Centre for
Economic
and Financial
Research
at
New Economic
School

April 2013

Asymmetric Trade Estimator in Modified Gravity: Corporate Tax Rates and Trade in OECD Countries

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Working Paper No 200

CEFIR / NES Working Paper series

Asymmetric Trade Estimator in Modified Gravity:

Corporate Tax Rates and Trade in OECD Countries

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April 9, 2013

Abstract

To study the potentially distortionary impact of differing corporate income tax rates on international trade flows, we use an augmented empirical specification of the gravity model. Incorporating an asymmetric trade barrier measure into a modified gravity model, we capture the impact of corporate income tax rates via the price mechanism impact on trade. Holding other factors constant in a gravity model, one should theoretically expect asymmetric corporate income tax rates to impact bilateral trade flows. High (low) tax states have an implied price (dis)advantage relative to trade partners. However, gravity models have explicitly assumed that trade barriers are symmetric between countries. Using asymmetric trade barrier measures of corporate income tax rates differences between countries, we find that bilateral corporate income tax rates wedges do not impact bilateral international trade flows. Our empirical results are robust to alternative proxies for tax asymmetries and exclusion restrictions based on trade regions and time periods.

Key words: gravity, asymmetric barriers, corporate income tax

JEL Codes: F14, H25, H26

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The authors would like to thank Edison Yu for his research assistance and comments from Timothy Earl, Daisy Elliott, James Dylan, and Michelle Tyler. All remaining errors are the authors alone.

Introduction

The question of whether differing corporate income tax rates distort international trade flows is not new, but far from resolved. Countries should trade according to their comparative advantages. Therefore, tax systems should raise revenue in ways that minimize behavioral responses. Nevertheless, taxes on corporate income seem to affect companies' location choice and investment decisions (Desai and Hines, 2009; Desai et al., 2004; de Mooij and Ederveen, 2003; Desai and Dharmapala, 2011). In this case, corporate income tax wedges between countries should also affect the direction of trade. This is however far from obvious since there is little empirical evidence that corporate income tax wedges affect trade. On the one hand, the literature finds that trade depends on country specific non-tax factors, such as labor costs, access to local productive assets, or stable economic policy. On the other hand, the public finance literature finds mixed results on the relationship between indirect and direct taxes on international trade (Desai and Hines, 2005; Slemrod, 2004; Keen and Syed, 2006). While evidence of intra-firm transfer pricing exists, there is little evidence of country-wide shifts in trade.

Combining datasets on bilateral trade and corporate income tax rates into a gravity model of trade, this paper links the trade and public finance literatures to explore the relationship between international trade and corporate taxation. Although gravity models traditionally define trade barriers as symmetric because "there are so many equilibria with asymmetric barriers that lead to the same equilibrium trade flows as with symmetric barriers…(Anderson and Van Wincoop 2003)," recent research has begun to address the lack of asymmetric barrier estimators in standard gravity models (Bergstrand et al. 2013). In this paper, we construct a variation of the gravity model of international trade where corporate income taxes are treated as an asymmetric barrier impacting bilateral trade flows through a change in the price of imports and exports. The model also

implies that the size of the distortion to trade generated by corporate income taxation depends on country size differentials, and may not occur for small bilateral tax differentials. More importantly, the model also implies that countries with large tax asymmetric barriers have incentives to offsets the cost of these barriers with adjustments to other asymmetric barriers, therefore offsetting or reducing the distortion to trade. Studying asymmetric barriers allows us to examine a new range of trade restrictions and explore why the law of one price does not hold empirically. Then we estimate the impact of corporate income taxes on international trade based on OECD countries from 1981 to 2008. We find that corporate income tax rates have no impact on international trade flows. The results are robust to alternative proxies for effective corporate tax rates differentials, and various specifications of the gravity model of trade, as well as sample exclusion restrictions. While profit shifting may occur through intra-firm transfer pricing, there is no evidence that asymmetric tax rates between bilateral trading partners impact international trade flows as the country level, which supports the prediction that countries are likely to offset negative asymmetric barriers with positive barriers.

This paper proceeds in four sections. First, we present the literature linking trade with corporate income taxes. Second, we present a gravity model of international trade treating income taxes as asymmetric barriers and construct a theoretical model that explains how income taxes may distort trade flows. Third, we lay out the empirical model, which in turns avoids multicollinearity that plagues previous empirical specifications and allows for asymmetric pricing of trade. Fourth, we present the results, and we finally conclude that asymmetric trade barriers in the form of corporate income tax rates have no distortionary impact on trade flows between countries. However, when considering broader measures of asymmetry, including tax and non-tax barriers, these barriers have the expected impacted on trade.

Motivation and Background

One may think of various ways that corporate income taxes (CIT) affect trade. To illustrate the potential tradeoff faced by firms subject to different levels of corporate income taxation, take the following simple example of a company located in a high tax country H that sells both in its domestic market and in a low tax country L's market. Country L has a 10% CIT and country H has a 40% CIT. All else equal, the firm in country L subject to the 10% CIT enjoys a significant production cost advantage relative to a firm in country H subject to a 40% CIT.

In theory, the macroeconomic impact of fiscal policy on international trade highly varies depending on the degree of mobility of capital flows (Summers, 1988), assumptions about the endogeneity of factors of production to trade (Baxter, 1992), or the capital intensity of traded goods (Helpman, 1976). There are a host of tax and non-tax factors that affect both firms' location choices and trade patterns, making it almost impossible to empirically isolate the impact of a specific factor.[1] Although there is a wide literature on the impact of corporate income taxes on investment and firm's location, there is almost no empirical research on the impact of corporate income taxes on trade patterns.[2] The lack of research on the relationship between corporate income taxes and trade is puzzling because if corporate income taxes significantly affect the location of production, they should also indirectly affect trade patterns (e.g., the direction of trade or the nature of traded goods). Summers (1988) builds a model in which the impact of

[1] For a review of factors that affect FDI and trade, see for example OECD (2007). Desai et al (2009) show that FDI has positive spillover effects on domestic production.

[2] de Mooij and Ederveen (2003) and Devereux and Maffini (2007) provide a detailed review of the literature on the relationship between taxes and FDI. Scholes and Wolfson (2009) link FDI decisions with changes in the definition of tax bases rather than tax rates. Swenson (1994) finds empirical evidence in favor of this view. However Auerbach and Hasset (1993) and Willard (1994) find this hypothesis inconsistent with other data. Hines (1996) finds that that 1the impact of CIT rates on trade patterns depends on the home treatment of foreign-source income. Devereux et al. (2008) find evidence of tax competition across countries and its effect on the real economy.

tax incentives such as lower tax rates on trade balances depends on the mobility of capital flows. However, he concludes that it is difficult to assess the impact of fiscal policy on trade or capital flows because, even if capital was perfectly mobile, there is clear evidence that fiscal incentives for investment are coupled with other policies aimed at stabilizing current account balances. In theory, investment tax incentives, such as lower corporate income tax rates or investment tax credits, should increase domestic investment. As long as capital is perfectly mobile, investment is also financed by capital inflows, which deteriorates trade or current account balances. However, empirical evidence that investment is highly correlated to domestic savings suggesting that either capital is immobile or governments enact policies that stabilize capital flows, which seems to be corroborated by our findings for OECD countries. The latter seems to explain why fiscal policy does not seem to deteriorate competitiveness in practice. For example, many OECD countries revenue rely more on other taxes than on the CIT (e.g., a VAT).

As previous models generally show, fiscal incentives for investment have the potential to affect the trade balance--in either direction--through their impact on FDI. There is a large theoretical and empirical literature that investigates the impact of corporate taxes on FDI. Research has also investigated the relationship between FDI and trade. The literature on how CIT affect FDI is comprehensively reviewed and analyzed by in de Mooij and Ederveen (2003) who show that the impact of corporate income taxes on FDI is generally significant and large, but the size of elasticity strongly varies along the choice of the tax rate in econometric specifications. In particular, economists have criticized using country statutory tax rates in empirical research because they do not capture many aspects of tax codes

and other regulatory environments that affect long-term location choices.[3] Nevertheless, economists agree that each tax rate measure provides specific advantages and drawbacks (Gordon et al, 2003; de Mooij and Ederveen, 2003). This paper uses several proxies for corporate income tax wedges and selectively presents them.

The link between FDI and trade has generally been twofold and provides us with insights on the intricacies involved in evaluating the impact of taxes on trade. In theory, FDI and trade can be perceived by firms as either complements or substitutes, or occur through horizontal or vertical integration. Yi (2003), Hummels et al. (2001), and Hansen et al. (2005) emphasize the role of vertical specialization behind the motivation to engage in FDI. Hummels et al. (2001) find that vertical specialization through FDI explains 30 percent of the growth of exports between 1970 and 1990. Hansen et al. (2005) find that imported inputs of foreign affiliates of US firms depend significantly and negatively on the host country corporate income tax rate, confirming the role of corporate taxes on vertical international trade. Desai et al. (2009) find that lower foreign corporate income tax rates significantly increase exports from domestic US parents.

All in all, it is clear that most research recognize that corporate income taxes affect FDI and that FDI affects international trade, but few research investigates the direct impact of corporate income taxes on international trade. [4] The factors that directly affect trade have been widely identified by the trade literature, using gravity models of trade, which we cover next. Although it is still

[3] The authors show that using marginal effective tax rates or average effective tax rates generally yields larger elasticities. Desai et al. (2004) show that state and local taxes have an impact of similar size on FDI than country statutory rates.

[4] It remains far from clear whether corporate income taxes generate economic distortions—such as offsetting countries comparative advantages--, or whether the impact of corporate income tax wedges on investment solve a market failure, such as the lack of investment in developing countries. There is a large literature on the impact of tax competition on real economic activity (Devereux et al., 2008) crystalized by fears that the removal of barriers in the European Union would encourage tax avoidance (Sinn, 1990).

unclear that corporate income taxes affect the real economy, there is more consensus that corporate income taxes have nominal effects through income shifting.[5]

In spite of the direct effect of corporate income taxes on the price of traded goods (Melvin, 1979) and the indirect effect through FDI (Hines, 1996; Devereux et al., 2008), the empirical relationship between corporate taxation and international trade is unclear. Melvin (1979) develops a model where corporate income taxes increase the price of traded goods in two ways—directly through the increased required rate of return by investors, and indirectly though the increase in the cost of inputs. He also provides evidence that this effect varies across industries depending on capital intensity. He concludes: "it was found that the corporate income tax tends to raise all commodity prices […] and since imports are not subject to this tax, the overall effect must be to increase imports and decrease exports." He also finds that the impact of corporate income taxes on trade patterns, through increased prices of traded goods, varies across sectors, depending on the capital intensity of traded goods.

Contrary to the public finance literature, sophisticated models in the trade literature allow for a direct link between international trade flows and corporate income taxes. However, these models show that international trade is essentially explained by non-tax factors such as relative market sizes, distance between countries, and other specific non-tax factors that facilitate or restrict trade (Balding 2010 and Brainard, 1997).[6]

The trade literature has shown that non-tax factors outweigh tax factors,

[5] This is beyond the focus of this paper. Important drivers for tax induced income shifting include transfer pricing practices by multinational companies (Gruber and Mutti, 1991), or corporate inversions. Transfer prices merely affect the price of goods traded within groups, implying income shifting with no real effect on trade patterns (Clausing, 2001, 2003; Bartlesman and Beetsma, 2003; Bucovetsky and Haufler, 2008; Devereux, 2008).

[6] Few models of international trade focus on corporate income taxes, and therefore, overall, it is unclear whether corporate income tax differentials between countries either directly or indirectly affect trade patterns.

indicating that tax policy does not impact real economic activity. For instance, industrial concentration and agglomeration factors appear to have a greater influence on firm location decisions—and therefore trade--than tax rates (Baldwin and Okuba, 2009; Baldwin and Krugman, 2004). Focusing on the United States, Wheeler and Mody (1992) find that corporate income tax rates have no significant impact while industrial concentration or agglomeration decisions are "the dominant influence on investors calculations." Countries may compete on measures of economic performance, public goods, or government and economic stability rather than after tax prices. Research indicates that higher social expenditure as a percentage of GDP is positively related with FDI, suggesting that multinationals value public spending (Gorg et al. 2009).[7]

In spite of the lack of consensus and the limited empirical evidence that corporate income taxes and the risk of tax competition have real effects on the economy, politicians are concerned when "international investment tax policy of one country…affect(s) resource allocation and income distribution in both countries *even in a small country world* (Batra and Ramachandran 1980)."[8] The concern of policy makers is not just income shifting between high and low tax states but whether tax rate differentials between countries have the potential to reallocate resources to where they can be more productive. However, the evidence supporting a link between trade levels or openness and tax competition is mixed (Overesch and Rincke, 2011; Clausing, 2008). Research on tax competition indicates that high tax states have a higher probability of lower tax rates in the presence of low tax neighbors (Heinemann et al. 2010). Keen and Syed (2006) estimate the link between corporate income tax rates, capital flows, and trade, and

[7] Ferrett and Wooton (2010) show that trade costs are also an important non-tax factor influencing location decisions. Firms appear to favor multiple production centers especially in the presence of trade costs, minimizing the impact of tax competition between states on decisions of where to locate manufacturing facilities.

[8] Emphasis added and not in the original text.

find that reductions in a trading partner's corporate tax rates result in a short term increase in net exports but also that the trade balance quickly returns to its initial trend with no long term impact.

In this paper we further test whether corporate income taxes have long-term effects on trade. Our central approach is to augment a gravity model of trade by recognizing the asymmetric nature of corporate income taxes, which we further describe in the following section.

Asymmetric Trade Barriers With a Gravity Framework

We build our theoretical model of the impact of asymmetric trade barriers within a gravity model of international trade by borrowing from the Anderson and Van Wincoop framework (2003). In their work, they state that they "achieve a very useful simplification by assuming that the trade barriers are symmetric…(Anderson and Van Wincoop 2003)."[9] While this simplification is useful for theoretical modeling considerations, it overlooks important trade barriers between states such as taxes. Trade barriers enter the gravity model via the price index specified by Anderson and Van Wincoop (2003) in equation (1):

$$(1)\ P_j = \left[\sum_i (\beta_i p_i t_{ij})^{1-\sigma}\right]^{1/(1-\sigma)}$$

where j is the importer and i is the exporter. P_j is the consumer price index in country j, p_i is the supply price of goods sold by each exporter i's, t_{ij} is the symmetric trade barrier between countries i and j, β_i is a production distribution variable for country i, and σ is the elasticity of substitution between goods in country i and country j. Equation (1) states that the price level in country j is equal to the price of goods in each country i given a symmetric trade friction

[9] The authors note not only the mathematical complexity but also the multiple equilibrium that complicate the final analysis. They write that "there are many equilibria with asymmetric barriers that lead to the same equilibrium trade flows as with symmetric barriers, so that empirically they are impossible to distinguish."

variable and the propensity of consumers to substitute between domestic and foreign goods. In this formulation, however, the symmetric trade barrier variable t_{ij} provides little information about its impact on trade other than as a discounting factor on the flow of trade between states via the price index similar to an "iceberg" effect. Defining $p_{ij} = p_i t_{ij}$ and recognizing that $t_{ij} = t_{ji}$ we can eliminate *t* from the P_j price index. Put another way if $p_{ij} = p_i t_{ij}$, the price of the good in country *j* imported from country *i* is equal to the price of the good in country *i* weighted by the cost of the symmetric trade barrier, then $p_{ji}=p_j t_{ji}$ and $p_{ji}=p_{ij}$. Relative prices enter the trade flow equation as specified from Anderson and Van Wincoop in equation (2).

$$(2)\ x_{ij} = \left(\frac{\beta_i p_i t_{ij}}{P_j}\right)^{1-\sigma} y_j$$

Where x_{ij} represents exports from country i to country j and y_j is the income of country j. Equation (2) provides a simplified gravity equation for trade between states. The simplification of treating trade barriers as symmetric allows price indexes to be expressed in terms of income shares, bilateral trade barriers, and σ (the elasticity of substitution). In other words, trade is a function of domestic prices in *i* and *j*, the symmetric (or structural) trade friction between states such as distance, and the willingness to shift purchasing habits between countries (also assumed uniform). This reduces international trade to an analysis of price levels between states discounted by a frictional bilateral constant. However, in practice tradable good prices differ across borders by not insignificant amounts. While the assumption of symmetric trade barriers suffices for the border puzzle addressed by Anderson and Van Wincoop (2003), it provides little theoretical benefit when considering a variety of trade puzzles such as why the law of one price fails

empirical support (Rogoff, 1996).[10] To introduce asymmetric trade barriers, we rewrite equation (1) as:

$$(3) P_j = \left[\sum_i (\beta_i p_i \lambda_{ij} t_{ij})^{1-\sigma}\right]^{1/(1-\sigma)}$$

In this modified price equation, we allow for the continued presence of a symmetric structural friction variable represented by t_{ij}. However, we also add an asymmetric trade barrier variable represented here as λ_{ij}. With symmetric trade barriers, like transportation costs related to distance, and assuming that $p_i=p_j$, the barrier has the same effect on exporters in countries i and j, and the after barrier prices are the same. However, with an asymmetric barrier such as taxes, even if pre-tax prices are the same, the after barrier prices differ by the tax wedge. Whereas $t_{ij}=t_{ji}$ is the symmetrical barrier, λ_{ij} may or may not equal λ_{ji}. We proceed by creating an asymmetric trade barrier variable for corporate income taxes given the observed heterogeneity in corporate income tax rates between states. The asymmetric tax trade barrier variable is written as:

$$(4)\ \lambda_{ij} = \frac{p_i\rho_i - p_i\rho_i\tau_i}{p_j\rho_j - p_j\rho_j\tau_j}\ or\ \lambda_{ij} = \frac{\frac{1}{1-tax_i}}{\frac{1}{1-tax_j}} = \frac{1-tax_j}{1-tax_i}$$

The asymmetric trade barrier variable is the ratio of after tax prices, where p is the price, ρ is the expected profit margin—assumed to be uniform across states where $\rho_i=\rho_j$--and τ is the top statutory corporate income tax rate.[11] If, ceteris paribus, $1-tax_j>1-tax_i$ then country j enjoys an asymmetric advantage relative to its trading partner country i (and symmetrically for country j). This implies an increased cost of exports and a reduced cost of imports for country i. Equation (4) has important implications. First, we assume that the distribution of τ_i (the top statutory corporate income tax rate in country i) over time is normally distributed with the

[10] Anderson and Van Wincoop (2003) address the border puzzle described by McCallum (1995) as the fact that the volume of trade within a country tends to be higher than the volume of trade between countries and countries across its borders.

[11] This is not a restrictive assumption, as there is no evidence that expected returns systematically vary across developed countries.

mean being an effective tax rate that is systematically related to the statutory tax rate.[12] While the effective tax rate can vary from the statutory tax rate, as long as they are related, then the statutory tax rate remains a valid proxy to estimate the asymmetric trade barrier.[13] As domestic tax rates enter the price index, they can be considered an asymmetric trade barrier that influences the flow of trade between states. Holding all other things constant, the level of taxation alters price levels. Second, if effective tax rates are equal across countries, then λ_{ij} equals unity and the trade barrier becomes symmetric. However, as long as tax wedges are different from zero, taxes create an asymmetric trade barrier that can provide a cost advantage to a country relative to its trading partner, as presented in equation (4).

The inclusion of observable asymmetric trade barriers within the standard gravity model provides clear and testable hypothesis of how these barriers affect international trade flows. Rewriting the trade price factor as $p_{ij} = p_i t_{ij} \lambda_{ij}$, the baseline gravity equation defined in equation (9) of Anderson and Van Wincoop (2003) becomes:

$$(5)\ x_{ij} = \frac{y_i y_j}{y^w}\left(\frac{\lambda_{ij} t_{ij}}{\Pi_i P_j}\right)^{1-\sigma}$$

Exports from country i to country j is the product of the interaction of i and j's incomes and the ratio of total trade barriers (symmetric and asymmetric) by prices (put in real terms). We can then substitute equation (11) of Anderson and Van Wincoop to obtain:

$$(6)\ P_j = \left[\sum_i \left(\frac{\lambda_{ij} t_{ij}}{\Pi_i}\right)^{1-\sigma} \theta_i\right]^{1/(1-\sigma)} \text{ and}$$

$$(7)\ \Pi_i = \left(\sum_j \left(\frac{\lambda_{ji} t_{ij}}{P_j}\right)^{1-\sigma} \theta_j\right)^{1/(1-\sigma)}$$

[12] In robustness tests later provided in the empirical section we include estimates of the effective tax rate rather than the statutory tax rate.

[13] This remains valid if the relationship between the statutory and effective tax rate is non-linear.

When Π_i is the price index for country i, in the absence of asymmetric trade barriers where θ is the world income share, the balance of trade is a function of the domestic price distribution and symmetric bilateral trade costs.[14] However, in the presence of asymmetric trade barriers holding all other things constant, when λ_{ij} is not equal to 1, even with uniform domestic after tax prices and production distribution between states, trade will be affected by a factor of the asymmetric trade barrier and the elasticity of substitution.

Therefore, assuming that tax rates are greater than 0 but smaller than 1, we derive the asymmetric trade barrier with respect to tax rates to obtain:

$$(8)\ d\lambda_{ij} = \frac{1-tax_j}{(1-tax_i)^2}\ dtax_i\ - \frac{1}{1-tax_i} dtax_j$$

Equation (8) implies that any change in the tax rate in country *i*, will have an exponential impact on its asymmetric trade barrier. This has an immediate pass through effect on prices when we derive the price level with regards to trade barriers as clarified in equation (9):

$$(9)\ dP_i = \frac{1-tax_j}{1-tax_i}\left(\frac{1}{2} - \theta_i + \frac{1}{2}\sum_k \theta_k^2\right) dt_{ij} + \frac{1}{1-tax_i} dtax_i - \frac{1}{1-tax_j} dtax_j$$

Equation (9) provides an estimate for the pass through effect of changes in the corporate income tax rate on the price index of country *i*. The change in prices is primarily dependent on the size of the tax asymmetry between i and j and the size of country i's share of global income θ_i. This implies that when the tax asymmetry is large it can have an especially large impact on prices. However, if the difference between tax_i and tax_j is small, the impact on prices comes from the share of global income θ_i. The second implication is that for most countries, the

[14] Anderson and Van Wincoop (2003), seeking to provide a theoretical explanation and better estimate of McCallum's (1995) model, focus on the impact of national borders and distance explicitly defining a symmetric trade barrier as $b_{ij}d^{\rho}_{ij}$, where *b* is 1 when region *i* and *j* are in the same country and 1 plus a "tariff equivalent of the border barrier" when located in different countries, and *d* is the distance between *i* and *j*.

impact of θ_i on the effect of the asymmetric barrier should be small as most countries are small relative to the rest of the world. In other words, the asymmetric barrier will only matter for very large or very small countries. For a very large country, the impact on prices will be much smaller. For a very small country, the impact on prices will be much larger. This leads to the last primary equation of interest, detailing how an asymmetric change in corporate income taxes impacts the gravity export in equation (10):

$$(10)\ d\left(x_{ij}\frac{y^w}{y_i y_j}\right) = (1-\sigma)\lambda_j^{-\sigma}\ d\left(\frac{\lambda_j t_{ij}}{P_i P_j}\right)$$ [15]

The key variables are σ and λ_{ij}. When σ (elasticity) is large (greater than 1), then the impact on exports should be small and negative. However, when σ is small (smaller than 1, approaching 0), the impact on exports should increase. Where λ_{ij}, is the asymmetry between countries i and j, λ_j is the after-tax value in country j or 1-tax_j. The derivation of the impact of asymmetric trade barriers, focused on corporate tax rates, provides some clear implications.

The integration of the asymmetric trade barrier variable in the price has one additional important implication. Excluding asymmetric trade barriers implicitly requires that the law of one price holds.[16] This implies:

$$(11)\ p_{ij} = p_i t_{ij} = p_{ji} = p_j t_{ji} = p^w$$

where p^w is a uniform world price. However, the existence of asymmetric trade barriers allows prices between states to diverge based upon the asymmetric wedge. If we rewrite equation (11) to allow for the existence of an asymmetric trade barrier, we obtain:

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[15] Please see appendix 1 for a more detailed mathematical explanation of the derivation of equations 9 and 10.

[16] As stated previously, $p_{ij} = p_i t_{ij}$, meaning that the price of a good in country i equals the price in country j when factoring a frictional symmetric trade factor. For instance, this factor can be the "iceberg" effect of trade where, as distance between countries increases, trade between states decreases. As traders arbitrage prices of tradable goods, prices rise in the exporting country and drop in the importing country.

$$(12) p_{ij} = p_i t_{ij} \lambda_{ij} \approx p_{ji} = p_j t_{ij} \lambda_{ji} \; iff \; \lambda_{ij} \approx \lambda_{ji}$$

However, as the wedge between asymmetric trade barriers increases, equation (12) becomes:

$$(12') p_{ij} = p_i t_{ij} \lambda_{ij} \neq p_{ji} = p_t t_{ij} \lambda_{ji} \; iff \; \lambda_{ij} \neq \lambda_{ji},$$

which implies the following prediction of relative price ratios:

$$(13) \frac{p_{ij}}{p_w} - \frac{p_{ji}}{p_w} \approx \lambda_{ij} - \lambda_{ji}$$

Prices between states will diverge by the difference of their individual asymmetric barriers.[17] Relative to a high corporate income tax state, a low corporate income tax state has a significant price advantage. This leads to our first testable hypothesis:

> *Hypothesis #1: Low corporate income tax rate states have an asymmetric price advantage relative to high corporate income tax rate states. This should increase their exports to and reduce their imports from high tax states.*

Hypothesis 1 implies that, all other things equal, λ_{ij} is *negatively* related to exports from country i. In other words, an increase in the corporate income tax rate of country i relative to country j increases the price level in country i relative to country j (at least in the short run), implying that the new equilibrium after arbitrage features reduced exports from high tax state i to low tax state j.[18]

However, holding all other things constant ignores the potential impact of public goods that accrue from government expenditures. Rewriting λ_{ij} to allow for the existence of other (non-tax) asymmetries gives:

$$(14) \lambda_{ij} = \frac{\lambda_{i1} + \lambda_{i2} + \ldots + \lambda_{in}}{\lambda_{j1} + \lambda_{j2} + \cdots + \lambda_{jn}}$$

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[17] Though we do not pursue the issue of price divergence in this paper focusing instead on the impact on trade flows, the theoretical discovery of a reason for the divergence of price divergence between states in a bilateral framework should not be overlooked.

[18] In the empirical part, we test different measures of relative price advantages and variations of high and low tax states to estimate these differences.

Equation (14) allows for a range of potential asymmetric trade barriers to exist in addition to corporate income tax rates. For instance, high corporate income tax rates may be used to pay for higher levels of human capital or infrastructure, offsetting any loss of price competitiveness due to tax differentials. This leads to the second testable hypothesis.

> *Hypothesis #2: If $\lambda_{ij}>0$ or is statistically insignificant, then other asymmetric trade barriers offset the (dis)advantage of divergent tax rates. If $\lambda_{i1} > \lambda_{j1}$ and λ_{ij} is greater than 0, then $\lambda_{i2} <\lambda_{j2}$.*

Hypothesis 1 makes a clear prediction about the effect of tax rate differentials on direction of bilateral trade flows between states. Hypothesis 2 however predicts that if λ_{ij} is greater than zero or statistically insignificant, then other asymmetric barriers reduce the (dis)advantage of tax rates. In other words, all other things are not constant. We empirically test hypothesis 2 by extending the basic gravity model to study the portfolio of asymmetric trade barriers facing country *i* with regards to trading partners *j* through *n*. The model intuitively implies that when country *i* faces asymmetric trade barriers relative to its trading partners *j*, country *i* will attempt to equalize total weighted trade barriers by offsetting known disadvantages with other advantages (e.g., arbitrage over asymmetric trade barriers). However, if corporate income tax rates impact the price of exports—which would occur for instance if the cost of offsetting corporate income taxes with other asymmetric barriers is larger that the cost of their impact on the price of exports--bilateral asymmetric tax rates differentials *should* shift international trade flows and production away from high tax states towards low tax states.

Data and Methodology

To test for the distortionary impact on international trade of heterogeneous corporate taxes, we integrate a comprehensive dataset of OECD countries into a revised gravity model. As mentioned earlier, trade is likely to be highly driven by

factors other than tax considerations. We focus on OECD countries because they are more likely to be similar along non-tax factors (e.g., accounting rules, economic and political conditions).[19]

The data come from several sources. First, bilateral direction of trade and gross domestic product data comes from the International Monetary Fund. Our choice of the trade variable is the level of imports.

Because we use Baldwin and Taglioni (2006)'s revised gravity model, the only gravity variable that needs to be considered is the interacted natural log of nominal GDP. Second, statutory corporate income tax rates are from the OECD. We use top statutory central corporate income tax rates of 30 OECD countries from 1981 to 2008. In addition to countries' central statutory corporate income tax rates and as a proxy for effective marginal tax rates, we use the estimated effective average and effective marginal tax rates provided by the Institute of Fiscal Studies's database.[20] As noted by Devereux et al (2002), a proxy for the effective corporate income tax rate should also take into account differences in the tax base, which one can partly achieve by accounting for differences between countries' other tax provisions such as tax depreciation allowances.

To estimate the relationship between bilateral trade flows and tax rates, our baseline model is the modified gravity model specified by Baldwin and Taglioni (2006). We borrow from their theoretical specification in several ways. First, following Baldwin and Taglioni (2006), we disaggregate the dependent variable into imports rather than total real trade, as bilateral trade is not necessarily balanced, depending heavily on country size. Second, we use the

[19] Also, OECD countries account for the majority of international trade.
[20] Depreciation allowances are taken from the Institute for Fiscal Studies (Devereux et al., 2002).They are calculated for a panel of 16 OECD countries from 1979 to 2005. New investment is assumed to be financed by equity or retained earnings. Economic depreciation is assumed to be uniform across countries, at 12.25% for machinery and equipment. The common inflation rate is 3.5% and the real interest rate is 10%. The expected rate of economic profit is 10%. To calculate marginal and average effective tax rates, the IFS uses the combined corporate income tax rate including federal and local corporate income tax rates. http://www.ifs.org.uk/publications/3210

nominal value of trade rather than the deflated real value, as the time variant country fixed effect controls for inflation. Third, we use time variant country dummies and time invariant country pair dummies rather than the fixed importer, exporter, and year effects. Although this model is econometrically preferred because it is less prone to multicollinearity, it is also computationally intensive. Nevertheless, with a large enough database, it produces unbiased results as demonstrated in Baldwin and Taglioni (2006). Like them, we omit most country specific and country pair specific invariant variables like distance and land area, which are already accounted for in the array of dummy variables. A primary advantage of the gravity model is the exogenous nature of its explanatory variables (e.g., distance). However, these variables are generally country specific or country pair specific, and invariant. Therefore, to prevent multicollinearity between them and the fixed effects, one should substitute a comprehensive set of country and pair dummies for these exogenous variables (Baldwin and Taglioni, 2006). Our model is as follows:

$$(15)\ lnIMP_{ijt} = \ln\left(GDP_{it} * GDP_{jt}\right) + TVX_{it} + TVI_{jt} + TICP_{ij} + \lambda_{ijt} + \varepsilon_t$$

where, the dependent variable is the natural log of nominal imports by country i from country j in year t. The only observed traditional gravity variable is the natural log of joint nominal GDP of countries i and j in year t. TVX and TVI are a comprehensive set of time variant exporter and importer dummy variables. They control for unobserved characteristics of a country that affect its propensity to trade, such as its remoteness or home bias. TICP is a comprehensive set of time invariant country pair dummy variables. They control for unobserved characteristics of pairs of countries, such as bilateral trade agreements or distance. The variable of interest here is the asymmetric bilateral trade barrier between the two counties i and j, defined as $\lambda_{ijt}=d(\tau_{it}, \tau_{jt})$, where λ is the asymmetric barrier

between i and j's tax systems. We use both continuous and discrete measures for an asymmetric variable. Continuous measures include the simple ratio of corporate income tax rates in countries *i* and *j* represented as λ in equation (4).[21] Because tax asymmetries may only matter for large tax wedges, which would be the case for example in the presence of large unobserved non-tax costs, we also create a variety of simple dummy variables to represent larger discrete changes of tax ratios. Large discrepancies between neighboring states corporate income tax rates provide—in theory and all else equal--incentives to shift trade to low tax states.[22] Therefore we run separate regressions with a variety of dummy variables for high and low tax wedges in different trade areas, further explained in the results section.

The Results

To test the impact of asymmetric trade barriers captured in the form of divergent tax rates, we present our baseline results from estimating equation (15) in Tables 1 and 2. Our baseline regressions are unlikely to be contaminated by multicollinearity, a problem that was criticized in previous trade literature (Baldwin and Taglioni, 2006). The value of the asymmetric trade barrier is neither correlated with the time invariant country pairs or the time variant country fixed effects, as it is a quasi time variant country pair. In other words, the methodology successfully avoids potential multicollinearity using the Baldwin-Taglioni gravity.

Table 1 shows results where λ_{ijt} is a continuous asymmetric trade barrier defined in equation (4) as the ratio of corporate income tax rates in countries j and i respectively, while table 2 shows results where we utilize a dummy variable

[21] Although we estimate several measures of the continuous tax wedge, we only report those based on published OECD statutory tax rates. Other results are available on demand.
[22] Hines (1996) finds that corporate income tax wedges may only have a significant effect when they are large enough.

separating low and large values of the continuous asymmetric barrier (more or less than unity). A value of the continuous variable smaller (larger) than unity means that the corporate income tax rate in the importing country i is smaller (larger) than that of the exporting country j, in which case the dummy variable equals to 0 (unity). However, our model and the use of a gravity model of trade implies that as λ_{ijt} increases, this should provide an asymmetric cost advantage to the exporting country. The results do not confirm this prediction. Asymmetric trade barriers defined as divergent corporate income tax rates demonstrate no statistical significance. In the five baseline regressions shown in table 1, using the time invariant country pair and the time variant country fixed effects, the continuous measure of the asymmetric trade barrier is only statistically significant in regressions using all years from 1981 to 2008. However, the results are not robust to the time period considered. Limiting the data to four, six, eight and twelve year cross sectional panels does not yield any significant impact of the continuous tax asymmetric variable. Likewise, as shown in table 2, regressions replacing the continuous asymmetric trade barrier with a discrete measure of the asymmetric barrier do not yield a significant impact of the tax wedge on trade. Nevertheless, it is worth noting that the coefficient produces the expected sign even if it is insignificant. Therefore even if they are not statistically significant, they consistently confirm the model's prediction that a smaller corporate income tax rate in the importing country than in the exporting country provides an implicit price benefit to the importing country.

Expanding the Data

The results presented so far in tables 1 and 2 use the top statutory central corporate income tax rates calculated by the OECD and presented in appendix 1. However, as mentioned earlier, many other parameters of countries' tax systems that affect investment decisions are not reflected in statutory tax rates. Although

it is impossible to control for all of these provisions, we control for some of the most important countries' variations in effective corporate income tax rates, namely differences across countries' tax depreciation allowances, aimed at stimulating corporate investment through reduced effective tax rates. For this, we use data from the Institute for Fiscal Studies (IFS), provided for a subsample of 19 countries from 1979 to 2005.[23] Table 3 shows the results using the continuous version of the asymmetric tax barrier, and table 4 shows the results using the discrete version of the effective marginal tax rate (EMTR) and the effective average tax rate (EATR). The primary finding is the status quo: tax asymmetries have no statistically significant impact on trade levels.

Since calculating effective tax rates requires specific assumptions about inflation, discounting, the investment mix, and the source of finance, we use four different definitions of the EATR and the EMTR, as provided by the IFS. The first is our base case and assumes the same level of inflation, depreciation, and discounting across countries. In this base case, investment is in plant and machinery, and is financed by equity or retained earnings. The second case substitutes debt financing for equity financing retaining all other assumptions from the base case. The third definition substitutes investment in industrial buildings for plant and machinery, but maintains all other assumptions from the base case. The fourth definition of effective tax rates replaces the inflation rate with country specific data for inflation, but maintain all other assumptions from the base case. This implies a large range of tax rates both across countries and over time. For example, the EATR of Finland in 1979 is 45 percent when investment in equipment is assumed to be financed by equity or retained earnings, but falls to 12 percent when financed by debt. The results from the baseline model using statutory tax rates are robust to the use of proxies for effective tax rates. In

[23] Please see a full description of variables used in Appendix 3.

the few instances where we do find statistical significance, the results are not robust to the time period considered, and not infrequently provide a theoretically incorrect sign. For instance as shown in table 3, using a continuous measure of the tax asymmetry, the estimated impacts of EMTR-debt with investment in machinery and EMTR with investment in industrial buildings are both statistically significant but have opposite signs. Furthermore, the estimated impact of the EMTR-debt with investment in industrial buildings, is statistically and economically significant in regressions using the full panel, but no longer significant when the period is limited to four, six, eight, and twelve year intervals.

Results using binary dummy variables reveal similar levels of statistical insignificance. The only binary asymmetric dummy variable with significance is the EMTR-base, which has a small negative theoretically impact. Also, the impact of the EMTR-debt in a period limited to six years cross sections is statistically significant and positive. However, the lack of general significance and specifically of the effective marginal tax rate when using country specific inflation, reveals that the finding of statistical significance should be placed in context.

Asymmetric Tax Thresholds

In the previous results we used both continuous values and binary dummy variables. However, it is still possible that asymmetric tax rates are important factors of trade in a gravity trade model beyond certain cost thresholds. For example, very small changes in asymmetric tax costs may have no impact but larger differentials *may* have a statistically significant impact. For instance, a 3% shift in asymmetric costs may have no impact on trade, but a 15% difference in relative tax rates may have a significantly larger impact on trade. To test this, we use a tax threshold of either 10 percent or 20 percent. For instance, for the 10 percent threshold, we create a categorical variables equal to -1 if the tax wedge is

smaller than 0.9, 0 if the tax wedge is between 0.9 and 1.1, and 1 if the tax wedge is above 1.1. Results are presented in table 5.[24] Again, in most regressions there is no statistical significance of the asymmetric barrier. Regardless of the value used for the threshold, the results do not support the prediction that asymmetric tax wedges beyond a small or large threshold impact international trade flows. Three specific findings are worth emphasizing in regressions using categorical asymmetric tax wedges. First, when using OECD statutory corporate tax rates and the 10 percent threshold tax wedge, the impact of the asymmetric tax barrier is statistically significant in the full panel, with an estimated effect of 3 percent. The asymmetric tax barrier using the 10 percent threshold is also statistically significant for alternative time periods, with an estimated impact on trade generally between 3 and 9 percent. Such small values imply that trade is highly inelastic, as prices increase more than trade volume declines. Second, in regressions using the 20 percent threshold with OECD statutory corporate income tax rates, the asymmetric tax barrier has a statistically insignificant impact on trade. Given the significance of the estimated effect of the asymmetric tax barrier when using the 10 percent tax wedge variable but not when using the 20 percent tax wedge, it seems likely that countries with large tax asymmetric barriers differences arbitrage these barriers with other frictions that prevent trade. Third, when using the 10 percent threshold, the impact of the tax asymmetry based on the EATR using country specific values for inflation and interest rates is statistically significant when using the full panel or when the data are limited to 6 and 12-year intervals, but no longer significant when the period is limited to 4 and 8-year intervals. Fourth, when using a 20 percent threshold, virtually all tax barriers based on effective tax rates have an insignificant impact on trade.

[24] We define a 10 percent tax wedge as an asymmetric barrier value between .9 and 1.1. Therefore, raw asymmetric barrier values smaller than .9 are coded -1 and values greater than 1.1 are coded 1 with all other observations coded 0.

Changing Space and Time

To further test the impact of taxes on international trade, we test all previously defined asymmetric tax barriers variables but change both the geographic and time components. Given that there is a cluster of developed countries in Europe, and to limit the impact of unobserved differences between countries, we run regressions focusing only on intra-European trade. A country is considered to be in Europe if it is geographically located in Europe rather than being based on political or institutional mechanisms. Given the geographic proximity, political and economic union, and cultural similarity, this set of countries is a natural choice to investigate the impact of asymmetric tax trade barriers on trade flows between states. The results are, once again, similar to the baseline regressions. Asymmetric tax rate barriers have no statistically significant impact on intra-European international trade. Of all the regressions that exclude non-European trade partners, only the ones using EMTRs and EATRs with country-specific inflation rates and using the 10 percent tax wedge dummy as a proxy for the tax asymmetric barrier show a statistically significant impact on trade but the signs of the estimated impact are theoretically incorrect. In other words, European countries with higher tax rates import *less* from European countries with lower tax rates. All other estimates including other proxies for tax rate wedges, continuous or and binary results are insignificant, and not presented here for sake of space. In line with previous findings, the estimated impact of tax wedge variables are insignificant whether using the baseline continuous statutory rates value or the 20 percent discrete tax rate wedge as proxies. We suspect that this is due to the fact that asymmetric tax barriers impact the margins of natural trading partners but have no impact on countries that do not trade intensively. In other words, the relatively large 20 percent asymmetric tax barrier is only one of many factors restricting trade between states resulting in their insignificant estimated effect on

trade.

We also divide the data into groups before and after 1996. Given changes in the patterns of developed country trade, it may be possible that exogenous developments over time impact the potential timing of the importance of corporate income tax rate wedges. In line with previous results, there is no evidence that asymmetric tax rate barriers impact international trade flows between developed countries in selected periods. When rerunning all regressions, dividing into two time periods, pre- and post-1996, and excluding all non-European countries, we find no statistically significant impact of tax wedges on trade. There is one interesting finding. For the pre-1996 EATR with country specific variables using a 10 percent tax wedge dummy, we find a statistically significant impact of tax wedges on trade both for the whole panel and for all cross sections, but again with the theoretically incorrect sign. No other variables demonstrate robust significance. Given the frequency of statistical insignificance and the occasional theoretically correct estimated sign with statistical significance, the results merely demonstrate that tax rate wedges do not have the predicted impact on international trade. However, the post-1995 results are uniformly insignificant. In other words, tax rates mattered prior to 1996 but not after. This may be due to a variety of factors including large reductions in corporate income tax rates across countries—due to increased tax competition--or production flexibility. There is little robust evidence to support the idea that corporate income tax rate differences impact international trade flows between developed countries.

Conclusion

In this paper, we augment a gravity model of trade with asymmetric trade barriers to investigate the theoretical impact of corporate income tax rate differentials between countries on trade flows. Our theoretical model has two main

implications. First corporate income tax wedges should affect trade patterns though an effect on relative prices, but the size of the distortion to trade depends on the relative asymmetry and the relative size of trading partners. Second, because corporate income tax rates are one instrument from a larger set of asymmetric trade barriers, countries have an incentive to arbitrage between positive and negative tax barriers, thereby offsetting or "blurring" the size of the distortion of corporate income taxes on trade patterns. We test our model empirically using an augmented gravity model of trade with various proxies for bilateral corporate income tax rate wedges and 30 OECD countries from 1981 to 2008. Many variations of our empirical approach based on different proxies for corporate income tax rates, trading areas, and time periods consistently show that corporate income tax rate have at most a very small impact on international trade flows, thereby suggesting that countries likely arbitrage across a variety of asymmetric barriers.

Our results are neither surprising nor incompatible with a potential effect of corporate income tax wedges on the real economy and in particular international trade. First, recent research has shown that the variation in statutory corporate income tax rates in OECD countries is much larger than the variation in average effective tax rates (Gravelle, 2011; Markle and Shackelford, 2011; Devereux et al., 2008). This suggests that, if not through real economic effects, companies have other ways to smooth their effective tax payments in reaction to corporate income tax wedges, such as income shifting, transfer pricing, or other tax accounting strategies. We find evidence of this trend, as estimates of the impact of tax differentials based on effective corporate income tax rates instead of statutory corporate income rates are almost never significant. Second, there is empirical evidence that corporate income tax differentials affect the real economy in ways that are not reflected in traditional models of international trade. For instance, research finds that outbound FDI and domestic production are not

substitutes, but complements (Desai et al., 2009; Eaton and Tamura, 1994) , that FDI is significantly related to trade of intermediate goods--or vertical production (Yi, 2003), and and that FDI induces trade (Yamayaki, 1991; Fontagne and Pajot, 1997). Finally, corporate income tax wedges may not affect trade flows but may still affect the structure of trade. For example, it is has been suggested as part of the debate over corporate income tax reform in the U.S. that the persistent high corporate income tax rate offsets US comparative advantage in capital intensive goods. Further research should investigate the effect of direct and indirect corporate taxes on the composition of trade.

Bibliography

Anderson, James and van Wincoop, Eric. 2003. "Gravity with Gravitas: A Solution to the Border Puzzle." *American Economic Review*, 93, 1. 170-92

Auerbach, Alan J. and Hassett, Kevin. "Taxation and Foreign Direct Investment in the United States: A Reconsideration of the Evidence," in Alberto Giovannini, R. Glenn Hubbard, and Joel Slemrod, eds., Studies in international taxation. Chicago: University of Chicago Press, 1993, pp. 119-44.

Balding, Christopher. 2010. "Joining the World Trade Organization: What is the Impact?" *Review of International Economics*, 18, 1. 193-206

Baldwin, Richard and Toshihiro Okuba. 2009. "Tax Reform, Delocation, and Heterogeneous Firms." *Scandanavian Journal of Economics*, 111, 4. 741-64

Baldwin, R. and D. Taglioni. 2006. "Gravity for Dummies and Dummies for Gravity Equations." NBER Working Paper No. 12516

Baldwin, Richard and Paul Krugman. 2004. "Agglomeration, Integration, and Tax Harmonisation." *European Economic Review*, 48, 1. February. 1-23

Bartelsman, Eric and Roel Beetsma. 2003. "Why Pay More? Corporate Tax Avoidance Through Transfer Pricing in OECD Countries." *Journal of Public Economics*, 87, 9. September. Pp. 2225-52

Batra, Raveendra and Rama Ramachandran. 1980. "Multinational Firms and the Theory of International Trade and Investment." *The American Economic Review*, 70, 3. June. 278-90

Baxter, Marianne. 1992. "Fiscal Policy, Specialization, and Trade in the Two-Sector Model: The Return of Ricardo?" *Journal of Political Economy*, 100, 4. 713-44

Bergstrand, Jeffrey, Peter Egger, and Mario Larch. 2013. "Gravity Redux: Estimation of Gravity-Equation Coefficients, Elasticities of Substitution, and General Equilibrium Comparative Statics Under Asymmetric Bilateral Trade Costs." *Journal of International Economics*. 89, 1. January. 110-21

Brainard, S. Lael. 1997. “An Empirical Assessment of the Proximity-Concentration Trade-off Between Multinational Sales and Trade.” *The American Economic Review*. 87, 4. September. 520-44

Bucovetsky, Sam and Andreas Haufler. 2008. Tax Competition When Firms Choose Their Organization Form: Should Tax Loopholes for Multinationals Be Closed?” *Journal of International Economics.* 74, 1. 188-201

Clausing, Kimberly. 2008. “A Closer Economic Integration and Corporate Tax Systems.” *Global Economy Journal*. 8, 2. Article 2.

Clausing, K. A. 2001. “The Impact of Transfer Pricing on Intrafirm Trade”, in Hines (ed.), *International Taxation and Multinational Activity,* 173-94.

Clausing, Kimberly. 2003. “Tax Motivated Transfer Pricing and US Intrafirm Trade Prices.” *Journal of Public Economics*, 87, 9. September. 2207-2223

de Mooij, Ruud A. and Sief Ederveen. 2003. “ Taxation and Foreign Direct Investment: A Synthesis of Empirical Research”. *International Tax and Public Finance,* 10, 6. November. 673-91

Desai, Mihir . A. and James R. Hine. 2005. “Value-Added Taxes and International Trade.” NBER. November.

Desai, Mihir . A., C. Fritz Foley, and James R. Hine. 2004. “Foreign Direct Investment in a World of Multiple Taxes.” *Journal of Public Economics*, 8. 2727-44.

Desai, Mihir . A., C. Fritz Foley, and James R. Hine. 2009. “Domestic Effects of the Foreign Activities of U.S. Multinationals.” *American Economic Journal: Economic Policy*, 1, 1. February. 181-203.

Desai, Mihir, A. and Dhammika Dharmapala. 2011. "Dividend Taxes and International Portfolio Choice,” *The Review of Economics and Statistics*. 93, 1. 266-84.

Devereux, Michael P., Rachel Griffith, and Alexander Klemm. 2002. “Corporate income tax reforms and tax competition.” *Economic Policy*, 17, 35. 449-95.

Devereux, Michael P., Ben Lockwood, Michela Redoano. 2008. "Do Countries Compete over Corporate Tax Rates?" *Journal of Public Economics*, 92, 5. 1210-35

Devereux, Michael P. and G. Maffini. 2007, The impact of taxation on the location of capital, firms and profit: A survey of empirical evidence. Oxford University Centre for Business Taxation Working Paper 07/02.

Devereux, Michael P. 2008. "Tax International Corporate Income: Economic Principles and Feasibility." Center for Business Taxation Oxford University Working Paper

Eaton, J. and A. Tamura. 1994. "Bilateralism and regionalism in Japanese and US trade and direct foreign investment patterns." *Journal of the Japanese and International Economies*, 8, 4. 478-510.

Ferrett, Ben and Ian Wooton. 2010. "Competing for a Duopoly: International Trade and Tax Competition." *Canadian Journal of Economics*, 43, 3. August. 776-94.

Fontagne, L. and Michel Pajot. 1997. "How Foreign Direct Investment Affects International Trade and Competitiveness: and Empirical Assessment." Cepii Discussion Paper No. 97-17.

Gordon, Roger, Laura Kalambokidis and Joel Slemrod. 2003. "A New Summary Measure of the Effective Tax Rate on Investment." NBER, Working Paper, No. 9535.

Gorg, Holger, Hassan Molana, and Catia Montagna. 2009. "Foreign Direct Investment, Tax Competition, and Social Expenditure." *International Review of Economics and Finance*, 18, 1. January. Pp. 31-37

Gravelle, Jane. 2011. International Corporate Tax Rates Comparisons and Policy Implications." Congressional Research Service. CRS Report for Congress. R41743. March.

Grubert, Harry and John Mutti. 1991. "Taxes, Tariffs, and Transfer Pricing in Multinational Corporate Decision Making." *The Review of Economics and Statistics*, 73, 2. May 1991. Pp. 285-93

Heinemann, Friedrich, Michael Overesch, and Johannes Rincke. 2010. “Rate Cutting Tax Reforms and Corporate Tax Competition in Europe.” *Economics and Politics.* 22, 3. 498-518

Helpman, Elhanan. 1976. “Macroeconomic Policy in a Model of International Trade with a Wage Restriction.” *International Economic Review*, 17,2. 262-77.

Hines, J. R. 1996. “Taxes and the Location of Foreign Direct Investment in America.” *American Economic Review,* 86, 5. 1076-94.

Hummels, David, Jun Ishii, and Kei-Mu Yi. 2001. The nature of international investment income. *Quarterly Journal of Economics*, 94, 4. 793-98.

Hansen , Gordon H., Raymond J. Mataloni, Jr., and Matthew J. Slaughter. 2005. Vertical production networks in multinational firms. *Review of economics and statistics*, 87, 4. 664-78.

Keen, Michael and Murtaza Syed. 2006. “Domestic Taxes and International trade: Some Evidence.” IMF Working Paper WP/06/47

Markle, Kevin S., and Douglas A. Shackelford. 2011. “Cross-country Comparisons of Corporate Income Taxes.” *National Tax Journal*, 65, 493-528.

McCallum, John. 1995. “National Borders Matter: Canada-U.S. Regional Trade Patterns.” *American Economic Review*, 85, 3. June. 615-23

Melvin, J. 1979. “Short-Run Price Effect of the Corporate Income Tax and Implications for International Trade.” *American Economic Review* 69, 5. 765-74.

Overesch, Michael and Johannes Rincke. 2011. “What Drives Corporate Tax Rates Down? A reassessment of Globalization, Tax Competition, and Dynamic Adjustment o Shocks.” *The Scandinavian Journal of Economics*, 113, 3. September. 579-602.

Rogoff, Kenneth. 1996. “The purchasing power parity puzzle.” *Journal of Economic Literature,* XXXIV, June, 647-68.

Scholes, Myron S. and Wolfson, Mark A. “Taxes and business strategy: A planning approach.” 4th ed. Englewood Cliffs, NJ: Prentice- Hall, 2009.

Sinn, Hans-Werner. 1990. “Tax Harmonization and Tax Competition in Europe.” *European Economic Review*. 34, 2. 489-504

Slemrod, Joel. 2004. “Are Corporate Tax Rates, or Countries, Converging?” *Journal of Public Economics* 88. 1169–86.

Summers, Lawrence H. 1988. “Tax Policy and International Competitiveness.” In Frenkel, Jacob A, ed. *International Aspects of Fiscal Policies*. 349-86.

Swenson, D. 1994. “The impact of U.S. tax reform on foreign direct investment in the United States. Journal of Public Economics, 54. 243-66.

Wheeler, David and Ashoka Mody. 1992. “International Investment Location Decisions: The Case of US Firms.” *Journal of International Economics*. 33, 1. August. 57-76

Willard, K. Leigh. 1994. “Do taxes level the playing field?: How U.S. tax policy affects the investment decisions of foreign affiliates in the United States.” The Columbia Journal of World Business, 29, 4. 20-28.

Yamawaki, H. 1991 "Exports and Foreign Distributional Activities : Evidence on Japanese Firms in the United-States *"The Review of Economics and Statistics*, LXXIII, 2. 294-300.

Yi, Kei-Mu. 2003. Can vertical specialization explain the growth of world trade?” *Journal of Political Economy*. 111, 1. 52-102.

Appendix 1 - Central government statutory corporate income tax rates and decline by time period, selected years

Country	1981	1990	2005	2011	1981-2011	1990-2011	2005-2011
Australia	46	39	34	30	-16	-9	-4
Austria	55	30	34	25	-30	-5	-9
Belgium	48	41	40.2	34	-14	-7	-6.2
Canada 1/	37.8	28.8	29.1	22.1	-15.7	-6.7	-7
Denmark	40	40	32	28	-12	-12	-4
Finland	43	25	29	26	-17	1	-3
France 2/	50	42	37.8	35	-15.1	-7.1	-2.8
Germany 3/	56	50,0	42.2	26.4	n/a	n/a	-15.8
Greece	45	46	40	32	-13	-14	-8
Hungary	n.a.	40	18	16	n/a	-24	-2
Iceland	n.a.	n.a.	30	18	n/a	n/a	-12
Ireland	45	43	24	12.5	-32.5	-30.5	-11.5
Italy 1/	40	52.2	37	33	-7	-19.2	-4
Japan	42	37.5	30	30	-12	-7.5	0
Luxembourg 4/	40	34	31.2	22.9	-17.1	-11.1	-8.3
Mexico	42	36	35	30	-12	-6	-5
Netherlands	48	35	35	31.5	-16.5	-3.5	-3.5
New Zealand	45	33	33	33	-12	0	0
Norway	29.8	29.8	28	23.8	-6.1	-6.1	-4.3
Portugal	47	36.5	32	25	-22	-11.5	-7
Spain	33	35	35	35	2	0	0
Sweden	40	40	28	28	-12	-12	0
Switzerland	9.8	9.8	8.5	8.5	-1.3	-1.3	0
Turkey	n.a.	n.a.	33	30	n/a	n/a	-3
United Kingdom	52	34	30	30	-22	-4	0
United States	46	34	35	35	-11	1	0

Source: OECD Tax Database.

1/ Top regional rate

2/ Including regional rate

3/ Including surcharge and top regional rate

4/ Not including surcharge in 1981 and 1990.

Appendix 2 – Mathematical Derivation of the Gravity Model Given Asymmetric Trade Barriers the Example of Tax Rates

Given the base asymmetric trade barrier where:

$$(1)\lambda_{ij} = \frac{1/(1-tax_i)}{1/(1-tax_j)} = \frac{1-tax_j}{1-tax_i}$$

Which when derived yields the following:

$$(2)d\lambda_{ij} = \frac{1-tax_j}{(1-tax_i)^2}d\text{tax}_\text{i} - \frac{1}{1-tax_i}d\text{tax}_j$$

Inserting asymmetry into the base gravity model and deriving yields:

$$(3)d\left(x_{ij}\frac{y^w}{y_i y_j}\right) = (1-\sigma)\lambda_j^{-\sigma}d\left(\frac{\lambda_j t_{ij}}{P_i P_j}\right)$$
$$= -(1-\sigma)\lambda_{ij}^{1-\sigma}\lambda_{ij}^{-1}d\lambda_{ij} + (1$$
$$-\sigma)\lambda_{ij}^{1-\sigma}\left[1-\frac{1}{2}\left(1+\sum_k \theta_k^2\right)(\lambda_i+\lambda_j)+\lambda_i\theta_i+\lambda_j\theta_j\right]dt$$

This then yields:

$$(4) -\frac{1-\sigma}{(1-tax_j)^{1-\sigma}(1-tax_i)^{\sigma}}dtax_i + \frac{1-\sigma}{(1-tax_j)^{2-\sigma}(1-tax_i)^{\sigma-1}}dtax_j +$$
$$\frac{(1-\sigma)(1-tax_i)^{1-\sigma}}{(1-tax_j)^{1-\sigma}}\left[1-\frac{1}{2}(1+\sum_k\theta_k^2)\,\frac{(1-tax_i)^2+(1-tax_j)^2}{(1-tax_i)(1-tax_j)}+\frac{1-tax_j}{1-tax_i}\theta_i+\right.$$
$$\left.\frac{1-tax_i}{1-tax_j}\theta_j\right]dt$$

When we do the same for the price equation this yields the following:

$$(5)\ dP_i = \lambda_i\left(\frac{1}{2}-\theta_i+\frac{1}{2}\sum_k\theta_k^2\right)dt_{ij} + \frac{P_i}{\lambda_i}d\lambda_i =$$
$$\frac{1-tax_j}{1-tax_i}\left(\frac{1}{2}-\theta_i+\frac{1}{2}\sum_k\theta_k^2\right)dt_{ij} + \frac{1}{1-tax_i}dtax_i - \frac{1}{1-tax_j}dtax_j$$

Appendix 3—Variable Description

Variable Type	Description
Continuous Asymmetric Trade Barrier	As defined in equation 4 and appendix 1, a continuous numerical variable, or tax wedge, ranging theoretically from greater than 0 to infinity. Observed values range between .5 and 2.
Asymmetric Dummy Trade Barrier Variables	Coded as 1 when the continuous asymmetric trade barrier is greater than or equal to 1 and 0 when less than 1.
Tax Wedge Categorical Variables	Creates a variable from the continuous asymmetric trade barrier value equal to -1, 0, or 1 for specified very small, medium, or large values of the tax wedge to test whether small differences in countries corporate income tax rates affect trade differently from larger differences. Values below the specified wedge are coded as -1 and values above the specified wedge are coded as 1.
Intra-Europe Trade	European geographic specific. If a country is geographically on the European continent it is considered intra Europe trade. There are no political considerations such as European Union member.
4, 6, 8, and 12 year cross sectional panel	Regressions are run over the whole period or during specified time periods. For instance, the 8-year cross sectional panel covered 1984, 1992, 2000, and 2008.
OECD Corporate Tax Rates	The OECD corporate tax rate is the central government statutory tax rate for OECD member countries that were members for all or most of the time series.
EMTR/EATR Base	Investment in plant and machinery, financed by equity or retained earnings, taxation at shareholder level not included, real discount rate: 10%, inflation rate: 3.5%, depreciation rate: 12.25%.
EMTR/EATR Debt	Investment in plant and machinery, financed by debt, taxation at shareholder level not included, real discount rate: 10%, inflation rate: 3.5%, depreciation rate: 12.25%.
EMTR/EATR Building	Investment in industrial buildings, financed by equity or retained earnings, taxation at shareholder level not included, real discount rate: 10%, inflation rate: 3.5%, depreciation rate: 12.25%.
EMTR/EATR Country and Time Specific	Investment in plant and machinery, financed by equity or retained earnings, taxation at shareholder level not included, real discount rate: 10%, inflation rate: IMF data on actual inflation rate, depreciation rate: 12.25%.

Table 1 – Baseline Results Using Continuous Asymmetric Value

	All Years	4 Year Cross Sectional Panel	6 Year Cross Sectional Panel	8 Year Cross Sectional Panel	12 Year Cross Sectional Panel
Natural Log Joint GDP	.57* (.03)	.56* (.05)	.57* (.05)	.58* (.06)	.54* (.06)
Continuous Asymmetric Trade Barrier	-.37* (.09)	-.69 (.58)	-.32 (.76)	-.93 (.93)	-.69 (.98)
Observations	15,508	4,104	2,910	2,424	1,680
R-squared	.97	.97	.97	.97	.97

Standard errors are in parentheses

Table 2 – Baseline Results Using Dummy

	All Years	4 Year Cross Sectional Panel	6 Year Cross Sectional Panel	8 Year Cross Sectional Panel	12 Year Cross Sectional Panel
Natural Log Joint GDP	.57* (.03)	.55* (.05)	.57* (.06)	.57* (.06)	.53* (.06)
Asymmetric Trade Barrier Dummy	-.00 (.01)	-.01 (.02)	-.01 (.03)	-.03 (.04)	-.03 (.04)
Observations	15,095	3,987	2,833	2,357	1,631
R-squared	.97	.97	.97	.97	.97

Standard errors are in parentheses

Table 3 - IFS Raw Tax Asymmetries

	Full Panel	4 Year Cross Sectional Panel	6 Year Cross Sectional Panel	8 Year Cross Sectional Panel	12 Year Cross Sectional Panel
EATR Base	-.07 (.10)	.55 (.86)	.55 (1.03)	.65 (1.15)	.40 (1.35)
EMTR Base	.03 (.07)	.73 (.62)	.68 (.72)	.80 (.79)	.66 (.95)
EATR Debt	.15 (.35)				
EMTR Debt	.43* (.10)	.01 (.56)	.14 (.75)	.36 (.87)	.07 (.98)
EATR Industrial Building	-.26* (.07)	.06 (.40)	.07 (.47)	.15 (.54)	-.05 (.61)
EMTR Industrial Building	-.21* (.06)	.02 (.32)	.05 (.37)	.10 (.42)	-.06 (.48)
EATR Country Specific	.02 (.09)	.56 (.50)	.47 (.56)	.63 (.61)	.37 (.72)
EMTR Country Specific	.09 (.07)	.74 (.41)	.69 (.46)	.75 (.49)	.57 (.60)
Statutory Rate	-.18* (.07)	-.03 (.33)	-.00 (.43)	-.06 (.49)	-.19 (.56)

Standard errors are in parentheses

Table 4 - IFS Binary Dummy Tax Asymmetries

	Full Panel	4 Year Cross Sectional Panel	6 Year Cross Sectional Panel	8 Year Cross Sectional Panel	12 Year Cross Sectional Panel
EATR Base	-.019 (.013)	-.02 (.03)	-.02 (.04)	-.02 (.04)	-.08 (.06)
EMTR Base	-.06* (.01)	-.07** (.03)	-.06*** (.04)	-.08*** (.04)	-.11*** (.06)
EATR Debt	-.02*** (.01)	-.03 (.03)	-.04 (.04)	.01 (.04)	-.07 (.06)
EMTR Debt	.06* (.01)	.04 (.03)	.06*** (.04)	.05 (.04)	.04 (.06)
EATR Industrial Building	-.03** (.01)	-.00 (.03)	-.02 (.04)	-.00 (.04)	.01 (.06)
EMTR Industrial Building	-.02 (.01)	-.01 (.03)	-.02 (.04)	-.01 (.04)	-.02 (.06)
EATR Country Specific	-.00 (.01)	-.01 (.03)	-.01 (.04)	.01 (.04)	-.05 (.06)
EMTR Country Specific	-.02 (.01)	-.04 (.03)	-.05 (.04)	-.02 (.04)	-.09 (.06)

Standard errors are in parentheses

Table 5 - OECD & IFS 10% and 20% Tax Wedge Dummies (-1, 0, 1)

	Full Panel	4 Year Cross Sectional Panel	6 Year Cross Sectional Panel	8 Year Cross Sectional Panel	12 Year Cross Sectional Panel
OECD 10% Wedge	.03**	.08*	.03	.12*	.09**
	(.01)	(.02)	(.03)	(.03)	(.04)
OECD 20% Wedge	-.00	-.01	.01	.00	-.03
	(.01)	(.03)	(.04)	(.04)	(.05)
EATR Base 10% Wedge	-.03*	-.03	-.05	.01	-.06
	(.01)	(.03)	(.04)	(.04)	(.05)
EATR Base 20% Wedge	.01	.03	.01	-.02	.05
	(.01)	(.03)	(.05)	(.05)	(.06)
EMTR Base 10% Wedge	.03*	.04***	.01	.03	.01
	(.01)	(.03)	(.03)	(.04)	(.05)
EMTR Base 20% Wedge	.03**	.04	.01	.08***	.07
	(.01)	(.03)	(.04)	(.05)	(.06)
EMTR Debt 10% Wedge	.00	-.03	-.03	-.03	-.06
	(.01)	(.03)	(.03)	(.04)	(.05)
EMTR Debt 20% Wedge	-.03***	-.04	-.09**	-.00	-.02
	(.02)	(.03)	(.04)	(.05)	(.06)
EATR Country 10% Wedge	-.04*	-.05	-.08**	-.06	-.11**
	(.01)	(.03)	(.04)	(.04)	(.05)
EATR Country 20% Wedge	-.01	-.00	.01	-.01	-.02
	(.01)	(.03)	(.04)	(.05)	(.06)
EMTR Country 10% Wedge	-.00	.00	-.01	-.02	-.01
	(.01)	(.03)	(.03)	(.04)	(.04)
EMTR Country 20% Wedge	-.00	-.01	-.01	-.02	-.04
	(.01)	(.03)	(.04)	(.05)	(.05)
EATR 10% Building Wedge	-.01	-.00	.00	-.00	-.04
	(.01)	(.02)	(.03)	(.03)	(.04)
EATR 20% Building Wedge	-.00	.03	-.00	-.05	.01
	(.01)	(.03)	(.04)	(.05)	(.07)
EMTR 10% Building Wedge	-.00	.01	-.01	.05	-.04
	(.01)	(.02)	(.03)	(.03)	(.04)
EMTR 20% Building Wedge	.01	.03	-.01	-.02	.02
	(.01)	(.03)	(.04)	(.05)	(.06)
Statutory 10% Wedge	.02***	.06**	.05	.09**	.09**
	(.01)	(.02)	(.03)	(.04)	(.04)
Statutory 20% Wedge	-.07*	-.09**	-.08	-.08	-.15**
	(.02)	(.04)	(.05)	(.05)	(.06)

Standard errors are in parentheses.

Table 6 - Selected Results Varying Time and Geography

	Full Panel	4 Year Cross Sectional Panel	6 Year Cross Sectional Panel	8 Year Cross Sectional Panel	12 Year Cross Sectional Panel
EATR Country 10% Wedge 1982-1995	-.06* (.01)	-.09** (.04)	-.09** (.05)	-.14* (.05)	-.16** (.07)
EMTR Country 10% Wedge 1982-1995	-.02 (.01)	-.02 (.03)	-.02 (.04)	-.05 (.04)	-.03 (.06)
EATR Country 20% Wedge 1982-1995	-.01 (.02)	.02 (.04)	.03 (.06)	.01 (.06)	.07 (.09)
EMTR Country 20% Wedge 1982-1995	-.01 (.02)	-.04 (.04)	-.02 (.05)	-.08 (.05)	-.02 (.09)
EATR Country 10% Wedge 1996-2008	-.01 (.02)	-.01 (.04)	-.09 (.06)	.08 (.09)	-.08 (.09)
EMTR Country 10% Wedge 1996-2008	.04** (.02)	.03 (.04)	-.00 (.05)	.05 (.08)	.01 (.08)
EATR Country 20% Wedge 1996-2008	-.02 (.03)	-.05 (.05)	-.00 (.06)	-.06 (.12)	-.08 (.09)
EMTR Country 20% Wedge 1996-2008	.02 (.03)	.05 (.05)	.02 (.06)	.11 (.10)	-.01 (.09)
Intra-European Trade with No Time Exclusions					
EATR Base 10% Wedge	-.03* (.01)	-.03 (.03)	-.08** (.04)	-.04 (.04)	-.06 (.05)
EMTR Base 10% Wedge	.01 (.01)	.01 (.03)	-.00 (.03)	.01 (.04)	.02 (.05)
EATR Base 20% Wedge	.02 (.02)	.03 (.03)	.02 (.04)	.03 (.05)	.03 (.05)
EMTR Base 20% Wedge	.02*** (.01)	.02 (.03)	.02 (.04)	.05 (.05)	.05 (.06)
EATR Country 10% Wedge	-.08* (.01)	-.09* (.03)	-.11* (.03)	-.09** (.04)	-.11** (.05)
EMTR Country 10% Wedge	-.03* (.01)	-.06** (.03)	-.07** (.03)	-.08** (.03)	-.09** (.04)
EATR Country 20% Wedge	-.01 (.01)	.01 (.03)	-.01 (.04)	-.03 (.04)	-.09*** (.05)
EMTR Country 20% Wedge	-.03** (.01)	.01 (.03)	-.02 (.03)	-.02 (.04)	-.02 (.05)

Standard errors are in parentheses