When the firm's capital is above a cutoff $\bar{k} \geq 0$, they receive a tax credit at the rate $\tau^{\Pi,K}$, making their overall tax burden $\tau^\Pi - \tau^{\Pi,K}$. If their capital is below this threshold, then they pay the standard rate of τ^Π. A newly-entered firm faces a similar problem as in (10). The recursive equilibrium is defined similarly to that in appendix E.

Quantitative Exercise

I calibrate the closed economy to a situation where all firms below the tax break cutoff pay the statutory rate, while those above pay a reduced rate. I calculate this reduced rate using information from the baseline model of the main paper. The counterfactual exercise then gives a further reduction to these large firms, where the size of the reduction is of the same magnitude received by the multinationals when the repatriation tax is removed. More formally, the value I use in the calibration is

$$\tau^{\Pi,K} = \iota^H \tau^\Pi + (1 - \iota^H) \iota^U (\tau^{\Pi*} + \tau^{\Pi,U}) + (1 - \iota^H)(1 - \iota^U) \tau^{\Pi*}$$
$$= [\iota^H + (1 - \iota^H) \iota^U] \tau^\Pi + (1 - \iota^H)(1 - \iota^U) \tau^{\Pi*}$$

where $\iota^H, \iota^U \in [0,1]$ are the fraction of earnings made in H and the fraction of overseas earnings repatriated from the baseline. Notice that the second line follows from the definition of the repatriation tax. This is a weighted average of statutory rates, where the weights depend upon the operations, earnings and repatriation strategies of FDI firms. In the counterfactual, I then use the following rate

$$\tau^{\Pi,K} = \iota^H \tau^\Pi + (1 - \iota^H) \tau^{\Pi*}$$

73

which simply sets the repatriation tax to zero. This counterfactual rate is the weighted average of the U.S. and foreign statutory rates. The difference between the two rates comes to be 0.24% — the counterfactual reduces the parameter $\tau^{\Pi,K}$ by this amount. This exercise is conducted with a view to give these large firms a further tax break that mirrors the reduction in the effective rate received by multinationals in the baseline. I then calibrate the size threshold $\bar{k}$ inside the model to give the same fraction of firms receiving the tax breaks as there are multinationals in the data. This cutoff size is found to be 1.55x the size of the average incumbent in the model.

There are then two further sets of parameters to be calibrated. The first are those that are calibrated outside the model in the baseline (such as χ), these are taken to be the same here. See table 3 for these values. The remaining parameters are also calibrated inside the model — $(\phi, f^{HQ}, f^{HQ,C}, \zeta_0, \zeta_1, \xi, \kappa)$. All of the parameters, which are different from the baseline exercise, are shown in table 8. The counterfactual results are presented in table 9.

Symbol	Value	Moment targeted	Data moment	Model moment
ϕ	$1.7 * 10^{-3}$	Investment rate	0.07	0.03
f^{HQ}	0.11	$W = 1$	1.00	1.00
$f^{HQ,C}$	0.13	Entry/exit rate	0.11	0.11
κ	0.00	Normalisation	—	—
ζ_0	$1 * 10^{-8}$	Fraction equity issuance	0.04	0.04
ζ_1	$7.7 * 10^{-5}$	Size of equity issuance	0.21	0.19
ξ	0.17	Mean leverage	0.13	0.14
$\bar{k}$	1.55x ave	Fraction M	0.35	0.34
$\tau^{\Pi,K}$	0.32	Baseline M effective rate	0.32	0.32

Table 8: Parameters used in closed economy model. Notes: all of the above are calibrated internally with the exception of the tax rate faced by firms of sufficient size.

The reform has a considerably weaker effect in the closed economy setting. Firms receiving the higher tax break are limited with regard to expansion opportunities relative to the open economy setting. The value gains that ensue are consequently smaller, leading to a 0.13% increase in the measure of firms, in contrast with 0.46% in the baseline. Firms extend themselves further with investment at the intensive margin in order to cross the tax break threshold, leading to a 0.13% increase in the capital stock. This then catalyses a substitution towards capital and away from labour as an input of production, driving a decrease in variable labour employment. This substitution offsets the upward-pressure on the wage from the rise in entry, giving a slight decrease in the wage. Firms borrow

74

more in light of more collateral, in order to take advantage of tax shields, with debt rising by 0.7%. The tax revenue losses are smaller than the baseline given that there's no offshoring or overseas profit shifting effects. Notice also that the absence of terms of trade effects implies fewer general equilibrium disciplining devices. These effects result in a much smaller welfare gain of 0.01%. These much more moderate effects highlight the importance of considering the open economy when evaluating tax reforms.

Variable	Baseline	Closed economy
Measure of firms	0.46	0.13
Measure of entrants	0.24	0.13
Capital stock	0.09	0.13
Dividends	5.12	0.12
Equity issuance	5.23	-0.51
Debt	-5.39	0.74
Tax collections	-0.32	-0.22
Wage	0.12	-0.01
Consumption/utility	0.29	0.01

Table 9: Steady state results. The two sets of numbers presented are those from the baseline exercise and the closed economy. All numbers are percentage differences of the variable from the pre-reform steady state after multiplication by 100. The capital stock number reports the change in the domestic capital stock for the baseline.

Appendix I   Calibration of FEIM

Table 10 shows the parameter values, data moments and the corresponding model moment for the FEIM. There are a couple of things to note here. I target the growth rate in capital for new firms from the baseline by adjusting the average productivity of new entrants. I also match the growth rate in employment for new firms by adjusting the fixed operating cost for HQ since this directly impacts exit and indirectly the upgrading to engage with the F market. I adjust the fixed establishment cost for FDI for a domestic firm to hit the average foreign sales intensity of multinationals' subsidiaries over years 1–5 of their life. Lastly, the ξ parameter is adjusted to match the leverage ratio of firms in the data. An alternative here could be to leave this parameter the same as in the baseline. This would amplify the difference between the FEIM and baseline quantitative results since a larger ξ would give a bigger jump in multinational value as these firms get more tax shields from

75

higher borrowing against their assets.

Parameter	Value	Target moment	Data	FEIM	Source
f^{HQ}	0.05	Unit wage	1.00	1.00	Normalisation
$f^X(D)$	0.13	Transition (D, s_t), $s_t \in \{X, M\}$	0.04	0.07	Baseline
$f^X(M)$	0.06	Transition (M, X)	$4 * 10^{-3}$	$4 * 10^{-3}$	Compustat
$f^{X,C}$	0.05	Transition (X, X)	0.86	0.85	Compustat
$f^M(X)$	0.20	Transition (X, M)	0.07	0.09	Compustat
$f^{M,C}$	0.11	Transition (M, M)	0.98	0.97	Compustat
$\kappa(D)$	0.02	Entry/exit rate	0.10	0.08	Literature
$\kappa(s_t), s_t \neq D$	0.00	Normalisation	0.00	0.00	Normalisation
ν_Θ^T	0.20	Mean growth rate 1–5 years (capital)	0.14	0.14	Baseline
$f^{HQ,C}$	0.10	Mean growth rate 1–5 years (employment)	0.12	0.14	Baseline
$f^M(D)$	0.45	Mean F affiliate sales intensity 1–5 years	0.42	0.44	Baseline
d_{HF}	1.40	Mean export sales intensity	0.15	0.19	Compustat
ϕ	0.03	Mean investment rate	0.07	0.09	Compustat
ξ	0.13	Mean leverage	0.13	0.13	Compustat
A^*	0.45	Unit demand	1.00	1.00	Normalisation

Table 10: FEIM parameters and moments

Appendix J   Data Appendix

Firm Statuses

The following procedure is used to classify firms as domestic, exporter or multinational.
Note that I keep foreign firms in the data in the case of the empirical validation exercise of
section V.i; I drop foreign firms in the calculation of the calibration transition probabilities.

1. Download and combine the Compustat Fundamentals Annual and Historical Segment
   data sets.

2. Match firms in the two data sets using their global company key (GVKEY).

3. Identify U.S. and foreign firms. A firm is classified as a U.S.-based if both its foreign
   incorporation code (FIC) and company headquarters code (LOC) are for the U.S as in
   Fillat & Garetto (2015). If a company is identified as having been a U.S. firm at any

76

point in its data history, I classify it as a U.S. firm, (to ensure that re-incorporated U.S. firms aren't treated as foreign). Otherwise it is classed as a foreign firm.

4. Drop any observations that are not denoted in U.S. Dollars.

5. Eliminate double-counting of information in firm-years.

6. Drop any observations before 1979 and after 2017.

7. Drop firms with SIC codes over the ranges (SIC $\geq$ 4900 & SIC $\leq$ 4999) | (SIC $\geq$ 6000 & SIC $\leq$ 6999) | (SIC $\geq$ 9000) as in Hennessy, Levy, & Whited (2007).

8. For U.S. firms, determine if a given firm-year contains the reporting of geographical segments or not. If so, drop the business segments reported. Otherwise keep the business segments reported. If a foreign firm, drop the observation if only a business segment is reported.

9. Check if a DATADATE-GVKEY combination reports the same segment multiple times (using the variable SID to identify segments). If so, drop them.

10. Check if any firms report the obsolete total geographic segment (GEOTP = 1), if so drop them.

11. Classify firms as domestics, exporters and multinationals. A firm is a multinational if they report an overseas geographical segment (with a maximum value of the variable GEOTP = 3) and have a positive value of sales. A firm is an exporter if they report export sales and no overseas geographical segment (they may have reported geographic segments with a maximum value of GEOTP = 2 or they may only have reported business segments with export income if based in the U.S.). All other firms are classified as domestics.

12. Replace a data item with a missing value if it has a data code reported.

13. Aggregate the information for firm-years across all the remaining segments present. I create new foreign variables for the overseas (GEOTP = 3) segments to distinguish them from domestic activities (i.e. now there is a sales variable and a foreign sales variable for a given firm-year).

14. Keep only one observation per firm year: drop all the segment-level variables and just keep the aggregates.

15. Adjust for temporary downward foreign status changes. As in Fillat & Garetto (2015), if a firm's status drops for a single time period, I adjust the observation. Specifically, I look at at firm's status for time $t-1$ and $t+1$ and compare with their status at time t. If they were an exporter in $t-1$ and $t+1$ but their status dropped to domestic at time t, I adjust to make them an exporter at time t. Similarly if their status dropped from multinational at $t-1$ and $t+1$ to exporter or domestic at time t, I replace the t status with multinational.

16. Save the resulting dataset for use in calculating descriptive statistics.

Descriptive Statistics

1. Download Fundamentals annual data from Compustat (North America Daily, Fundamentals Annual).

2. Label firms as either being from the U.S. or abroad: as in Fillat & Garetto (2015), classify as US only if their LOC and FIC codes are equal to the U.S. For these summary statistics, drop a firm if it's classified as foreign.

3. Drop if currency is not in USD.

4. Delete repeated observations for a given firm-year.

5. Drop if the data year is before 1979 or after 2017.

6. Drop firms based on their SIC codes. Drop if $4900 \leq SIC \leq 4999$ or $6000 \leq SIC \leq 6999$ or $SIC \geq 9000$.

7. Keep only the industrial format of the data: drop if indfmt = FS.

8. Merge with the historical segments information. Extract a firm's status as either a domestic, exporter or multinational for a given firm-year observation.

9. Define variables as in Bazdresch, Kahn, & Whited (2018). Total assets = at, net payments = dv + prstkc - sstk, gross investment = capx, net debt = dltt + dlc - che.

78

10. Drop if total asset or sales are negative.

11. Drop if above-defined variables are not reported.

12. Retrieve summary statistics for ratios after dropping the top and bottom 1% for each of the corresponding ratios.

13. Depreciation rate is defined as dp/ppegt: drop the top and bottom 1%.

14. Export sales intensity conditions on a firm having exporter status. I find the firm's aggregate domestic sales across all geographic segments for the year (using sales) and export sales similarly (using salexg). The intensity is defined as the ratio of export sales to total sales; I trim the top and bottom ratios by 1%.

15. For the productivity and size premia: drop the top and bottom 1% for all firms. Then regress the estimated productivity draw against a categorical variable for the foreign status, dummies for SIC code and the data year.

16. To estimate the productivity process with Olley & Pakes (1996), I follow all the steps in the applied paper by Yasar, Raciborski, & Poi (2008).

Parameters Calibrated Outside the Model

1. The import share in consumption λ comes from the World Bank (World Bank, 2021) website: Imports of goods and services (% of GDP).

2. The foreign corporate tax rate $\tau^{\Pi*}$ is calculated using a few sources. I find the top ten countries by employment of U.S. multinationals, which are not tax havens as defined by Tørsløv, Wier, & Zucman (2018) or in the top six countries for U.S. cash holdings abroad as given by Faulkender, Hankins, & Petersen (2019).[32] Employment data are taken from the BEA for 2017: U.S. Direct Investment Abroad, All Foreign Affiliates (data for 2009 and forward), Employment, 2017. I then find the corporate tax rates of these countries using Deloitte (2017). The top ten by employment in order (with 2017 tax rate in parenthesis) are: China (25%), Mexico (30%), India (30%), Canada (15%), Brasil (34%), Germany (15%), France (33.33%), Japan (23.9%), Australia (30%), Philippines (30%).

---

[32]The only country in the top six that is not a tax haven is the United Kingdom.

Appendix K   Full TCJA

Variable	Baseline	Full TCJA
Measure of firms	0.46	2.98
Measure of entrants	0.24	3.11
Fraction of exporters	-1.09	-5.95
Fraction of multinationals	0.40	5.68
Domestic capital	0.09	34.69
Overseas capital	1.32	2.27
Dividends	5.12	20.84
Equity issuance	5.23	27.76
Debt	-5.39	-19.09
Price of H goods in F	-1.44	-4.82
Repatriations	39.51	25.72
Tax collections	-0.32	-2.77
Wage	0.12	11.45
Output	0.41	8.07
Consumption/utility	0.29	10.24

Table 11: Steady state results for the 21% reduction in the domestic rate of the full TCJA exercise.

Table 11 presents the steady state results for the full TCJA and compares with the baseline results. The magnitudes are generally larger given it's a 14% reduction for all U.S. firms as opposed to a 0.24% reduction for only multinationals. The starkest contrast comes from the large-scale substitution of firms away from labour towards capital, giving a 35% increase in the aggregate capital stock with the full TCJA. Notice also that aggregate debt decreases by almost 20%. This is comes from the lower debt tax shield per unit of borrowing coming from the reduced tax rate.

Appendix L   Empirical Validation Details

This appendix presents details of the placebo and difference-in-difference regressions in table 12. Figure 3 gives a graphical verification of the parallel trends assumption. Table 13 shows the parameter values, data and model moments for the re-calibration. The model is slightly augmented to accommodate this exercise; I adjust the exporter problem to allow for the pre-reform tax credits. These credits apply to firms that are able to generate

80

export income in the given period. Specifically, the exporter Bellman equation for firms with $s_{t-1} = X$ changes to

$$\widehat{v}_t(\varphi_t, X) = \max_{\{z_t, y_{t+1}\}} d_t + \beta_{t+1} \mathbb{E}_t[v_{t+1}(\varphi_{t+1})]$$

subject to

$$d_t = e_t - (\mathbb{1}_{e_t < 0})\zeta_t$$

$$e_t = \pi_t - v_t - v_t^* - f_t - \Lambda_t i_t - \Lambda_t \phi_t + \frac{b_{t+1}}{1 + R_{t+1}} - b_t + b_t \left(1 - \frac{1}{1 + R_t}\right)\tau^\Pi$$

$$v_t = \tau^\Pi \{p_t q_t - (1 - \varepsilon_t)[W_t n_t + W_t f^{HQ,C} + W_t f^{X,C}]\}$$

$$v_t^* = \tau^{\Pi,X} \{p_t^* q_t^* - \varepsilon_t [W_t n_t + W_t f^{HQ,C} + W_t f^{X,C}]\}$$

$$\varepsilon_t = \frac{d_{HF} q_t^*}{q_t + d_{HF} q_t^*}$$

$$\pi_t = p_t q_t + p_t^* q_t^* - W_t n_t$$

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

$$b_{t+1} \leq \xi \Lambda_t k_{t+1}.$$

where v_t and v_t^* are the taxes the firm pays on domestic and export profits respectively. Given that all the domestic factors of production are used jointly to produce goods for sale both domestically and abroad, I assume that costs are attributed based on the branch's fraction in total output, captured by ε_t. Export profits are subject to the tax rate $\tau^{\Pi,X}$. The exercise is conducted such that in the pre-reform setting (pre-2005), $\tau^{\Pi,X} = 0.85\tau^\Pi$, while post reform $\tau^{\Pi,X} = \tau^\Pi$.

	2000	2001	2002	2003	2004	2005
U.S. firm	0.0258**	0.0135	0.0123	0.0160**	0.0119*	0.0132**
	(2.43)	(1.41)	(1.29)	(2.14)	(1.66)	(2.14)
Treatment	-0.00781	0.000514	-0.00462	0.000100	-0.00488*	0.00611
	(-1.13)	(0.14)	(-0.84)	(0.03)	(-1.80)	(1.42)
Interaction	-0.0123*	-0.00117	0.00364	-0.00403	0.00125	-0.0114**
	(-1.68)	(-0.26)	(0.62)	(-1.14)	(0.40)	(-2.42)
N	9784	9370	8925	8598	8344	8143

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

	2006	2007	2008	2009	2010	2011
U.S. firm	0.00179	0.00881	0.0136**	0.00953*	0.00759	0.00739
	(0.28)	(1.35)	(2.39)	(1.68)	(1.39)	(1.61)
Treatment	-0.00265	-0.00807**	-0.000395	-0.00317	-0.00147	-0.00129
	(-0.71)	(-2.00)	(-0.13)	(-0.90)	(-0.39)	(-0.91)
Interaction	0.00703*	0.00483	-0.00411	-0.00194	-0.000204	-0.00214
	(1.65)	(1.08)	(-1.08)	(-0.52)	(-0.05)	(-0.93)
N	7859	7520	7219	7016	6928	6929

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 12: Regression estimates of (11). Notes: these results use placebo treatments for all years except that of the actual reform in 2005. Coefficients correspond to explanatory dummy variables for U.S. firm, treatment year and the interaction of the two respectively. Constant term estimates are suppressed. Standard errors are clustered at the SIC level.
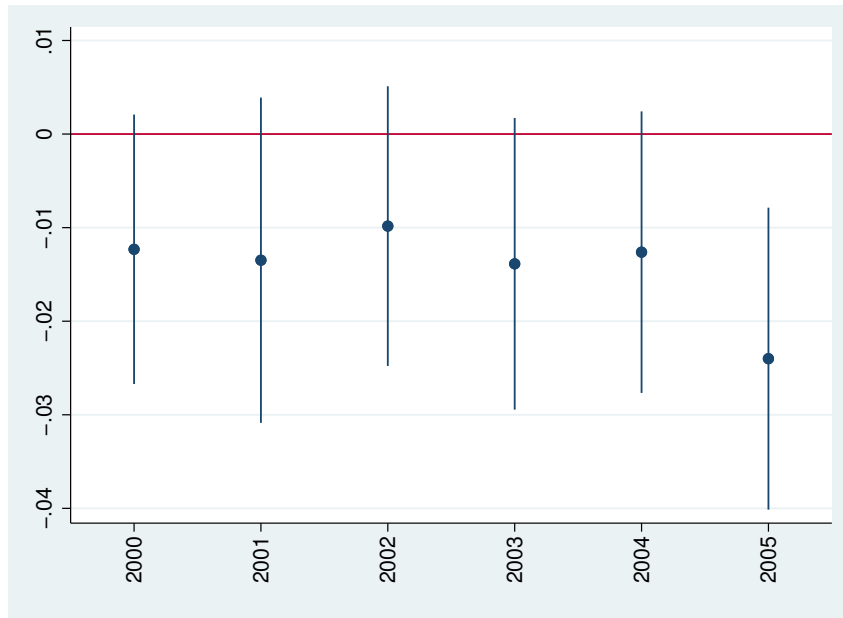
Figure 3: Parallel trends assumption. This presents coefficients from dynamic regression $x_{it} = \gamma_0 + \sum_{t'=2000}^{2005} \gamma_{t'} g_{t'} h_i + \gamma_1 h_i + a_t + \epsilon_{it}$ where h_i is an indicator for a U.S. firm, $g_{t'}$ is an indicator for when the year is $t' \in \{2000, ..., 2005\}$, a_t is a time fixed effect. This regression is run for the years $t \in \{1999, ..., 2005\}$, standard errors are clustered at the SIC level.

Parameter	Value	Target moment	Data	VE	Source
f^{HQ}	0.01	Unit wage	1.00	1.00	Normalisation
$f^{HQ,C}$	0.07	Entry/exit rate	0.10	0.11	Literature
$f^X(D)$	0.25	Transition $(D, s_t), s_t \in \{X, M\}$	0.04	0.04	Compustat
$f^X(M)$	0.06	Transition (M, X)	$5 * 10^{-3}$	$4 * 10^{-3}$	Compustat
$f^{X,C}$	0.07	Transition (X, X)	0.86	0.85	Compustat
$f^M(D)$	0.49	Fraction M	0.31	0.35	Compustat
$f^M(X)$	0.20	Fraction X	0.11	0.11	Compustat
$f^{M,C}$	0.13	Transition (M, M)	0.97	0.97	Compustat
$\kappa(D)$	0.12	Transition (X, M)	0.07	0.10	Compustat
$\kappa(s_t), s_t \neq D$	0.00	Normalisation	0.00	0.00	Normalisation
d_{HF}	1.45	Mean export sales intensity	0.15	0.16	Compustat
ϕ	0.35	Mean investment rate	0.07	0.08	Compustat
ξ	0.30	Mean leverage	0.15	0.15	Compustat
ζ_0	0.01	Frac. equity issuance	0.04	0.04	SDC & Literature
ζ_1	0.25	Mean equity iss. to market cap.	0.21	0.22	SDC & Literature
A^*	0.55	Unit demand	1.00	1.00	Normalisation

Table 13: Empirical validation exercise (VE) parameters and moments. Notes: these moments correspond to the 1979–2004 sample.

Appendix M Static Model Details

This appendix details the static variant of the model whose results are discussed in section VI.i.

Model

Notation here all has the same interpretation as in section II, albeit without time subscripts. The model has the same six agents as the baseline model. All agents excepting the H firms and H household behave in the same manner as in the dynamic context. The only difference for the H household is that they no longer trade in bonds.

Home firms are all ex-ante identical. They pay their fixed establishment cost of entry f^{HQ}. A mass of M^T of firms enter, after which they then all draw their idiosyncratic productivity shocks θ. Conditional on their shock, they then decide what status to take: exit (E) domestic (D), exporter (X) and multinational (M). After making their status

choice, they then choose their optimal prices, quantities and employment subject to their demand curves in each country. Their initial value to entry is given by

$$v^T = -f^{HQ} + \beta \mathbb{E}^\Theta[v(\theta)]$$

where the expectation is with respect to the ergodic distribution of equation (4). The conditional value function is given by

$$v(\theta) = \max_{s \in S} \; \widehat{v}(\theta, s)$$

where $S = \{E, D, X, M\}$. The conditional value of exit is $v(\theta, E) = 0$. That for a domestic is

$$\widehat{v}(\theta, D) = \max_z \; (1 - \tau^\Pi)(pq - Wn - \Lambda k - W f^{HQ,C})$$

subject to

$$\theta k^\alpha n^{1-\alpha} \geq q$$
$$q = \left(\frac{p}{P^H}\right)^{-\sigma} C^H$$

where $z_t = (p, q, k, n)$. The conditional value for an exporter is

$$\widehat{v}(\theta, X) = \max_z \; (1 - \tau^\Pi)(pq + p^*q^* - Wn - \Lambda k - W f^{HQ,C} - W f^{X,C})$$

subject to

$$\theta k^\alpha n^{1-\alpha} \geq q + d_{HF} q^*$$
$$q = \left(\frac{p}{P^H}\right)^{-\sigma} C^H$$
$$q^* = \left(\frac{p^*}{P^{H*}}\right)^{-\sigma} C^{H*}$$

85

where $z = (q, p, q^*, p^*, k, n)$. Finally, the conditional value for a multinational is

$$\widehat{v}(\theta, M) = \max_{z} \ (1 - \tau^\Pi)(pq - Wn - \Lambda k - W f^{HQ,C})$$

$$+ (1 - \tau^{\Pi,U} - \tau^{\Pi*})(p^*q^* - W^*n^* - \Lambda k^* - W^* f^{M*,C})$$

subject to

$$\theta k^\alpha n^{1-\alpha} \geq q$$

$$\theta (k^*)^\alpha (n^*)^{1-\alpha} \geq q^*$$

$$q = \left(\frac{p}{P^H}\right)^{-\sigma} C^H$$

$$q^* = \left(\frac{p^*}{P^{H*}}\right)^{-\sigma} C^{H*}.$$

where $z = (q, p, q^*, p^*, k, n, k^*, n^*)$. The cross-sectional measure is given as

$$\mu(\theta) = M^T \sum_{s \in \{D,X,M\}} \int_\theta \Theta^T(d\theta).$$

The market clearing conditions are defined similarly as in the baseline model (see appendix E). The equilibrium in this static model is defined as a scenario where

1. All optimising agents are optimising,

2. All markets are clearing,

3. Both governments are on their budget constraints,

4. There is an endogenous cross-sectional measure of H firms,

5. The free entry condition holds for H firms,

6. The national accounts balance.

Calibration

All parameters calibrated outside the model are the same as in the baseline. Those calibrated inside the model are $(f^{HQ}, f^{HQ,C}, f^{X,C}, f^{M,C}, A^*, \kappa(s), d_{HF})$ for $s \in \{D, X, M\}$.

86

Parameter	Value	Target moment	Data	Static	Source
f^{HQ}	0.02	Unit wage	1.00	1.00	Normalisation
$f^{HQ,C}$	$6.3 * 10^{-3}$	Exit rate	0.11	0.10	Literature
$f^{X,C}$	$4.3 * 10^{-3}$	Fraction X	0.08	0.11	Compustat
$f^{M,C}$	0.02	Fraction M	0.35	0.37	Compustat
$\kappa(s)$	0.00	Zero	0.00	0.00	Normalisation
d_{HF}	1.65	Export intensity	0.15	0.15	Compustat
A^*	0.66	Unit demand	1.00	1.00	Normalisation

Table 14: Static model parameters and moments.

Appendix N   Deferrability Exercise

Here I detail the calibration of the static model, used to infer the importance of deferrability strategies in the baseline. I note that the fraction of repatriation taxes to overall tax collections in the baseline model is around 1%. I then calibrate the repatriation tax inside the static model to match this as a target moment — this gives a rate of 2%. I refer to this simulation hereafter as the static deferrability (SD) exercise. The remaining parameters are chosen to match the same targets as in table 14. The counterfactual then removes the 2% repatriation tax; the results are in table 15.

Variable	Baseline	SD
Measure of entrants	0.24	0.00
Dividends	5.12	1.01
Equity issuance	5.23	0.56
Tax collections	-0.32	-0.84
Price of H goods in F	-1.44	-0.12
Output	0.41	-0.01
Consumption/utility	0.29	-0.04

Table 15: Static deferrability exercise. Note: the baseline results correspond to the steady state changes.

Appendix O   Symmetric Static Model Exercise

The model here has the same structure as in appendix M with the exception that foreign firms are also heterogeneous over productivity. The results are presented in table 16. This

87

symmetric model involves solving for a set of aggregate objects

$$(P^H, P^F, P^{H*}, P^{F*}, C^H, C^F, C^{H*}, C^{F*}, W, W^*)$$

as opposed to simply (P^{H*}, C^{H*}, W) in the asymmetric static model.

Variable	Static	SS
Measure of firms	-1.79	0.00
Fraction of exporters	-5.27	-15.79
Fraction of multinationals	5.27	15.79
Tax collections	-5.10	-2.34
Price of H goods in F	-1.04	-1.26
Wage	-0.89	-1.06
Output	-0.58	-0.86
Consumption/utility	-1.17	-1.29

Table 16: Symmetric static model