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On the Incentive Compatibility of Universal Adoption of Destination-Based Cash Flow Taxation

Abstract

We analyze the incentives for an individual country to deviate from destination-based cash flow taxation (DBCFT) in a two-country model in which both countries have adopted DBCFT. A change in a country's corporate tax rate, degree of taxation of capital income, and/or level of border adjustment generates welfare effects that can be decomposed into fiscal effects, a price level effect, and relative price effects. We establish that at least one country will have an incentive to deviate from universal DBCFT by reducing the deduction for capital investments, even with asymmetric countries. For the deviations involving reduction in border adjustments, we show that both countries will have an incentive to deviate in the symmetric case. Universal DBCFT will not be incentive compatible in a one-shot tax setting game, so commitment mechanisms will be required to sustain it as an equilibrium.

JEL-Codes: H730, H210, F230.

Keywords: destination-based taxes, source-based taxes, cash-flow taxes.

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The original title was "Can Destination-based Cash Flow Taxes Arise in Equilibrium?"

1 Introduction

Two key components of corporate income tax policy specify the tax rate applied to net export income relative to domestic income and the extent to which capital expenses are tax deductible. Both dimensions were at play leading up to the passage of the Tax Cuts and Jobs Act (TCJA) (U.S. Congress 2017)[1], which prompted general discussion by tax policy experts.[2] One particular policy that has been shown to have desirable global efficiency properties is destination-based cash flow taxation (DBCFT). The destination-based component of DBCFT involves a border adjustment that exempts export revenue from taxation and does not allow a tax deduction for imported inputs, while the cash flow component allows firms to fully deduct capital expenses from taxable income in the year the expenses are incurred.[3] In contrast, source-based income taxation (SBIT), the policy observed in most countries, taxes net export and domestic income equally and allows a tax deduction for capital expenses based on economic depreciation.

A number of authors have analyzed the potential benefits of allowing the tax deductibilty of capital expenses.[4] Advocates of DBCFT also note that taxing on a destination basis eliminates the incentive to manipulate transfer price manipulation by multinational firms. In particular, Auerbach and Devereux (2018) (AD) develop a two-country model with competitive multinational firms and show that universal adoption of DBCFT results in a globally efficient allocation of capital and an efficient level of public good provision.

A natural question to ask is whether universal adoption of DBCFT would be incentive compatible, in the sense that no country would have an incentive to deviate from DBCFT by imposing some tax on capital income or by introducing a source-based component into the tax system. This question is important from a policy perspective, because the presence of deviation incentives would require the introduction of some form of commitment mechanism to sustain an efficient international

[1]See Tax Reform Task Force (2017).

[2]For instance, see Auerbach and Holtz-Eakin (2016), Auerbach et al (2017), Becker and Englisch (2017), and Benzell, Kotlikoff and LaGarda (2017).

[3]Cash flow taxation also has implications for how debt and interest payments are taxed. We abstract from these issues in this paper.

[4]Studies of the economic effects of the tax deductibility of capital expenses include Brown (1948), Sandmo (1979), Shome and Schutte (1993), and Bond and Devereux (2002). These papers have tended to focus on efficiency, and not tax competition equilibrium. Gordon and Hines (2002) and Keen and Konrad (2013) provide surveys of the fiscal spillovers that can arise when countries or regions set policies unilaterally.

tax agreement.

In this paper we use the AD model to address the incentives of a country to deviate from an initial equilibrium in which all countries have adopted DBCFT to tax firms. We decompose the effect of tax policy changes into fiscal effects and price change effects. The fiscal (or tax exporting) effect arises from a change in the tax revenues collected from foreign investors at given prices. Price effects take two forms: a price level effect and a relative price effect. The price level effect reflects the change in prices of traded goods in one country relative to their prices in trading partners. Relative price effects, on the other hand, result from changes in the prices of non-traded goods in a country relative to traded goods prices. Tax rate changes will be neutral in their effect on resource allocation if they result in price level changes but do not alter relative prices. A country will have no incentive to deviate from an initial equilibrium if tax policy changes are neutral with respect to resource allocation and do not redistribute tax revenues between countries.

To illustrate the role of fiscal and price effects in the incentive to deviate from universal DBCFT, we focus on two types of tax policy changes: a change in the deductibility of capital goods purchases from a company's corporate tax base and a change in the degree of border adjustment. The reduction in the deductibility of capital investments involves a shift from a pure cash flow tax in the direction of an income tax, and we show that such a change involves both a fiscal effect and a relative price effect. The tax exporting effect results from the capture of revenues on the taxation of capital from foreign shareholders of multinational firms, and will be positive for any deviating country. The relative price effect results from the fact that an increase in the cost of capital will raise the cost of a multinational firm's output, which transfers income from consumers to producers in each market. This effect could be either positive or negative for a deviating country. In the case of perfectly symmetric countries, the relative price effects in each market cancel out, so that either country would gain from introducing some taxation of capital income. When countries are asymmetric, the relative price effects have opposite signs in the two countries, so that at least one country must gain from deviating.

A reduction in the border adjustment will have a price level effect, as well as fiscal and relative price effects. The price level effect arises because the border adjustment results in a decrease in the price of traded goods in the deviating country relative to its partner. In contrast to the introduction of a tax on capital income, we show that the sign of the relative price effects will be the same for either country if it deviates. We show that in the symmetric country case, either country will gain from a reduction in its border adjustment in the neighborhood of universal DBCFT. In the asymmetric country case the analysis is more complicated since the answer depends on the direction of trade in the intermediate good and the pattern of consumption. We identify sufficient conditions for a reduction in the border adjustment to be welfare improving for at least one country.

Our results add to the existing literature on the comparison of DBCFT and SBIT. As in AD, a marginal change in a country's corporate tax rate from globally optimal rates under universal DBCFT is neutral, in the sense that it has no effect on the allocation of resources or distribution of resources between countries. In our terminology, the tax rate change has a price level effect, but no fiscal effect or relative price effect, a result which also holds for our exercise in the neighborhood of universal DBCFT. AD also consider the effect of taxing income from capital when taxation is source-based. Their only definitive result in this regard, is that neither country has a unilateral incentive to increase its capital tax when the countries are symmetric and both levy a source-based tax rate of zero.[5] In all other instances, they generate ambiguous welfare effects from a shift from cash flow taxation towards income taxation. In contrast, our Proposition 1 considers the effect of the introduction of a capital tax in a destination-based system, and shows that at least one country must benefit from introducing some capital taxation in that case. Our result differs from theirs because we do not require revenue neutrality of tax policy changes: a deviating country benefits by reducing the deductibilty of capital costs in order to capture tax revenues from foreign shareholders of the multinationals.

AD also consider the effect of introducing a source-based cash flow tax (with a corresponding tax-revenue neutral reduction in the destination-based tax rate). This exercise is similar to our analysis of the effect of reducing the border adjustment in our Proposition 2, although their assumption that introducing a source-based tax moves consumer prices in the same direction is contradicted by our Lemma 3. We should also note that despite the existence of spillover effects of these tax policy changes, Devereux et al (2021, pp 298-300) argue that universal adoption of DBCFT is incentive compatible. Our results serve to identify the incentives to deviate on the various policy

[5]See the first case analyzed on p. 89 in AD.

parameters from universal adoption of DBCFT, and to identify the characteristics (pattern of trade, consumption patterns, and distribution of firm ownership) that affect the magnitude of these incentives).

Becker and Englisch (2020) also use the AD model to consider the incentives for a country to deviate towards DBCFT from SBCFT. Thus, their paper does not address the question of whether universal DBCFT can be an equilibrium outcome. Bond and Gresik (2020) consider the incentives for unilateral changes in tax policy parameters in a North/South model of heterogeneous firms where the decision on whether to become a multinational is endogenous and the South country uses a source-based income tax. In that model, spillovers between countries arise from changes in the number of varieties in a monopolistic competition model. In contrast, the present model focuses on a North/North setting where both countries start with DBCFT.

By considering whether the choice of DBCFT in both countries would be an equilibrium in a game where countries can unilaterally set tax policy parameters, our paper is similar to the international trade literature on the potential for multilateral institutions to sustain an efficient free trade equilibrium. In the international trade literature, terms of trade externalities make an efficient free trade equilibrium unsustainable in a one shot tariff setting game (see Bagwell and Staiger (2002)). The incentives for deviation from universal DBCFT differ in that tariffs are border instruments that discriminate between domestic and foreign suppliers of traded goods, whereas the tax policy parameters we consider involve a mix of border instruments and non-discriminatory instruments.

The question of whether the border adjustments under a DBCFT have spillover effects to other countries is related to the literature on whether a destination-based Value Added Tax (VAT) system distorts international trade. Grossman (1980) and Feldstein and Krugman (1990) have shown that VAT border adjustments raise prices of importables and exportables by the same percentage (our price level effect), and thus have no effects on domestic resource allocation in a model without multinational firms. Costinot and Werning (2019) show that the result can be extended to border adjustments with multinational firms if the productions sets of the affiliates in different countries are independent. The neutrality of border adjustments breaks down in the model we consider because the firms' production sets are linked across countries due to the presence of intra-firm mobility of managerial inputs.[6]

Section 2 characterizes the equilibrium of the AD model when preferences, technologies, and ownership shares can differ across countries, and introduces the three tax policy parameters that we analyze. Section 3 examines the effects of deviations in each of the policy parameters from an initial globally efficient cooperative setting where both countries adopt DBCFT. Section 4 offers some concluding remarks.

2 The model

We study the AD model, which provides a simple structure for capturing the effects of corporate tax policy on a multinational firm's decisions regarding capital investment and the allocation of its capital and "managerial capital" between production facilities in different countries. There are two countries, denoted Home and Foreign, each with a representative consumer that consumes two consumption goods and the services of a public good funded out of tax revenues. Foreign variables are denoted by an *. The Home (Foreign) household begins with L (L^*) divisible units of an endowment good which we refer to as labor. Labor can be converted into good 2 under conditions of constant returns to scale and perfect competition, and we choose units of labor in each country such that one unit of labor is required to produce a unit of good 2. Good 2 can be used as a (non-tradable) consumption good, c_2, a traded capital good, k, or a public good, g.

Good 1 is a non-traded consumption good that is produced by multinational firms using units of an intermediate good that can be produced by a multinational in its affiliates in either country. It is assumed that there is a fixed number of homogeneous multinational firms that are price takers in input and output markets, so that we can characterize their behavior using that of a representative firm. The intermediate good is produced by the representative firm using inputs of capital (k) and managerial skill (m) according to the production function $f(k, m)$ in its Home affiliate and $f^*(k^*, m^*)$ in its Foreign affiliate, with both strictly concave production functions

[6]Some recent macroeconomic papers focus on how exchange rates and prices adjust in response to border adjustments, e.g. Baumann, Dieppe, and Dizioli (2017), Barro and Furman (2018) and Barbiero et al (2018). Barbiero et al derive a neutrality condition in a macroeconomic model without multinational firms that requires restrictions on monetary policy, pricing policy and the form of international asset holdings. We abstract from these short run effects and focus on long run adjustments.

exhibiting decreasing returns to scale. The firm's aggregate purchase of the capital input is denoted by K, which is purchased from good 2 firms and can be allocated between countries. The firm is endowed with M units of managerial skill that is perfectly mobile between countries. Let x (x^*) denote the quantity of the intermediate good used for production of the final good in Home (Foreign). The fact that the intermediate good can be traded between locations yields

$$x_1 + x_1^* = f(k, m) + f^*(K - k, M - m). \tag{1}$$

The firm produces the non-traded final consumption good from the intermediate input and a fixed factor according to the technology $c_1 = h(x_1)$ in Home and $c_1^* = h^*(x_1^*)$ in Foreign, where $h(\cdot)$ and $h^*(\cdot)$ are strictly concave functions.

Eq. (1) allows each affiliate to sell some of its intermediate good production to the other affiliate. Net exports by Home are $e = f(k, m) - x_1$. We assume that any such trades occur at an arm's length transfer price, q, which is equal to the marginal cost of the selling affiliate. Thus, as shown in AD,

$$q = \begin{cases} p_2/f_1(k, m) & if\ e > 0 \\ 1/f_1^*(K - k, M - m) & if\ e < 0, \end{cases} \tag{2}$$

where subscripts on the f and f^* functions denoted partial derivatives. The arm's length price is not manipulable by the multinational but can change with changes in either country's tax policy. Eq. (2) rules out firms manipulating their transfer price on intra-firm trade in order to reduce their total tax liability. In the case of universal DBCFT, the multinational will not have an incentive to manipulate transfer prices as we discuss below. For other cases, this assumption would be consistent with effective enforcement of transfer pricing by tax authorities. We will show that our results continue to hold even if the multinational has the ability to manipulate q or set a transfer price that differs from q.

Given these definitions, after-tax multinational profit from good 1 production and sales equals

$$\pi = p_1 c_1 + p_1^* c_1^* - p_2 k - p_2^*(K - k) - T_1 - T_1^* \tag{3}$$

where $p_1(p_1^*)$ is the Home (Foreign) price of good 1, $p_2(p_2^*)$ is the Home (Foreign) price of good 2 and of capital, and $T_1(T_1^*)$ is the Home (Foreign) affiliate's corporate tax bill. Firms are assumed to choose K, m, k, and x_1 to maximize global after-tax profits.

Home consumer preferences are given by the quasi-linear utility function, $U = u(c_1) + c_2 + \nu(g)$, where $u(\cdot)$ and $\nu(\cdot)$ are increasing and strictly concave functions. Similarly, Foreign consumer preferences are $U^* = u^*(c_1^*) + c_2^* + \nu^*(g^*)$. Consumer income consists of labor income and ownership shares of the multinational. Letting w denote the wage rate and β the share of multinational profits owned by the Home consumer, Home household income is $wL + \beta\pi$ and Foreign income is $w^*L^* + \beta^*\pi$, where $\beta + \beta^* = 1$. We choose units of good 2 in the foreign country as the numeraire, so the household budget constraints for the respective countries will be

$$p_2c_2 + p_1c_1 = wL + \beta\pi \text{ and } c_2^* + p_1^*c_1^* = w^*L^* + \beta^*\pi. \tag{4}$$

Utility maximization implies that $u'(c_1) = p_1/p_2$ and $u^{*\prime}(c_1^*) = p_1^*$.

2.1 Government Tax and Spending Policy

Governments in each country impose corporate income taxes on firms selling goods 1 and 2 based on their respective definitions of taxable income. Labor costs are assumed to be deductible from corporate income in each country, while the cost of the managerial input or fixed factors in the production of consumption goods are not deductible.

For good 1 sales, the multinational is taxed in each of its production locations based on the definition of taxable income and deductible expenses in that location.[7] Home tax policy is characterized by the parameters $\{t, \lambda, \delta\}$. The corporate tax rate t is the rate that is applied to the Home definition of income for the Home affiliate. $\lambda \in [1-t, 1]$ is the after-tax cost of a unit of capital to the firm. In the case of a cash flow tax, all capital expenses are deductible and $\lambda = 1 - t$. In an income tax system where capital costs are not deductible from taxable income, $\lambda = 1$. We treat λ as a continuous choice variable of Home, since countries can affect the after-tax cost of capital by varying depreciation allowances

[7] We assume that each country adopts an exemption or territorial system for dividend payments so that the multinational incurs no additional taxes to distribute its profit to shareholders.

The parameter $\delta \in [0,1]$ is the border adjustment parameter indicating the share of the tax rate that is imposed by the home country on exports trade in the intermediate good and the share of the imported intermediates that are deductible from Home taxable income. The tax liability to the Home government on intra-firm trade is δtqe. Under a destination-based tax system $\delta = 0$, since export sales of the intermediate good are not subject to income tax and imports from the Foreign plant are not tax deductible. In contrast, $\delta = 1$ under a source-based system because sales of intermediate goods are counted as part of local income and purchases of imported inputs from the Foreign plant are deductible from corporate income. We also treat δ as a continuous choice parameter, which allows for partial border adjustments of tax liabilities for imports and exports.[8] Foreign tax policy is similarly characterized by $\{t^*, \lambda^*, \delta^*\}$.

Given these definitions, government tax revenues from good 1 sales are

$$T_1 = t \cdot \left(p_1 c_1 + \delta qe - \frac{1-\lambda}{t} p_2 k \right) \text{ and } T_1^* = t^* \cdot \left(p_1^* c_1^* - \delta^* qe - \frac{1-\lambda^*}{t^*} p_2^* (K-k) \right) \tag{5}$$

and after-tax multinational profit is

$$\pi = (1-t)p_1 c_1 - \lambda p_2 k + (1-t^*)p_1^* c_1^* - \lambda^* p_2^* (K-k) + (\delta^* t^* - \delta t) qe. \tag{6}$$

The last term in (6) shows that the tax differential $\delta^* t^* - \delta t$ creates an income shifting incentive at the margin for intra-firm trade. If $\delta^* t^* < \delta t$, as might occur if Home has a higher corporate tax and both countries have source-based systems, the firm has an incentive to increase its Home imports of the intermediate good in order to shift income to the Foreign affiliate. If both countries adopt DBCFT, intra-firm trade has no effect on the tax bill and there is no income shifting incentive on intra-firm trade. As AD point out, if the countries are sufficiently asymmetric the actual direction of trade can be the opposite of that suggested solely by the sign of $\delta^* t^* - \delta t$. For example, Home may import the intermediate input if final good demand is significantly larger at Home, even if $\delta^* t^* > \delta t$.

[8] For example, the Tax Cuts and Jobs Act included some partial border adjustment in the form of the Base Erosion and Anti-Abuse Tax (BEAT) provision, which limits the deductibility of payments by multinationals to foreign subsidiaries in low tax locations. China's use of partial refunds of VAT payments on exports (Chandra and Long (2013)) provides an example of the use of partial border adjustments in a destination-based VAT system.

In the production of good 2, firms incur no capital expenses and are perfectly competitive. These firms can buy the endowment good from the Home (Foreign) consumer at $w(w*)$ and sell good 2 at $p_2(1)$. In order for sector 2 firms to earn zero profit on domestic sales, it must be that $p_2 = w$ and $p_2^* = w^* = 1$. Note however that the linkage between prices of good 2 between countries will depend on the deductibility of the cost of imported inputs and the tax treatment of export income. When Home is a net exporter of capital, it can sell a unit to a Foreign importer at a price of p_{2x} and earn after-tax profit of $(1 - \delta t)p_{2x} - (1 - t)w$. After-tax profit for the Foreign importer from this trade is $(1 - t^*)p_2^* - (1 - \delta^* t^*)p_{2x}$. Zero profit for the Home exporter and the Foreign importer then implies that $p_{2x} = (1 - t^*)/(1 - \delta^* t^*)$ and

$$p_2 = w = \frac{(1 - t^*)(1 - \delta t)}{(1 - t)(1 - \delta^* t^*)} = \frac{1 - \delta t}{1 - t} p_{2x}. \tag{7}$$

Similar calculations show that when Foreign is the capital exporter, one gets the same expressions for p_2 and p_2^* and the Foreign export price is $p_{2x}^* = (1 - t^*)/(1 - \delta^* t^*) = p_{2x}$.[9]

We refer to a tax policy change that alters p_2 as having a price level effect, since it alters the price of traded goods in the home country relative to that in foreign. Under universal DBCFT (i.e. $\delta = \delta^* = 0$), changes in the corporate tax rate are fully passed through to the domestic price of traded goods. In contrast, there is no price level effect of a corporate tax rate change if a country has adopted a source based tax system ($\delta = 1, \delta^* = 1$). Changes in the degree of border adjustment in the neighborhood of universal DBCFT, which we consider below, will have price level effects with $\frac{dp_2}{d\delta} = -tp_2$ and $\frac{dp_2}{d\delta^*} = t^* p_2$. Finally, observe that changes in the deductibility of capital costs do not have a price level effect under any system.

For $\delta \in [0, 1)$, it can be seen from (7) that $p_2 > p_{2x}$. If Home imports the capital good, $p_2 - p_{2x}$ represents the border adjustment tax collected by Home due to the less than complete deductibility of imported capital goods from firm profits. If Home exports the capital good, $p_2 - p_{2x}$ is the subsidy paid by the Home government per unit of capital exports due to the exemption of profits on export sales. Home is an importer (exporter) of capital when $c_2 + k + g > (<) L$. Using a similar argument

[9] AD derive different price formulas for the destination-only cases because they let good 2 be the numeraire in each country and then use an exchange rate. The above prices imply the same relative prices as in AD.

for Foreign, the government revenue collected from taxes on capital trade will be

$$T_2 = \frac{t(1-\delta)}{1-t} p_{2x}(c_2 + k + g - L) \text{ and } T_2^* = \frac{-t^*(1-\delta^*)}{(1-t^*)} p_{2x}(L^* - c_2^* - k^* - g^*). \tag{8}$$

The exporting country effectively subsidizes the capital trade whereas the importing country earns tax revenue on it when $\delta < 1$.[10]

We assume that government spending is equal to tax revenues so $p_2 g = T_1 + T_2$ and $g^* = T_1^* + T_2^*$. Using the government budget constraint and (8), we have

$$g = \frac{T_1}{p_{2x}} + \frac{t(1-\delta)(c_2 + k - L)}{1-t} \text{ and } g^* = \frac{T_1^*}{p_{2x}} + \frac{t^*(1-\delta^*)(c_2^* + k^* - L^*)}{1-t^*}. \tag{9}$$

The labor market equilibrium condition requires that $L = c_2 + g + k + z_2$, where z_2 denotes net exports of capital. Substituting the labor market condition and (9) into the household budget constraint, (4), yields the condition for current account balance,

$$qz_2 + p_{2x}e + \beta\pi - \pi^h = 0 \tag{10}$$

where π^h is the profit generated by the Home affiliate. Current account balance requires that the value of net exports of capital and intermediate goods evaluated at border prices equal the net payment of multinational profits to foreigners.

2.2 Market Equilibrium

Holding each country's tax policy fixed, a market equilibrium satisfies profit maximization by the multinational, utility maximization by Home and Foreign consumers, and market clearing. At an interior equilibrium where the multinational produces and sells in both countries, differentiation of

[10] We simplify by assuming that when a country exports good 2, the tax authority is willing to subsidize sector 2 firms that have negative reported tax liabilities. If the government were to require tax payments to be non-negative, then firms in sector 1 would have an incentive to integrate with sector 2 firms that export capital goods in order to offset their positive tax liabilities on sales of good 1. In that case the tax collections on sector 2 activities would be the same as in (8).

(6) yields the multinational's profit-maximizing choices:

$$\pi_k = 0 \Rightarrow (1-t^*)p_1^* h^{*\prime}(x_1^*)(f_1(k,m) - f_1^*(K-k, M-m)) = \lambda p_2 - \lambda^* + (\delta t - \delta^* t^*) f_1(k,m) q, \quad (11)$$

$$\pi_m = 0 \Rightarrow (1-t^*)p_1^* h^{*\prime}(x_1^*)(f_2(k,m) - f_2^*(K-k, M-m)) + (\delta^* t^* - \delta t) f_2(k,m) q = 0, \quad (12)$$

$$\pi_K = 0 \Rightarrow (1-t^*)p_1^* h^{*\prime}(x_1^*) f_1^*(K-k, M-m) - \lambda^* = 0, \quad (13)$$

and

$$\pi_{x_1} = 0 \Rightarrow (1-t)p_1 h'(x_1) - (1-t^*)p_1^* h^{*\prime}(x_1^*) - (\delta^* t^* - \delta t) q = 0. \quad (14)$$

These necessary conditions can be used to illustrate the "tax wedges" created by the choice of tax parameters by the respective governments. Equations (11) and (12) illustrate how tax policy affects a multinational's allocation of inputs between countries. If $\lambda p_2 > \lambda^*$, the after-tax cost of capital is higher in Home than in Foreign, which creates an incentive to substitute capital investment in Foreign for that in Home. If $\delta t > \delta^* t^*$, there is an incentive for the firm to declare income in Foreign rather than in Home, which creates an incentive to shift both capital investments and the use of managerial input toward Foreign. Equation (13) shows that a multinational will equate its after-tax marginal revenue product of capital in Home to the after-tax cost of capital in Foreign. Finally, equation (14) shows that if $\delta t > \delta^* t^*$, after-tax marginal revenue will be higher in Foreign than in Home, reflecting an incentive to substitute Home sales for Foreign sales.

Observe that with universal DBCFT, $\lambda p_2 = \lambda^* = 1 - t^*$ and $\delta t = \delta^* t^* = 0$, so the marginal products of capital and the managerial input will be equated across countries from (11) and (12). In addition, we have from (13), (14), and the necessary conditions for consumer optimization that the marginal value of an additional unit of the intermediate good in each country will be equated to the common marginal cost of production of the intermediate, $u'(c_1)h'(x_1) = u^{*\prime}(c_1^*)h'(x_1^*) = 1/f_1(k,m)$. Thus, the quantities c_1, c_1^*, K, k and m will be invariant to the choices of tax rates by the countries. Furthermore, the fact that firm profits are independent of q with $\delta = \delta^* = 0$ means that, even if it could, the multinational has no incentive to manipulate transfer prices to reduce its tax burden.

We impose the following assumption on multinational firm technology:

Assumption 1 *At an interior universal DBCFT equilibrium, the multinational's production tech-*

nology satisfies

$$\begin{aligned}\Delta &= f^*_{11}(k^*,m^*)(f_{22}(k,m)+f^*_{22}(k^*,m^*)) - f^*_{12}(k^*,m^*)(f_{12}(k,m)+f^*_{12}(k^*,m^*)) > 0 \\ & \textit{and} \qquad (15) \\ \Delta^* &= f_{11}(k,m)(f_{22}(k,m)+f^*_{22}(k^*,m^*)) - f_{12}(k,m)(f_{12}(k,m)+f^*_{12}(k^*,m^*)) > 0.\end{aligned}$$

To understand the restriction imposed by Assumption 1, consider how the cost minimizing usage of capital for a multinational changes as its total output of the intermediate good increases. The strict concavity of the production functions for the intermediate goods ensures that $\Delta + \Delta^* > 0$, which guarantees that an increase in output will result in greater usage of capital for the firm as a whole. However, how that increased capital usage is allocated across the affiliates is determined by the signs of Δ and Δ^*. An increase in output of the multinational will result in an increase in capital usage by the Home (Foreign) affiliate if, and only if, $\Delta > 0$ ($\Delta^* > 0$). Thus, the Assumption can be interpreted as requiring that capital be a "normal" input in each affiliate, in the sense that each affiliate employs more capital as the output of the firm rises.

Assumption 1 must hold when the intermediate good technologies are identical across countries, even if there are differences in preferences and the final good production technologies. To illustrate the restrictions imposed when the intermediate good technologies differ across locations, suppose the technologies are Cobb Douglas with $f(k,m) = k^{\alpha}m^{\gamma}$ and $f^*(k^*,m^*) = (k^*)^{\alpha^*}(m^*)^{\gamma^*}$ for $\alpha+\gamma < 1$ and $\alpha^*+\gamma^* < 1$. Assumption 1 will be satisfied if $\alpha+\gamma^* < 1$ and $\alpha^*+\gamma < 1$, regardless of any asymmetry among preferences or final good production technologies. The requirement is that the factor shares of the factors that are mobile within the firm not differ too much across locations.

3 Unilateral Tax Incentives with DBCFT in Both Countries

As AD note, the market equilibrium when both countries adopt DBCFT has desirable efficiency properties, because the choice of the corporate income tax has no effect on the location of production of intermediate or final goods. Therefore, it would be desirable for Home and Foreign to coordinate their policy choices so that both countries adopt DBCFT and set tax rates that lead to efficient global provision of public goods. Would such a system be immune to unilateral deviations by Home and Foreign in their choice of tax policy parameters, or would some form of commitment mechanism be required to sustain an equilibrium with DBCFT in each country? In this section we address this question by examining whether Home can benefit by deviating from globally efficient universal DBCFT and globally efficient tax rates by changing any of the policy parameters $\{t, \delta, \lambda\}$ and similarly for Foreign.

We begin by considering Home's choice of tax rate to maximize national welfare. Evaluating the profits of a representative multinational when both countries have a DBCFT using (6), (7), and the consumer optimization problem yields

$$\pi = (1 - t^*)(u'(c_1)c_1 + u^{*\prime}(c_1^*)c_1^* - K), \tag{16}$$

which is independent of Home's choice of tax rate. Consistent with AD, the countries' tax rates under universal DBCFT are pure profit taxes.

Solving (4) and (9) yields government spending and Home good 2 consumption of

$$g = \frac{t\beta\pi}{1 - t^*} = t\beta(u'(c_1)c_1 + u^{*\prime}(c_1^*)c_1^* - K) \tag{17}$$

and

$$c_2 = L + \frac{(1 - t)\beta\pi}{1 - t^*} - u'(h(x_1))h(x_1). \tag{18}$$

When Home raises its corporate tax rate on the multinational activity that takes place in Home, part of that tax falls on the owners of the multinational in Foreign when $\beta^* > 0$. This suggests an incentive for Home to use its corporate tax rate to capture revenue from Foreign. However, changes in the tax rate also affect the revenue collected on capital trade. Equations (17) and (18) show that when the effect on capital tax revenues is included, the impact of an increase in the Home corporate tax rate on Home tax revenues depends on its ownership share in the multinational, and not on its share of global production revenue. Analogous expressions exist for c_2^* and g^*.

If the tax rates are set non-cooperatively, Home will set its tax rate such that $\frac{dU}{dt} = 0$. The change in Home welfare will be

$$\frac{dU}{dt} = \frac{p_1}{p_2}\frac{dc_1}{dt} + \frac{dc_2}{dt} + v'(g)\frac{dg}{dt}. \tag{19}$$

Since x_1, c_1 and π are independent of the Home tax rate, we have from (17) and (18) that $\partial c_2/\partial t = -\beta\pi/(1-t^*) = -\partial g/\partial t$. Assuming that Home's share of multinational profits is sufficiently large that $\beta\pi/(1-t^*) \geq (v')^{-1}(1)$, Home's optimal policy is to choose t such that $v'(g) = 1$. In addition, because government spending in any market equilibrium under universal DBCFT, as in (17), is independent of the other country's tax rate, Home has the dominant strategy tax rate of

$$t = \frac{(v')^{-1}(1)}{\beta[u'(c_1)c_1 + u^{*\prime}(c_1^*)c_1^* - K]} \tag{20}$$

as long as the expression in (20) is not greater than 1. Thus, Home's unilateral choice of its tax rate results in an efficient level of Home government spending.[11] A similar result holds for Foreign.

A Unilateral Incentive to Shift Away From Full Cash Flow Taxation

Next, we examine the incentive of each country to deviate from the use of a cash flow tax, $\lambda = 1 - t$ and $\lambda^* = 1 - t^*$, while maintaining the destination-based taxation principle, $\delta = \delta^* = 0$. Such a change will leave p_2 unaffected, since the price of good 2 is determined by the border adjustment policies.

To determine the effect of an increase in a capital tax, we note from the necessary conditions in (11)-(14) that an increase in λ or λ^* increases the firm's cost of using capital in the respective location. The following comparative statics results are established in the Appendix by totally differentiating the multinational firm's necessary first-order conditions and taking into account the impact of changes in multinational firm output on market prices.

Lemma 1 *If Assumption 1 holds and universal DBCFT yields an interior market equilibrium, an increase in either λ or λ^* will reduce the representative firm's total capital investment and the output of good 1 in each country, and increase the price of good 1 in each country. In particular,*

[11] If lump sum transfers were feasible, neither government would have an incentive to raise more revenue because it would simply redistribute the excess amount back to its households to offset a reduction in c_2.

the price increases will satisfy

$$\frac{dp_1}{d\lambda^*} = \frac{\Delta^*}{p_2\Delta}\frac{dp_1}{d\lambda} > 0 \textit{ and } \frac{dp_1^*}{d\lambda^*} = \frac{\Delta^*}{p_2\Delta}\frac{dp_1^*}{d\lambda} > 0. \tag{21}$$

An increase in λ raises the cost of using capital in Home production of the intermediate, which results in the substitution of production of the intermediate from Home to Foreign and a decline in overall capital investment by the multinational. The higher cost of production of the intermediate good results in a decline in the output of good 1 and an increase in the price in each location. Thus, an increase in λ or λ^* has a common relative price effect across countries but has no price level effect.

To evaluate the effect of an increase in λ on Home welfare, we focus on the case where there is an interior solution with $v'(g) = (v^*)'(g^*) = 1$. From (19), the effect of an increase in the Home tax on capital on Home welfare from (19) is

$$\frac{dU}{d\lambda} = \frac{p_1}{p_2}\frac{dc_1}{d\lambda} + \frac{d(c_2 + g)}{d\lambda}. \tag{22}$$

Using (4) and (9), we can express $c_2 + g$ as

$$c_2 + g = L + \frac{\beta\pi}{1 - t^*} - \frac{p_1}{p_2}c_1 + \frac{k(t - (1 - \lambda))}{1 - t}. \tag{23}$$

Differentiating (23), using the Envelope Theorem to calculate $d\pi$, and substituting the result in (22) yields

$$\left.\frac{dU}{d\lambda}\right|_{\lambda=1-t,\lambda^*=1-t^*} = \frac{\beta^* k}{1 - t} - \beta^*\frac{c_1}{p_2}\frac{dp_1}{d\lambda} + \beta c_1^*\frac{dp_1^*}{d\lambda}. \tag{24}$$

The first term in (24) represents the fiscal effect associated with exporting taxes to non-residents. Raising one's capital tax rate generates tax revenue benefits that are proportional to the ownership share of non-residents, since the tax is being collected on the profits held by Foreign residents. The remaining two terms in each expression represent the relative price effects through changes in the prices for good 1. An increase in p_1 transfers income from Home consumers to the multinational firm, which harms Home when $\beta^* > 0$. An increase in p_1^* transfers income from Foreign consumers to the firm, which benefits Home when $\beta > 0$.

A similar expression is obtained for the effect of an increase in Foreign's capital tax on Foreign welfare:

$$\left.\frac{dU^*}{d\lambda^*}\right|_{\lambda=1-t,\lambda^*=1-t^*} = \frac{\beta k^*}{1-t^*} + \beta^* \frac{c_1}{p_2}\frac{dp_1}{d\lambda^*} - \beta c_1^* \frac{dp_1^*}{d\lambda^*}. \tag{25}$$

A unilateral increase in its capital tax will increase its welfare by collecting tax revenues from non-residents. The only question for either country is whether the resulting relative price effects move welfare in the opposite direction by enough to offset the fiscal effects.

In a symmetric economy with identical technologies and preferences across countries and $\beta = 1/2$, $\Delta = \Delta^* > 0$ and $\beta^* \frac{c_1}{p_2}\frac{dp_1}{d\lambda^*} = \beta c_1^* \frac{dp_1^*}{d\lambda^*}$ so the relative price effect for each country will be 0. In the perfectly symmetric case, each country has a unilateral incentive to increase its capital tax. When the countries are asymmetric, the value of Foreign's relative price effect will equal Home's relative price effect scaled by $-\Delta^*/(p_2\Delta)$ according to Lemma 1. Since the countries' relative price effects will necessarily have opposite signs, at least one country must benefit from deviating from universal DBCFT by raising its tax on capital. Observe that Home's gain from the change in multinational firm profit is increasing in β and in c_1^*/c_1. Thus, a Home deviation is most attractive when Home residents own a larger share of the multinational firm, and when a larger share of multinational firm sales are being collected from Foreign consumers.

This analysis implies the following proposition.

Proposition 1 *If Assumption 1 holds and universal DBCFT yields an interior market equilibrium, then at least one country will have a unilateral incentive to reduce the tax deduction for capital expenses.*

Proposition 1 reveals that non-cooperative universal adoption of DBCFT is undermined by unilateral incentives of at least one country to allow less than a full tax deduction for capital expenses. Proposition 1 holds even if the model allowed for transfer price and/or arm's length price manipulation because any incentive to shift income between the countries is eliminated when both countries adopt full destination-based taxation.

A Unilateral Incentive to Shift Away From Full Border Adjustment

In this section, we examine the effect of a unilateral shift away from full border adjustment for each country. We evaluate changes in a country's welfare from an increase in its border adjustment, δ or δ^*, starting from a market equilibrium where both countries have adopted DBCFT and tax rates are such that $v'(g) = v^{*\prime}(g^*) = 1$. We show that a change in the border adjustment by either country has both a price level and a relative price effect, and we derive expressions for the effects of these price changes on welfare.

The following result shows that the effects of border adjustments by Home and Foreign on prices and firm outputs are proportional and in opposite directions:

Lemma 2 *Changes in the border adjustments satisfy*
(a) $\frac{dp_2}{d\delta} = -tp_2$ *and* $\frac{dp_2}{d\delta^*} = t^* p_2$*, and*
(b) for a firm choice variable $y \in \{x_1, K, m, k\}$, $\frac{dy}{d\delta} = -\frac{t}{t^*}\frac{dy}{d\delta^*}$.

Part (a) follows immediately from the no arbitrage condition for good 2. It can be seen from the necessary conditions for the firm's optimization problem that changes in the border adjustments satisfying $td\delta = t^* d\delta^*$ will have no effect on firm output decisions, which establishes (b). Note that the result in (b) will also hold for x_1^*, and hence for the consumption and price changes of good 1 in both countries.

Since in general a unilateral change in δ will affect the firm's necessary first-order conditions, border adjustments will have both price level and relative price effects and thus will not be neutral in their effect. It can be shown that if the production of good 1 takes place between independent firms trading intermediate inputs and managerial inputs at arm's length prices, reductions in the border adjustment would have no effect on the relative prices and countries would not have an incentive to manipulate the border adjustment. Thus, the non-neutrality of border adjustments results from the internal reallocation of the managerial input in multinational firms.

As was the case for a change in λ, the change in Home welfare from a change in δ will be the price weighted change in consumption of good 1 and good 2/public good consumption when there is efficient provision of the public good. To establish the effect of δ on $c_2 + g$, we obtain from (4) and (9),

$$c_2 + g = L + \frac{\beta\pi}{1-t^*} - \frac{(1-t)p_1 c_1}{1-t^*} + \frac{t\delta qe}{1-t^*} - \delta tk. \tag{26}$$

Differentiating eq. (26), applying the Envelope Theorem to π, and substituting into the welfare expression yields

$$\left.\frac{dU}{d\delta}\right|_{\delta=\delta^*=0} = \beta^* t\left(\frac{p_1}{p_2}c_1 - k\right) + \frac{\beta^* tqe}{1-t^*} - \beta^* c_1 u''(c_1)\frac{\partial c_1}{\partial \delta} + \beta c_1^* u^{*\prime\prime}(c_1^*)\frac{\partial c_1^*}{\partial \delta}. \tag{27}$$

Changes in δ affect Home welfare through a fiscal effect, a price level effect, and a relative price effect. The first term is the effect of a reduction in p_2 on multinational profits from sales in the Home market at fixed c_1, which must be positive at an interior solution. The Home benefit comes from the fact that the increased tax revenues are a transfer from Foreign shareholders to the Home treasury, so the benefit to Home is increasing in β^*.

The second term is the effect on c_2+g of an increase in δ on tax revenue from trade in intermediate goods because the reduction in the border adjustment introduces a source-based element to the corporate tax. If the Home affiliate is an exporter of the intermediate good, Home tax revenue will increase with an increase in δ because Home captures some revenue on export sales. In contrast, an increase in δ will reduce Home tax revenue if Home imports the intermediate good by making a portion of the cost of imports deductible.

The remaining terms in (27) are the effect of the relative price changes of good 1 in each country on Home welfare, since $\frac{d(p_1/p_2)}{d\delta} = u''(c_1)\frac{dc_1}{d\delta}$ and similarly for $\frac{dp_1^*}{d\delta}$. A reduction in p_1/p_2 transfers income from the multinationals to Home consumers, which benefits Home to the extent that the multinational is owned by Foreign residents. Similarly, an increase in p_1^* transfers income from Foreign consumers to the multinational, which benefits Home to the extent that it has ownership in multinationals.

The incentive to deviate from universal DBCFT by altering δ will depend on the magnitude of these potentially conflicting effects. The price level effect provides an incentive to deviate, but the remaining terms depend on the pattern of trade and magnitude of relative price changes. To provide some insight about the importance of these effects, it is useful to start with the symmetric case with identical preferences, production functions, and ownership shares in the multinational.

In the symmetric case, there will be no trade between the affiliates, $e = 0$, so the second term in (27) is zero.

To evaluate the relative price terms, we need the following result which is proven in the Appendix:

Lemma 3 *In the case where technologies and preferences are identical across countries and* $\beta = 1/2$*,*

$$\frac{dK}{d\delta} = 0 \text{ and } \frac{dc_1}{d\delta} = -\frac{dc_1^*}{d\delta} > 0. \tag{28}$$

The increase in δ has no effect on the representative multinational's capital stock, but results in a reallocation of sales from the Foreign market to the Home market. The reason for the reallocation of sales to the Home market is that an increase in δ creates an incentive to produce more of the intermediate good in the Foreign affiliate and ship it to the Home market. From the multinational's first-order conditions, (11) and (12), it can be seen that an increase in δ will create an incentive to allocate more of K and M to the Foreign affiliate, while from (14) the incentive is to allocate more of the intermediate to the Home market. The latter observation suggests that as long as overall production of the input does not change by too much, a condition that is satisfied in the symmetric case, the firm will have an incentive to increase sales of the final good in Home and reduce them in Foreign. An increase in Home consumption and a decrease in Foreign consumption would then have a positive effect on Home welfare, so that each country would have an incentive to reduce the border adjustment in the symmetric case.[12]

For the asymmetric country case, it is also useful to examine the effect of a change in Foreign's border adjustment on Foreign welfare. Proceeding as in the case for the Home country, we obtain

$$\left.\frac{dU^*}{d\delta^*}\right|_{\delta=\delta^*=0} = \beta t^* \left(p_1^* c_1^* - k^*\right) - \frac{\beta t^* q e}{1-t^*} + \beta^* c_1 u''(c_1)\frac{\partial c_1}{\partial \delta^*} - \beta c_1^* u^{*\prime\prime}(c_1^*)\frac{\partial c_1^*}{\partial \delta^*}. \tag{29}$$

The first term is the gain from taxation on local sales, and must be positive at an interior solution as was the case for the Home country. The second term captures the tax revenue effect from a change in the border adjustment on trade in the intermediate, which has the opposite sign

[12]Note that in contrast to our Lemma 3, AD (p 85) evaluate the welfare effects assuming that relative prices of good 1 move in the same direction in each country

from that for the Home country. The country that exports the intermediate will gain tax revenue on export sales by reducing the degree of border adjustment.

For the relative price effects, represented by the last two terms in (29),it follows from Lemma 2 that the an increase in δ will have the opposite effect on relative prices as does an increase in δ^*. However, comparing (27) and (29), it can be seen that if the Home country benefits (loses) from the relative price effects by raising δ, then the Foreign country will also benefit (lose) from raising δ^*. The relative price change for good 1 in each country resulting from a change in δ^* has the opposite sign from that resulting from a change in δ but the welfare effects have the same sign. Note the contrast of this result to the case of the reduction in the deduction for capital expenses, where an increase in λ and λ^* moved relative prices in the same direction and generated welfare effects with opposite signs.

We can summarize the results of this section as follows:

Proposition 2 *If Home and Foreign have identical preferences, technologies, and multinational ownership shares, each country has a unilateral incentive to deviate from universal DBCFT by reducing its border adjustment.*

If Home and Foreign are asymmetric, there are conflicting effects. Both countries can gain tax revenue on domestic sales and the exporter (importer) of the intermediate will gain (lose) revenue from a reduction in the degree of border adjustments. For the relative price effects, either both gain or both lose from deviating from a full border adjustment.

4 Conclusion

We have identified how fiscal effects and price effects resulting from these tax parameter changes create an incentive for countries to deviate from universal DBCFT when there are multinational firms engaged in intra-firm trade. We have also showed how the deviation incentives depend on the allocation of ownership of the multinational firms across countries and the pattern of trade when countries are asymmetric.

The fiscal effects of imposing a tax on capital usage derive from shifting part of the tax burden to Foreign owners of the multinational. Price effects do arise from a change in one country's corporate tax policy, but they must be positive for at least one country. From an equilibrium perspective, small deviations from DBCFT do not generate first-order efficiency losses because global welfare is optimized under universal DBCFT. Moreover, our analysis of a reduction in the deductions for capital expenses applies in both symmetric economies and asymmetric economies. Deviation incentives due to the price effect are stronger in countries that have a larger share of firm ownership.

We also show that the existence of intra-firm trade and cross-border ownership of firm profits means that border adjustments will not be neutral. A change in the border adjustment has an effect on the prices of traded goods that is the same as a combined import tariff and export subsidy for traded goods. In the presence of intra-firm trade in the multinational, border adjustments will result in a reallocation of capital and managerial resources between countries. In the symmetric country case, both countries have an incentive to deviate from DBCFT. In the asymmetric country case, there will be conflicting incentives. Both countries gain tax revenue from local sales by reducing the degree of border adjustment, and the country exporting (importing) the intermediate will gain (lose) revenue. In contrast to the case of deviating from a pure cash flow tax, the relative price effects of reducing the border adjustment will be in the same direction for both countries.

Our analysis has shown that in order for a universal agreement on the use of DBCFT to be honored by each country, a commitment mechanism will be required to prevent countries from making unilateral deviations in their tax treatment of capital income and in their adherence to a fully destination-based tax principle. The use of repeated interactions between countries to sustain cooperation using history dependent strategies would be one possible solution, although countries tend not to change their corporate tax rates very often. Developing a repeated game approach to supporting cooperation on tax policy remains an area for future research.

5 Appendix

Proof of Lemma 1: To establish the results in Lemma 1, we calculate comparative statics using the necessary conditions in (11)-(14). We totally differentiate these conditions with respect to λ and λ^* and evaluate at $\delta = \delta^* = 0$, $\lambda = 1-t$, $\lambda^* = 1-t^*$, taking into account the impact of changes in outputs on consumer prices. Recalling that in a market equilibrium with universal DBCFT that

$f_1(k,m) = f_1^*(K-k, M-m))$ and $f_2(k,m) = f_2^*(K-k, M-m)$, we have

$$\pi_{kk}dk + \pi_{km}dm + \pi_{kK}dK + \pi_{kx_1}dx_1 = p_2 d\lambda - d\lambda^*, \tag{30}$$

$$\pi_{km}dk + \pi_{mm}dm + \pi_{mK}dK + \pi_{mx_1}dx_1 = 0, \tag{31}$$

$$\begin{aligned} \pi_{kK}dk \quad &+ \quad \pi_{mK}dm + \pi_{KK}dK + \pi_{Kx_1}dx_1 + \\ (1 \quad &- \quad t^*)h^{*\prime}(x_1^*)f_1^*(K-k, M-m)\frac{dp_1^*}{dx_1^*}(f_1^*(K-k, M-m)dK - dx_1) = d\lambda^*, \end{aligned} \tag{32}$$

and

$$\begin{aligned} &\pi_{kx_1}dk + \pi_{mx_1}dm + \pi_{Kx_1}dK + \pi_{x_1x_1}dx_1 + (1-t)h'(x_1)\tfrac{dp_1}{dx_1}dx_1 \\ &-(1-t^*)h^{*\prime}(x_1^*)\tfrac{dp_1^*}{dx_1^*}(f_1(K-k, M-m)dK - dx_1) = 0 \end{aligned} \tag{33}$$

as $dx_1^* = f_1^*(K-k, M-m)dK - dx_1$, $dp_1/dx_1 = p_2u''(c_1)h'(x_1)$, and $dp_1^*/dx_1^* = u^{*\prime\prime}(c_1^*)h^{*\prime}(x_1^*)$. The subscripts on π in (30)-(33) refer to derivatives of the multinational's profit function holding prices constant.

Direct calculation yields at a universal DBCFT market equilibrium that $\pi_{kk} = (1-t^*)p_1^*h^{*\prime}(x_1^*)(f_{11}(k,m) + f_{11}^*(K-k, M-m)) < 0$, $\pi_{km} = (1-t^*)p_1^*h^{*\prime}(x_1^*)(f_{12}(k,m) + f_{12}^*(K-k, M-m)) > 0$, $\pi_{kK} = -(1-t^*)p_1^*h^{*\prime}(x_1^*)f_{11}^*(K-k, M-m) > 0$, $\pi_{kx_1} = \pi_{mx_1} = 0$, $\pi_{mm} = (1-t^*)p_1^*h^{*\prime}(x_1^*)(f_{22}(k,m) + f_{22}^*(K-k, M-m)) < 0$, $\pi_{mK} = -(1-t^*)p_1^*h^{*\prime}(x_1^*)f_{12}^*(K-k, M-m) < 0$, $\pi_{KK} = (1-t^*)p_1^*[h^{*\prime\prime}(x_1^*)f_1^{*2}(K-k, M-m) + h^{*\prime}(x_1^*)f_{11}^*(K-k, M-m)] < 0$, $\pi_{Kx_1} = -(1-t^*)p_1^*h^{*\prime\prime}(x_1^*)f_1^*(K-k, M-m) > 0$, and $\pi_{x_1x_1} = (1-t)p_1h''(x_1) + (1-t^*)p_1^*h^{*\prime\prime}(x_1^*) < 0$. It is straightforward but tedious to show that the leading principal minors of the Hessian matrix associated with the multinational firm's optimization problem at fixed prices alternate in sign, with those of odd order negative under Assumption 1. Therefore, the Hessian is negative definite and the optimization problem of a representative firm is strictly concave in $\{k, m, K, x_1\}$.

The effect of changes in K and x_1 on prices are captured by the terms

$$\begin{aligned} a_1 &= (1-t^*)u^{*\prime\prime}(h^*(x_1^*))h^{*\prime}(x_1^*)^2 f_1^*(K-k, M-m)^2 < 0, \\ a_2 &= -(1-t^*)u^{*\prime\prime}(h^*(x_1^*))h^{*\prime}(x_1^*)^2 f_1^*(K-k, M-m) > 0, \text{and} \\ a_3 &= (1-t^*)u^{\prime\prime}(h(x_1))h^{\prime}(x_1)^2 + (1-t^*)u^{*\prime\prime}(h^*(x_1^*))h^{*\prime}(x_1^*)^2 < 0. \end{aligned}$$

We then have

$$\begin{pmatrix} \pi_{kk} & \pi_{km} & \pi_{kK} & 0 \\ \pi_{km} & \pi_{mm} & \pi_{mK} & 0 \\ \pi_{kK} & \pi_{mK} & \pi_{KK}+a_1 & \pi_{Kx_1}+a_2 \\ 0 & 0 & \pi_{Kx_1}+a_2 & \pi_{x_1x_1}+a_3 \end{pmatrix} \begin{pmatrix} dk \\ dm \\ dK \\ dx_1 \end{pmatrix} = \begin{pmatrix} p_2 d\lambda - d\lambda^* \\ 0 \\ d\lambda^* \\ 0 \end{pmatrix}. \tag{34}$$

We can also establish using the properties of the Hessian of the firm's optimization problem and the fact that $a_1a_3 - a_2^2 > 0$ that the 4x4 matrix in (34), which we denote by $\nabla^2\Pi$, is negative definite. We thus have $|\nabla^2\Pi| > 0$.

To solve efficiently for $dK/d\lambda$ and $dx_1/d\lambda$, we define

$$|AK\lambda| = \begin{vmatrix} \pi_{kk} & \pi_{km} & p_2 & 0 \\ \pi_{km} & \pi_{mm} & 0 & 0 \\ \pi_{kK} & \pi_{mK} & 0 & \pi_{Kx_1}+a_2 \\ 0 & 0 & 0 & \pi_{x_1x_1}+a_3 \end{vmatrix} = p_2(\pi_{x_1x_1}+a_3)((1-t^*)p_1^*h^{*\prime})^2\Delta < 0 \tag{35}$$

and

$$|Ax\lambda| = \begin{vmatrix} \pi_{kk} & \pi_{km} & \pi_{kK} & p_2 \\ \pi_{km} & \pi_{mm} & \pi_{mK} & 0 \\ \pi_{kK} & \pi_{mK} & \pi_{KK}+a_1 & 0 \\ 0 & 0 & \pi_{Kx_1}+a_2 & 0 \end{vmatrix} = -p_2(\pi_{Kx_1}+a_2)((1-t^*)p_1^*h^{*\prime})^2\Delta < 0. \tag{36}$$

where $\pi_{mk}\pi_{Km} - \pi_{Kk}\pi_{mm} = ((1-t^*)p_1^*h^{*\prime})^2\Delta$ from the definition in Assumption 1. This establishes $dK/d\lambda = |AK\lambda|/|\nabla^2\Pi| < 0$ and $dx_1/d\lambda = |Ax\lambda|/|\nabla^2\Pi| < 0$. Using the fact that $\frac{dx_1^*}{d\lambda} = f_1^*(K-k, M-m)\frac{dK}{d\lambda} - \frac{dx_1}{d\lambda}$ in the neighborhood of a universal DBCFT market equilibrium, $dx_1^*/d\lambda$ can be shown to be negative. One can also evaluate the good 1 price changes as

$$\frac{dp_1}{dx_1}\frac{dx_1}{d\lambda} = \frac{p_2^2 u'' h'((1-t^*)p_1^* h^{*\prime})^3 \Delta (h^{*\prime\prime} u^{*\prime} + u^{*\prime\prime} h^{*\prime})}{|\nabla^2 \Pi|} > 0 \tag{37}$$

and

$$\frac{dp_1^*}{dx_1^*}\frac{dx_1^*}{d\lambda} = \frac{u^{*\prime\prime}((1-t^*)p_1^*)^3 (h^{*\prime})^4 \Delta (h'' u^{*\prime} + u^{*\prime\prime} h^{*\prime})}{|\nabla^2 \Pi|} > 0. \tag{38}$$

Analogously,

$$|AK\lambda^*| = \begin{vmatrix} \pi_{kk} & \pi_{km} & -1 & 0 \\ \pi_{km} & \pi_{mm} & 0 & 0 \\ \pi_{kK} & \pi_{mK} & 1 & \pi_{Kx_1} + a_2 \\ 0 & 0 & 0 & \pi_{x_1x_1} + a_3 \end{vmatrix} = (\pi_{x_1x_1} + a_3)((1-t^*)p_1^* h^{*\prime})^2 \Delta^* < 0 \tag{39}$$

and

$$|Ax\lambda^*| = \begin{vmatrix} \pi_{kk} & \pi_{km} & \pi_{kK} & -1 \\ \pi_{km} & \pi_{mm} & \pi_{mK} & 0 \\ \pi_{kK} & \pi_{mK} & \pi_{KK} + a_1 & 1 \\ 0 & 0 & \pi_{Kx_1} + a_2 & 0 \end{vmatrix} = -(\pi_{Kx_1} + a_2)((1-t^*)p_1^* h^{*\prime})^2 \Delta^* < 0 \tag{40}$$

where we use the fact that $\pi_{kk}\pi_{mm} - \pi_{km}^2 = (1-t^*)p_1^*(h^{*\prime})^2(\Delta + \Delta^*)$. Thus, $dK/d\lambda^* = |AK\lambda^*|/|\nabla^2\Pi| < 0$ and $dx_1/d\lambda^* = |Ax\lambda^*|/|\nabla^2\Pi| = \frac{\Delta^*}{p_2\Delta}\frac{dx_1}{d\lambda} < 0$. Similarly, we have $\frac{dx_1^*}{d\lambda^*} = f_1^* \frac{dK}{d\lambda^*} - \frac{dx_1^*}{d\lambda^*} = \frac{\Delta^*}{p_2\Delta}\frac{dx_1^*}{d\lambda} < 0$.

Combining these results, we have $\frac{dp_1^*}{d\lambda^*} = \frac{\Delta^*}{p_2\Delta}\frac{dp_1^*}{d\lambda}$ and $\frac{dp_1}{d\lambda^*} = \frac{\Delta^*}{p_2\Delta}\frac{dp_1}{d\lambda}$.

Proof of Lemma 2:

To establish the effect of a change in the border adjustments, $\{\delta, \delta^*\}$, we totally differentiate (11)-(14) and evaluate at universal DBCFT, which yields

$$\begin{pmatrix} \pi_{kk} & \pi_{km} & \pi_{kK} & 0 \\ \pi_{km} & \pi_{mm} & \pi_{mK} & 0 \\ \pi_{kK} & \pi_{mK} & \pi_{KK} + a_1 & \pi_{Kx_1} + a_2 \\ 0 & 0 & \pi_{Kx_1} + a_2 & \pi_{x_1x_1} + a_3 \end{pmatrix} \begin{pmatrix} dk \\ dm \\ dK \\ dx_1 \end{pmatrix} = \begin{pmatrix} t^*(td\delta - t^* d\delta^*) \\ qf_2(td\delta - t^* d\delta^*) \\ 0 \\ -t^* q(td\delta - t^* d\delta^*) \end{pmatrix}. \tag{41}$$

where the left matrix on the left hand side is the negative definite matrix $\nabla^2\Pi$ from Lemma 1. The effects of a change in δ are obtained using the fact that $\frac{dp_2}{d\delta} = -tp_2$.

To solve efficiently for $dK/d\delta$ and $dx_1/d\delta$ define

$$AK\delta = \begin{pmatrix} \pi_{kk} & \pi_{km} & tt^* & 0 \\ \pi_{km} & \pi_{mm} & tqf_2 & 0 \\ \pi_{kK} & \pi_{mK} & 0 & \pi_{Kx_1} + a_2 \\ 0 & 0 & -tt^*q & \pi_{x_1x_1} + a_3 \end{pmatrix} \tag{42}$$

and

$$Ax\delta = \begin{pmatrix} \pi_{kk} & \pi_{km} & \pi_{kK} & tt^* \\ \pi_{km} & \pi_{mm} & \pi_{mK} & tqf_2 \\ \pi_{kK} & \pi_{mK} & \pi_{KK} + a_1 & 0 \\ 0 & 0 & \pi_{Kx_1} + a_2 & -tt^*q \end{pmatrix}. \tag{43}$$

Then, $dK/d\delta = |AK\delta|/|\nabla^2\Pi|$ and $dx_1/d\delta = |Ax\delta|/|\nabla^2\Pi|$.

In a symmetric economy, $|AK\delta| = t^2q(\pi_{Kx_1} + a_2)|\nabla_2^2\pi| + t^2(\pi_{x_1x_1} + a_3)(\pi_{km}\pi_{mK} - \pi_{kK}\pi_{mm})$, where $\nabla_k^2\pi$ is the k^{th} order principal minor of $\nabla^2\pi$ and $\pi_{kk}\pi_{mK} - \pi_{kK}\pi_{km} = 0$. Further simplification yields

$$|AK\delta| = 2t^2(1-t)^2p_1^2(h')^2\nabla^2 f[2q(\pi_{Kx_1} + a_2) + \pi_{x_1x_1} + a_3] = 0 \tag{44}$$

so, at $\delta = \delta^* = 0$ and $t = t^*$, $dK/d\delta = 0$ and $dx_1^*/d\delta = -dx_1/d\delta$. It is also the case in a symmetric economy that

$$\begin{aligned} |Ax\delta| \quad &= -t^2(\pi_{Kx_1} + a_2)(\pi_{km}\pi_{mK} - \pi_{mm}\pi_{kK}) - t^2q|\nabla_3^2\Pi| \\ &= 2t^2(1-t)^3p_1^2(h')^2\nabla^2 f f_1[u'h'' - u''(h')^2] - t^2q|\nabla_3^2\pi| \end{aligned} \tag{45}$$

so

$$|Ax\delta| = -2t^2(1-t)^3p_1^2(h')^2\nabla^2 f \left(p_1f_1h'' + (h')^2f_1u'' + qp_1h'f_{11}\right) > 0. \tag{46}$$

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Referee Appendix - Not intended for publication

Derivation of eq. (24): $dU/d\lambda$ evaluated at $\lambda = 1 - t$, $\lambda^* = 1 - t^*$, and $\delta = \delta^* = 0$.

The tax rates are set at their equilibrium values under universal DBCFT so $dU/d\lambda = u'(c_1)dc_1/d\lambda + d(c_2 + g)/d\lambda$.

When $\delta = \delta^* = 0$, $p_2 = (1-t^*)/(1-t)$, $p_{2x} = 1 - t^*$, and eq. (5) implies that $T_1 = tp_1c_1 - (1-\lambda)p_2k$ and $T_1^* = t^*p_1^*c_1^* - (1-\lambda^*)k^*$. From eq. (6), $\pi = (1-t)p_1c_1 - \lambda p_2 k + (1-t^*)p_1^*c_1^* - \lambda^* k^*$ so that, by the Envelope Theorem, $d\pi = (1-t)c_1dp_1 - p_2kd\lambda + (1-t^*)c_1^*dp_1^*$.

Solving eqs. (4) and (9) for c_2 and g implies that $g = t\beta\pi/(1-t^*) + k(t-1+\lambda)/(1-t)$, $c_2 = L + \beta\pi/p_2 - p_1c_1/p_2$, and $c_2 + g = L + \beta\pi/(1-t^*) - u'(c_1)c_1 + k(t-1+\lambda)/(1-t)$. Thus,

$$\frac{dc_2}{d\lambda} = \frac{\beta(1-t)}{(1-t^*)}\frac{d\pi}{d\lambda} - \frac{p_1}{p_2}\frac{dc_1}{d\lambda} - \frac{c_1}{p_2}\frac{dp_1}{d\lambda}$$

and

$$\frac{dg}{d\lambda} = \frac{\beta t}{1-t^*}\frac{d\pi}{d\lambda} + \frac{k}{1-t} + \frac{(t-1+\lambda)}{1-t}\frac{dk}{d\lambda},$$

so that, at $\lambda = 1 - t$,

$$\frac{dU}{d\lambda} = \frac{\beta^* k}{1-t} - \beta^* \frac{c_1}{p_2}\frac{dp_1}{d\lambda} + \beta c_1^* \frac{dp_1^*}{d\lambda},$$

which is eq. (24). The derivation for eq. (25) is analogous.

Derivation of eq. (27): $dU/d\delta$ evaluated at $\lambda = 1 - t$, $\lambda^* = 1 - t^*$, and $\delta = \delta^* = 0$.

The tax rates are set at their equilibrium values under universal DBCFT so $dU/d\delta = u'(c_1)dc_1/d\delta + d(c_2 + g)/d\delta$.

When $\lambda = 1-t$ and $\lambda^* = 1-t^*$, $p_2 = (1-t^*)(1-\delta t)/(1-t)(1-\delta^* t^*)$, $p_{2x} = (1-t^*)/(1-\delta^* t^*)$, and eq. (5) implies that $T_1 = t(p_1c_1 - p_2k + \delta qe)$ and $T_1^* = t^*(p_1^*c_1^* - k^* - \delta^* qe)$. From eq. (6), $\pi = (1-t)(p_1c_1 - p_2k) + (1-t^*)(p_1^*c_1^* - k^*) + (\delta^* t^* - \delta t)qe$ so that, by the Envelope Theorem, $d\pi = (1-t)(c_1dp_1 - kdp_2) + (1-t^*)c_1^*dp_1^* - tqed\delta$.

Solving eqs. (4) and (9) for c_2 and g implies that at $\delta^* = 0$

$$g = \frac{t}{1-t^*}(p_1c_1 - p_2k + \delta qe) + \frac{t(1-\delta)}{1-t}(c_2 + k - L),$$

$c_2 = L + \beta\pi/p_2 - p_1 c_1/p_2$, and

$$c_2 + g = L + \frac{\beta\pi}{1-t^*} - \frac{1-t}{1-t^*} p_1 c_1 + \frac{t\delta qe}{1-t^*} - \delta tk.$$

Thus, at $\delta = 0$

$$\begin{aligned} \frac{d(c_2+g)}{d\delta} &= \frac{\beta}{1-t^*}\left((1-t)c_1\frac{dp_1}{d\delta} - (1-t)k\frac{dp_2}{d\delta} + (1-t^*)c_1^*\frac{dp_1^*}{d\delta} - tqe\right) \\ &- p_1\frac{1-t}{1-t^*}\frac{dc_1}{d\delta} - \frac{(1-t)c_1}{1-t^*}\frac{dp_1}{d\delta} + \frac{tqe}{1-t^*} - tk \end{aligned}$$

where $p_1 = p_2 u'(c_1)$ and $p_1^* = u^{*\prime}(c_1^*)$ so $(1-t)p_1/(1-t^*) = u'(c_1)$, $dp_1/d\delta = u'(c_1)dp_2/d\delta + p_2 u''(c_1)dc_1/d\delta$, $dp_1^*/d\delta = u^{*\prime\prime}(c_1^*)dc_1^*/d\delta$, and $dp_2/d\delta = -t(1-t^*)/(1-t)$. Substituting this expression for $d(c_2+g)/d\delta$ into the formula for $dU/d\delta$ yields eq. (27).