

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

Adam Hal Spencer[†]

March 12, 2019

Abstract

I develop a dynamic quantitative framework, with heterogeneous firms and financial frictions, to study impact of corporate tax reforms directed at multinational firms. The model quantifies the impact of such reforms on productivity, GDP and welfare. Firms draw idiosyncratic productivity shocks, invest in capital and choose optimal financial structure. They choose endogenously whether to service the foreign market, through either exporting or FDI. I apply the framework to the removal of the U.S. repatriation tax as in the 2017 Tax Cuts and Jobs Act. The impact trades-off two selection effects — offshoring from more U.S. multinationals versus greater entry that drives-out less productive firms. Comparing steady states, the tax reform brings higher productivity, GDP, welfare and approximate revenue neutrality. Dynamics are significant: along the transition, there are temporary welfare losses from short-term adverse labour market conditions. Financial frictions are also significant: their exclusion brings welfare losses when comparing steady states.

Keywords: Productivity, Financial Frictions, Corporate Tax, Firm Heterogeneity, FDI, Repatriation Tax

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

*I thank Oliver Levine, Dean Corbae, Noah Williams, Charles Engel, Mark Ready, Michael Gofman, Arlene Wong, Pol Antras, David Brown, Toni Braun, Nitya Pandalai-Nayar, Giammario Impulitti, Joseph Farhat, Jonathan Dingle, Juan Carlos Suarez Serrato, Arpad Abraham, Bernd Theilen and Kim Ruhl for valuable comments. Conference participation at the Spring 2016 Midwest Macro Meeting, 2017 Midwest Finance Meeting, 2017 Econometric Society North American Summer Meeting, Monash Early Career Economist Conference, 2018 New Faces in International Economics Conference, 2018 Money Macro and Finance Conference, the 2018 Econometric Society European Summer Meeting, the 2018 European Trade Study Group, 2018 National Tax Association Meeting, 2018 Vienna Macroeconomics Workshop, 2018 Spanish Economic Association, XXVI Meeting on Public Economics (EEP) and the 2018 European Association of Law and Economics (EALE) is appreciated. Seminar participation at UW-Madison, University of Chicago (Booth School of Business), UW-Whitewater, The University of Nottingham and the Federal Reserve Bank of Atlanta is also much appreciated. I'm extremely grateful for financial support offered by the departments of Economics and Finance at UW-Madison and through EALE's Göran Skogh Prize. I received outstanding computational support from the Center for High Throughput Computing (CHTC) and the Simulation Based Engineering Lab (SBEL). All remaining errors are my own.

[†]School of Economics, The University of Nottingham, E-mail: Adam.Spencer@nottingham.ac.uk [new], ahs Spencer@wisc.edu [old].

I Introduction

“The activities of multinational firms account for almost one-third of world GDP and about one-fourth of employment” (OECD, 2018a). Policymakers often give close attention to the tax treatment of multinationals — there exists an abundance of recent examples of tax reforms targeted specifically at these firms. The U.S. Tax Cuts and Jobs Act (TCJA) of 2017 sought to reduce the U.S. tax burden on domestically-incorporated multinationals to increase their competitiveness (U.S. Speaker’s Office, 2017). Cuts to the corporate tax rate in the U.K. in 2015 took place with an objective of attracting FDI from abroad (HM Government, 2013). In 2019, the OECD proposed a version of a global minimum tax as a coordinated effort to curb tax evasion by multinationals (OECD, 2019). Due to the magnitude of multinationals’ operations, tax policies that target them can potentially spillover to affect the entire universe of firms. Through equilibrium effects in goods and factor markets, these tax reforms can affect the profitability and incentives of non-multinationals that can be much lesser in size and productivity, making the impact further-reaching than likely intended.

This paper asks the question: how do tax reforms aimed at multinationals affect productivity, GDP and welfare? There are three key components to my answer. First, I build a new dynamic framework with intensive and extensive margin investment that can be utilised to quantify the effects of such targeted reforms on the entire firm cross-section and how they aggregate to affect the macroeconomy. The impact on the real economy depends crucially on the responsiveness of non-multinationals’ investment behaviours to the changes in local market conditions coming from the equilibrium effects. Financial frictions, through their influence on the cost of capital, can be a significant determinant of this investment responsiveness. There is a large literature documenting that smaller firms tend to be impacted more by financial frictions (e.g. Hennessy & Whited (2007)) — a fact pertaining to non-multinationals since they are typically smaller in size (Flaen, 2014). The second key component in the analysis is to incorporate financial frictions, allowing for the study of their impact on the aggregate responses to these tax reforms targeted at multinationals. The final component, after the development of the model, is to apply this new framework to the study the quantitative impact of a recent policy episode — the removal of the U.S. *repatriation tax* — an aspect of the TCJA.

The quantitative model involves firms that draw idiosyncratic productivity shocks each period from a persistent distribution and produce using capital and labour in a decreasing

returns to scale production function as in Hopenhayn (1992). Capital investment is subject to adjustment costs and participation in the industry involves paying a fixed operating expense each period. Firms have the option to exit the industry after their productivity draw, should the current and continuation value from producing be less than their liquidation value. Those that remain in the industry choose whether to operate as a pure domestic or to also service the overseas market — the latter being able to sell abroad either as exporters or multinationals. Both exporting and multinational statuses involve pairs of additional fixed costs over being a domestic: a capital expense in the first period of their establishment and an additional operating expense in each period subsequent. Exporters incur variable (iceberg) transport costs associated with sending their goods abroad, while multinationals produce directly in the foreign country using an additional production function that makes use of an overseas capital stock. There is an endogenous measure of new entrants into the industry each period, who incur a fixed capital expense prior to receiving their initial productivity draws and commencing operations as a domestic firm.

The financial frictions incorporated are standard in the corporate finance literature: debt tax shields (interest tax deductions) and costly equity issuance. Firms can issue one-period debt securities, which are collateralised by the liquidation values of their domestic and overseas capital stocks. In addition they can issue new equity, which incurs a cost that is increasing and convex in the size of the issuance.¹ More borrowing raises value for shareholders through interest tax deductions, while too much of it can increase the cost of equity in the future — optimal leverage trades-off these two effects.² This trade-off causes the firms' collateral constraints to occasionally bind over time. In this way, the model resembles an open economy version of the general equilibrium framework with financial frictions of Gomes (2001), while disentangling debt and equity financing as in Hennessy & Whited (2007).

The model is solved numerically with parameters disciplined by data to capture the interactions between multinationals and other firms in 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. The fixed operating and capital expenses for each ac-

¹This 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.

²I.e. say a firm receives a low productivity shock at time t and needs to issue new equity. A larger debt repayment from the previous period raises the size of the issuance they undertake.

tive firm status (entrant, domestic, exporter and multinational) are identified by matching transition probabilities across the different statuses. Matching these transitions is crucial to accurately quantifying the equilibrium effects associated with tax reforms targeted at multinationals. These reforms change the value of being a multinational relative to the other firm statuses — fewer or more firms may undertake FDI. This has implications for goods and factor prices domestically, which feed-back to affect the behaviour of firms across the whole distribution.

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.³ 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.

U.S. policymakers removed the repatriation tax in an attempt to increase the profitability of U.S. multinationals. Opponents however feared that it would be a negative for the American worker through depression of wages and outsourcing of export production (Bernstein, 2017). These two competing effects make this particular reform the ideal exercise to run in the context of the new modelling framework developed in this paper. The outsourcing concerns can only be evaluated in a framework where firms can choose endogenously between exporting and FDI. Endogenous entry and exit of firms allows for the measurement of the extent of the increased profitability argument and its implications for cross-sectional and aggregate U.S. variables. Which of these effects dominates in terms of real activity and welfare is ultimately a quantitative question.

The steady state of the model is calibrated to U.S. pre-TCJA data and a quantitative exercise is performed where the repatriation tax is set equal to zero. The U.S. domestic corporate rate is set to the statutory rate of 35% and the overseas rate faced by U.S. multinationals to be the G20 average of 30%, giving a statutory repatriation tax of 5% pre-reform. In the pre-reform steady state, U.S. firms draw stochastic repatriation tax rate shocks — there is some probability of paying the statutory rate, with complementary prob-

³This deferrability option applied to earnings generated through firms' core business activities — around 90% of those made by U.S. firms make abroad. Those that it doesn't apply to include dividends, royalties and interest; I abstract from these types of earnings in my analysis.

ability of getting a temporary one-period reduction. This feature is designed to capture the capture the notion of a *repatriation tax holiday*, such as that in the Homeland Investment Act of 2005, which lowers the expected future repatriation tax rate and increases the benefit of deferral. A lower expected future rate translates into a smaller real effect associated with the reform in the steady state. I study the long-run impact of the reform on the steady state distribution and macroeconomy, as well as mapping the transition dynamics between the two steady states. The parameter values implied by the data are such that the equilibrium of the model resembles that of Helpman, Melitz, & Yeaple (2004). A hierarchy of average productivities emerges where exiting firms are at the bottom, followed by domestics, exporters and then multinationals. The export-FDI trade-off is such that exporters incur lower fixed costs, while multinationals avoid iceberg costs.

There are three key takeaways from the counterfactual exercise. The first is that that tax reforms targeted at multinationals can have a quantitatively significant impact on the macroeconomy through selection effects. While the offshoring of U.S. export production leads to downward-pressure on domestic activity, greater entry due to higher potential future profits for new U.S. firms outweighs this effect in the long-run. U.S. productivity increases by 1.2%, driving a rise in GDP of 0.4%, a higher wage of 0.2% and welfare gains of 0.2% in the post-reform steady state. Higher U.S. tax collections from this increased domestic activity roughly outweigh any lost taxes on repatriations or offshored export production, bringing approximate revenue neutrality. The second key takeaway is that dynamics matter: some of the beneficial effects of the U.S. reform observed in the long-run move in the opposite direction in the transition. In particular, decreased labour demand from downsizing exporters in the periods shortly after impact outweigh higher labour demand from new entrants, leading to a temporary decrease in the U.S. wage and short-run welfare losses. The third key takeaway is that financial frictions also matter: shutting-down the equity issuance costs in the model (in the pre-reform steady state) and running the counterfactual leads to weaker long-run equilibrium effects. The entry effect associated with higher profits is outweighed by the offshoring effect, leading to welfare losses of 0.1% in the post-reform steady state.

Heterogeneity matters in the counterfactual; the tax reform results in changes to the cross-section. Prior to the reform, the trade-off between exporting and FDI is a matter of higher variable costs for the former versus higher fixed costs for the latter. Removing the repatriation tax changes this trade-off by further increasing the variable cost advantage of the FDI choice — multinationals face a lower tax obligation. This results in a 0.1%

increase in the fraction of multinationals and a decrease of a similar magnitude for exporters in the steady state. Fewer firms incurring iceberg costs increases the supply of U.S. goods abroad, leading to a 0.4% decrease in the price they fetch overseas. Although this lower price abroad depresses the profitability of firms that remain exporters after the reform, it raises the continuation value of firms with bright prospects to undertake FDI in the future. Newly-created firms that operate rather than exit of the first period of their incumbency tend to be relatively productive. The reform increases the value to being a U.S. entrant, leading to a rise in the measure of such firms in the new steady state. More firms operating in the U.S. has the effect of shifting the domestic labour demand curve upward, causing the U.S. wage to increase. This leads to a re-allocation effect, where increased competition drives-out some of the small and unproductive incumbent firms at the bottom-end of the distribution to make way for more productive entrants. The entry and exit rate rises by 0.03% in the steady state distribution.

The changes in the cross-section from removing the repatriation tax have implications for economic aggregates. Following the reform, there are more firms, which have higher productivity in aggregate in the new steady state. In addition, more firms bring with them an increase in the U.S. capital stock of 1%. These effects combined yield a rise in domestic output, which outweighs the offshored export production, bringing an overall increase in U.S. GDP. U.S. firms become more profitable in the aggregate, leading to an increase in dividend distributions to households, which bolsters welfare. From a modelling viewpoint, these are effects that one can't get at in a standard representative firm framework. From a more general viewpoint, it makes sense to think that large incumbent U.S. multinationals are unlikely to adjust much in the way of real domestic activities in response to this policy reform.⁴ The real effects I report are driven by new multinationals and the re-allocation of resources away from less productive firms that only service the domestic market.

Dynamics are significant in the counterfactual exercise — merely comparing across steady states can lead one to over-state the effects of the policy reform. The adjustment to the cross-section of firms is gradual, making consideration of the transition path essential. Firms that export are larger and more productive on average than pure domestics. Exporters at the pinnacle of the productivity hierarchy are those that stand to benefit the most from changing their status to FDI to reap the variable cost savings with the tax re-

⁴This intuition squares with the results of Dharmapala, Foley, & Forbes (2011), who study the impact of the Homeland Investment Act of 2005. They found that, rather than boosting domestic investment as hoped, incumbent U.S. multinationals mainly paid-out their tax savings in the form of dividends.

form. These firms tend to hold large domestic pre-reform capital stocks in order to service both markets. Given that capital investment is subject to adjustment costs, these firms downsize gradually in the periods subsequent to the reform before expanding their operations overseas. This spills-over to adversely effect the U.S. labour market at the reform's impact: the domestic labour demand of these firms contracts faster than their capital stock, leading to downward-pressure on the U.S. wage. Although the measure of U.S. entrants jumps to 4% in the impact period, this effect's positive influence on labour is outweighed by the downsizing of productive exporters, yielding a 0.05% decrease in the domestic wage. The welfare gains are 0.2% when comparing across steady states, in contrast with 0.1% overall when also accounting for the transition path.

Financial frictions play an important role in shaping the effects of the reform in the counterfactual through their interaction with equilibrium effects. Firms that expand to become multinationals in a given period need to issue new equity to finance both their initial fixed and variable capital expenditures associated with their overseas subsidiaries. When equity issuance is costly, it increases the marginal cost associated with establishing the subsidiary's overseas capital stock. As a consequence, new multinationals tend to be smaller in size in the presence of the friction. Recall that the supply of U.S. goods to the overseas market increases when the repatriation tax is removed given the decrease in output losses from iceberg costs. This rise in supply is smaller in magnitude when equity issuance is costly, resulting in a smaller foreign price drop than in the friction's absence. The overseas price of U.S. goods falls by 0.6% when running the counterfactual without costly equity issuance, contrasting against the 0.4% drop when the cost is present. This larger price drop in the absence of the friction takes a greater toll on the profitability of exporting firms, causing them to cut-back more on their labour demand. The foreign output price drop pushes-back to a greater extent against the higher value to entering the industry, leading to a dampened increase in the mass of new entrants of 0.4%, in contrast with 1.4% with the friction. The equilibrium effects associated with the reform are weaker without costly equity issuance, causing the offshoring effect to outweigh the increased profitability effect. This leads to a decrease in the domestic wage and in welfare of -0.1% in the post-reform steady state.

This paper contributes to several different literatures. The first is that, which studies the interaction of firm heterogeneity, international policy reforms and selection effects. Studies in this area typically focus on the effect of trade liberalisation policies and find that they have a significant impact on the economy through changes in the cross-section. Melitz

(2003) studies the effect of trade reforms in a model with endogenous exit, domestic and exporter firm statuses. Helpman, Melitz, & Yeaple (2004) include an additional status for multinationals. Some more recent studies include Eaton, Kortum, & Kramarz (2011) and Antràs & Yeaple (2014). These papers study the impact of reforms targeted specifically at exporters. I contribute to this literature by instead focusing on reforms targeted at multinationals, an area in which there are relatively few papers. McGrattan & Prescott (2009), Burstein & Monge-Naranjo (2009) and Ramondo (2014) consider the gains from opening-up to FDI from foreign firms. Ramondo & Rodríguez-Clare (2013) study the interaction of openness to FDI and trade simultaneously to find that gains can be quantitatively large. McGrattan (2012) studies FDI openness reforms to find that, while there are gains to be realised in the long-run, there can be temporary declines in domestic activity in the transition. Papers in this area typically are static with heterogeneous firms or dynamic with representative firms. I add to the literature by bringing together both heterogeneity and dynamics.

The second area I contribute to is the quantitative trade literature that thinks about dynamics and asset accumulation. The traditional international trade firm selection models are static. Alessandria, Choi, & Ruhl (2014) develop a model where firms can invest in lowering their variable export costs and find that dynamics can lead to welfare gains from policies that would be supposed to lead to losses in a static context. Ruhl & Willis (2017) illustrate the importance of dynamics in accurately capturing the life-cycle of expansion of exporting firms. Fitzgerald, Haller, & Yedid-Levi (2016) consider a model where firms can learn over time about their idiosyncratic demand through investment in their customer base. Brooks & DAVIS (2019) think about dynamics, capital, the export decision and credit constraints in a dynamic Melitz (2003) framework. Ravikumar, Santacreu, & Sposi (2017) study capital accumulation along the transition path following trade liberalisation. This literature thus far has mainly focused on the domestic — export decision in a dynamic context; I add to this area of study by additionally accounting for the choice to be a multinational firm. Ramondo, Rodríguez-Clare, & Tintelnot (2015) find that the inclusion of multinationals in a calibrated model can substantially increase the gains from policy reforms than a model with trade only. In a similar spirit, I show that changes to the value of this additional discrete choice, through price effects, can have a quantitatively significant impact on the entire distribution of firms.

A third literature my paper speaks to quantifies the role of tax reform on aggregate productivity. Restuccia & Rogerson (2008) study the impact of taxes and more general

policies on output and measured TFP in the context of heterogeneous firms. A paper close to mine in methodology and general question is Gourio & Miao (2009) who study the impact of dividend and capital gains tax cuts in the context of a general equilibrium model with heterogeneous firms. Chen, Qi, & Schlagenhauf (2018) study the impact of corporate tax reform on productivity and employment. Acemoglu, Akcigit, Alp, Bloom, & Kerr (2018) consider innovation for productivity improvements and find the counter-intuitive result that taxes on R&D can lead to productivity gains from allocating skilled labour from low to high productivity firm types. I add to this literature with another counter-intuitive result: taxes levied on multinationals can serve somewhat of a protectionist role through keeping small and unproductive firms alive. A tax on the largest of firms has an impact on the smallest of firms through selection effects, which translates into a meaningful quantitative effect on aggregate productivity.

A fourth body of research that this work contributes to is the papers on structural corporate finance. An excellent review of this area of work is given in Strebulaev & Whited (2012). Studies in this area often seek to understand the financial frictions driving corporate financial policy with dynamic models. Riddick & Whited (2009) and Nikolov & Whited (2014) study the impact of various frictions on corporate cash holdings. Li, Whited, & Wu (2016) quantify the impact of collateral v.s. taxes on capital structure choices. These papers typically work in a partial equilibrium setup: they'll use simulated method of moments on a fixed number of firms and time periods to calibrate their models. A noticeable exception is Gomes (2001), who considers financial frictions in a general equilibrium context. I add to this literature by thinking about financial frictions and equilibrium effects in an open economy setting. Removing the repatriation tax in my model lends itself to a counter-intuitive result with regard to capital structure. Prior to the reform, U.S. multinationals would often defer repatriation of their overseas earnings and use them as collateral to raise borrowings domestically in order to minimise their tax obligation.⁵ Multinationals in my model can use such strategies — overseas capital is on the right-side of their collateral constraint. In a model without selection effects, it makes sense to think that aggregate borrowing by U.S. firms would decrease subsequent to the reform — U.S. multinationals would likely use repatriated overseas earnings in place of debt. In my model, the reform brings about more U.S. multinationals, meaning more firms with an overseas capital stock against which they can borrow. These firms expand their borrowing to take advantage of

⁵For instance, see a 2014 Bloomberg headline: “Apple Borrows \$12b in Bonds to Keep Cash Overseas” (Gangar & Robinson, 2014).

the debt tax shields: this expansion of borrowing outweighs the contraction from incumbent multinationals, leading to an increase in aggregate U.S. debt. This is a result that would not be attainable in a typical partial equilibrium context.

A fifth area of research I contribute to is a small body of work that aims to evaluate the impact of the repatriation tax on the behaviour of U.S. firms. In terms of the structural approach, Gu (2017) studies the interaction of repatriation tax reform, financial frictions and cash holdings in the context of a partial equilibrium model with a fixed number of firms. Curtis, Garin, & Mehkari (2017) study the anticipatory effects associated with news shocks surrounding removing the repatriation tax. Albertus, Glover, & Levine (2018) study how the tax and agency conflicts affect the overseas investment of incumbent U.S. multinationals. In the empirical context, Arena & Kutner (2015) study the effect of similar reforms in the context of the U.K. and Japan on the financial behaviour of their 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. The novelty of my paper 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 discusses a prologue model, which is designed to highlight the intuition for the selection effects and impact of financial frictions. Section III details the quantitative model used in the analysis. Section IV describes the calibration strategy and section V gives the results of the counterfactual; section VI concludes.

II Prologue Model: the Static Partial Equilibrium Case

The purpose of this section is to illustrate two things within the context of a simple model. The first is how tax reforms targeted at multinationals can affect the entire cross-section of firms through equilibrium effects. The second is to give an intuition for financial frictions interact with the equilibrium effects to shape the impact of these tax reforms. I illustrate the mechanisms by focusing specifically on the effects of removing the repatriation tax.

i Static Model without Financial Frictions

The model has two countries: Home (H) and Foreign (F) and this model is from the perspective of firms incorporated in the Home Country. The Home firms operate in a perfectly competitive environment as in Hopenhayn (1992) and select into different modes of servicing the two markets as in Helpman, Melitz, & Yeaple (2004). The government in the Home Country taxes corporate earnings at a rate of τ^C while that of the Foreign Government is denoted by τ^{C*} . I assume that $\tau^{C*} < \tau^C$ since the U.S. statutory rate was the highest in the OECD prior to the TCJA. The Home Government is also assumed to levy a repatriation tax rate denoted by $\tau^{C,U} = \tau^C - \tau^{C*}$ prior to the reform.

The Home firms receive idiosyncratic productivity shocks; conditional on their draw, they choose whether to exit the industry (E), operate as a pure domestic (D), an exporter (X) or a multinational (M). There is an exogenous demand for the goods made by these firms in Home and Foreign, which I assume are perfectly inelastic. The good sold in the Home Country is taken to be the numeraire, while there is an endogenously-determined price of goods in the Foreign Country denoted by P^{H*} . Productivity shocks are drawn from a uniform distribution: $\theta \in \mathcal{U}[\underline{\theta}, \bar{\theta}]$ and are applied to a production function of the form $y = \theta$, where y denotes their output in a given market. That is — the output of a firm who chooses to produce is equal to their productivity — they need not hire any factor inputs.⁶ I assume that the production functions used in Home and Foreign, for a given firm, are identical. There is a fixed and exogenous unit mass of firms operating in the industry and their objective is standard: to maximise the present expected value of dividends to shareholders net of taxes.⁷

Subsequent to their productivity draw at the start of the model, firms make a discrete choice with regard to their status. A firm that exits leaves the industry without operating. A domestic firm services only the Home market. Exporters and multinationals sell to both the Home and Foreign markets. Firms are required to pay a fixed cost along each extensive margin, in which they decide to operate. A purely domestic firm will pay fixed cost x^D , while exporters and multinationals pay additional costs x^X and x^M respectively.⁸ The

⁶The usual motivation for heterogeneous firms operating simultaneously in Hopenhayn (1992) models is decreasing returns to scale in production technologies. The setup here is a more extreme motivator for heterogeneity — each firm can only produce a fixed number of goods given by their draw of θ .

⁷I assume that all of the firms' shareholders are in the Home Country. IRS studies have shown that, in 2005, 13.9% of U.S. firm assets are owned by foreigners (Reuters, 2005). While this has implications for tax collections in the counterfactual, I abstract from it here since it's relatively small.

⁸I abstract from fixed costs of entry, prior to drawing θ here, as the model is partial equilibrium.

exporter-FDI trade-off is such that exporters incur a proportional iceberg cost associated with sending their goods abroad, while being a multinational involves a higher incremental fixed cost: $x^M > x^X$. The value to a firm's shareholders, conditional on their productivity draw, is given as

$$V(\theta) = \max[V^E(\theta), V^D(\theta), V^X(\theta), V^M(\theta)],$$

where $V^j(\theta)$ denotes the value of discrete choice $j \in \{E, D, X, M\}$ given the productivity draw. The conditional values are given by

$$\begin{aligned} V^E(\theta) &= 0 \\ V^D(\theta) &= -x^D + (1 - \tau^C)\theta \\ V^X(\theta) &= -x^D - x^X + (1 - \tau^C)\theta + (1 - \tau^C)(1 - i)P^{H*}\theta \\ V^M(\theta) &= -x^D - x^M + (1 - \tau^C)\theta + (1 - \tau^{C,U} - \tau^{C*})P^{H*}\theta \end{aligned}$$

where $i \in [0, 1]$ represents the iceberg cost associated with exporting goods. Each of the non-exit choices yield value equal to the upfront cost of investment plus the after-tax revenues from their production. A couple of things to notice: an exporter's income from selling abroad is entirely taxable by the Home Government since all the production takes place in their jurisdiction. For a multinational, their overseas earnings are taxed at two rates — τ^{C*} and $\tau^{C,U}$ — they pay taxes to the Foreign Government at the time the earnings are generated, then the Home Government taxes at the rate $\tau^{C,U}$ upon repatriation.⁹

Equilibrium in this model is defined as a scenario, in which all the firms are optimising and the markets for goods in each country clear — price P^{H*} adjusts endogenously to clear the Foreign market. I assume that the cost of moving up another discrete choice becomes more costly relative to the benefit to ensure non-zero regions for each status.¹⁰ A hierarchy of firms eventuates — the least productive exit, followed by pure domestics, exporters and multinationals. Figure 1 depicts the solutions pre-reform (top, with $\tau^{C,U} = \tau^C - \tau^{C*}$) and post-reform (bottom, with $\tau^{C,U} = 0$). Notice that the prices have subscripts $\tau^{C,U} = \tau^C - \tau^{C*}$ and $\tau^{C,U} = 0$ to denote that they are the clearing prices for the two respective cases. Each cut-off is equal to the incremental cost to benefit ratio of moving up another

⁹Notice that all the earnings are repatriated at the end of the period by a multinational and paid-out as dividends since the model is static.

¹⁰Details regarding the specific assumptions imposed are deferred to the appendix.

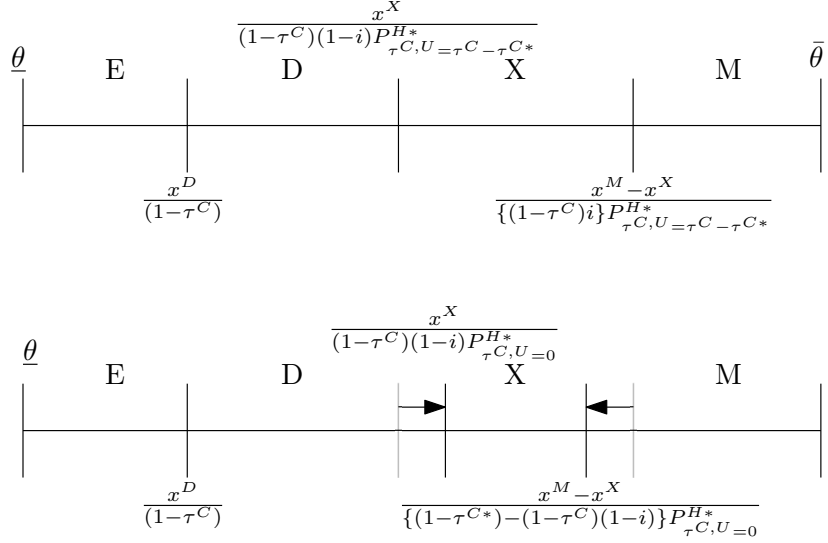


Figure 1: Removing the repatriation tax

discrete choice in the hierarchy.

The market clearing P^{H*} can be solved-for analytically in this model: it is shown in the appendix to be increasing in the repatriation tax levied by the Home Government. There are two effects associated with removing the repatriation tax on the cross-section. The first is a direct effect, which changes the nature of the exporter-multinational choice trade-off. The second is an equilibrium effect, which comes about through changes in the endogenous price P^{H*} .

For the first effect, when the tax is removed, the incremental benefit to being a multinational increases with all else constant. In addition to saving on their iceberg costs, firms that undertake FDI will also save on their tax bill relative to an exporter, causing a downward-movement of the corresponding productivity cut-off. When there are more multinationals, it means fewer firms incurring proportional iceberg costs — causing the supply of goods to the Foreign market to increase. This is the catalyst for the second effect — the price in the Foreign market decreases. This equilibrium effect dampens the rise in the multinational benefit, but also serves to affect firms on the margin between being domestics and exporters. A lower P^{H*} means a lower benefit to being an exporter over a domestic, shifting that cut-off upwards. Note that fewer Home exporters puts upward-pressure on P^{H*} ; since the firms that switch to FDI are more productive, this effect is outweighed however leading the price to fall.

Prior to the reform, the repatriation tax was only borne by multinationals — the most productive of firms in this environment. Many critics of this aspect of the TCJA have focused primarily on the likely behavioural effects on incumbent U.S. multinationals and postulate that real effects are unlikely to eventuate.¹¹ This prologue model with selection effects has two things to say about such a focus — the first is that it overlooks the impact on firms that are just below the FDI productivity cut-off. The switching effect of these firms can have significant implications for their profitability, as they save on export costs, or more generally are able to take advantage of lower overseas factor prices in production. This can be important for welfare, as their switching status will ultimately mean more value for U.S. shareholders.

The second comment is that focusing solely on incumbent multinationals totally misses the equilibrium effects on the cross-section. Those firms affected by this channel are much more grass-roots than Apple — in this prologue model they're less productive firms on the domestic-exporter margin — this reform has implications for their productivity. More generally though, this prologue model is in partial equilibrium: while it gets at price effects on the cross-section, it abstracts from features such as firm entry and the effect on domestic factor prices. To get at these equilibrium effects and assess their importance, a quantitative model is necessary, motivating the analysis through the model outlined in section III. Before going into details about the quantitative model though, the next subsection briefly explores the role of financial frictions in the context of this prologue model and shows how they can serve to amplify equilibrium effects.

ii Static Model with Financial Frictions

In this subsection, I assume that some fraction of Home firms (denoted $\omega \in [0, 1]$) need to finance their fixed investment cost using costly external financing; firms draw this binary financing shock (need external financing or need not) at the same time as their productivity shock. The financing premium is proportional to the size of the fixed costs the firms raise

¹¹For instance, see moss, who discusses the reforms in the context of Apple. The contention is that, since firms like Apple utilised aggressive tax-planning strategies prior to the reform, it's unlikely that removing the tax will spur domestic investment. Dharmapala, Foley, & Forbes (2011) empirically study the impact of temporary repatriation tax holidays and find little real effects when examining incumbent multinationals in an academic context.

at the start of the period as in Gomes (2001)

$$\zeta(e) = \zeta_1 e$$

for some $\zeta_1 > 0$ where e denotes the size of the external financing issuance. Firms that issue new financing will be referred to as *constrained firms* hereafter; the others will be referred to as *unconstrained firms*. In this augmented setup, constrained firms will have conditional value functions given by

$$\begin{aligned} V_C^E(\theta) &= 0 \\ V_C^D(\theta) &= (-x^D)(1 + \zeta_1) + (1 - \tau^C)\theta \\ V_C^X(\theta) &= (-x^D - x^X)(1 + \zeta_1) + (1 - \tau^C)\theta + (1 - \tau^C)(1 - i)\widehat{P}^{H*}\theta \\ V_C^M(\theta) &= (-x^D - x^M)(1 + \zeta_1) + (1 - \tau^C)\theta + (1 - \tau^{C,U} - \tau^{C*})\widehat{P}^{H*}\theta \end{aligned}$$

where the C subscript denotes constrained firms and the price goods sold in the Foreign market is denoted by \widehat{P}^{H*} to emphasise that it will be different to P^{H*} from the previous subsection. An unconstrained firm will have the same value functions as in the previous subsection, albeit with the alternative price. This external financing premium serves to increase the upfront cost borne by the constrained firms when they make non-exit discrete choices.

Figure 2 illustrates the difference in the discrete choices in the case without financial frictions (top) relative to the case with frictions for unconstrained (middle) and constrained (bottom) firms respectively. The frictions lead to considerably more heterogeneity in the distribution. The equilibrium market clearing price in the Foreign Country with financial frictions (\widehat{P}^{H*}) can be shown to satisfy the following

$$\widehat{P}^{H*} = P^{H*} \sqrt{1 + \omega(2\zeta_1 + \zeta_1^2)} \quad (1)$$

meaning that it is higher than the clearing price without frictions (P^{H*}) if $\omega > 0$ and $\zeta_1 > 0$.¹² The intuition stems from a re-allocation effect. Firms that are unconstrained incur lower upfront costs for each discrete choice. As a result, the productivity standard to service the Foreign market will be lower than for a constrained firm; firms on the

¹²N.B. figure 2 (and figure 3 to follows) substitutes out \widehat{P}^{H*} for equation 1 in the denominator of each cut-off to make comparison easier.

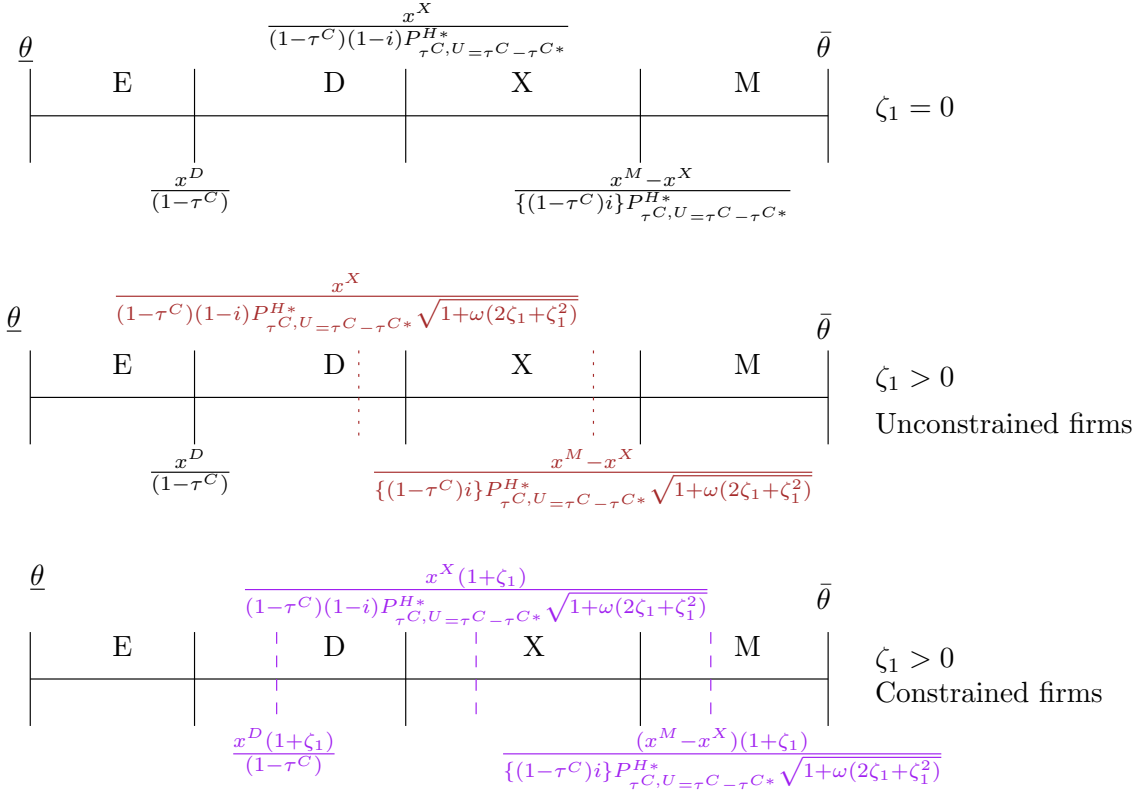


Figure 2: Equilibrium discrete choices with financial frictions

domestic-exporter margin that are unconstrained will produce less than their constrained counterparts. The presence of this financial friction leads to a re-allocation of resources from more towards less productive firms. Equation (1) illustrates the core of the motivation for including financial frictions in the quantitative model. These frictions have a bearing on the extent of the equilibrium effects that ensue as a result of these tax reforms targeted at multinationals.

Figure 3 shows the effect of the removing the repatriation tax on the cross-section of firms in this model. The cut-offs move in the same direction for both types of firms with frictions as without, albeit with asymmetric magnitudes. Constrained firms reap the greatest benefits of the tax removal, resulting in larger movements in their cut-offs than those for unconstrained firms. The re-shuffling of the firm cross-section, in addition to the size of the equilibrium effect from the policy change ultimately depend on the parameters ω and ζ_1 .

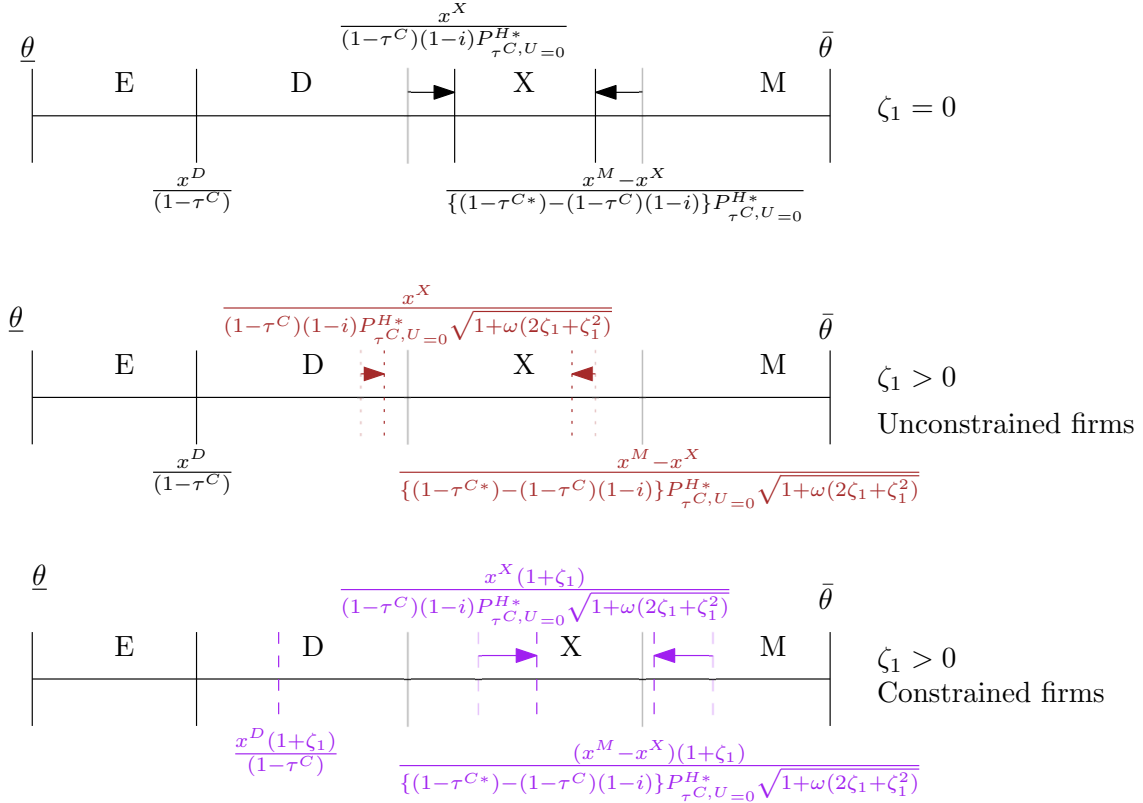


Figure 3: Removing the repatriation tax with financial frictions

The main takeaways from this prologue model are twofold. The first point to note is the importance of equilibrium and selection effects in evaluating this reform. A thorough evaluation of its effects requires the use of a model with several types of firms: not just large incumbent multinationals. The second takeaway is that financial frictions interact with these equilibrium effects. The model of section III that follows is guided by these insights and builds-off this prologue model with heterogeneity while incorporating additional ingredients for an effective quantitative study. The model is dynamic and adopts a rigorous approach to estimating the equilibrium effects through accounting for entry/exit in addition to domestic factor price movements. These are essential features for accurately capturing the effects of this reform on domestic productivity and GDP.

III Quantitative Model

The quantitative model is fully dynamic in discrete time for $t \in \{0, 1, 2, 3, \dots\}$. There are two countries: Home (H) and Foreign (F) and six types of agents, households, firms and government in each of the two countries. I assume that there are two varieties of goods: one made by the firms from each country; representative households in Home and Foreign have preference over each type of good. This preference for both varieties facilitates trade in the model. There are three markets in each country — Home goods, Foreign goods and labour — they are all assumed to be geographically segmented. In what follows, superscripts labelled $i \in \{H, F\}$ denote variables for firms incorporated the corresponding country. Variables with star superscripts correspond to the operations of firms in the Foreign Country, while those without are in the Home Country. For example, P^H (P^F) and P^{H*} (P^{F*}) are the prices of Home (Foreign) goods fetched in the Home and Foreign Countries respectively. All markets in each country are assumed to be perfectly competitive.

i Quantitative Model Environment

i.1 Households

i.1.1 Home Households

The representative household in the Home Country has a period utility function of the form $U(\mathcal{C}(C_t^H, C_t^F), L_t)$ where U denotes their utility, $\mathcal{C}(C_t^H, C_t^F)$ denotes an index of their consumption over Home goods (C_t^H) and Foreign goods (C_t^F) and $L_t \in [0, 1]$ denotes their supply of labour. The two types of consumption goods are aggregated and enter into their preferences through the function

$$\mathcal{C}(C_t^H, C_t^F) = [\lambda(C_t^H)^\eta + (1 - \lambda)(C_t^F)^\eta]^{\frac{1}{\eta}}$$

where $\lambda \in [0, 1]$ is some share of spending on the Home consumption goods and η is related to the Armington elasticity of substitution between the two varieties of goods by $1/(1 - \eta)$. The aggregated price of consumption goods faced by the Home household is given by

$$P_t = [\lambda^{\frac{1}{1-\eta}} (P_t^H)^{\frac{\eta}{1-\eta}} + (1 - \lambda)^{\frac{1}{1-\eta}} (P_t^F)^{\frac{\eta}{1-\eta}}]^{\frac{1-\eta}{\eta}}$$

where P_t^H represents the price of Home goods, (which is normalised to unity), P_t^F is the price of Foreign goods. The formal optimisation problem for the Home household is given by

$$\max_{C_t^H, C_t^F, L_t, D_{t+1}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{\mathcal{C}(C_t^H, C_t^F)^{1-\sigma}}{1-\sigma} + \chi(1-L_t) \right]$$

subject to the constraint

$$P_t^H C_t^H + P_t^F C_t^F + \mathbb{E}_t[Q_{t+1} D_{t+1}] = D_t(1-\tau^D) + W_t L_t(1-\tau^L)$$

where $0 < \beta < 1$ is the discount factor and $\chi \geq 0$ is the labour disutility parameter, σ is the coefficient of relative risk aversion, W_t is the wage rate and τ^L is the tax rate on labour income. Q_{t+1} is the stochastic discount factor for one period ahead payoffs for the household, D_{t+1} is the payoff in period $t+1$ of the portfolio held at the end of period t , (which includes shares in firms) and τ^D is a tax rate on dividend distributions to households.

i.1.2 Foreign Households

Rather than specifying a problem for the Foreign household, I instead take a more reduced-form approach for the purpose of simplicity. I assume that the Foreign household supplies labour perfectly elastically at the prevailing wage rate in the Foreign Country and that their demand for goods made by the Home firms is given by a demand curve along the lines of Hopenhayn (1992). It takes the form

$$Q^{D,H*} = \frac{Q^*}{P^{H*}}$$

for some constant $Q^* > 0$.¹³ I adopt this approach since the purpose of this paper is mainly to focus on the domestic effects associated with this policy reform. Specifying an exogenous demand curve still allows for intuitive price effects in the Foreign market without explicitly solving their optimisation problem.

¹³In earlier versions of this paper, I have incorporated a formal problem for the Foreign household. It doesn't significantly affect the results.

i.2 Firms

i.2.1 Home Firms

Home firms make choices each period regarding their extensive margin investment similarly to in the previous section; they choose whether to exit (E), be a pure domestic (D), an exporter (X) or a multinational (M).¹⁴ These choices involve various configurations of fixed capital and operational costs, (to be described later). Conditional on this choice, they are then able to invest in each country at the intensive margin through capital stocks. In what follows, I omit firm-level notation and superscripts $c \in \{H, H^*\}$ correspond to variables in the Home and Foreign Country for these firms respectively.

Fixed Costs

Firms incur fixed costs associated with their extensive margin choices. In particular, a new entrant firm will pay cost $x^N > 0$ as a fixed capital expenditure to enter the industry. Each period, a Home firm pays a fixed operating cost $x^{D,O} > 0$ associated with their Home operations. The first period, in which an incumbent firm opts to upgrade to become an exporter or a multinational firm, they pay another fixed capital investment, denoted by $x^X > 0$ and $x^M > 0$ respectively. From the next period onwards, they incur fixed operating costs associated with their export and FDI activities, denoted by $x^{X,O} > 0$ and $x^{M^*,O} > 0$ respectively. Notice the importance of the type of costs that are paid in terms of tax revenues — the operating costs are tax deductible while the capital expenditures are not. Moreover it's important to distinguish between these two types of fixed costs from the perspective of matching entry and exit rates out of each status in the calibration, (to be discussed later).

Technology

The Home firms produce using a decreasing returns to scale technology in each location, in which they choose to operate; they produce using labour and capital as factors in each location. A firm who is a domestic or an exporter will have a capital stock in the Home Country (denoted by k_t^H). A multinational will have an additional capital stock in the Foreign Country, (denoted by $k_t^{H^*}$). I assume a common productivity θ_t within a given

¹⁴Previous versions of this paper have also considered allowing for corporate inversions where U.S. multinationals re-incorporate abroad to avoid repatriation taxes. Including this option does not significantly affect the quantitative results. See appendix C for more details about how including this additional choice would affect the model setup.

firm across the two countries to keep the state space small. The productivity process for a given firm is

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

where $0 < \rho_\theta < 1$ captures persistence while $\sigma_\theta > 0$ measures volatility. The probability distribution function for the technology shock is denoted by $G(\theta_t|\theta_{t-1})$. The inputs and productivity value are combined through a production function of the form

$$y_t^c = \theta_t (n_t^c)^\gamma (k_t^c)^\alpha, \quad 0 < \alpha, \gamma < 1, \quad \alpha + \gamma < 1$$

where y^c denotes output produced in country c . The capital laws of motion for a multinational are given by

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

where i_t^c denotes investment at time t in $c \in \{H, H^*\}$ and $0 < \delta < 1$ represents the common depreciation rate. Moreover, should a firm opt to be a domestic for the period, its sole capital stock, k_t^H , will also follow the above. A firm that operates as an exporter is assumed to utilise the capital stock k_t^H twice for a given period.¹⁵ This setup is to capture the idea that there is one plant that a firm utilises in the Home Country for its goods to be sold at Home and abroad. As a result, their capital will depreciate twice for a given period

$$k_{t+1}^H = i_t^H - (1 - 2\delta)k_t^H.$$

Finally firms pay an adjustment cost for changing each of their capital stocks

$$\Phi^c(i_t^c, k_t^c) = \frac{\phi}{2} \left(\frac{i_t^c}{k_t^c} \right)^2 k_t^c,$$

¹⁵I have also tried other ways of specifying the exporter production process — specifically by assuming that they hold a separate capital stock for production of export goods. The interpretation of this alternative would be that exporters have two separate plants — one for production of domestically-sold goods and another for exported goods. This assumption seems far from reality however, in addition to adding another continuous state variable to the problem. Another alternative could be to assume that all of the exporter's production takes place at once and then some fraction of the output is sent overseas. The issue with this is that, given that firms are price takers in this model, this will expose exporters to corner solutions based on the size of P^H relative to P^{H^*} . It is possible in this scenario for exporters to never sell their goods domestically, which again does not seem to square very well with the real world.

which is of a standard convex form designed to preserve concavity of the firm period payoff function.

Stochastic Repatriation Tax Rate

I assume that the Home firms are exposed to idiosyncratic shocks to their repatriation tax rate under the worldwide system to capture the notion of anticipation of temporary repatriation tax reductions.¹⁶ Specifically, multinationals may find it optimal to save-up large amounts of earnings abroad in anticipation of a reduction in their effective repatriation tax rate in some future period. This feature is added to the model with an eye to avoiding over-stating the effects of the counterfactual results. Notice that this shock is assumed to be idiosyncratic to the firms, rather than an aggregate shock, for computational tractability.¹⁷ I denote the time-varying repatriation tax rate as $\tau_t^{C,U}$ and that rate is drawn from some transition function denoted by $Q_\tau(\tau_t^{C,U} | \tau_{t-1}^{C,U})$, (which will be discretised later).

Objective Function

The objective of the firms is to maximise the expected discounted value of dividends, net of personal dividend taxes, paid to shareholders in the Home country

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

where $0 < \beta < 1$ represents the discount factor of the household and d_t is the period t dividend it pays. The equity issuance premium is modelled as in Gomes (2001) such that the dividend cash flow from the firm to shareholders is given by

$$d_t = e_t - \mathbf{1}_{e_t < 0}[\zeta(e_t)]$$

where e_t is the dividend to households prior to the payment of equity issuance costs and $\zeta(e_t)$ is a convex function of the pre-cost dividend. The firm pays dividends to its shareholders when e_t is positive; when e_t is negative, it can instead be interpreted as a seasoned

¹⁶These temporary reductions were often referred to as “repatriation tax holidays”. One occurred through the Homeland Investment Act of 2004.

¹⁷Obviously it is more natural to think about such a shock as being common to all firms. Extending the model to this case will be very burdensome computationally and is an avenue for future research.

equity offering. In the negative case, the issuance cost is of the form

$$\zeta(e_t) = \zeta_0 + \zeta_1|e_t| + \zeta_2e_t^2$$

for $\zeta_0, \zeta_1, \zeta_2 > 0$, which says that the equity issuance premium is comprised of a fixed cost, a cost proportional to the size of the issuance in addition to a squared term.¹⁸ One can think of the cost as capturing factors such as floatation fees paid to underwriters in addition to information asymmetries.

Repatriations of Multinationals

A multinational Home firm will decide each period on how much to repatriate from, (or send to), its overseas subsidiary. Denote this variable by u_t , which is written as

$$u_t = (1 - \tau^{C*}) (P_t^{H*} \theta_t (k_t^{H*})^\alpha (n_t^{H*})^\gamma - W_t^* n_t^{H*} - x^{M*,O}) - i_t^{H*} - \Phi^{H*}(i_t^{H*}, k_t^{H*})$$

where positive values of u_t denote a dividend from the subsidiary to the parent and vice-versa. Notice that this expression says that the dividend is made up of the after-tax earnings of the subsidiary, less what it re-invests in its overseas capital stock and pays in adjustment costs. It fetches price P_t^{H*} on its output in Foreign and pays two types of operating costs — its overseas labour bill and its fixed operating cost.

Borrowing and Cash Holdings

The Home firms are assumed to be able to issue and hold riskless collateralised securities in the Home Country; I abstract from such holdings in the Foreign Country to keep the state space small.¹⁹ The control variable relevant to this decision for the firm is denoted by b_{t+1} : negative values denote cash holdings, while positive values resemble borrowings. The collateral constraint for borrowings follows Hennessy & Whited (2007). Specifically, I allow for firms to borrow up to some liquidation value of their capital stocks for next period

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

¹⁸The squared term allows one to pin-down an optimal interior solution for cash holdings of the firm.

¹⁹An alternative assumption could be to allow for defaultable debt and price the interest payments endogenously. This complicates the computational problem considerably and is left as an avenue for future research.

where $0 < \xi^c < 1$ for $c \in \{H, H^*\}$ is the liquidation value of the capital stock for given c . The right-side of the constraint says, in the case that the cash flows of the firm are sufficiently low, the firm can liquidate its assets to repay its debt obligations. The firm will have a capital stock for each country on the right hand side in the case that it's a multinational.

The firms borrow (save) at the riskless rate, denoted by $r > 0$, which is assumed to be exogenous.²⁰ The securities are obtained at a discount; firms choose the amount to pay-back (receive-back) in $t + 1$, b_{t+1} , and will receive (save) $b_{t+1}/(1 + r)$ at period t . In addition, they will receive tax benefits (pay tax costs) associated with the interest payments in the subsequent period of $b_{t+1} (1 - 1/(1 + r)) \tau^C$.

It is worth noting at this point that the firm's collateral constraint will be occasionally binding. The firm wants to borrow more to take advantage of the interest tax deductions, but it doesn't necessarily want to go all the way up to the constraint out of fear of increasing its equity costs next period. The more it borrows at t means the more it must repay at $t + 1$; if it gets a low productivity shock, the added borrowing at t might put further strain on its financing costs at $t + 1$.

Period Dividends to/from Shareholders

In what follows, denote $s_{t-1} \in \{M, X, D\}$ as representing the status of the firm in period $t - 1$: I define this variable to keep track of when a firm has/still needs to pay its capital expenditure to be an exporter or multinational. The period t dividend for a firm operating as a multinational is given by

$$\begin{aligned} e_t^M = & (1 - \tau^C) (P_t^H \theta_t (k_t^H)^\alpha (n_t^H)^\gamma - W_t n_t^H - x^{D,O}) - i_t^H - \Phi^H(i_t^H, k_t^H) \\ & + \left\{ \mathbb{1}_{u_t \geq 0} \left(\frac{1 - \tau_t^{C,U} - \tau^{C*}}{1 - \tau^{C*}} \right) + \mathbb{1}_{u_t < 0} \right\} u_t - (1 - \mathbb{1}_{s_{t-1}=M}) x^M \\ & + \frac{b_{t+1}}{1 + r} - b_t + b_t \left(1 - \frac{1}{1 + r} \right) \tau^C \end{aligned}$$

where if the firm was not a multinational at period $t - 1$, $(1 - \mathbb{1}_{s_{t-1}=M}) x^M = x^M$, meaning that they pay the capital expense to become a multinational at t . Notice also that the term involving tax rates multiplies the repatriations only when they are positive. In the event that the parent sends the subsidiary funds, the tax multiplier is omitted given that

²⁰I assume that borrowings are supplied to these firms perfectly elastically at the prevailing interest rate for simplicity.

such payments are not tax deductible. This dividend function says that the payout to shareholders of a multinational is comprised of the earnings it generates at Home, less what it re-invests in its Home capital and adjustment costs, plus the distributions it receives from the subsidiary (net of taxes) plus the cash flow from its debt financing activities. Notice the tax term that hits the repatriated earnings is divided by one less the Foreign corporate rate to levy the repatriation tax, $\tau_t^{C,U}$ on the firm's pre-tax earnings. A firm who chooses to be an exporter is faced with the following expression for their period dividends

$$\begin{aligned} e_t^X &= (1 - \tau^C) (P_t^H \theta_t (k_t^H)^\alpha (n_t^H)^\gamma - W_t n_t^H - x^{D,O}) - i_t^H - \Phi^H(i_t^H, k_t^H) + \\ &\quad (1 - \tau^C) (\{1 - i\} P_t^{H*} \theta_t (k_t^H)^\alpha (n_t^X)^\gamma - W_t n_t^X - x^{X,O}) - (1 - \mathbb{1}_{s_{t-1}=X}) x^X \\ &\quad + \xi^{H*} k_t^{H*} + \frac{b_{t+1}}{1+r} - b_t + b_t \left(1 - \frac{1}{1+r}\right) \tau^C. \end{aligned}$$

where the price fetched from export income is equal to P_t^{H*} rather than P_t^H as it's sold abroad. Also notice that the tax rate on export income is given by the Home corporate tax rate — exporting firms do not have Foreign subsidiaries — meaning that they are unable to minimise their tax burden on such income through deferral. The revenue that the exporting firms receive from abroad is scaled by $(1 - i)$ to account for the iceberg cost associated with sending the goods to the Foreign Country. Finally, should the firm come into the period with some overseas capital for the period, they can downsize and liquidate it and receive $\xi^{H*} k_t^{H*}$. The period dividends for a purely domestic firm are given by

$$\begin{aligned} e_t^D &= (1 - \tau^C) (P_t^H \theta_t (k_t^H)^\alpha (n_t^H)^\gamma - W_t n_t^H - x^{D,O}) - i_t^H - \Phi^H(i_t^H, k_t^H) \\ &\quad + \xi^{H*} k_t^{H*} + \frac{b_{t+1}}{1+r} - b_t + b_t \left(1 - \frac{1}{1+r}\right) \tau^C. \end{aligned}$$

Finally the period dividends for a Home firm that chooses to exit the industry is given by

$$e_t^E = \xi^H k_t^H + \xi^{H*} k_t^{H*} - b_t,$$

which is simply the liquidation value of their capital stocks after repayment of their debt obligations from last period. Notice that this amount will always be weakly positive on account of the firms' collateral constraint for borrowing.

i.2.2 Foreign Firms

Foreign firms produce are assumed to be homogeneous; there is assumed to be a representative firm for simplicity. They produce using a very simple constant returns to scale production function of the form

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

where Y_t^{F*} represents output and N_t^{F*} is labour they hire. The optimisation problem they solve is given by

$$\max_{\{N_t^{F*}\}} (1 - \tau^{C*}) [P_t^{F*}(Y_t^{F*} - X_t^*) + (1 - i)P_t^F X_t^* - W_t^* N_t^{F*}]$$

where X_t^* represents the amount of goods exported to the Home Country. The price these firms fetch for their output in each market is determined competitively and then taken as given by the Foreign firms: P^F and P^{F*} are their prices for the goods in the Home and Foreign Countries respectively. The earnings these firms generate are taxed at the Foreign domestic corporate tax rate.²¹ The shareholders of this representative Foreign firms are the Foreign household.

i.3 Government

i.3.1 Home Government

The Home Government has four sources of tax revenue: Home corporate taxes, Home repatriation taxes, dividends and labour. The amount of revenue they raise for a given period is as follows

$$P_t^H T_t = \tau^C (P_t^H Y_t^H - W_t N_t^H - \chi^{D,O}) + \tau^C (\{1 - i\} P_t^{H*} Y_t^X - W_t N_t^X - \chi^{X,O}) \\ + \tau^{C,U} U_t + \tau^D D_t^+ + \tau^L W_t L_t - B_t \left(1 - \frac{1}{1+r}\right) \tau^C$$

where T_t is their aggregated tax collections, Y_t^H is production by Home firms, N_t^H is labour hired by Home firms for production of domestic goods, Y_t^X is production by exporting Home firms, N_t^X is labour hired by Home firms for production of export goods, U_t is aggregate

²¹It is clear to see that these firms will generate zero earnings due to the assumption of constant returns to scale and competition. Nonetheless, I include the tax payment to the Foreign Government for completeness.

repatriations by Home firms and D_t^+ is aggregate dividends paid to Home households. The aggregate operating costs from domestic and export operations are denoted by $\chi^{D,O}$ and $\chi^{D,X}$ respectively. B_t denotes aggregate borrowing by Home firms: the term it's involved in denotes the aggregate debt tax shields the Government pays. I assume that the Home Government is unable to issue sovereign bonds to keep the problem parsimonious.

i.3.2 Foreign Government

The Foreign Government is assumed to have two sources of tax income — their domestic corporate taxes and personal taxes. The expression for their tax revenues is given by

$$\begin{aligned} P_t^{F*} T_t^* = & \tau^{C*} [P_t^{F*} (Y_t^{F*} - X_t^*) + \{1 - i\} P_t^F X_t^* - W_t^* N_t^{F*}] \\ & + \tau^{C*} (P_t^{H*} Y_t^{H*} - W_t^* N_t^F - \chi^{M*,O}) + \tau^{L*} W_t^* L_t^* \end{aligned}$$

where T_t^* is tax collections by the Foreign Government, Y_t^{H*} is aggregate production by Home multinationals in the Foreign Country, N_t^F is aggregate labour hired by Home firms in Foreign and $\chi^{M*,O}$ are aggregate operating fixed costs of Home multinationals.

i.4 Timing

Here the timing for Home firms in period t is described

- (1) Incumbents enter the period with state $(k_t^H, k_t^{H*}, b_t, \theta_{t-1}, \tau_{t-1}^{C,U})$.
- (2) Incumbents draw new exogenous shocks: θ_t and $\tau_t^{C,U}$.
- (3) Incumbents make extensive margin decision.
- (4) Incumbents make intensive margin decisions.
- (5) Entrants pay a fixed cost to enter.
- (6) Entrants make intensive margin decisions; are incumbents from $t + 1$ onward.

ii Quantitative Model Equilibrium

In this subsection, I describe the equilibrium behaviour of agents in the quantitative model. Notice that I leave time subscripts on all of the variables, as opposed to dropping them in the recursive formulations for Home firms. I follow this approach since I consider the

transition dynamics between steady states, as opposed to just comparing steady states themselves, in the counterfactual exercise later.

ii.1 Households

ii.1.1 Home Households

Given that there are no aggregate shocks in the model, the problem of the household boils-down to an entirely static program of the form

$$\max_{C_t^H, C_t^F, L_t} \frac{\mathcal{C}(C_t^H, C_t^F)^{1-\sigma}}{1-\sigma} + \chi(1-L_t)$$

subject to the constraint

$$P_t^H C_t^H + P_t^F C_t^F + D_t^- = L_t W_t (1 - \tau^L) + D_t^+ (1 - \tau^D)$$

where D_t^+ are positive dividends received by the household from the firms and D_t^- are new cash injections from the household to the firms. These variables D_t^+ and D_t^- are aggregate variables across all of the Home firms. The optimal split between expenditures on Home and Foreign goods are given by

$$C_t^H = \lambda \left[\frac{P_t^H}{P_t} \right]^{\frac{1}{\eta-1}} C_t$$

$$C_t^F = (1 - \lambda) \left[\frac{P_t^F}{P_t} \right]^{\frac{1}{\eta-1}} C_t.$$

Given an interior solution to the problem, the optimal aggregate variables are

$$C_t = \frac{W_t}{\chi P_t} [1 - \tau^L]$$

$$L_t = \frac{1}{W_t (1 - \tau^L)} \left[\frac{W_t}{\chi} [1 - \tau^L] + D_t^- - D_t^+ (1 - \tau^D) \right]$$

while those for a corner solution are

$$C_t = \frac{W_t}{P_t} L_t (1 - \tau^L) + \frac{1}{P_t} [E_t^+ (1 - \tau^E) - E_t^-]$$

$$L_t = 1.$$

ii.2 Firms

ii.2.1 Incumbent Home Firms Recursive Formulation

Denote the state vector of an incumbent firm by $\vec{\varphi}_t = (k_t^H, k_t^{H*}, b_t, \theta_t, \tau_t^{C,U})$. Then letting the firm's value function be denoted by $V_t(\vec{\varphi}_t)$, it's formal expression is given by

$$V_t(\vec{\varphi}_t) = \max_{s \in \{M, X, D, E\}} V_t^s(\vec{\varphi}_t)$$

where the index s is over all the potential discrete choices the firm can make at time t . The optimal discrete choice is a discrete policy function, which I'll denote by $s_t(\vec{\varphi}_t) \in \{M, X, D, E\}$. The firm's solution to this extensive margin decision will be a set of cut-off productivity levels, which will be functions of its other state variables. The difference of this model from the simple two period model of section II is that the discrete choices of the firm will now depend its entire state, (not θ_t). The value of the firm choosing to be a multinational this period is given by

$$V_t^M(\vec{\varphi}_t) = \max_{\{k_{t+1}^H, k_{t+1}^{H*}, b_{t+1}\}} d_t^M(\vec{\varphi}_t) + \beta \mathbb{E}_t[V_{t+1}(\vec{\varphi}_{t+1})]$$

$$\begin{aligned} d_t^M(\vec{\varphi}_t) &= e_t^M(\vec{\varphi}_t) - \mathbb{1}_{e_t^M(\vec{\varphi}_t) < 0} \zeta(e_t^M(\vec{\varphi}_t)) \\ e_t^M(\vec{\varphi}_t) &= (1 - \tau^C) (P_t^H \theta_t (k_t^H)^\alpha (n_t^H)^\gamma - W_t n_t^H - x^{D,O}) - i_t^H - \Phi^H(i_t^H, k_t^H) \\ &\quad + \left\{ \mathbb{1}_{u_t(\vec{\varphi}_t) \geq 0} \left(\frac{1 - \tau_t^{C,U} - \tau^{C*}}{1 - \tau^{C*}} \right) + \mathbb{1}_{u_t(\vec{\varphi}_t) < 0} \right\} u_t(\vec{\varphi}_t) - (1 - \mathbb{1}_{s_{t-1}(\vec{\varphi}_{t-1})=M}) x^M \\ &\quad + \frac{b_{t+1}}{1+r} - b_t + b_t \left(1 - \frac{1}{1+r} \right) \tau^C \\ u_t(\vec{\varphi}_t) &= (1 - \tau^{C*}) (P_t^{H*} \theta_t (k_t^{H*})^\alpha (n_t^{H*})^\gamma - W_t^* n_t^{H*} - x^{M*,O}) - i_t^{H*} - \Phi^{H*}(i_t^{H*}, k_t^{H*}) \\ i_t^H &= k_{t+1}^H - (1 - \delta) k_t^H \\ i_t^{H*} &= k_{t+1}^{H*} - (1 - \delta) k_t^{H*} \\ b_{t+1} &\leq \xi^H k_{t+1}^H + \xi^{H*} k_{t+1}^{H*}. \end{aligned}$$

The Bellman equation says that the value associated with the FDI choice is the period dividend plus the discounted continuation value. The choices of controls — debt and the two capital stocks — are subject to capital accumulation and borrowing constraints. The

Bellman equation for an exporter is given by

$$V_t^X(\vec{\varphi}_t) = \max_{\{k_{t+1}^H, i_t^H, b_{t+1}\}} d_t^X(\vec{\varphi}_t) + \beta \mathbb{E}_t[V_{t+1}(\vec{\varphi}_{t+1})]$$

$$\begin{aligned} d_t^X(\vec{\varphi}_t) &= e_t^X(\vec{\varphi}_t) - \mathbb{1}_{e_t^X(\vec{\varphi}_t) < 0} \zeta(e_t^X(\vec{\varphi}_t)) \\ e^X(\vec{\varphi}_t) &= (1 - \tau^C) (P_t^H \theta_t (k_t^H)^\alpha (n_t^H)^\gamma - W_t n_t^H - x^{D,O}) - i_t^H - \Phi^H(i_t^H, k_t^H) \\ &\quad + (1 - \tau^C) (\{1 - i\} P_t^{H*} \theta_t (k_t^H)^\alpha (n_t^X)^\gamma - W_t n_t^X - x^{X,O}) - (1 - \mathbb{1}_{s_{t-1}=X}) x^X \\ &\quad + \xi^{H*} k_t^{H*} + \frac{b_{t+1}}{1+r} - b_t + b_t \left(1 - \frac{1}{1+r}\right) \tau^C \\ i_t^H &= k_{t+1}^H - (1 - 2\delta) k_t^H \\ b_{t+1} &\leq \xi^H k_{t+1}^H. \end{aligned}$$

The choices of an exporter's control variables are again subject to capital accumulation and debt constraints. Notice though that the capital stock they choose in the Home Country is utilised twice — one for domestic good sales and again for export goods — meaning that the capital stock depreciates twice. If the firm chooses to be a pure domestic, its value is given by

$$V_t^D(\vec{\varphi}_t) = \max_{\{k_{t+1}^H, i_t^H, b_{t+1}\}} d_t^D(\vec{\varphi}_t) + \beta \mathbb{E}_t[V_{t+1}(\vec{\varphi}_{t+1})]$$

$$\begin{aligned} d_t^D(\vec{\varphi}_t) &= e_t^D(\vec{\varphi}_t) - \mathbb{1}_{e_t^D(\vec{\varphi}_t) < 0} \zeta(e_t^D(\vec{\varphi}_t)) \\ e^D(\vec{\varphi}_t) &= (1 - \tau^C) (P_t^H \theta_t (k_t^H)^\alpha (n_t^H)^\gamma - W_t n_t^H - x^{D,O}) - i_t^H - \Phi^H(i_t^H, k_t^H) \\ &\quad + \xi^{H*} k_t^{H*} + \frac{b_{t+1}}{1+r} - b_t + b_t \left(1 - \frac{1}{1+r}\right) \tau^C \\ i_t^H &= k_{t+1}^H - (1 - \delta) k_t^H \\ b_{t+1} &\leq \xi^H k_{t+1}^H. \end{aligned}$$

Finally, if the firm chooses to exit, it has associated value

$$V_t^E(\vec{\varphi}_t) = \xi^H k_t^H + \xi^{H*} k_t^{H*} - b_t,$$

which is simply the difference between liquidation values and debt obligations. The solution to the recursive formulation yields policy functions for the discrete choice and optimal control variables for investment in each country in addition to capital structure.

ii.2.2 Entrant Home Firm Recursive Formulation

A new entrant comes into the period after paying its fixed capital expenditure x^N , (where variables with N superscripts correspond to entering firms). It then proceeds to decide on how much to invest in a capital stock in the Home Country and how to finance it. Notice that I don't allow entrants to invest as multinationals to prevent the model from over-stating the entry effects of the policy change. The recursive formulation for a new entrant is thus given as follows

$$\begin{aligned} V_t^N &= \max_{\{k_{t+1}^H, i_t^H, b_{t+1}\}} -i_t^H - x^N + \frac{b_{t+1}}{1+r} + \beta \mathbb{E}_t^N [V_{t+1}(\vec{\varphi}_{t+1})] \\ i_t^H &= k_{t+1}^H \\ b_{t+1} &\leq \xi^H k_{t+1}^H. \end{aligned}$$

Notice that the value function V_t^N is not state dependent since all entrants come into the model identically. The continuation value of the firm is comprised of the discounted expected value of being an incumbent in the next period conditional on the choices it makes at t . The expectation operator is taken with respect to the distributions associated with entrants initial draws, denoted by \mathbb{E}_t^N .

ii.2.3 Foreign Firms

The simple setup for the representative Foreign firm yields FOCs that give the following relationships between wages and prices

$$\begin{aligned} P_t^{F*} &= W_t^* \\ (1-i)P_t^F &= P_t^{F*}. \end{aligned}$$

ii.3 Recursive Competitive Equilibrium

For the sake of brevity, I defer the formal definition of the recursive competitive equilibrium to the appendix. The equilibrium is such that agents in the model are optimising, budgets

balance and markets clear; the value to being a Home entrant firm is zero. There is a cross-sectional distribution of firms across their state variables, which I denote by $\mu_t(\vec{\varphi}_t)$. There is also an equilibrium measure of new entrants into the model, which I denote by \mathcal{M}_t^T . In the limit, there is convergence to a stationary competitive equilibrium, (steady state), where aggregate variables are all unchanging.

IV Calibration of Quantitative Model

In this section, details regarding the calibrated parameter values and the computational methods used are discussed in detail. One period in the model is calibrated to be a year. To estimate the parameters, I calibrate the pre-reform steady state of the model to match moments in the data.

i Parameters Calibrated Outside the Model

To reduce the computational burden associated with the model estimation, I select 26 parameters outside the model by drawing directly on data and other sources. Table 1 gives the specific parameter values that were calibrated outside of the model.

The exogenous interest rate at which the firms' riskless debt is borrowed is the average annualised T-bill rate over the sample period, which gives a rate of around 4.98%. The firm discount rate is then found using this estimate for the interest rate in addition to the expression $1/(1+r)$ to get a value a little above 0.95. The parameter η is chosen such that the Armington elasticity of substitution between varieties of goods in the Foreign Country is around 2. This value sits within the relatively wide range of values found in the literature, which seeks to estimate this elasticity, (for more details see Ruhl et al. (2008)). To keep the model computations simple, I set the labour disutility parameter equal to zero, thereby abstracting from the consumption-leisure tradeoff. The coefficient of relative risk aversion is set to unity: doing so means that evaluating a policy reform simply amounts to studying the implied change in consumption.

Name	Variable	Value	Source
Interest rate	r	0.05	T-bill rate
Discount factor	β	0.95	$1/(1+r)$
Variety parameter	η	0.50	Standard
Coefficient of relative risk aversion	σ	1.00	Standard
Labour disutility	χ	0.00	Standard
Share parameter	λ	0.50	Standard
Capital share	α	0.30	Gomes (2001)
Labour share	γ	0.65	Gomes (2001)
Depreciation rate	δ	0.15	Compustat
Technology persistence	ρ_θ	0.87	OP (1996) reg.
Technology standard deviation	σ_θ	0.32	OP (1996) reg.
Home corporate tax	τ^C	0.35	U.S. rate
Foreign corporate tax	τ^{C*}	0.30	G7 average
Home dividend tax	τ^E	0.15	U.S. rate
Home labour tax	τ^L	0.32	OECD (2018)
High Home repatriation tax	$\tau_H^{C,R}$	0.05	Statutory rate
Low Home repatriation tax	$\tau_L^{C,R}$	0.00	Tax holiday
$\tau_t^{C,U}$ transition probability (L, L)	$Q_\tau(\tau_L^{C,R}, \tau_L^{C,R})$	0.00	HIA
$\tau_t^{C,U}$ transition probability (L, H)	$Q_\tau(\tau_L^{C,R}, \tau_H^{C,R})$	1.00	HIA
$\tau_t^{C,U}$ transition probability (H, L)	$Q_\tau(\tau_H^{C,R}, \tau_L^{C,R})$	0.20	HIA
$\tau_t^{C,U}$ transition probability (H, H)	$Q_\tau(\tau_H^{C,R}, \tau_H^{C,R})$	0.80	HIA
Home firesale fraction	ξ^H	0.59	HW (2007)
Foreign firesale fraction	ξ^{H*}	0.59	ξ^H
Foreign demand parameter	Q^*	0.98	$P^{H*} = 1$
Iceberg cost	i	0.04	OR (2000)
Foreign wage	W^*	0.65	OECD data

Table 1: Parameters selected outside the model

The production function parameters are chosen such that the function of Home firms have slightly decreasing returns to scale. As in Gomes (2001), I set the production function parameters to sum to a number just less than one to be consistent with estimates of decreasing returns found by Burnside (1996). I set γ to be equal to the labour share in the data of 0.65 and α to 0.3, giving a sum of 0.95. The depreciation rate is taken from Compustat; it is found as the average of depreciation relative to assets over firms; it's estimated to be around 0.15. The parameters for the technology process are estimated using Compustat by using the Olley & Pakes (1992) (OP hereafter) procedure for estimating

firm-level productivities. The estimated parameters from these regressions yield ρ_θ and σ_θ as being equal to 0.90 and 0.32. These two parameter values are relatively standard and consistent with the literature. I then discretise the productivity process using these parameters using the Adda, Cooper, & Cooper (2003) method such that there are 15 productivity values in the model. New entrants receive draws from the ergodic distribution over productivity.

The U.S. domestic corporate tax rate is set equal to the rate of 35%, while the dividend rate is set as 15% — the pre-reform statutory rates.²² I take the Foreign Country’s corporate tax rate to be around 30%, which is the average corporate tax rate of the G7 countries. This then yields a statutory repatriation tax rate of 5%. The labour tax rate in the Home Country is taken from an OECD (2018b) report, which states that the average single worker in the United States faced a tax wedge of 31.7%.

I discretise the stochastic process for the repatriation tax to have two values — a high tax rate ($\tau_H^{C,R}$) and a low one ($\tau_L^{C,R}$). I choose the two rates to be the statutory rate and a zero rate respectively, to resemble normal times and tax holidays pre-reform along the lines of the Homeland Investment Act (HIA) of 2004. I select the transition probabilities such that a holiday can not be experienced for more than one period in a row and there is a 20% chance of a holiday during normal times. These probabilities are selected with the idea that a holiday comes roughly once every five years for a firm and that pressures/constraints on policymakers will prevent two tax holidays in a row. For new entrants, I set the respective probabilities to also be 20%-80%.

For the liquidation fraction in the Home Country, ξ^H , I take the same value estimated in Hennessy & Whited (2007) (HW), of 0.529. I choose to fix this parameter outside of the model rather than calibrating inside given that it’s likely that the calibration process will have some difficulty identifying $x^{D,O}$ and ξ^H both separately inside the model. This concern arises from the fact that ξ^H and $x^{D,O}$ both have an important bearing on the choice for firms to exit the industry in a given period. Given that ξ^H is a fraction, it is more reasonable to take this value as fixed and determine $x^{D,O}$ within the model. The liquidation parameter on the Foreign and export capital stocks are assumed to be the same as ξ^H for simplicity. I choose the foreign demand curve parameter such that the market clearing price of Home goods in Foreign is equal to one; the same as P^H , so that the fixed

²²Since I am only evaluating the removal of the repatriation tax, I keep these rates constant in the counterfactual exercise.

cost estimates aren't excessively large or small.²³

A conservative value for the iceberg export cost fraction, i , of 3.8% is chosen. I interpret this parameter as representing a transport cost and as a consequence, take this value from Obstfeld & Rogoff (2000) (OR) as the average value weighted freight cost for U.S. exports. I choose to fix this parameter outside of the model, as it is likely that the internal estimation procedure would have difficulty identifying it separately from the fixed operating and capital expenditures associated with being an exporter.

Due to the computational complexity of this problem, I choose to treat some of the prices in the model as fixed rather than determining them endogenously.²⁴ In particular, I choose to fix the wage rate in the Foreign Country to be 65% of that in the Home Country in the calibration exercise.²⁵ I arrive at this value using the OECD statistics database on average annual wages across member nations. This value less than one seems reasonable, as it gets at the idea that wages are relatively high in the U.S. Notice also that this low overseas wage captures this notion of U.S. firms outsourcing labour-intensive tasks to places where the input is cheaper. Given the simple problem associated with the representative Foreign firm, this assumption regarding W^* then gives implied values for P^F and P^{F*} endogenously.

ii Parameters Calibrated Inside the model

The remaining ten parameters, denoted by $\Theta = (x^N, x^X, x^M, x^{D,O}, x^{X,O}, x^{M*,O}, \phi, \zeta_0, \zeta_1, \zeta_2)$ are calibrated inside the model to match ten data moments. I draw on two main sources to generate the data moments. The first is a study by Nayar, Flaaen, Boehm, et al. (2016), which uses U.S. Census data to document transition probabilities and fractions of firms operating within each of the extensive margin statuses I have in this paper. The second is Compustat for generating financial moments and investment rates. Table 2 gives the parameters calibrated from within the model and their estimates in addition to the moments chosen for their identification.

The moments to be matched are chosen with a view to shed light on the corresponding parameter of interest. The fixed costs are adjusted to match firm dynamics moments. The

²³This approach does not lead to substantially different counterfactual results to using a Foreign household with endogenous decisions.

²⁴These computational concerns are associated with the curse of dimensionality. Every additional price that the model tries to pin-down endogenously increases number of loops exponentially.

²⁵In the counterfactual experiment, I keep this foreign wage rate fixed as it is assumed to be exogenous to the U.S. firms' and government's actions.

operating expenditures target the transition probabilities of staying within a particular status. For instance, $x^{X,O}$ is calibrated to match the probability of an exporter remaining as such next period. A higher value of the parameter makes it more likely that a firm, within that status who receives a low productivity shock, will exit. The capital expense fixed costs are chosen to match the transition probabilities between statuses. For example, x^M is adjusted to match the transition probability of a domestic firm upgrading to undertake FDI. The fixed cost of entry, x^N , is calibrated to the entry and exit rate of U.S. firms.

The financing parameters are chosen to match equity issuance moments. The fixed cost ζ_0 matches the frequency of equity issuance; should that parameter rise, the corresponding moment would be expected to decrease. The proportional cost ζ_1 matches the average equity issuance to book ratio and the squared coefficient ζ_2 matches the second moment of the issuance distribution. Finally the adjustment cost coefficient for investment ϕ is calibrated to match the average investment ratio in the data.

The calibration procedure is executed with the following objective function in mind

$$J(\Theta) = [\Pi^d - \Pi^s(\Theta)]'W[\Pi^d - \Pi^s(\Theta)],$$

Π^d are the moments in the data and $\Pi^s(\Theta)$ are the simulated moments from the model's pre-reform stationary equilibrium and W is a positive definite weighting matrix. I choose to set the weighting matrix equal to the identity, such that this objective function simplifies-down to the sum of squared deviations of the model moments from those in the data.

Before turning to discuss the estimated values of the parameters, it is worth taking some time to discuss how changes in the parameters in Θ change the objective function $J(\Theta)$. Given that the model solves for equilibrium, changes in parameters will typically lead to very moderate changes in the objective. For example, an increase in x^M would result in a decrease in the value associated with upgrading to become a multinational for an incumbent firm. Given that new entrants receive the expected value associated with an incumbent value function in the period following their entry, this will result in a decline in the value to entering the industry. So that the free entry condition is satisfied, the equilibrium wage in the equilibrium will increase. Moreover, a smaller supply to the Foreign output market causes P^{H*} to rise, partially mitigating the downward pressure on multinational activity induced by the higher fixed cost. Similar reasoning can be applied to variations in the other parameters. Ultimately, these equilibrium effects on the prices serve to ensure that the objective function is well-behaved, preventing small changes in

the parameters from inducing extreme changes in $J(\Theta)$. Notice however that the objective function is non-linear, meaning that exact matching of moments can be difficult, especially given that they are solved for simultaneously.

Name	Variable	Value	Moment Targeted
x^N	Fixed CAPEX for entry	0.48	Exit/entry rate
x^X	Fixed CAPEX for exporter	0.70	Transition probability (D,X)
x^M	Fixed CAPEX for multinational	1.30	Transition probability (D,M)
$x^{D,O}$	Fixed OPEX for domestic	0.30	Transition probability (D,D)
$x^{X,O}$	Fixed OPEX for exporter	0.21	Transition probability (X,X)
$x^{M*,O}$	Fixed OPEX for multinational	1.17	Transition probability (M,M)
ζ_0	Equity issuance cost	0.05	Fraction of firms issuing equity
ζ_1	Equity issuance cost	0.02	Mean issuance to book ratio
ζ_2	Equity issuance cost	0.01	Std. dev. issuance to book ratio
ϕ	Adjustment cost scaling	0.05	Mean investment to book ratio

Table 2: Parameters matched inside the model

The estimates for the fixed costs in table 2 can be best understood by comparing their relative magnitudes. The fixed capital expenditures required for becoming an exporter is 1.5 times the magnitude of entering as a domestic firm, while that of becoming a multinational is 2.7 times larger. The incremental fixed operating cost of being an exporter is actually smaller than the domestic operating cost, being around 2/3 of its size. Finally the operating cost of being a multinational is considerably larger than that of a domestic, being around 4 times larger.

In terms of financing, the results show a significant fixed, proportional and squared cost associated with issuing new equity. The fixed equity issuance cost is around 1/6 the size of the fixed operating expense to be a domestic firm. This magnitude seems sensible from the perspective that a firm with a relatively low productivity shock, which is forced to issue new equity, would only find it optimal to do so if the fixed cost was relatively small. The proportional issuance cost is around 2% of the size of the equity issuance and the squared coefficient sits at around half the magnitude of the proportional cost. Finally the adjustment cost parameter is relatively small in magnitude, which is likely driven by the presence of the two capital stocks for firms in the model.

Data Transition Probabilities				
t/t+1	Domestic	Exporter	Multinational	Exit
Domestic	84.62	5.41	0.03	9.93
Exporter	13.14	80.69	0.84	5.32
Multinational	0.27	1.86	91.75	6.13
Entrant	85.95	12.89	1.18	
Model Transition Probabilities (* targeted moments)				
t/t+1	Domestic	Exporter	Multinational	Exit
Domestic	76.90*	6.05*	0.07*	17.33
Exporter	10.69	85.21*	4.10	0.00
Multinational	14.70	0.00	85.30*	0.00
Entrant	95.00	3.91	1.09	

Table 3: Transition probabilities

iii Fit of the Model to the Data

Table 3 contrasts the transition probabilities in the data, taken from Nayar et al. (2016) against those of the calibrated model. Numbers inside the table under the model probabilities denoted with a * superscript were targeted in the calibration procedure. Separation of the operating and capital investment fixed costs allows the model to closely match the persistence of each status. Recall that the calibration procedure returned the result that $x^{X,O} < x^{D,O}$. This may be driving the over-persistence in the exporter status and over-exiting of domestic firms. The model does a good job of hitting the transitions to multinational status and persistence.

The model has difficulty hitting the exit rates for exporters and multinationals, instead grouping all of the exits into the domestic category. There are however some transitions from being a multinational or exporter down to a domestic firm. These non-domestics with low productivity shocks likely downsize before exiting the industry entirely. This may be due to the relatively low equity issuance costs that came out of the calibration procedure: it may be more profitable for these firms to issue new equity for a period and withstand the low productivity shock for a time before exiting.

Table 4 shows the summary statistics associated with the remaining moments that were targeted, in addition to some further non-targeted moments. The model generally does a good job of fitting the data. The fraction of firms issuing equity sits at around 1/3 of the firms in the model, while the mean and standard deviation of the equity issuance size

Targeted Moment	Data (%)	Model (%)
Fraction of firms issuing equity	33.14	30.14
Mean equity issuance to book ratio	5.60	4.52
S.D. of equity issuance to book ratio	21.41	20.92
Mean investment to book ratio	5.80	8.32
Exit rate	9.55	8.75
Untargeted Moment	Data (%)	Model (%)
Productivity advantage (X over D)	38.80	37.45
Productivity advantage (M over D)	53.70	48.21
Mean debt to book ratio	18.77	23.22
S.D. of debt to book ratio	41.01	37.89
Fraction of exporting (X) firms	15.64	23.02
Fraction of multinational (M) firms	5.60	7.12

Table 4: Summary statistics

are 4.5% and 20% respectively. These financing moments, in addition to the exit rate, are slightly lower in the model than the data: possibly indicating that the fixed capital expense associated with entry may be slightly over-estimated. That is — a lower entry cost would result in a higher equilibrium domestic wage, which may lead to more equity issuances and exits from the model.

The model is able to capture the division between exporting and multinational firms: with the fraction of the former comprising about 3 times the population of the latter in the distribution. Moreover, the productivity advantages of exporters and multinationals over pure domestic firms are well-approximated as non-targeted moments. Overall, the model is approximating moments relating to capital structure and firm dynamics appropriately, indicating that it will likely give reliable estimates of the policy reform given the main channels of effect.

V Quantitative Results: Removing the Repatriation Tax

In this section, the results of the policy reform are examined. The pre-reform scenario is with a positive repatriation tax — where firms can draw the statutory rate and temporary zero rate stochastically. The post-reform scenario is with the rate set at zero forever. The analysis proceeds in two stages. Firstly I report the results, coming from a comparison across the two steady states — giving an idea of the long-run effects of the policy change.

Secondly I report the transition path between the two. Recall that the pre-reform statutory rate in the calibration is set to 5%.

i Steady State Results

This section compares the stationary equilibria pre and post-reform. I proceed by describing the cross-sectional effects and then the aggregate effects in turn.

i.1 Cross-Sectional Results

Pre-Reform Transition Probabilities				
t/t+1	Domestic	Exporter	Multinational	Exit
Domestic	76.90	6.05	0.07	17.33
Exporter	10.69	85.21	4.10	0.00
Multinational	14.70	0.00	85.30	0.00
Entrant	95.00	5.00	0.00	
Post-Reform Transition Probabilities				
t/t+1	Domestic	Exporter	Multinational	Exit
Domestic	76.40	6.05	0.09	17.42
Exporter	10.75	85.25	4.00	0.00
Multinational	14.60	0.00	85.40	0.00
Entrant	95.00	5.00	0.00	

Table 5: Transition probabilities pre and post reform

Table 5 illustrates the transition probabilities between all of the different statuses for U.S. firms both pre and post reform. The reform increases the persistence associated with the multinational status by 0.1%, while decreasing the tendency of these firms to downsize to domestics by the same amount. The reform makes future earnings look more lucrative to incumbent multinationals; a larger region of the state space find it optimal to maintain their FDI status in the face of adverse productivity shocks. Notice also that the transition probability for domestic firms at time t to multinational at $t + 1$ has also increased by 0.02%. This means that, should an incumbent multinational downsize today, there is a higher probability that they will seek to return to FDI status in the future. The persistence of the multinational status increases as these incumbents seek to avoid paying the FDI capital expense again, which recall is 11% higher than the operating expense of FDI.

Interestingly, the persistence of the exporter status also increases by 0.04%, as similarly does the transition from exporter to domestic by 0.06%. At the same time, the transition from exporter to multinational decreases by 0.10%. At first glance, this result seems somewhat counter-intuitive. More firms are undertaking FDI, but the lower price in the foreign market makes it less likely that a new multinational would have had exporter status in a previous period. These firms find it less profitable to upsize given that there is more strain on their cashflow situation in the given period. Instead these firms are more likely to downsize in the current period, operate as a domestic firm for a period of time and then upgrade to FDI status in the future. The fraction of domestic firms at time t who exit increases by 0.09% due to the higher operating costs from the increased wage. Finally notice that the behaviour of entering firms is unchanged as these firms seek to expand their capital stock domestically to bolster their cash flow base before expanding to undertake FDI.

Moment	Pre-reform	Post-reform
Fraction of firms issuing equity	30.14	29.25
Mean equity issuance to book ratio	4.52	4.23
S.D. of equity issuance to book ratio	20.92	24.18
Mean investment to book ratio	8.32	8.18
Entry/exit rate	8.75	8.78
Productivity advantage (X over D)	37.45	37.33
Productivity advantage (M over D)	48.21	48.02
Mean debt to book ratio	23.22	23.65
S.D. of debt to book ratio	37.89	38.92
Fraction of exporting (X) firms	23.02	22.90
Fraction of multinational (M) firms	7.12	7.24

Table 6: Summary statistics pre and post reform

Table 6 depicts the pre and post reform summary statistics for the remaining moments mentioned in the calibration section. The policy reform has relatively strong implications for the cross-section of financing of U.S. firms. As a whole, they become less reliant on equity financing, both in terms of frequency (down by around 0.9%) and size (down by around 0.3% in magnitude). When the tax is removed, repatriated overseas earnings can be drawn upon without triggering tax losses to the U.S. Government. When a multinational parent is in need of additional financing domestically, it displaces part of its equity issuance with repatriations, thereby reducing the average issuance size and frequency.

Firm Status	Change (%)
Multinational	-0.17
Exporter	0.01
Domestic	0.03
Exiters	0.09

Table 7: Percentage changes in average productivity

In contrast, the distribution of issuance sizes becomes considerably more dispersed with the reform, as the standard deviation of the issuance to book ratio increases by a little under 4%. This effect is related to the switching of firms at the extensive margin. There is a 0.12% increase in the fraction of multinationals in the steady state. This means more firms incurring the higher fixed operating expense each period. Moreover, the productivity advantage for multinationals decreases by 0.19% — the average multinational is less productive. Smaller and less productive firms close to the margin, that would have been operating with a different status pre-reform need to undertake larger equity issuances to keep their overseas subsidiaries.

The policy change leads to an increase the mean leverage ratio of U.S. firms by 0.43%, coupled with a rise in the standard deviation by around 1%. This comes with a decrease in the average investment ratio by 0.14%. More firms operating as multinationals means more firms with overseas capital stocks, against which they can borrow. These firms at the upper-end of the distribution, who upgrade to become multinationals, will significantly increase their borrowing. However, smaller and less productive firms that remain domestics or exporters face a higher wage in the U.S. This higher wage reduces the marginal productivity associated with domestic investment, overall reducing the investment ratio and thereby lowering their own incentives for borrowing. This leads to an increase in the spread of the leverage distribution.

Table 7 illustrates the changes that take place to average productivity levels across each firm status. The fraction of multinational firms increases from 7.12% to 7.25%, which comes about due to a lower productivity standard for the status; the average productivity falls by 0.17%. In contrast, the fraction of exporters decreases, as it's squeezed at both the top and bottom ends of the distribution due to more FDI and lower Foreign output prices respectively. Moreover, the entry and exit rate increases by 0.03% due to the higher entry effect. As a result, the productivity standard for exporters, domestics and exiting firms increases by 0.01%, 0.03% and 0.09% respectively.

i.2 Aggregate Results

Variable	Change (%)	Variable	Change (%)
Measure of U.S. firms	1.39	Productivity	1.18
U.S. wage	0.23	Net repatriations	-1.35
Foreign output price	-0.44	Parent cash	-2.35
Domestic capital	1.01	Parent equity issuance	1.94
Foreign capital (U.S. firms)	2.34	Parent debt	2.48
Domestic output	0.40	Dividends	0.68
Exports	-0.30	U.S. Government taxes	-0.05
Foreign output (U.S. firms)	1.15	U.S. Welfare	0.18

Table 8: Percentage changes in aggregate variables.

Table 8 presents the percentage changes in aggregate variables across the pre and post reform steady states. To give the reader an idea of how the policy change affects the entrant's problem, I consider removing the repatriation tax while holding the prices/wages in the model constant (results not shown). Doing so causes the value to being an entrant to increase by around 4% of the fixed capital expense to enter, x^N . While entering firms can not opt to be multinationals right away, they can in the periods subsequent to their entry. This increase in value is spurred by higher continuation value associated with being a U.S. firm. The entry effect results in around a 1.4% increase in the mass of U.S. firms in the new steady state.

The rise in the fraction of firms undertaking FDI, combined with the entry effect leads to an increase in the measure of U.S. multinationals by 2.8%. Given the increase in supply of goods to the overseas market, this brings with it a decrease in the price of U.S. goods in Foreign by 0.4%. This lower Foreign price partly absorbs the increase in entry value associated with the tax removal. As an additional exercise for intuition, if I remove the tax with the new steady state Foreign price while holding the U.S. wage rate constant at the pre-reform value, the value to entering increases by 1.3% of the fixed entry cost. Given that the value gains were only partly offset by the Foreign price effects, the U.S. wage increases by 0.2% to bring the economy back to equilibrium.

More entrants into the industry bring with them a boom in the U.S. capital stock of around 1%. The increase in multinationals and decrease in the fraction of exporters causes overseas output by U.S. firms to increase by 1.1%, while export production declines by 0.3%. The higher wage drives some of the small and unproductive firms at the bottom-end

of the distribution out of the new steady state, this lends itself to a 1.2% increase in the productivity of U.S. firms. The higher productivity result, combined with a larger domestic capital stock results in an overall increase in U.S. output by 0.4%. Higher profitability of U.S. firms induces a rise in dividend distributions to shareholders of 0.7%.

Recall that one of the main arguments of opponents against this aspect of the TCJA was that giving U.S. firms more incentive to be multinationals would lead to outsourcing of production. The firms that switch from being exporters to multinationals in the wake of the reform are relatively productive; their departure brings with it a substantial degree of job destruction. However these results suggest that, quantitatively, the increase in the measure of U.S. firms, coupled with their higher overall level of productivity, lead to an overall increase in GDP and the domestic wage. Although this is evidence that pushes-back against this outsourcing of U.S. output idea, it is important to recall that there are no labour market frictions in this model.²⁶ Looking at the changes in wages and dividends gives a basic understanding of the direction, in which inequality moves a result of this reform. Although both workers and shareholders stand to benefit, the greater increase in dividends seems to skew the balance of inequality towards the latter.

The policy change induces a reduction in cash holdings by U.S. parents of 2.3%. This result agrees with those of previous studies, which have found that the presence of the repatriation tax has generally pushed U.S. firms towards holding more cash. Gu (2017), for example, found that the average cash to book ratio in the cross-section decreases in the face of this reform. Through my account of equilibrium effects, I can speak to how aggregate cash holdings are affected by this reform; the result is quite large quantitatively.

As more firms expand to become multinationals the aggregate level of net repatriations actually decreases by 1.3%: U.S. firms end up sending more funds to their overseas subsidiaries to establish their own capital stocks and start producing. With this overseas expansion, there arises a greater need overall for external financing for firms' capital expenditures. Both equity and debt issuance increase in the aggregate, by 1.9% and 2.5% respectively; the proportional increase in debt use is considerably larger than that of equity. This follows from the frictions present in the model: borrowing creates more value for firms due to lower tax payments, while issuing new equity triggers the issuance pre-

²⁶In my model, it is assumed that the workers displaced from export producers can easily re-allocate their labour towards working for the newly-entered firms. Adding labour market frictions, which would make these re-allocations imperfect, would generate sets of workers who stand to gain and others who stand to lose from this reform.

mium. However as new multinationals start to mature post-reform, internally-generated funds from their subsidiaries can be repatriated without triggering the repatriation tax, mitigating the need for new equity.

With this policy reform, the U.S. Government loses repatriated earnings as a source of revenues. A more considerable loss, however, is associated with the offshoring of export production as firms move towards FDI. These two sources of losses are almost offset by increased dividend and labour earnings taxes. In addition, the gains in productivity mean that U.S. firms that service the domestic market are generating more in the associated corporate tax revenues. All these gained revenues push-back to lead to approximate revenue neutrality. Moreover, these positive domestic activities are good from the perspective of the U.S. household. They are better-off as workers and they are better-off as shareholders in the U.S. firms. Welfare rises by around 0.2% in consumption equivalents.

i.3 Decomposition: Quantifying the Role of Financial Frictions

This subsection runs the steady state counterfactual with all parameters held constant except the costly equity issuance parameters. I set $\zeta_0 = \zeta_1 = \zeta_2 = 0$ and compare the corresponding pre-reform steady state with that post-reform. Comparing these counterfactual results with those with positive issuance costs gives an idea of how the financial frictions interact with the equilibrium effects of the model. Table 9 contrasts the aggregate counterfactual results with and without costly equity issuance. The second column in the table compares the aggregate variables pre-reform and post-reform, both of which are solved with $\zeta_0 = \zeta_1 = \zeta_2 = 0$, but all other parameters held constant. The third column re-writes the results of the previous subsection for ease of comparison.

The contrast in quantitative results across the two scenarios is quite striking. Recall that the policy reform induces selection effects along two key dimensions: more multinationals and a higher level of entry. The results of table 9 illustrate that the presence of financial frictions dampens the latter effect, while amplifying the former. Without financial frictions, the measure of U.S. firms increases by 0.4%, in contrast with 1.4% with. The level of exports and foreign output by U.S. firms decrease and increase by 0.4% and 2.5% respectively, which contrast against the corresponding values of 0.3% and 1.2% in the case with frictions.

Firms that expand to undertake FDI place considerable strain on their financial structure in the period of their status change — to such an extent that they need to issue new

equity. In addition to financing the fixed capital expense of FDI, they also need to obtain funds to invest at the intensive margin in their overseas capital stock. The presence of financial frictions increases the marginal cost of overseas capital for these expanding firms. The overseas capital stock increases by a much larger magnitude without frictions — 5.2% — in contrast with 2.3% with. A larger expansion along the FDI dimension drives larger price effects in the Foreign Country — the price of U.S. Goods in Foreign falls by 0.6% without frictions, contrasting against 0.4% in the case with frictions.²⁷

Variable	Change (%) ($\zeta_0 = \zeta_1 = \zeta_2 = 0$)	Change (%) ($\zeta_0, \zeta_1, \zeta_2 > 0$)
Measure of U.S. firms	0.36	1.39
U.S. wage	-0.05	0.23
Foreign output price	-0.62	-0.44
Domestic capital	0.26	1.01
Foreign capital (U.S. firms)	5.21	2.34
Domestic output	0.18	0.40
Exports	-0.42	-0.30
Foreign output (U.S. firms)	2.46	1.15
Productivity	0.31	1.18
Net repatriations	-0.46	-1.35
Parent cash	0.00	-2.35
Parent equity issuance	1.03	1.94
Parent debt	0.18	2.48
Dividends	0.10	0.68
U.S. Government taxes	-0.08	-0.05
U.S. Welfare	-0.12	0.18

Table 9: Percentage changes in aggregate variables with $\zeta_0 = \zeta_1 = \zeta_2 = 0$.

The larger decrease in the price of U.S. goods in Foreign in the case without frictions pushes-back against the domestic entry effects. Although removal of the tax still increases the option value of a new entrant becoming a multinational in future, the larger overseas price contraction causes a significant decrease in the value of expanding to become an exporter. Recall that the positive domestic labour market effects associated with this reform were driven by entry offsetting offshoring export production. The dampened increase in

²⁷Recall that the prologue model of section II derived the result that the change in P^{H*} would be larger in the presence of frictions. The opposite result here in the quantitative model stems from the inclusion of variable costs through capital stocks.

the measure of entrants leads to the offshoring effect to dominate quantitatively, leading to a 0.05% decrease in the U.S. wage.

The smaller entry effect means lower productivity gains — measured productivity increases by 0.3% in the case without frictions relative to 1.2% in the case with. These lower productivity gains lead to smaller rises in domestic output and dividend distributions, realising values of 0.2% and 0.1% in the case without frictions, relative to 0.4% and 0.7% in the scenario with. The culmination of the lower wage and smaller rise in distributions from firms leads to a decrease in U.S. welfare of 0.1%. The results of this subsection speak clearly to the debate regarding the efficacy of this aspect of the TCJA. Taking an off-the-shelf model of firm dynamics and selection (without financial frictions) leads one to side with the opponents of the reform. Consideration of financial frictions amplifies the equilibrium effects and brings about higher U.S. welfare. These results highlight the importance of paying attention to financial frictions when evaluating policy reforms — they have the potential to switch the direction of results and dramatically change the conclusions drawn.

ii Transition Dynamics

In this section, I describe the transition from the pre-reform steady state through that post-reform. I divide it up into three subsections — the first describes the design of the simulation — with particular emphasis on the timing of events and the equilibrium definition. The following two subsections show how cross-sectional and aggregate variables transition respectively.

ii.1 Design of Simulation

The announcement of the policy change and subsequent transition from the pre-reform steady state is described here in the context of the model’s timing outlined in subsection i.4 of section III. Announcement of the policy change takes place in period $t = 0$ to be effective from time $t = 1$ onwards; the model is assumed to converge to the post-reform steady state by period $t = 10$. Coming from the pre-reform steady state in period $t = -1$, the following sequence of events transpires in period $t = 0$:

- (1) Incumbents enter the period with state $(k_0^H, k_0^{H*}, b_0, \theta_{-1}, \tau_{-1}^{C,U})$.
- (2) Incumbents draw new exogenous shocks: θ_0 and $\tau_0^{C,U}$.
- (3) Incumbents make extensive margin decisions.

- (4) Incumbents make intensive margin decisions.
- (4') Policy reform is announced to be effective period $t = 1$ onwards.
- (5) Entrants pay a fixed cost to enter.
- (6) Entrants make intensive margin decisions; are incumbents from $t = 1$ onward.

From period $t = 1$ onwards, the sequence of events each period is the same as above without event (4'). The placement of event (4') is chosen in light of the one period time delay with regard to new entrants: recall that they pay their costs and make their investment decisions one period before commencing production as incumbents. The announcement taking place before event (5) means that new entrants coming into the model in period $t = 0$ are the first to respond to the policy change.

Two variables are affected by the reform in period $t = 0$: the policy functions for new entrants in addition to the measure of such firms. Notice that the behaviour of incumbent firms in the period is unaffected since their choices are sunk. Given that new entrants coming into the model in $t = 0$ are not participating in production or labour markets, prices and wages for the period will equilibrate markets based on the actions of incumbent firms. The behaviour of all agents in the economy are affected by the reform from $t = 1$ onwards. Prices, wages and the measure of new entrants in each time period adjust to ensure that the value to being an entrant is always zero and that markets always clear.

ii.2 Cross-Sectional Results

Figure 4 shows how the composition of domestics, exporters and multinationals change subsequent to the reform's announcement. These figures illustrate the changes in the fraction of firms in the cross-sectional distribution, relative to the corresponding fraction in the pre-reform steady state. For example, the post-reform steady state fraction of multinationals is 7.24%, which is 1.69% higher than the pre-reform fraction of 7.12%.

The reform is effective period $t = 1$ onwards. The implementation period sees a stark re-shuffling in the cross-section of U.S. firms: the fraction of multinationals increases by 1% and those for exporters and domestics decrease by around 0.1% and 0.2% respectively relative to the pre-reform steady state. Notice the contrast in shape of the paths followed by exporters and domestics: the majority of the overall decline in domestics takes place in the impact period, while the drop in exporters is more gradual. The intuition for this difference stems from capital accumulation and adjustment costs.

A firm that exports will have a relatively large U.S. capital stock for the purpose of production for both markets prior to the reform. For them to switch to multinational status in a single time period is expensive given that adjustment costs are increasing in the size of their investment and dis-investment. As a consequence, it is more profitable for an exporter to gradually reduce its domestic capital stock and expand to become a multinational in the subsequent periods. In contrast, a relatively productive pure domestic would find it somewhat easier to expand for FDI in the impact period, since they need not undertake such a dramatic scaling-down of domestic operations. Switching by pure domestics to multinational status drive the majority of the spike in FDI at $t = 1$. The gradual increase of the fraction of multinationals from its impact to post-reform steady state value is then driven predominantly by exporters switching status.

These results highlight the importance of thinking about the effects of policy reforms on firm selection in a dynamic context. See how these results contrast with the static prologue model of section II. In a static context with only productivity heterogeneity: the policy reform causes some firms that were previously exporters to undertake FDI. In the dynamic context, these firms are still predicted to switch, but their response is delayed due to adjustment costs.

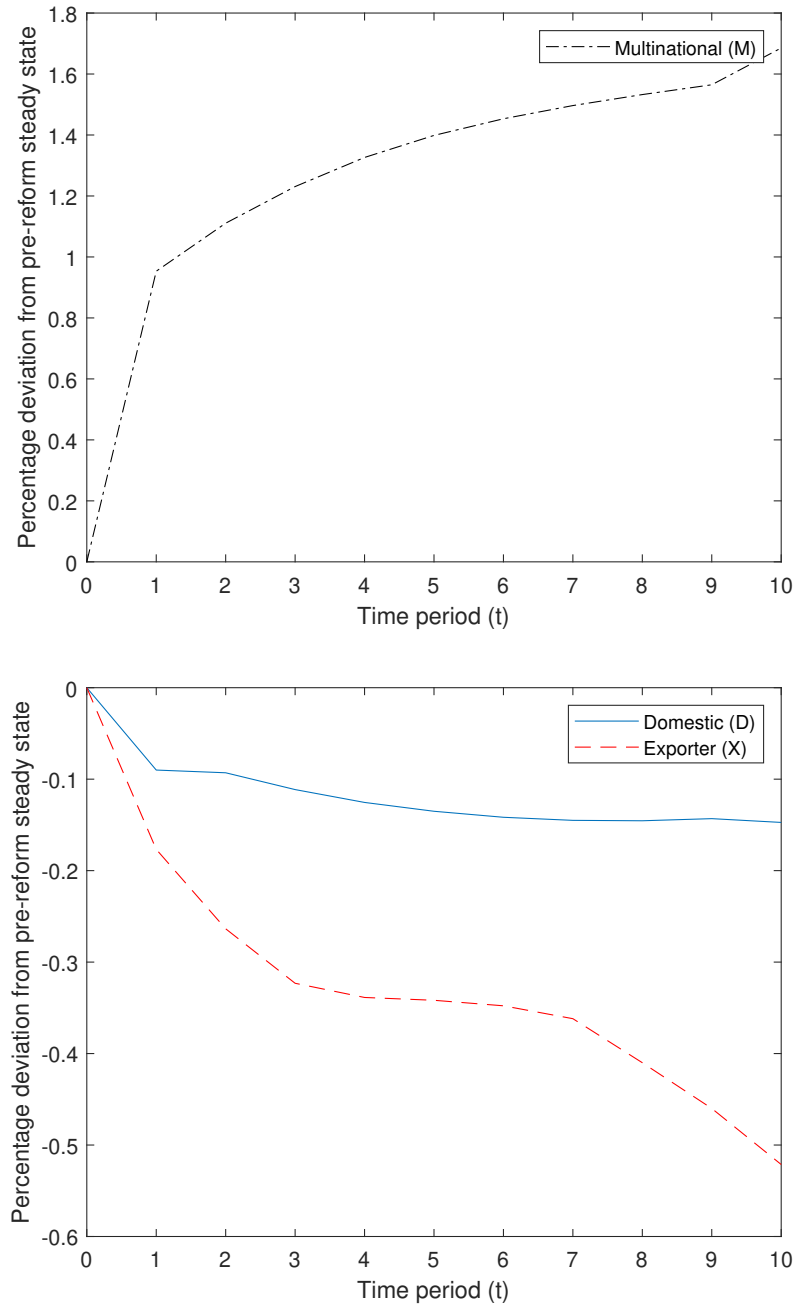


Figure 4: Transitions of the cross-section: fractions of firms in $\{M, X, D\}$ statuses

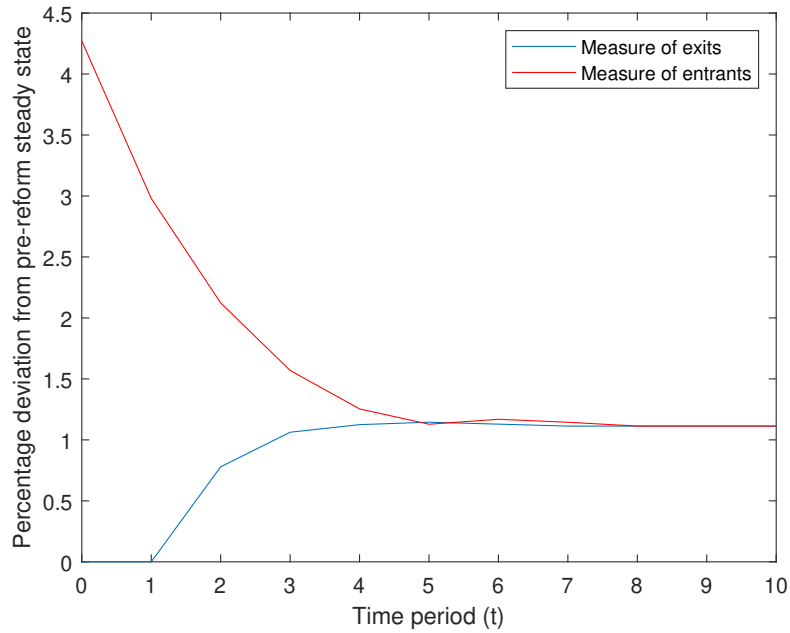


Figure 5: Transition of measures of entrants and exits

ii.3 Aggregate Results

Figure 5 neatly summarises the equilibrium effects associated with removing the repatriation tax along the transition path. In the period of announcement, $t = 0$, the measure of new entrants in the U.S. jumps dramatically to around 4.2% as these firms anticipate higher profitability associated with U.S. FDI in the periods subsequent. In the periods that follow, the measure declines gradually over time before settling at a little over 1% of its pre-reform steady state value. The measure of exiting firms responds somewhat slowly and gradually rises before coinciding with the measure of entrants at around $t = 5$ to form the new steady state.

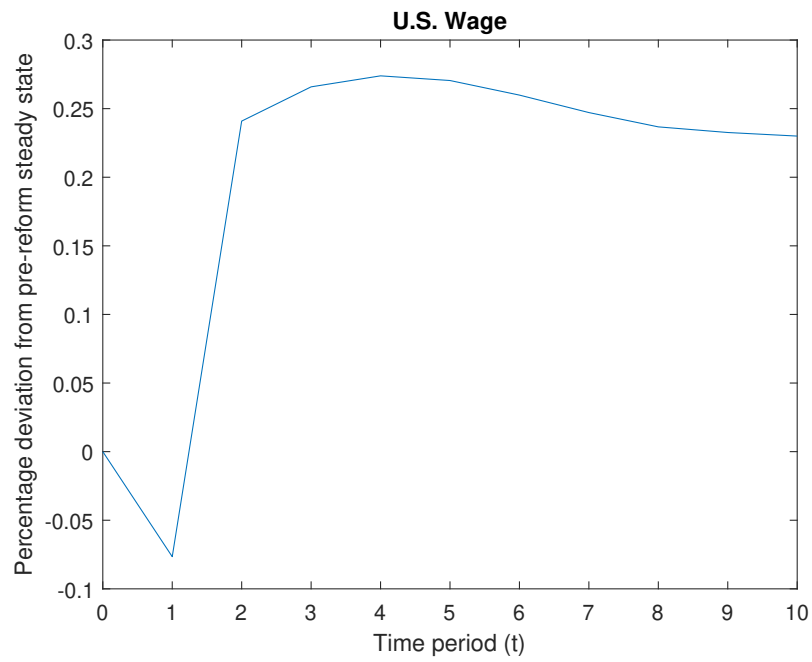


Figure 6: Wage and price transitions

Figure 6 depicts the transitional dynamics of the domestic wage and price of U.S. goods sold in Foreign. In the first period of impact, the U.S. wage drops to a value -0.05% below the pre-reform steady state. This follows from the evolution of the cross-section of firms that service the overseas market. The change of U.S. exporters to multinational status is not instantaneous on account of the capital adjustment costs. These firms start to downsize in $t = 1$, reducing their domestic labour demand as they seek to expand abroad in the period subsequent. This constitutes a temporary change in the input mixture of these downsizing firms — they move away from labour and more towards capital. As these downsizing exporters start to expand in $t = 2$ onward, the local labour market recovers, achieving a value of 0.25% above steady state. In terms of the overseas output price, the change is gradual again due to exporter dynamics. The price drops to around 0.12% in $t = 1$, then the rate of change slows before reaching the new steady state around $t = 10$.

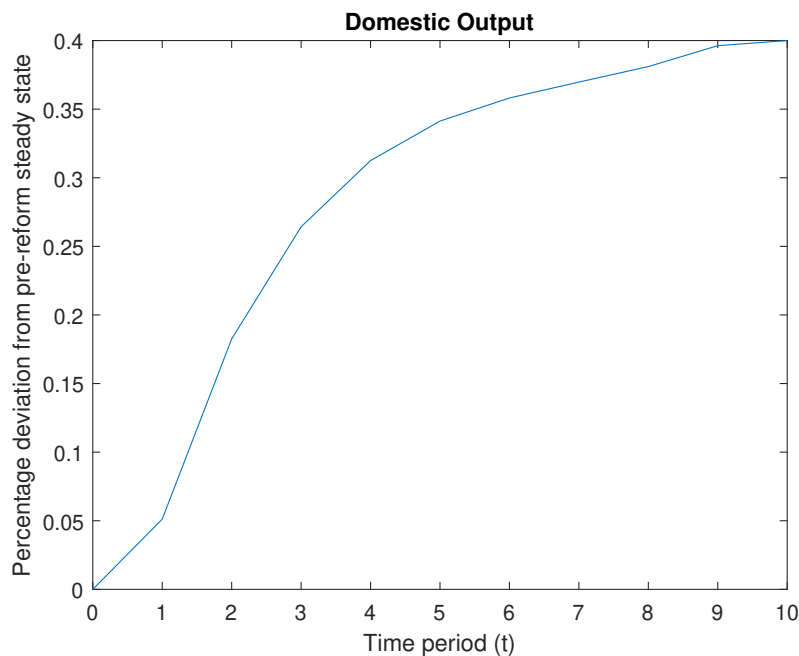


Figure 7: Transition of domestic output

The culmination of these effects is the time path of domestic output, which is depicted in figure 7. Output always sits above its pre-reform steady state value, but the rate at which it grows varies considerably. A relatively slow expansion to 0.05% in $t = 1$ contrasts against a rapid increase to 0.18% in the period following due to the push of new U.S.

firms an exporters to attain FDI status. The rate of growth then decreases gradually until output reaches its steady state value of 0.4%.

The transition of domestic U.S. consumption is depicted in figure 8. The time-path it follows is relatively intuitive. A long-run gain of welfare of 0.2% comes with a dip in the first few periods of the reform — two effects drive this temporary retraction. The first effect is that consumption gets displaced in period $t = 0$ due to a rise in equity issuance. The measure of new entrants rises — all of these new firms need to pay their fixed capital expenditures. This is a drain on the budget constraint of the household — they need to supply some of the new equity for the startups — meaning less income available for consumption. The second effect is the decline in the wage in $t = 1$: this further pushes-down the income of the household. The recovery of the labour market in the period subsequent drives relatively fast convergence to the post-reform steady state. In evaluating this policy for its overall impact on U.S. welfare, the impact is roughly 0.08% in consumption equivalents: the initial hit to welfare is offset by the long-run benefits to the economy.

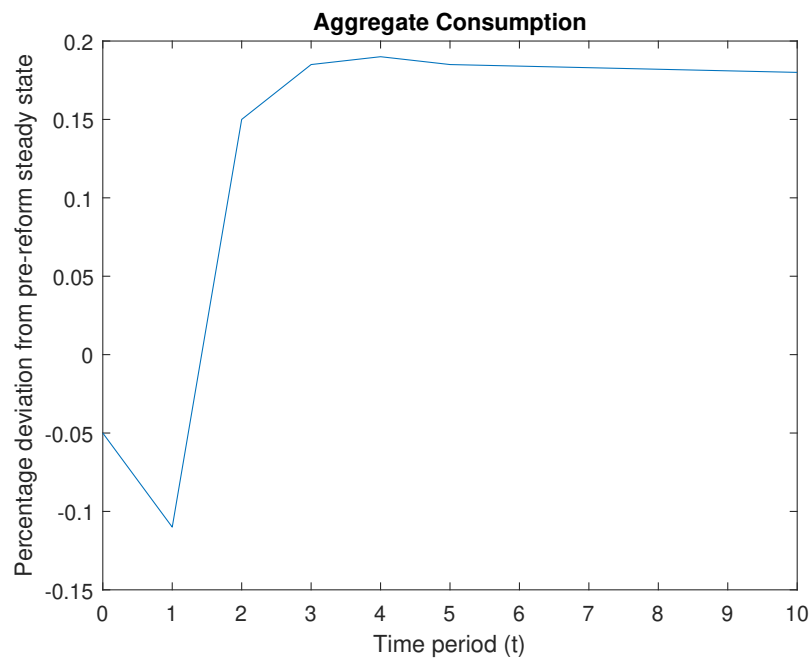


Figure 8: Transition of domestic consumption

The implications of this section are clear: comparing across steady states without

regard for the transmission between the two can over-state the positive effects associated with this policy change. Offshoring of production by firms that upgrade to FDI status lead to a temporarily lower wage. The positive entry effects associated with more profitable operations by U.S. firms in the long-run come with a large up-front cost in terms of fixed capital expenditures.

VI Concluding Remarks

Recent years have seen various tax reforms passed, which were targeted specifically at the earnings of multinational firms. This paper developed a dynamic model of firm selection and financial frictions that allows for the evaluation of the impact of such reforms on the entire firm cross-section and the implications for macroeconomic aggregates. The model is solved numerically with parameters chosen to match the distribution of firms in the data; it can be utilised to study the steady state and transitional effect of these tax reforms.

I apply this new framework to the removal of the U.S. repatriation tax — an aspect of the TCJA that was effective January 1st of 2018. This application is executed with a view to illustrate the quantitative significance of the channels discussed in the general modelling framework in response to tax reforms targeted at multinationals. There are three key messages the paper delivers. The first is that changes to the evolution of the firm cross-section in response to these tax reforms can aggregate to have a quantitatively meaningful impact on macro variables. The second is that the changes that ensue depend crucially on financial frictions — their inclusion can significantly alter the results to the point where opposite inferences may be drawn. The third is that studying short-run dynamics is important: their omission can lead to an over-statement of the reform’s effects.

Future research could involve the analysis of other types of financial frictions and how they interact with equilibrium effects from these reforms — some examples include costly firm default and agency conflicts. Extending the model to account for heterogeneous Foreign firms would allow for a more broader analysis of the impact of these reforms. The new framework developed in this paper is hoped to form a foundation, from which further explorations by researchers and policymakers can develop.

References

Acemoglu, D., Akcigit, U., Alp, H., Bloom, N., & Kerr, W. (2018). Innovation, reallocation,

- and growth. *American Economic Review*, 108(11), 3450–91.
- Adda, J., Cooper, R., & 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., & Ruhl, K. (2014). *Trade adjustment dynamics and the welfare gains from trade* (Tech. Rep.). National Bureau of Economic Research.
- Antràs, P., & Yeaple, S. R. (2014). Multinational firms and the structure of international trade. In *Handbook of international economics* (Vol. 4, pp. 55–130). Elsevier.
- Arena, M. P., & Kutner, G. W. (2015). Territorial tax system reform and corporate financial policies. *The Review of Financial Studies*, 28(8), 2250–2280.
- Bernstein, J. (2017). *Republican tax plan will lead to more offshoring of u.s. jobs and a larger trade deficit*. The Washington Post.
- Brooks, W., & DAVIS, A. (2019). Credit market frictions and trade liberalizations. *Journal of Monetary Economics*.
- Burnside, C. (1996). Production function regressions, returns to scale, and externalities. *Journal of monetary Economics*, 37(2), 177–201.
- 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.
- Chen, D., Qi, S., & Schlagenhauf, D. (2018). Corporate income tax, legal form of organization, and employment. *American Economic Journal: Macroeconomics*, 10(4), 270–304.
- Curtis, C. C., Garm, J., & Mehkari, M. S. (2017). *Repatriation taxes* (Tech. Rep.). Working paper.
- Dharmapala, D., Foley, C. F., & Forbes, K. J. (2011). Watch what i do, not what i say: The unintended consequences of the homeland investment act. *The Journal of Finance*, 66(3), 753–787.

- Eaton, J., Kortum, S., & Kramarz, F. (2011). An anatomy of international trade: Evidence from french firms. *Econometrica*, 79(5), 1453–1498.
- Fitzgerald, D., Haller, S., & Yedid-Levi, Y. (2016). *How exporters grow* (Tech. Rep.). National Bureau of Economic Research.
- Flaen, A. (2014). *Multinational firms in context*. Working Paper.
- 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.
- 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>)
- Gomes, J. F. (2001). Financing investment. *American Economic Review*, 91(5), 1263–1285.
- Gorodnichenko, Y., & Schnitzer, M. (2013). Financial constraints and innovation: Why poor countries don't catch up. *Journal of the European Economic Association*, 11(5), 1115–1152.
- 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.
- 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., & 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

- Hopenhayn, H. A. (1992). Entry, exit, and firm dynamics in long run equilibrium. *Econometrica: Journal of the Econometric Society*, 1127–1150.
- 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.
- Nayar, N. P., Flaaen, A., Boehm, C., et al. (2016). Multinationals, offshoring and the decline of us manufacturing. In *2016 meeting papers*.
- 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>
- OECD. (2018b). *Taxing wages — the united states*. OECD online. (<https://www.oecd.org/unitedstates/taxing-wages-united-states.pdf>)
- OECD. (2019). *Addressing the tax challenges of the digitalisation of the economy*. Retrieved from <https://www.oecd.org/tax/beps/public-consultation-document-addressing-the-tax-challenges-of-the-digitalisation-of-the-economy.pdf>
- Olley, G. S., & Pakes, A. (1992). *The dynamics of productivity in the telecommunications equipment industry* (Tech. Rep.). National Bureau of Economic Research.
- Ramondo, N. (2014). A quantitative approach to multinational production. *Journal of International Economics*, 93(1), 108–122.

- Ramondo, N., & Rodríguez-Clare, A. (2013). Trade, multinational production, and the gains from openness. *Journal of Political Economy*, 121(2), 273–322.
- Ramondo, N., Rodríguez-Clare, A., & Tintelnot, F. (2015). Multinational production: Data and stylized facts. *American Economic Review*, 105(5), 530–36.
- Ravikumar, B., Santacreu, A. M., & Sposi, M. (2017). Capital accumulation and dynamic gains from trade.
- Restuccia, D., & Rogerson, R. (2008). Policy distortions and aggregate productivity with heterogeneous establishments. *Review of Economic Dynamics*, 11(4), 707–720.
- Reuters. (2005). *Foreign ownership of u.s. companies jumps*. Retrieved from <https://www.reuters.com/article/us-companies-ownership-usa/foreign-ownership-of-u-s-companies-jumps-idUSN2744743020080827>
- Riddick, L. A., & Whited, T. M. (2009). The corporate propensity to save. *The Journal of Finance*, 64(4), 1729–1766.
- Ruhl, K. J., et al. (2008). The international elasticity puzzle. *unpublished paper, NYU*.
- Ruhl, K. J., & Willis, J. L. (2017). New exporter dynamics. *International Economic Review*, 58(3), 703–726.
- Strebulaev, I. A., & Whited, T. M. (2012). Dynamic models and structural estimation in corporate finance. *Foundations and Trends® in Finance*, 6(1–2), 1–163.
- U.S. 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>.)

Appendix A Details for Prologue Model

This appendix details, with formal propositions and proofs, the solution of the static partial equilibrium prologue model.

i Prologue Model without Financial Frictions

Start by denoting the exogenous demand for Home goods in Home and Foreign by $Q^{D,H}$ and Q^{D,H^*} respectively. Definition 1 begins by formally outlining what constitutes an equilibrium in this model.

Definition 1. (Equilibrium). Partial equilibrium in this model is a cut-off rule for firms, contingent on their productivity draw, which defines their discrete choice. The price P^{H^*} clears the market for goods made by the Home firms sold in the Foreign Country.

Assumption 1 is used to ensure that, in the equilibrium of the model, there will exist non-zero regions for each discrete choice for the firms, as we observe in the data.

Assumption 1.

- (a) The **incremental cost to benefit** ratio of being a multinational over an exporter is greater than that of being an exporter over a domestic, which is greater than that of being a domestic over an exiting firm. Formally, the following two inequalities hold

$$\frac{x^M - x^X}{P^{H^*}\{(1 - \tau^{C,U} - \tau^{C*}) - (1 - i)(1 - \tau^C)\}} > \frac{x^X}{P^{H^*}(1 - i)(1 - \tau^C)} \quad (2)$$

$$\frac{x^X}{P^{H^*}(1 - \tau^C)(1 - i)} > \frac{x^D}{(1 - \tau^C)} \quad (3)$$

- (b) The **demand** for goods made by the Home firms in the Foreign Country, Q^{D,H^*} , is perfectly inelastic — $Q^{D,H^*} = a$ for some $a > 0$.
- (c) The **distribution** for productivity is uniform — $\theta \sim U[\underline{\theta}, \bar{\theta}]$.

Assumption 1(a) states that it becomes progressively more costly to keep moving up a discrete choice in the hierarchy relative to the benefit. The first inequality in the assumption amounts to saying that the excess fixed cost of being a multinational over an exporter relative to the tax and iceberg cost savings, is larger than the additional fixed cost to revenue gains associated with being an exporter over a domestic. The second inequality says the same with regard to comparing the export-domestic decision to the domestic-exit decision. Notice that the first inequality imposes a restriction on the parameters of the problem, while the second inequality as written in terms of an endogenous object — P^{H^*} . Assumptions 1(b) and (c) are made in the interest of ensuring an analytical solution for P^{H^*} can be found.

Proposition 1. (Equilibrium discrete choices). Under assumption 1, the firm cut-off rules are such that a productivity hierarchy of firms materialises. Specifically, the least productive firms exit without producing, followed by domestic firms, exporters and finally multinationals. The cut-offs are such

- $\theta \leq \frac{x^D}{(1-\tau^C)} \Rightarrow$ exit the industry,
- $\frac{x^D}{(1-\tau^C)} < \theta \leq \frac{x^X}{PH^*(1-\tau^C)(1-i)} \Rightarrow$ operate as a purely domestic firm,
- $\frac{x^X}{PH^*(1-\tau^C)(1-i)} < \theta \leq \frac{x^M-x^X}{PH^*\{(1-\tau^{C,U}-\tau^{C*})-(1-i)(1-\tau^C)\}} \Rightarrow$ operate as an exporting firm,
- $\theta > \frac{x^M-x^X}{PH^*\{(1-\tau^{C,U}-\tau^{C*})-(1-i)(1-\tau^C)\}} \Rightarrow$ operate as a multinational firm.

Proof. Recall that there are four potential choices — exit (E), domestic (D), exporter (X) and multinational (M). For a firm to choose to be an exiter, it must be the case that

$$\begin{aligned}
V^E(\theta) &> V^D(\theta) \\
&\Rightarrow 0 > -x^D + (1-\tau^C)\theta \\
&\Rightarrow \theta < \frac{x^D}{(1-\tau^C)}
\end{aligned} \tag{4}$$

$$\begin{aligned}
V^E(\theta) &> V^X(\theta) \\
&\Rightarrow 0 > -x^D - x^X + (1-\tau^C)\theta + (1-\tau^C)(1-i)PH^*\theta \\
&\Rightarrow \theta < \frac{x^D + x^X}{(1-\tau^C)\{1 + (1-i)PH^*\}}
\end{aligned} \tag{5}$$

$$\begin{aligned}
V^E(\theta) &> V^M(\theta) \\
&\Rightarrow 0 > -x^D - x^M + (1-\tau^C)\theta + (1-\tau^{C,U} - \tau^{C*})PH^*\theta \\
&\Rightarrow \theta < \frac{x^D + x^M}{(1-\tau^C) + (1-\tau^{C,U} - \tau^{C*})PH^*}
\end{aligned} \tag{6}$$

For the firm to be a domestic, the following three inequalities must be satisfied

$$\begin{aligned}
V^D(\theta) &> V^E(\theta) \\
&\Rightarrow -x^D + (1 - \tau^C)\theta > 0 \\
&\Rightarrow \theta > \frac{x^D}{(1 - \tau^C)}
\end{aligned} \tag{7}$$

$$\begin{aligned}
V^D(\theta) &> V^X(\theta) \\
&\Rightarrow -x^D + (1 - \tau^C)\theta > -x^D - x^X + (1 - \tau^C)\theta + (1 - \tau^C)(1 - i)P^{H*}\theta \\
&\Rightarrow \theta < \frac{x^X}{(1 - \tau^C)(1 - i)P^{H*}}
\end{aligned} \tag{8}$$

$$\begin{aligned}
V^D(\theta) &> V^M(\theta) \\
&\Rightarrow -x^D + (1 - \tau^C)\theta > -x^D - x^M + (1 - \tau^C)\theta + (1 - \tau^{C,U} - \tau^{C*})P^{H*}\theta \\
&\Rightarrow \theta < \frac{x^M}{(1 - \tau^{C,U} - \tau^{C*})P^{H*}}
\end{aligned} \tag{9}$$

For the firm to be an exporter, it must be that the following hold

$$\begin{aligned}
V^X(\theta) &> V^E(\theta) \\
&\Rightarrow -x^D - x^X + (1 - \tau^C)\theta + (1 - \tau^C)(1 - i)P^{H*}\theta > 0 \\
&\Rightarrow \theta > \frac{x^D + x^X}{(1 - \tau^C)\{1 + (1 - i)P^{H*}\}}
\end{aligned} \tag{10}$$

$$\begin{aligned}
V^X(\theta) &> V^D(\theta) \\
&\Rightarrow -x^D - x^X + (1 - \tau^C)\theta + (1 - \tau^C)(1 - i)P^{H*}\theta > -x^D + (1 - \tau^C)\theta \\
&\Rightarrow \theta > \frac{x^X}{(1 - \tau^C)(1 - i)P^{H*}}
\end{aligned} \tag{11}$$

$$\begin{aligned}
V^X(\theta) &> V^M(\theta) \\
&\Rightarrow -x^D - x^X + (1 - \tau^C)\theta + (1 - \tau^C)(1 - i)P^{H*}\theta \\
&\quad > -x^D - x^M + (1 - \tau^C)\theta + (1 - \tau^{C,U} - \tau^{C*})P^{H*}\theta \\
&\Rightarrow \theta < \frac{x^M - x^X}{P^{H*}\{(1 - \tau^{C,U} - \tau^{C*}) - (1 - i)(1 - \tau^C)\}}
\end{aligned} \tag{12}$$

Finally to be a multinational, we must have

$$\begin{aligned}
V^M(\theta) &> V^E(\theta) \\
&\Rightarrow -x^D - x^M + (1 - \tau^C)\theta + (1 - \tau^{C,U} - \tau^{C*})P^{H*}\theta > 0 \\
&\Rightarrow \theta > \frac{x^D + x^M}{(1 - \tau^C) + (1 - \tau^{C,U} - \tau^{C*})P^{H*}} \tag{13}
\end{aligned}$$

$$\begin{aligned}
V^M(\theta) &> V^D(\theta) \\
&\Rightarrow -x^D - x^M + (1 - \tau^C)\theta + (1 - \tau^{C,U} - \tau^{C*})P^{H*}\theta > -x^D + (1 - \tau^C)\theta \\
&\Rightarrow \theta > \frac{x^M}{(1 - \tau^{C,U} - \tau^{C*})P^{H*}} \tag{14}
\end{aligned}$$

$$\begin{aligned}
V^M(\theta) &> V^X(\theta) \\
&\Rightarrow -x^D - x^M + (1 - \tau^C)\theta + (1 - \tau^{C,U} - \tau^{C*})P^{H*}\theta \\
&\quad > -x^D - x^X + (1 - \tau^C)\theta + (1 - \tau^C)(1 - i)P^{H*}\theta \\
&\Rightarrow \theta > \frac{x^M - x^X}{P^{H*}\{(1 - \tau^{C,U} - \tau^{C*}) - (1 - i)(1 - \tau^C)\}}. \tag{15}
\end{aligned}$$

The objective now is to place sufficient conditions on all the parameters of the problem to give a strict ordering of the cut-offs such that there are non-zero regions for all of the discrete choices. See that (2) gives that

$$\frac{x^M}{P^{H*}(1 - \tau^{C,U} - \tau^{C*})} > \frac{x^X}{P^{H*}(1 - \tau^C)(1 - i)}, \tag{16}$$

which when combined with (3) give the orderings

$$\begin{aligned} \frac{x^D}{(1-\tau^C)} &< \frac{x^D+x^X}{(1-\tau^C)\{1+(1-i)PH^*\}} < \frac{x^D+x^M}{(1-\tau^C)+(1-\tau^{C,U}-\tau^{C*})PH^*} \\ \frac{x^D}{(1-\tau^C)} &< \frac{x^X}{(1-\tau^C)(1-i)PH^*} < \frac{x^M}{(1-\tau^{C,U}-\tau^{C*})PH^*} \\ \frac{x^D+x^X}{(1-\tau^C)\{1+(1-i)PH^*\}} &< \frac{x^X}{(1-\tau^C)(1-i)PH^*} \\ &< \frac{x^M-x^X}{PH^*\{(1-\tau^{C,U}-\tau^{C*})-(1-i)(1-\tau^C)\}} \\ \frac{x^D+x^M}{(1-\tau^C)+(1-\tau^{C,U}-\tau^{C*})PH^*} &< \frac{x^M}{(1-\tau^{C,U}-\tau^{C*})PH^*} \\ &< \frac{x^M-x^X}{PH^*\{(1-\tau^{C,U}-\tau^{C*})-(1-i)(1-\tau^C)\}} \end{aligned}$$

where the first ordering gives that $\theta \leq \frac{x^D}{(1-\tau^C)}$ is sufficient for a firm to find it optimal to exit. The second ordering says $\frac{x^D}{(1-\tau^C)} < \theta \leq \frac{x^X}{(1-\tau^C)(1-i)PH^*}$ is sufficient for a firm to be domestic, while the third says $\frac{x^X}{(1-\tau^C)(1-i)PH^*} < \theta \leq \frac{x^M-x^X}{PH^*\{(1-\tau^{C,U}-\tau^{C*})-(1-i)(1-\tau^C)\}}$ gives an exporter and $\theta > \frac{x^M-x^X}{PH^*\{(1-\tau^{C,U}-\tau^{C*})-(1-i)(1-\tau^C)\}}$ gives a multinational. \square

The equilibrium discrete choices under this model are depicted in figure 9. A hierarchy of firms eventuates — the least productive of firms choose to exit the industry, followed by pure domestics, exporters and multinationals. Firms that are at the pinnacle of the productivity hierarchy seek to avoid incurring the iceberg transport cost: it's optimal for them to incur the higher fixed cost to undertake FDI. Notice that the cut-offs in the figure depend on the parameters of the problem. In particular, each cut-off moving up the hierarchy is equal to the incremental cost to benefit ratio of moving up another discrete choice. Of particular interest is the upper cut-off: it is defined by the productivity level such that the incremental fixed cost of FDI over exporting balances the incremental benefit. The incremental benefit is given by the earnings net of foreign corporate and repatriation

taxes less the earnings net of taxes and iceberg costs.

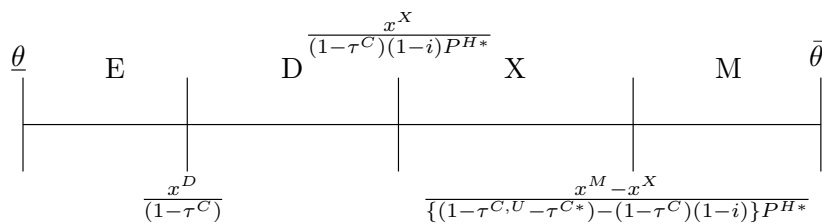


Figure 9: Equilibrium discrete choices

Proposition 2. (Equilibrium price). Under assumption 1, the market-clearing price is given by

$$P^{H*} = \sqrt{\frac{\left(\frac{x^X}{(1-\tau^C)(1-i)}\right)^2 + i \left\{ \left(\frac{x^M - x^X}{(1-\tau^C, U - \tau^{C*}) - (1-\tau^C)(1-i)}\right)^2 - \left(\frac{x^X}{(1-\tau^C)(1-i)}\right)^2 \right\}}{\bar{\theta}^2 - 2a(\bar{\theta} - \underline{\theta})}}$$

Proof. The total supply from Home firms in the Foreign market (denoted $Q^{S,H*}$) can be found as the total output of firms above the exporter cut-off less the iceberg transport costs

$$\begin{aligned} Q^{S,H*} &= \int_{\frac{x^X}{(1-\tau^C)(1-i)PH^*}}^{\bar{\theta}} \frac{\theta}{\bar{\theta} - \underline{\theta}} d\theta - i \int_{\frac{x^X}{(1-\tau^C)(1-i)PH^*}}^{\frac{x^M - x^X}{PH^* \{(1-\tau^C, U - \tau^{C*}) - (1-i)(1-\tau^C)\}}} \frac{\theta}{\bar{\theta} - \underline{\theta}} d\theta \\ &= \frac{1}{2(\bar{\theta} - \underline{\theta})} \left\{ \bar{\theta}^2 - \left(\frac{x^X}{(1-\tau^C)(1-i)PH^*} \right)^2 \right\} - \\ &\quad \frac{i}{2(\bar{\theta} - \underline{\theta})} \left[\left(\frac{x^M - x^X}{PH^* \{(1-\tau^C, U - \tau^{C*}) - (1-i)(1-\tau^C)\}} \right)^2 - \left(\frac{x^X}{(1-\tau^C)(1-i)PH^*} \right)^2 \right]. \end{aligned}$$

Equating this supply with demand, (which recall was supposed to be $Q^{D,H*} = a$ for $a > 0$),

gives

$$\begin{aligned}
a &= \frac{1}{2(\bar{\theta} - \underline{\theta})} \left\{ \bar{\theta}^2 - \left(\frac{x^X}{(1 - \tau^C)(1 - i)PH^*} \right)^2 \right\} - \\
&\quad \frac{i}{2(\bar{\theta} - \underline{\theta})} \left(\frac{x^M - x^X}{PH^* \{ (1 - \tau^{C,U} - \tau^{C*}) - (1 - i)(1 - \tau^C) \}} \right)^2 - \\
&\quad \frac{i}{2(\bar{\theta} - \underline{\theta})} \left(\frac{x^X}{(1 - \tau^C)(1 - i)PH^*} \right)^2 \\
\Rightarrow 2a(\bar{\theta} - \underline{\theta}) - \bar{\theta}^2 &= - \left(\frac{x^X}{(1 - \tau^C)(1 - i)PH^*} \right)^2 - \\
&\quad i \left(\frac{x^M - x^X}{PH^* \{ (1 - \tau^{C,U} - \tau^{C*}) - (1 - i)(1 - \tau^C) \}} \right)^2 - \\
&\quad i \left(\frac{x^X}{(1 - \tau^C)(1 - i)PH^*} \right)^2 \\
\Rightarrow PH^* &= \sqrt{ \frac{ \left(\frac{x^X}{(1 - \tau^C)(1 - i)} \right)^2 + i \left\{ \left(\frac{x^M - x^X}{(1 - \tau^{C,U} - \tau^{C*}) - (1 - \tau^C)(1 - i)} \right)^2 - \left(\frac{x^X}{(1 - \tau^C)(1 - i)} \right)^2 \right\} }{ \bar{\theta}^2 - 2a(\bar{\theta} - \underline{\theta}) } }.
\end{aligned}$$

□

The equilibrium price clears the Home goods market in the Foreign Country. For the price to exist, the demand as captured by the a parameter, can't be too large. The iceberg cost is incurred by all firms who export; a larger fraction of such firms relative to multinationals implies a higher price given that this cost comes out of output, thereby restricting the supply to the foreign market. Most importantly though, notice that the price is increasing in the Home Country's repatriation tax rate. Intuitively, as this tax rate increases, the incentive for a firm to operate as a multinational is diminished, meaning more exporters, resulting in a lower output supply due to iceberg costs for a given productivity level. The next assumption ensures that the price effects associated with the reform will not be too extreme.

Assumption 2. The fixed cost of being a multinational relative to an exporter is “sufficiently large”. More specifically, the following holds

$$(x^X)^2 i + (x^M - x^X)^2 (1 - i) - (1 - \tau^C)^3 (i)^3 (1 - i) > 0.$$

This assumption ensures that the fraction of multinational firms will not be too large prior to the reform. This assumption is needed to sign the movement in the cut-off between being an exporter and multinational in the reform. The fraction of multinationals has to be sufficiently small to ensure that an increase in the repatriation tax doesn't lead to an enormous price effect.

Combining the results of propositions 1 and 2 yields an intuition for the effect of removing the repatriation tax on the cross-section of U.S. firms. Proposition 3 summarises these effects on the Home firm cut-off rules for their discrete choices.

Proposition 3. (Removing the repatriation tax). Under assumptions 1 and 2, going from a scenario with $\tau^{C,U} > 0$ to another with $\tau^{C,U} = 0$ causes the productivity standard for being a multinational Home firm to decrease and that for exporting firms to increase.

Proof. To characterise how the cut-offs change, we need to first study the impact on the market clearing price. See that

$$\frac{dP^{H*}}{d\tau^{C,U}} = \frac{i \left(\frac{x^M - x^X}{\{(1 - \tau^{C,U} - \tau^{C*}) - (1 - \tau^C)(1 - i)\}^2} \right)}{\bar{\theta}^2 - 2a(\bar{\theta} - \theta)} \frac{1}{P^{H*}}. \quad (17)$$

Denote the cut-off between being an exporter and a multinational by

$$\Gamma = \frac{x^M - x^X}{P^{H*} \{(1 - \tau^{C,U} - \tau^{C*}) - (1 - i)(1 - \tau^C)\}}.$$

See then that

$$\frac{\partial \Gamma}{\partial \tau^{C,U}} = \frac{d\Gamma}{d\tau^{C,U}} + \frac{\partial \Gamma}{\partial P^{H*}} \frac{dP^{H*}}{d\tau^{C,U}} \quad (18)$$

where

$$\begin{aligned} \frac{d\Gamma}{d\tau^{C,U}} &= \frac{x^M - x^X}{P^{H*} \{(1 - \tau^{C,U} - \tau^{C*}) - (1 - \tau^C)(1 - i)\}^2} \\ \frac{\partial \Gamma}{\partial P^{H*}} &= - \frac{x^M - x^X}{(P^{H*})^2 \{(1 - \tau^{C,U} - \tau^{C*}) - (1 - \tau^C)(1 - i)\}}. \end{aligned}$$

Hence we can express (18) as

$$\begin{aligned} \frac{\partial \Gamma}{\partial \tau^{C,U}} &= \frac{x^M - x^X}{PH^* \{(1 - \tau^{C,U} - \tau^{C*}) - (1 - \tau^C)(1 - i)\}^2} \times \\ &\quad \left\{ 1 - \frac{i \{(1 - \tau^{C,U} - \tau^{C*}) - (1 - \tau^C)(1 - i)\}}{(PH^*)^2 [\bar{\theta}^2 - 2a(\bar{\theta} - \underline{\theta})]} \right\} \\ &= \frac{x^M - x^X}{PH^* \{(1 - \tau^{C,U} - \tau^{C*}) - (1 - \tau^C)(1 - i)\}^2} \times \\ &\quad \left\{ 1 - \frac{i \{(1 - \tau^{C,U} - \tau^{C*}) - (1 - \tau^C)(1 - i)\}}{\left(\frac{x^X}{(1 - \tau^C)(1 - i)}\right)^2 + i \left\{ \left(\frac{x^M - x^X}{(1 - \tau^{C,U} - \tau^{C*}) - (1 - \tau^C)(1 - i)}\right)^2 - \left(\frac{x^X}{(1 - \tau^C)(1 - i)}\right)^2 \right\}} \right\} \end{aligned}$$

meaning that the change in the cut-off is positive provided that

$$1 - \frac{i \{(1 - \tau^{C,U} - \tau^{C*}) - (1 - \tau^C)(1 - i)\}}{\left(\frac{x^X}{(1 - \tau^C)(1 - i)}\right)^2 + i \left\{ \left(\frac{x^M - x^X}{(1 - \tau^{C,U} - \tau^{C*}) - (1 - \tau^C)(1 - i)}\right)^2 - \left(\frac{x^X}{(1 - \tau^C)(1 - i)}\right)^2 \right\}} > 0$$

Under the pre-reform U.S. system with the statutory rate equal to $\tau^{C,U} = \tau^C - \tau^{C*}$, this simplifies to

$$\begin{aligned} &1 - \frac{i(1 - \tau^C)}{\left(\frac{x^X}{(1 - \tau^C)(1 - i)}\right)^2 + i \left\{ \left(\frac{x^M - x^X}{i(1 - \tau^C)}\right)^2 - \left(\frac{x^X}{(1 - \tau^C)(1 - i)}\right)^2 \right\}} > 0 \\ &\Rightarrow (x^X)^2 i + (x^M - x^X)^2 (1 - i) - (1 - \tau^C)^3 (i)^3 (1 - i) > 0, \end{aligned}$$

which is a necessary and sufficient condition to ensure that the cut-off increases. The case for the domestic-exporter cut-off follows simply from the fact that the price P^{H*} increases: thus a decline in the tax rate decrease the price, which causes said cut-off to shift upwards. \square

ii Prologue Model with Financial Frictions

Assumption 3. The **external financing premium** (denoted $\zeta(e)$) is assumed to be proportional to the size of the firm's financing needs — their fixed costs. That is

$$\zeta(e) = \zeta_1 e$$

for some $\zeta_1 > 0$ where e denotes the size of the external financing issuance.

The following proposition summarises the equilibrium discrete choices in the model with frictions.

Proposition 4. (Equilibrium discrete choices with financial frictions). Under assumptions 1 and 3, the firm cut-off rules are such that two separate hierarchies of firms materialise — one constrained firms and one for unconstrained firms. For both hierarchies, the least productive firms exit, followed by pure domestics, then exporters and multinationals. The cut-offs for unconstrained firms are the same as in proposition 1, except with the alternative price \widehat{P}^{H*} . The cut-offs for constrained firms are given by

- $\theta \leq \frac{x^D(1+\zeta_1)}{(1-\tau^C)} \Rightarrow$ exit the industry,
- $\frac{x^D(1+\zeta_1)}{(1-\tau^C)} < \theta \leq \frac{x^X(1+\zeta_1)}{\widehat{P}^{H*}(1-\tau^C)(1-i)} \Rightarrow$ operate as a purely domestic firm,
- $\frac{x^X(1+\zeta_1)}{\widehat{P}^{H*}(1-\tau^C)(1-i)} < \theta \leq \frac{(x^M-x^X)(1+\zeta_1)}{\widehat{P}^{H*}\{(1-\tau^C, U-\tau^{C*})-(1-i)(1-\tau^C)\}} \Rightarrow$ operate as an exporting firm,
- $\theta > \frac{(x^M-x^X)(1+\zeta_1)}{\widehat{P}^{H*}\{(1-\tau^C, U-\tau^{C*})-(1-i)(1-\tau^C)\}} \Rightarrow$ operate as a multinational firm.

Proof. This simply follows from the proof of proposition 1 with the fixed cost for the constrained firms adjusted to include the equity premium. \square

Proposition 5. (Equilibrium price with financial frictions). Under assumptions 1 and 2, the market-clearing price is given by

$$\widehat{P}^{H*} = P^{H*} \sqrt{1 + \omega(2\zeta_1 + \zeta_1^2)}$$

Proof. The supply is augmented to account for the constrained and unconstrained firms. The supply from the unconstrained firms is the same as in the proof of proposition 2 above — $Q^{S,H*}$ — except with the alternative price $\widehat{P}^{S,H*}$. Denote the supply by the constrained

firms as Q_c^{S,H^*} . See then that

$$\begin{aligned}
Q_c^{S,H^*} &= \int_{\underline{\theta}}^{\bar{\theta}} \frac{x^X(1+\zeta_1)}{(1-\tau^C)(1-i)\widehat{P}^{H^*}} \frac{\theta}{\bar{\theta}-\underline{\theta}} d\theta - i \int_{\frac{x^X(1+\zeta_1)}{(1-\tau^C)(1-i)\widehat{P}^{H^*}}}^{\frac{(x^M-x^X)(1+\zeta_1)}{\widehat{P}^{H^*}\{(1-\tau^{C,U}-\tau^{C^*})-(1-i)(1-\tau^C)\}}} \frac{\theta}{\bar{\theta}-\underline{\theta}} d\theta \\
&= \frac{1}{2(\bar{\theta}-\underline{\theta})} \left\{ \bar{\theta}^2 - \left(\frac{x^X(1+\zeta_1)}{(1-\tau^C)(1-i)\widehat{P}^{H^*}} \right)^2 \right\} - \\
&\quad \frac{i}{2(\bar{\theta}-\underline{\theta})} \left[\left(\frac{(x^M-x^X)(1+\zeta_1)}{\widehat{P}^{H^*}\{(1-\tau^{C,U}-\tau^{C^*})-(1-i)(1-\tau^C)\}} \right)^2 - \left(\frac{x^X(1+\zeta_1)}{(1-\tau^C)(1-i)\widehat{P}^{H^*}} \right)^2 \right].
\end{aligned}$$

It's clear then that the total supply is given by $\omega Q_c^{S,H^*} + (1-\omega)Q^{S,H^*}$, to which demand $Q^{D,H^*} = a$ is equated: one can then re-arrange for \widehat{P}^{H^*} in the same way as for the proof of proposition 2. \square

The equilibrium depicted in figure 2 is likely intuitive but the mechanics driving the differences in the equilibrium behaviour between constrained and unconstrained firms are actually quite deep. There is a striking asymmetry between the discrete choices made by the two firm types. Take for example firms that are on the margin between being a domestic and an exporter. The firms over the region

$$\left[\frac{x^X}{P^{H^*} \sqrt{1 + \omega(2\zeta_1 + \zeta_1^2)(1-\tau^C)(1-i)}}, \frac{x^X(1+\zeta_1)}{P^{H^*} \sqrt{1 + \omega(2\zeta_1 + \zeta_1^2)(1-\tau^C)(1-i)}} \right]$$

can justify operating as exporters when they are unconstrained, but not in the case that they are constrained. There is a re-allocation of resources away from firms that are relatively more productive yet constrained and towards firms that are less productive yet unconstrained. There is a larger degree of heterogeneity in discrete choices in the model with financial frictions than less; the heightened degree of dispersion is accounted for through the equilibrium price. Notice as two special cases: when $\omega = 0$ (all unconstrained) and $\omega = 1$ (all constrained). In both of these cases, the cross-section collapses down to the same scenario as for the case without financial frictions. Given that the firms are all the same in these two special cases, there is no re-allocation of resources away from one type to another.

Proposition 6. (Removing the repatriation tax with financial frictions). Under

assumptions 1 and 2, going from a scenario with $\tau^{C,U} > 0$ to another with $\tau^{C,U} = 0$ has quantitatively differential effects on the equilibrium discrete choices of constrained and unconstrained firms. For both types of firms, the productivity standard for being a multinational decreases and that for an exporter increases. The movements in the cut-offs are both quantitatively larger for constrained firms.

Proof. Firstly notice that the change in the price with financial frictions is now given by

$$\begin{aligned}\frac{d\widehat{P}^{H*}}{d\tau^{C,U}} &= \frac{d\{P^{H*}\sqrt{1+\omega(2\zeta_1+\zeta_1^2)}\}}{d\tau^{C,U}} \\ &= \sqrt{1+\omega(2\zeta_1+\zeta_1^2)}\frac{dP^{H*}}{d\tau^{C,U}}\end{aligned}$$

where the last line comes from the proof of proposition 3. This says that the change in price will be larger in the case with financial frictions than without. In particular, notice the special case that if $\omega = 1$, then $\frac{d\widehat{P}^{H*}}{d\tau^{C,U}} = (1+\zeta_1)\frac{dP^{H*}}{d\tau^{C,U}}$, meaning that if all firms are constrained, then the changes in the price are perfectly scaled by the issuance premium. Notice then that the expression $\frac{1+\zeta_1}{\sqrt{1+\omega(2\zeta_1+\zeta_1^2)}} \geq 1$, with equality when $\omega = 1$. Notice then that we can re-write the expressions for the cut-offs for an unconstrained firm as

- $\theta \leq \frac{x^D}{(1-\tau^C)} \Rightarrow$ exit the industry,
- $\frac{x^D}{(1-\tau^C)} < \theta \leq \frac{x^X}{P^{H*}\sqrt{1+\omega(2\zeta_1+\zeta_1^2)}(1-\tau^C)(1-i)} \Rightarrow$ operate as a purely domestic firm,
- $\frac{x^X}{P^{H*}\sqrt{1+\omega(2\zeta_1+\zeta_1^2)}(1-\tau^C)(1-i)} < \theta \leq \frac{x^M-x^X}{P^{H*}\sqrt{1+\omega(2\zeta_1+\zeta_1^2)}\{(1-\tau^{C,U}-\tau^{C*})-(1-i)(1-\tau^C)\}} \Rightarrow$ operate as an exporting firm,
- $\theta > \frac{x^M-x^X}{P^{H*}\sqrt{1+\omega(2\zeta_1+\zeta_1^2)}\{(1-\tau^{C,U}-\tau^{C*})-(1-i)(1-\tau^C)\}} \Rightarrow$ operate as a multinational firm.

and those for a constrained firm as

- $\theta \leq \frac{x^D(1+\zeta_1)}{(1-\tau^C)} \Rightarrow$ exit the industry,
- $\frac{x^D(1+\zeta_1)}{(1-\tau^C)} < \theta \leq \frac{x^X(1+\zeta_1)}{P^{H*}\sqrt{1+\omega(2\zeta_1+\zeta_1^2)}(1-\tau^C)(1-i)} \Rightarrow$ operate as a purely domestic firm,
- $\frac{x^X(1+\zeta_1)}{P^{H*}\sqrt{1+\omega(2\zeta_1+\zeta_1^2)}(1-\tau^C)(1-i)} < \theta \leq \frac{(x^M-x^X)(1+\zeta_1)}{P^{H*}\sqrt{1+\omega(2\zeta_1+\zeta_1^2)}\{(1-\tau^{C,U}-\tau^{C*})-(1-i)(1-\tau^C)\}} \Rightarrow$ operate as an exporting firm,
- $\theta > \frac{(x^M-x^X)(1+\zeta_1)}{P^{H*}\sqrt{1+\omega(2\zeta_1+\zeta_1^2)}\{(1-\tau^{C,U}-\tau^{C*})-(1-i)(1-\tau^C)\}} \Rightarrow$ operate as a multinational firm.

As a consequence, we study changes due to removing the repatriation tax in light of scaled versions of the cut-offs without financial frictions. In particular, notice that because of the $\sqrt{1 + \omega(2\zeta_1 + \zeta_1^2)}$ in the denominator of each cut-off for the unconstrained firms, the movement in the cut-off for the unconstrained firms will be smaller than that in the case without financial frictions. Conversely, the constrained firm cut-offs contain the scaling factor $\frac{1+\zeta_1}{\sqrt{1+\omega(2\zeta_1+\zeta_1^2)}}$, meaning that the change is larger than that of the case without financial frictions. That is — the cut-off movements for the case with financial frictions will be scaled versions of the movements, which take place in the cut-offs without financial frictions. They all move in qualitatively the same direction. \square

Appendix B Recursive Competitive Equilibrium

i Cross-Sectional Distribution of Home Firms

Recall that the cross-sectional distribution is denoted by $\mu_t(\vec{\varphi}_t)$ where

$$\vec{\varphi}_t = (k_t^H, k_t^{H*}, b_t, \theta_t, \tau_t^{C,U}).$$

Denote the policy functions for new entrant firms as $h_{k^H}^E$ and h_b^E for Home capital and bonds respectively and the rate, at which they enter the industry as \mathcal{R}_t . Similarly define the policy functions for the incumbent firms as $h_{k^H}(\vec{\varphi}_t)$, $h_{k^{H*}}(\vec{\varphi}_t)$ and $h_b(\vec{\varphi}_t)$ for Home capital, Foreign capital and debt respectively. The cross-section of firms across the states then evolves according to

$$\begin{aligned} \mu_{t+1}(\vec{\varphi}_{t+1}) = & \mathcal{R}_t \int_{\tau^{C,U}, \theta} \mathbb{1}_{k_{t+1}^H = h_{k^H}^E, b_{t+1} = h_b^E} \bar{Q}_\theta(d\theta_{t+1}) \bar{Q}_\tau(d\tau_{t+1}^{C,U}) \\ & + \int_{\tau^{C,U}, \theta, b, k^{H*}, k^H} \Gamma[(\vec{\varphi}_{t+1}), (\vec{\varphi}_t)] \mu_t(dk_t^H, dk_t^{H*}, db_t, d\theta_t, d\tau_t^{C,U}) \end{aligned}$$

where \bar{Q}_θ and $\bar{\tau}_\theta$ are the distributions from which entrants initial shocks are drawn and $\Gamma[(\vec{\varphi}_{t+1}), (\vec{\varphi}_t)]$ represents the probability of an incumbent transitioning between the two sets of states. Specifically this is given by

$$\Gamma[(\vec{\varphi}_{t+1}), (\vec{\varphi}_t)] = \mathbb{1}_{[k_{t+1}^H = h_{k^H}(\vec{\varphi}_t), k_{t+1}^{H*} = h_{k^{H*}}(\vec{\varphi}_t), b_{t+1} = h_b(\vec{\varphi}_t)]} (1 - z_t(\vec{\varphi}_t)) Q_\theta(\theta_{t+1} | \theta_t) Q_\tau(\tau_{t+1}^{C,U} | \tau_t^{C,U})$$

where $z_t(\vec{\varphi}_t)$ is an indicator equalling one when a firm with a given state exits, $Q_\theta(\theta'|\theta)$ is the conditional distribution over incumbent shocks and $Q_\tau(\tau^{C,U'}|\tau^{C,U})$ is that for repatriation tax rate shocks. The function $\Gamma[(\vec{\varphi}_{t+1}), (\vec{\varphi}_t)]$ is the conditional transition probability between the productivity and repatriation tax shocks multiplied by two indicators — one which denotes staying in the industry and another for the corresponding state variables. Recall also that R_t is the rate of entry into the industry, which is defined such that

$$\int_{\tau^{C,U}, \theta, b, k^{H*}, k^H} \mu_t(dk_t^H, dk_t^{H*}, db_t, d\theta_t, d\tau_t^{C,U}) = 1,$$

which guarantees that $\mu_t(k_t^H, k_t^{H*}, b_t, \theta_t, \tau_t^{C,U})$ gives a probability distribution over the state space.

ii Stationary Equilibrium Definition

The stationary competitive equilibrium is an invariant equilibrium, to which the model converges. In what follows, I drop time subscripts from variables of interest given that they are unchanging. The stationary equilibrium is defined as a list

$$\{P, P^*, P^H, P^F, P^{H*}, P^{F*}, W, W^*, \mu, \mathcal{R}, \mathcal{M}\}$$

such that the following conditions hold

- (1) Home households optimise,
- (2) The free entry condition for Home firms holds

$$V^T = 0,$$

- (3) μ is an invariant stationary distribution of Home firms,
- (4) R is the rate of entry/exit of Home firms,
- (5) \mathcal{M} is the measure of entering Home firms,
- (6) P is the equilibrium price index at Home,
- (7) P^* is the equilibrium price index in Foreign,

(8) P^H clears the Home goods market at Home, with market clearing given by

$$Y^H - X = C^H + T + E^+ - E^- + \zeta(E^-) + \sum_{c \in \{H, X, F\}} [I^c + \Phi^c] + U + J \\ + \mathcal{M} [x^D(1 - R) + x^X(1 - R - F) + x^M F + x^N R]$$

where I^c is the aggregate investment along margin c , Φ^c is aggregate adjustment cost along margin c , N^c is aggregate hiring along margin c , U and J are aggregate repatriations and funds sent to subsidiaries respectively and F is the fraction of multinationals in the stationary distribution.

(9) P^{H*} is the equilibrium price of goods made by Home firms sold in the Foreign Country, with market clearing given by

$$X(1 - i) + Y^F = C^{H*}$$

(10) P^F is the equilibrium price of goods made by Foreign firms sold in the Home Country, with market clearing given by

$$X^*(1 - i) = C^F$$

(11) P^{F*} is the equilibrium price of goods made by Foreign firms sold in the Foreign Country, with market clearing given by

$$Y^{F*} - X^* = C^{F*} + T^*$$

(12) W is the equilibrium wage in the Home Country, which has market clearing

$$N^H + N^X = L$$

(13) W^* is the equilibrium wage in the Foreign Country, with market clearing

$$N^{H*} + N^{F*} = L^*$$

Appendix C Allowing for Corporate Inversions

Earlier versions of this paper have allowed for a fourth U.S. firm status — a corporate inversion. Firms who wish to invert can pay an additional fixed capital expenditure once-off in excess of what they have already paid to be a multinational firm. From there onwards, they'll pay an additional operating cost. Denote the inversion status as I , where the fixed capital and operating expenditures are denoted by x^I and $x^{I*,O}$ respectively. The benefit associated with an inversion is that the firm is now no longer a U.S. firm — as a consequence, it is no longer subject to the repatriation tax. The value associated with this choice would be given by

$$\begin{aligned}
 V_t^I(\vec{\varphi}_t) &= \max_{\{k_{t+1}^H, k_{t+1}^{H*}, i_t^H, i_t^{H*}, b_{t+1}\}} d_t^I(\vec{\varphi}_t) + \beta \mathbb{E}_t[V_{t+1}(\vec{\varphi}_{t+1})] \\
 d_t^I(\vec{\varphi}_t) &= e_t^I(\vec{\varphi}_t) - \mathbb{1}_{e_t^I(\vec{\varphi}_t) < 0} \zeta(e_t^I(\vec{\varphi}_t)) \\
 e^I(\vec{\varphi}_t) &= (1 - \tau^C) (P_t^H \theta_t (k_t^H)^\alpha (n_t^H)^\gamma - W_t n_t^H - x^{D,O}) - i_t^H - \Phi^H(i_t^H, k_t^H) \\
 &\quad + u_t(\vec{\varphi}_t) - (1 - \mathbb{1}_{s_{t-1}(\vec{\varphi}_{t-1})=I}) x^I + \frac{b_{t+1}}{1+r} - b_t + b_t \left(1 - \frac{1}{1+r}\right) \tau^C \\
 u_t(\vec{\varphi}_t) &= (1 - \tau^{C*}) (P_t^{H*} \theta_t (k_t^{H*})^\alpha (n_t^{H*})^\gamma - W_t^* n_t^{H*} - x^{M*,O} - x^{I*,O}) - i_t^{H*} - \Phi^{H*}(i_t^{H*}, k_t^{H*}) \\
 i_t^H &= k_{t+1}^H - (1 - \delta) k_t^H \\
 i_t^{H*} &= k_{t+1}^{H*} - (1 - \delta) k_t^{H*} \\
 b_{t+1} &\leq \xi^H k_{t+1}^H + \xi^{H*} k_{t+1}^{H*}.
 \end{aligned}$$

where notice that the tax term $\left(\frac{1 - \tau_t^{C,U} - \tau^{C*}}{1 - \tau^{C*}}\right)$ is no longer multiplying the amount of earnings repatriated. Note that nayar2016multinationals actually consider inverting firms in their study of the U.S. census data. The persistence in this status and switching transition probability can be used to calibrate the associated fixed costs. In the stationary equilibrium, the productivity hierarchy of U.S. firms is adjusted relative to the main body of the paper such that the absolute pinnacle of firm productivity is occupied by inverters in each period. Notice that, since these firms do not pay repatriation taxes under the U.S. worldwide system, they are a drain on U.S. tax revenues. As a result, in removing the repatriation tax, the presence of inverters in the model actually serves to strengthen the tax revenue neutrality result. Given that the fraction of inverting firms is small ($< 0.1\%$

of U.S. firms), I omit this extra discrete choice from the main analysis as their inclusion has no significant impact on the results.

Appendix D Computational Algorithm

i Steady State

1. Discretise: set grids for the state variables: $k^H, k^{H*}, b, \theta, \tau^{C,R}$.
2. Guess an initial price for Home goods in the Foreign Country: P_0^{H*} .
3. Guess an initial wage in the Home Country: W_0 .
4. Solve the Home firm problem: given the wage and price, solve the firm's optimisation problem to obtain its value function and policy functions for its capital choice in Home and Foreign, new debt holdings and its extensive margin status.
5. Solve the Home entrant's problem to obtain the value associated with entry.
6. Check the free-entry condition for the Home firms: if $V^N = 0$ then continue. Otherwise
 - If $V^N > 0$, increase the wage and return to step 4.
 - If $V^N < 0$, decrease the wage and return to step 4.
7. Guess an initial distribution of firms across the states. Iterate using the law of motion for the cross section defined in appendix B.i and the policy functions found in step 4 until convergence.
8. Derive the equilibrium measure of firms, \mathcal{M} , from the labour market clearing condition. Find the aggregate labour demand associated with a unit mass — from the stationary distribution found in step 7. The equilibrium measure comes from taking the labour supplied by the Home household and dividing by the labour demand associated with the unit mass; this approach utilises the linearity of the stationary measure.
9. Check the market clearing condition for Home goods in the Foreign market. Find the demand for goods using the Foreign demand curve — excess demand (ED^{H*})

is the difference of this number from aggregate supply of goods from multinationals and exporters corresponding to the equilibrium measure found in step 8. If excess demand equals zero, then stop. Otherwise

- If $ED^{H^*} > 0$ then increase P^{H^*} and return to step 2.
- If $ED^{H^*} < 0$ then decrease P^{H^*} and return to step 2.

10. Back-out other aggregates and cross-sectional measures using the equilibrium measure of firms and stationary distribution.

ii Transition Dynamics

1. Guess time paths for three equilibrium objects — $\{\mathcal{M}_t^j, W_t^j, (P_t^{H^*})^j\}_{t=0}^T$ — which are the measure of entering Home firms, the Home wage and the price of Home goods in the Foreign Country. The superscript j denotes the loop in the computational algorithm, so this initial guess is denoted by $j = 1$. Fix the final values at time T to be those in the post-reform steady state. The values of W_0 and $P_0^{H^*}$ are fixed at the pre-reform steady state, as is \mathcal{M}_{-1} . Notice though that \mathcal{M}_0 is allowed to change in order for the free-entry condition at time $t = 0$ to be achieved.
2. Iterate *backwards* on the incumbent Home firm's problem. Use the post-reform steady state value function as the continuation value for incumbents when they make their time $T - 1$ decisions. This process will generate a sequence of time-varying incumbent firm value functions $\{V_t(\vec{\varphi}_t)\}_{t=1}^T$ where $V_T(\vec{\varphi}_T)$ is the post-reform steady state value function. In addition, this process yields a time-varying sequence of optimal policy functions for incumbents.
3. Iterate backwards on the Home new entrant firm's problem, utilising the sequence $\{V_t(\vec{\varphi}_t)\}_{t=1}^T$ found from 2. This process yields the optimal policy functions for new entrants, in addition to a sequence $\{(V_t^N)^j\}_{t=0}^T$ of their ex-ante values to entering.
4. Iterate *forwards* on the measure of Home firms, starting with that which corresponds to the pre-reform steady state. Denote the measure corresponding to state $\vec{\varphi}_t$ as

$\widehat{\mu}_t(\vec{\varphi}_t)$. The law of motion for this measure is given by

$$\begin{aligned}\widehat{\mu}_{t+1}(\vec{\varphi}_{t+1}) = & \mathcal{M}_t^j \int_{\tau^{C,U,\theta}} \mathbb{1}_{k_{t+1}^H = h_{k^H}^E, b_{t+1} = h_b^E} \overline{Q}_\theta(d\theta_{t+1}) \overline{Q}_\tau(d\tau_{t+1}^{C,U}) \\ & + \int_{\tau^{C,U,\theta,b,k^{H*},k^H}} \Gamma[(\vec{\varphi}_{t+1}), (\vec{\varphi}_t)] \widehat{\mu}_t(dk_t^H, dk_t^{H*}, db_t, d\theta_t, d\tau_t^{C,U})\end{aligned}$$

where $\Gamma[(\vec{\varphi}_{t+1}), (\vec{\varphi}_t)]$ is a transition function, which depends on the policy functions for incumbents found in step 2. It's specific form is the same as in appendix B section i. This process yields a sequence of time-varying measures $\{\widehat{\mu}_t(\vec{\varphi}_t)\}_{t=1}^T$.

5. Utilising the policy functions and firm measures found in steps 2 and 4 respectively, compute the excess demand in the Home labour market and market for Home goods in the Foreign Country. This yields time-varying sequences of excess demands $\{(ED_t^L)^j, (ED_t^{H*})^j\}_{t=1}^T$, where $(ED_t^L)^j$ is that for the labour market and $(ED_t^{H*})^j$ is that for the Home goods in Foreign at time t , each for algorithm loop j .
6. Update the time-paths for the equilibrium objects to obtain new sequence $\{\mathcal{M}_t^{j+1}, W_t^{j+1}, (P_t^{H*})^{j+1}\}_{t=0}^T$ using the computed sequence $\{(V_t^N)^j, (ED_t^L)^j, (ED_t^{H*})^j\}_{t=1}^T$. Specifically, I use the updating process

$$\begin{aligned}\mathcal{M}_t^{j+1} &= \mathcal{M}_t^j + \kappa_{\mathcal{M}}(V_t^N)^j \\ W_t^{j+1} &= W_t^j + \kappa_W(ED_t^L)^j \\ (P_t^{H*})^{j+1} &= (P_t^{H*})^j + \kappa_{PH^*}(ED_t^{H*})^j\end{aligned}$$

for some appropriately-chosen parameters $\kappa_{\mathcal{M}}$, κ_W and κ_{PH^*} . Take the new sequence $\{\mathcal{M}_t^{j+1}, W_t^{j+1}, (P_t^{H*})^{j+1}\}_{t=0}^T$ and return to step 2. Continue this process until the sequence of values to entering and excess demands converges to zero at every point in time.