International Transfer Pricing and Tax Avoidance: Evidence from Linked Trade-Tax Statistics in the UK*

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Abstract

This paper employs unique data on export transactions and corporate tax returns of UK multinational firms and finds that firms manipulate their transfer prices to shift profits to lower-taxed destinations. It further shows that the 2009 tax reform in the UK, which changed the taxation of corporate profits from a worldwide to a territorial system, led to a substantial increase in transfer mispricing. We provide evidence for a trade creation effect of transfer mispricing, and estimate substantial transfer mispricing in non-tax haven countries with low-to-medium-level corporate tax rates, and in R&D intensive firms.

Keywords: transfer pricing, corporate taxation avoidance, multinational firms
JEL Classification: F23, H25, H32

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1 Introduction

Globalization has led to the concentration of economic activity within a small number of multinational corporations (MNCs). This development has made it more challenging for governments to raise revenue from corporate income tax, as MNCs can shift their profits across borders to reduce their tax bills.[1]

A key instrument that MNCs use to shift profits is under or over charging transfer prices on transactions between related parties within the MNC group (transfer mispricing). For example, to reduce its pre-tax profits (and hence corporate taxes), an MNC can charge artificially low prices for exports sold to a related party in a low-tax country.[2] Tax-motivated transfer mispricing can take place in trade in real goods as well as in services, and in particular in the form of royalty and licensing payments on intellectual property rights held abroad.[3]

In recent years, policy-makers have become increasingly concerned about this issue as the extent of profit shifting has intensified and the potential revenue at stake is substantial.(Zucman, 2014; Beer et al., 2018). At the same time, there is a trend among countries to change from worldwide to territorial taxation of foreign-source income of their MNCs.[4] Both the UK and Japan switched to territorial taxation in 2009. Following the passage of the Tax Cuts and Jobs Act (TCJA) in December 2017, the U.S. has also moved toward a territorial system, excluding from U.S. taxation the active business income that is earned

[1]See, among others, Harris et al. (1993), Hines and Rice (1994), and Desai et al. (2006) for evidence of general profit shifting by MNCs to low-tax countries, including tax havens. Heckemeyer and Overesch (2017) and Beer et al. (2018) review recent empirical evidence on profit shifting and provide consensus estimate on the magnitude of the semi-elasticity of reported profits by MNCs in response to international tax differential of around 0.8 to 1, respectively.

[2]Conversely, an MNC can pay artificially high prices when buying from a related party in a low-tax country. Most countries use the *arm's length principle*, which stipulates that internal prices between related parties should resemble prices that would prevail between independent parties. Yet, despite extensive guidelines by the Organisation for Economic Co-operation and Development (OECD) and the United Nations (UN), there can be significant room for subjective interpretation. Conceptually, there may even be no "correct" arms-length price if there are no comparable third-party transactions.

[3]See, for example, evidence presented in Dischinger and Riedel (2011).

[4]The worldwide approach taxes the worldwide income of MNCs, typically with a non-refundable credit for foreign taxes paid, and liability to domestic tax being deferred until dividends are paid from the foreign subsidiary to the parent company in the home country. The territorial approach does not tax foreign earnings of MNCs in the home country.

abroad.[5]

This paper presents new evidence on tax-motivated transfer mispricing in real goods. It uses a unique data set that combines the tax records of UK MNCs in manufacturing and their international trade transactions over the years of 2005-2011. The empirical strategy employs two distinct approaches to identify the causal effect of the corporate income tax differential between the destination country and the UK on the unit price of exports by UK MNCs. The first empirical approach controls for omitted variable bias by including a full set of firm–market–product fixed effects, product–market–year fixed effects, and firm–product–year fixed effects in a triple-difference regression. Identifying variation comes from the differential change in the price charged by a UK multinational with a subsidiary relative to the price charged by a UK MNC without a subsidiary in the same country in response to a change in the tax rate difference between the destination country and the UK. The second approach exploits a different source of variation, namely the larger incentives to shift profit following the 2009 UK territorial tax reform, to quantify the effects of a shift from a worldwide to a territorial treatment of foreign profits on transfer mispricing.

We find strong evidence for tax-motivated transfer mispricing in manufacturing exports to low-tax destinations. A one percentage point increase in the UK-destination country tax differential reduces related-party export prices relative to arm's-length export prices by three percent. The extent of tax-motivated transfer mispricing increased substantially after the UK's move to a territorial tax system.[6] Under the territorial tax system, a one percentage point increase in the tax difference reduces related-party export prices relative to arm's-length export prices by another 1.5 percent. Our findings also uncover heterogeneous transfer

[5]The move from worldwide to territorial system in the U.S. is subject to important caveats, including a one-time transition tax on unrepatriated profits, and a minimum tax on overseas income that is in excess of 10 percent of the return on tangible assets abroad ("Global Intangible Low Taxed Income (GILTI)"). See, for example, Chalk et al. (2018) for a detailed discussion of the territorial reform in the U.S.

[6]This reform fundamentally changed the taxation of foreign earnings from a worldwide regime to a territorial regime in the UK. Under the worldwide regime, foreign earnings of UK MNCs were liable to additional UK taxes when repatriating from countries with a lower statutory tax rate than the UK. In contrast, the territorial regime exempts foreign earnings of UK MNCs from UK taxes altogether. We discuss the reform in more detail in section 2.

mispricing among countries and across firms: we uncover transfer mispricing in countries that are not classified as tax havens and have low to intermediate tax rates. Moreover, there is more transfer mispricing in firms with high R&D intensities, with the marginal effect of the tax differential rising to 6.4 percent for those undertaking the most R&D.

Our benchmark findings are comparable with the size of the tax effects on transfer prices estimated in Clausing (2003), Bernard et al. (2006), and Flaaen (2016) but are larger than the effects found in Davies et al. (2018), Vicard (2015) and Cristea and Nguyen (2016). We show that some of the differences can be attributed to omitted variable bias, as previous studies used smaller sets of fixed effects in the empirical analysis, and other differences in the empirical approach such as the way that the key variables of interest are measured and the type of variation that is exploited for identification. Ultimately, the semi-elasticity of transfer prices (and more generally, reported profits by MNCs) with respect to the international tax differential is not a structural parameter, but varies with the design of the corporate and the overall tax system in a country.

Our paper adds to the literature in four distinct ways. First, we show in a simple model that a shift from a worldwide to a territorial system in taxing foreign profits of MNCs leads to stronger transfer mispricing, and we provide empirical evidence that corroborates the theoretical prediction. Second, we find substantial transfer mispricing in tangible goods by UK MNCs to non-tax-haven countries. We do not find evidence for mispricing of exports to tax haven countries, most of which experienced no or little changes in their tax rates over the sample period. Given that our identification strategy relies on tax changes over time, it is not surprising that we do not find any significant results for tax havens. Third, our results suggest that transfer mispricing is concentrated in the most R&D-intensive firms. This finding is robust to controlling for differential effects by firm size and the type of product traded and is consistent with that R&D investment facilitates transfer mispricing by making goods more specific. Fourth, thanks to the rich data and the relatively large number of MNCs headquartered in the UK, our regression specifications include more fixed effects than

previous studies, allowing for a clean identification of tax-motivated transfer mispricing.[7] Moreover, the 2009 UK reform in the taxation of cross-border corporate income provides us with a quasi-natural experiment that introduced exogenous changes in the tax incentives of profit shifting that are unrelated to the level of the tax rate differential, corroborating the causal effect of taxes on transfer prices.

Our findings have several implications for tax policy design. First, they show that there is substantial profit shifting through transfer mispricing in tangible goods by UK MNCs. This represents an area of revenue leakage that warrants further attention of the UK tax authority. While the quantitative evidence is UK-specific, the empirical analysis can be extended to other countries with the suitable data in order to help uncovering the extent of tax-motivated transfer mispricing elsewhere. Second, we find that the shift to the territorial system increased the extent of tax-motivated transfer mispricing, highlighting a relevant revenue cost of moving away from the worldwide system. Third, the finding that transfer mispricing is concentrated in non-haven countries with low to medium tax rates suggests that policy-makers should be mindful of potential revenue loss not only to tax havens but also to other trading partners that have low statutory corporate income tax rates. Finally, tax-motivated transfer mispricing is not uniform across firms, but concentrated in the most R&D-intensive ones. This pattern provides useful direction to guide risk assessment by tax authorities.

Literature Several papers have analyzed transfer-pricing behavior of multinational firms. An early literature, including Grubert and Mutti (1991), Harris et al. (1993), Hines and Rice (1994), and Collins et al. (1998), provided indirect evidence for tax-motivated profit shifting by MNCs, showing that their pre-tax profits are systematically correlated with tax differentials across countries. Heckemeyer and Overesch (2017) and Beer et al. (2018) survey the

[7] Bernard et al. (2006) and Flaaen (2016) use U.S. Census data that allow them to directly look at the price wedge within a multinational firm, implicitly taking out much of the time-invariant variation. However, our country–product–year and firm–product–year fixed effects improve upon their specifications by controlling for time-variant non-tax factors that may confound the effect of the tax wedge. Further details are discussed in section 3.

recent empirical literature on tax-motivated profit shifting, quantifying the consensus estimate of the semi-elasticity of reported profits with respect to the international tax differential of around 0.8 and 1 percent, respectively.

Clausing (2003) was the first to provide direct evidence on manipulated prices, using U.S. industry-level data. In another seminal paper, Bernard et al. (2006) employed transaction-level data from the U.S. Census to study a wide set of factors that can lead to manipulated transfer prices, including corporate taxes and tariffs. More recently, Flaaen (2016) uses the same data to study transfer-price manipulation by U.S. multinationals in response to the 2004 Home Investment Act.

Closely related to our work are three papers that also use detailed trade data to study transfer-price manipulations for a set of different countries. Davies et al. (2018) and Vicard (2015) exploit information on French firms, whereas Cristea and Nguyen (2016) employ Danish data. We discuss differences across these papers in detail in section 5. Finally, Hebous and Johannesen (2015) analyze firm-level trade data on German MNCs, providing evidence that they shift profits to tax havens through services trade.

The remainder of the paper is structured as follows. Section 2 provides background on transfer pricing and the 2009 tax reform. Section 3 explains the empirical approach, Section 4 describes the data, Section 5 presents the main empirical results, and Section 6 presents the heterogeneity results. Section 7 concludes with a discussion of policy implications and avenues for future research.

2 Institutional Background

This section provides an overview of transfer pricing, explaining the arm's length principle that generally guides the setting of transfer prices and several weaknesses of this approach. It then discusses the 2009 tax reform that changed the UK's taxation of foreign profits from a worldwide to a territorial system.

2.1 Transfer Pricing

Transfer pricing is the setting of prices for internal (intra-firm) transactions in goods, services, intangibles, and capital flows within an MNC. Transfer pricing affects the allocation of pre-tax profits that each party earns from a cross-border transaction within an MNC and the amount of corporate tax that is due in both countries. Consider a UK pharmaceutical group that buys raw material from a subsidiary in China. How much the UK parent pays its Chinese subsidiary for each unit of the raw material — the transfer price — affects how much profit the Chinese affiliate earns and how much local tax it pays, and the amount of profit and corporate tax faced by the UK parent company.

Most tax authorities, including Her Majesty's Revenue & Customs (HMRC) in the UK, use the arm's length principle to guild transfer pricing.[8] The arm's length principle stipulates that a transfer price should be the same as if the two parties involved were two independent companies, that is, the same as a comparable market transaction.[9] Given the nature of related-party transactions, a range of arm's length prices may exist for the same transaction. Conceptually, there may even be no "correct" arms-length price if there are no comparable third-party transactions. Comparable transactions may also be costly to observe for the tax authority due to information asymmetry. If comparable arm's-length prices are not accessible, they may be difficult to infer. Given these weaknesses in the implementation of the arm's-length principle, MNCs may be able to charge artificially low prices for exports sold to low-tax countries, or artificially high prices for inputs coming from low-tax countries, to reduce their global tax liability.

[8]The arm's length principle is established in Article 9 (1) of the OECD Model Double Tax Treaty and is the framework for the extensive network of bilateral income tax treaties between OECD countries, and many non-OECD governments.

[9]Setting the transfer price involves the search for a comparable transaction and the application of an appropriate transfer-pricing method. Two transactions are regarded as comparable when either there are no material differences between them or reasonable accurate adjustments can be made to eliminate the effect of such differences (OECD, 2011). The OECD Guidelines also provide a set of criteria to assess comparability between controlled and uncontrolled transactions in terms of characteristics of products or services, functions performed by each party taking account of the assets used and risks assumed, contractual terms, economic circumstances, and business strategies.

Many countries implement transfer-pricing regulations as a countermeasure to mitigate revenue losses from transfer mispricing. The tightness of these regulations varies from mere acknowledgement of the arm's length principle to requirement of detailed transfer-pricing reports. Rigid regulations increase the cost of transfer mispricing and are found to be somewhat effective in curbing the extent of profit shifting in developed countries.[10] In the UK, transfer-pricing documentation requirements are a part of the domestic law, specifying that documentation must be available upon request. Unlike most OECD countries, the UK does not have a prescribed list of documentation requirements, and detailed disclosures are not currently required as part of corporate tax records.

2.2 The 2009 Tax Reform

Worldwide vs territorial taxation Domestic taxation of foreign earnings is a key consideration for MNCs when setting their transfer prices, as it affects their global corporate tax bill. Countries typically use one of two predominant approaches – 'worldwide' or 'territorial'– in taxing foreign earnings of their MNCs. Under 'worldwide' taxation, an MNC pays taxes on its domestic and foreign income, though a credit is often given for foreign taxes paid to avoid double taxation.[11] Under territorial taxation, an MNC only pays taxes on profits in the source country, with no tax levied on profits repatriation.[12]

[10]For example, Riedel et al. (2015) show that the introduction and tightening of transfer pricing rules raises (lowers) reported operating profits of high-tax (low-tax) affiliates and reduces the sensitivity of affiliates' pre-tax profits to corporate tax rate changes. Transfer pricing regulation may also have unintended consequences on real investment by MNCs by increasing their effective cost of capital, as documented in de Mooij and Liu (2018).

[11]In the case of the UK, there was a limit on the extent of credits from high-tax countries that could be used to offset additional tax on dividends from low-tax countries.

[12]This statement only applies to active income of foreign affiliates, which is essentially earnings through business activity. Passive income refers to income from activities in which the recipient is not directly involved, such as investment income or royalty income. Unlike with the treatment of active income, taxes on passive income are typically due when the income is earned; no deferral of taxes is allowed. Anti-deferral rules are defined in the Controlled Foreign Company (CFC) rules to prevent the shifting of income to tax havens.

The 2009 reform of taxing foreign profits Until 2009, UK-based MNCs were taxed on their worldwide income, although taxation of foreign income was deferred until repatriation as dividends. In 2009, the UK switched from worldwide to territorial taxation, by exempting UK-based MNCs from UK tax for all dividends and distributions received from foreign affiliates. This fundamental change of the tax system made repatriation of profits less costly and should therefore increase the extent of transfer mispricing by UK MNCs. Note that it is plausible that before 2009, part of the foreign earnings were already brought back to the UK in some other complicated, non-taxable way.[13] To the extent that tax planning activities are costly, it remains the case that the amount of tax savings from profit shifting net of costs is larger under the territorial tax system.[14]

The territorial regime was a key element of the foreign profits package that was introduced in the 2009 Finance Bill, with exemptions applying to dividends received from July 1, 2009 onwards.[15] In addition to dividend exemptions, the package included two other elements that carried important implications for UK MNCs. First, a worldwide debt cap on the finance expenses of companies was introduced as an extension to the UK's thin capitalization rules. The debt cap limits tax deductions for interest expenses by UK MNCs to the external gross interest expense of the worldwide group. The worldwide debt cap rule became effective on 1 January 2010, and is expected to restrict the extent of debt shifting by a small number of companies for which the debt cap is binding.

The other change was a tightening of the controlled foreign company (CFC) regime. Under the existing CFC regime at the time of territorial reform, both active and passive income were liable to UK taxation, if a subsidiary was defined as a CFC. However, there were a series of exemptions from being defined as a CFC, including an exemption for actively

[13]For example, the UK did not restrict parent companies from borrowing from foreign subsidiaries, contrary to the United States' treatment of "deemed" dividends under I.R.C. §956.

[14]In addition, the worldwide system could also cause some costly distortion in the allocation of investment across countries, for example, by setting business activities in high-tax countries to generate additional taxes to offset taxes on dividends repatriation from low-tax countries.

[15]Unlike the TCJA that imposed a deemed repatriation tax on undistributed foreign earnings of US MNCs, the exemption in the UK reform was 100 percent and did not impose any tax on undistributed foreign profits.

trading subsidiaries. One way to avoid UK taxes was to mix passive income with active income in a trading subsidiary so that the former goes untaxed in the UK. Under the newly proposed CFC regime, all passive income is liable to UK taxation, including all passive income in active subsidiaries. The reform of the CFC regime, however, was perceived as hurting the ability of the UK to attract MNCs. In response to these concerns, only minimal changes were made to the CFC regime in 2009 while the new CFC regime only took effect in January 2013 - after our period of analysis. While the UK first shifted to a territorial system and only later strengthened its anti-avoidance rules, the recent US territorial reform directly included a series of anti-avoidance measures to limit profit shifting under the new regime.

Neither of the two rules discussed above is expected to have a first-order effect on MNCs' transfer mispricing behavior. The full reform strengthening CFC rules only took place after our sample period and the worldwide debt cap had a negligible effect as it only affected a very small fraction of UK MNCs. To the extent that the worldwide debt cap had an effect, it likely strengthened the incentive to shift profits through transfer pricing (as a substitute for debt shifting) and thus might explain a small part of the increase in transfer mispricing that we observe.

Finally, a great feature of the territorial reform is that its exact announcement and implementation dates were not known in advance. We can therefore exploit variation in the tax incentives to shift profits generated by the reform to study transfer mispricing in a quasi-experimental setting.[16]

2.3 Testable Predictions

In the following, we discuss the three main testable predictions that we take to the data and briefly explain the intuition behind them. In Appendix A we show how to formally derive

[16]This paper focuses on the changing incentives of profit shifting accompanying the territorial tax reform. Other studies, for example, Egger et al. (2015) and Liu (2017), examine the effect of the territorial tax reform on dividend repatriation and fixed capital investment by UK multinationals, respectively.

these predictions in an extension of the standard transfer-pricing model.

Basic Framework Suppose a MNC sells the same product to a lower-tax destination at arm's length and to a related party. To lower its tax bill, the MNC has an incentive to under-price its related-party exports. The government applies the arm's length principle and imposes a fine on the MNC that increases in the difference between the arm's length price and the related-party price charged. The MNC selects a transfer price that optimally trades off the tax savings from underpricing related-party exports with the expected size of the fine imposed by the government.

Prediction 1 (Transfer Mispricing) *The transfer price for exports to low-tax destinations is below the arm's length price and falls in the tax rate difference.*

Now, consider a tax reform that changes the treatment of corporate profits from a worldwide system with deferral to a territorial system. Under the worldwide system, repatriating profits back to the headquarters is costly due to repatriation taxes. While tax payments can be deferred by reinvesting profits abroad, this still represents a second-best solution. For this reason, under worldwide taxation, a pound of post-tax profits abroad is less valuable than a pound of post-tax profits at home. In contrast, under territorial taxation, repatriation is costless and after-tax profits abroad and after-tax profits at home are equally valuable to the MNC. A shift from a worldwide system with deferral to a territorial system should therefore increase the incentives for profit shifting and thus for transfer mispricing.

Prediction 2 (Tax Systems) *For the same tax rate difference, when selling to lower-tax destinations, MNCs mis-price their transfer prices by more under a territorial system than under a worldwide system.*

Finally, notice that the amount of profits shifted through transfer mispricing is proportional to the quantity of goods shipped to a destination. A challenge for an MNC that wants to shift profits may be that it has relatively small trade flows to countries that have

low tax rates. As the extent of transfer mispricing is limited by the fine imposed by the government, a solution to that problem would be to create artificial trade flows to low-tax destinations. As delivering too large quantities to a market reduces the MNC's profit margin there, an MNC only creates an artificially large trade flow if transfer mispricing incentives are sufficiently strong, that is if the tax rate difference is very large.

Prediction 3 (Trade Creation) *Suppose transfer mispricing incentives are sufficiently strong. Then, MNCs export more than the first-best quantities (in the absence of taxation) to destinations where their transfer mispricing incentives are the strongest.*

3 Empirical Strategy

In this section, we present two distinct empirical specifications that are employed in testing the three predictions on transfer mispricing.

Baseline: Testing Prediction 1 Our baseline specification estimates the transfer pricing behavior of MNCs in a triple-difference regression. Specifically, we estimate:

$$\ln p_{ijkt} = \alpha_{ijk} + \alpha_{jkt} + \alpha_{ikt} + (\beta_1 \Delta\tau_{jt} \times I_{low,t} + \beta_2 \Delta\tau_{jt} \times I_{high,t}) \times Aff_{ij} + \epsilon_{ijkt}, \qquad (1)$$

where p_{ijkt} is the average unit price of exports of product k to country j by firm i in year t. $\Delta\tau_{jt} \equiv |\tau_{jt} - \tau_{UK,t}|$ is the absolute difference in statutory corporate tax rates between the destination country j and the UK in year t. $I_{low,t}$ ($I_{high,t}$) are indicators that take the value of one if the destination country has a lower (higher) statutory tax rate than the UK in year t, and zero otherwise. Aff_{ij} is a dummy indicator that takes a value of one if the MNC firm i has at least one affiliate in country j, and zero otherwise. α_{ijk} is a firm–market–product fixed effect, α_{jkt} is a product–market–year fixed effect, and α_{ikt} is a firm–product–year fixed effect.[17]

[17] We employ the Stata module, *reghdfe*, as the model includes a large number of fixed effects. The module was developed by Correia (2015), and it efficiently estimates models that include high-dimensional fixed

With inclusion of the fixed effects, identification relies on the differential change in the price charged by a multinational on exports with a subsidiary in a country relative to the price charged by a multinational without a subsidiary in the same country in response to a change in the tax rate difference between that country and the UK.[18] Taking the full set of fixed effects is crucial for insulating the causal effect of tax differences. More specifically, α_{ijk} takes out the average price a firm charges for a product in a given market. This fixed effect is essential, as firms often supply goods of different quality to different destination markets.[19] The second fixed effect, α_{jkt}, controls for the average price of a product in a year across all firms, taking out all shocks to the supply and demand of a product that are common across firms. Finally, α_{ikt} controls for the average price a firm charges for a product in a given year. This fixed effect controls for all shocks to the supply or demand of a firm's product that are common across markets. The coefficients β_1 and β_2 therefore capture the causal effect of tax differences on transfer prices, controlling for all of the main supply and demand factors that could confound the effect of taxes on prices.

As discussed in **Prediction 1**, we expect β_1 to be negative if MNCs systematically *reduce* the export prices for transactions with their foreign affiliates to shift more profits into low-tax countries in response to an *increase* in $\Delta\tau_{jt}$. Similarly, we expect β_2 to be positive when MNCs systematically increase the export prices for transactions with their foreign affiliates to shift more profits out of high-tax countries in response to an increase in $\Delta\tau_{jt}$. However, predictions with respect to the high-tax countries are less clear cut. For example, if MNCs could claim full tax credits for taxes paid on profits abroad to offset their domestic tax liability under the worldwide system, we expect β_2 to be zero. Alternatively, UK MNCs can shift profits directly from subsidiaries in high-tax countries into subsidiaries

effects.

[18] We implicitly assume that the share of intra-firm trade of an MNC to a country where it has a subsidiary is independent of tax rate changes. While there is no direct test for this assumption given the lack of direct information on related-party trade, our second identification strategy that relies on the 2009 regime change in the taxation of foreign profits should alleviate this concern, as it is unrelated to changes in the level of tax rates.

[19] See, e.g., Hallak (2006), Khandelwal (2010), and Hallak and Schott (2011) on the importance of product quality in international trade.

in low-tax countries, which makes profit shifting into the UK unnecessary and implies a zero β_2. Following Davies et al. (2018), our baseline regression controls for pricing to-market determinant by including the interaction between Aff_{ij} and the log of per-capita GDP of the foreign country ($lnGDPPC_{jt}$). This variable is also useful to control for the size of vertical FDI which is likely to be larger in countries with lower corporate tax rates. Our baseline regression does not include any firm-level or country-level controls, as any variation at that level is absorbed by the fixed effects. To account for possible correlation in export prices among all the UK multinationals trading with the same destination market, we cluster the standard errors by country-year pairs.

Tax Reform: Testing Prediction 2 We exploit the regime change in the UK's taxation of foreign profits in 2009 as a quasi-natural experiment. As discussed in Section 2, the reform from worldwide to territorial taxation created stronger incentives for UK multinationals to shift profits into lower-tax destinations from 2009 onward. To check whether the reform indeed led to more transfer mispricing, we run the following regression:

$$\begin{aligned} \ln p_{ijkt} = \alpha_{ijk} + \alpha_{jkt} + \alpha_{ikt} + (\beta_1 \Delta\tau_{jt} \times I_{low,t} + \beta_2 \Delta\tau_{jt} \times I_{high,t}) \times Aff_{ij} \\ + (\beta_3 \Delta\tau_{jt} \times I_{low,t} + \beta_4 \Delta\tau_{jt} \times I_{high,t}) \times Aff_{ij} \times Post_t + \epsilon_{ijkt}, \end{aligned} \tag{2}$$

where $Post_t$ is an indicator that takes the value of one if year t is after the tax reform and zero otherwise. Given that the reform took place in the second half of the fiscal year, we drop observations in 2009 for cleaner identification.[20] The main coefficients of interest are now β_3 and β_4. If the reform increased incentives for transfer price manipulation, as discussed in **Prediction 2**, we would expect a negative β_3. We expect the coefficient β_4 to be either zero if MNCs avoid shifting profits from high-tax countries to the UK, or to be positive as the territorial system eliminates tax credits on foreign taxes paid and thus might induce UK

[20] That is, $Post_t$ is equal to zero until 2008 and equal to one from 2010 onward.

MNCs to shift profits into the UK.[21]

Trade Creation: Testing Prediction 3 Finally, we test whether UK MNCs trade more with countries into which they shift profits. For this purpose, we re-run specifications (1) and (2), replacing the dependent variable by the log of quantities. **Prediction 3** implies a positive and significant coefficient for β_1 in specification (1) and for β_3 in specification (2), respectively.

4 Data

Data Sources Our data set is constructed by merging three databases.[22] The first database includes transaction-level export data from 2005 to 2011 provided by the HMRC. Specifically, each record includes, among others, the firm's trader ID (anonymized), the product code (15-digit HMRC Integrated Trade Tariff Code[23], the destination country, the export value in British pounds, and the weight in kilograms.[24] The unit of observation in our empirical analysis is a firm–product–destination–year price. We collapse the transaction data to that level, computing total export value, total quantity, and average unit price.

The second database, the FAME ownership database of Bureau Van Dick, is also at the firm level and provides information, for each company, on the name and location of its ultimate parent and subsidiaries, if applicable.[25] Based on the ownership information, we

[21] As discussed earlier, β_4 equal 0 is the most plausible case, as a UK MNC would most likely directly shift its profits from a high-tax jurisdiction to an affiliate in a low-tax country, without re-routing them through the UK headquarters.

[22] Appendix B provides a detailed description of the data sources, the matching procedure, and the summary statistics for the sample.

[23] The 15-digit HMRC product code is comparable to the HS10 code used in the U.S. The full sample for manufacturing MNCs has about 15,000 products and the main estimation sample has about 3,000 products. For comparison, there are about 16,000 HS10 import codes in the U.S. 1992 classification (Pierce and Schott, 2012).

[24] Transactions within the EU only need to be reported by firms whose exports in a given calendar year exceed a certain threshold (for example, £250,000 in 2016). Firms are required to report all transactions with countries outside the EU.

[25] The ownership data set is from the FAME website in 2015. We define ultimate parents as shareholders that have more than 50 percent total shareholding. The total shareholding was calculated by summing up the direct percentage of shares and indirect percentage shares in FAME. The FAME data set provides

group the population of UK companies into one of the following categories: (1) domestic or unknown;[26] (2) stand-alone exporters; (3) subsidiaries of a foreign parent company; (4) parent companies and subsidiaries of a UK-headquartered MNC groups with at least one subsidiary outside the UK. Figure A.1 Panel A shows the number of UK affiliates in each of the 108 countries that had UK exporting partners in 2011. Table 1 presents for each category the number of firms, their share in total exports and their share in total assets within manufacturing. UK MNCs account for 39 percent of exports and hold about 13 percent of total assets within the manufacturing sector.

Table 1. Distribution across firm types

	Number of Unique Firms	Share of Exports	Share of Total Assets
Domestic group or Undefined	765,324	29.1%	70.3%
Stand-alone exporter	33,266	7.6%	1.1%
Foreign-owned subsidiary	52,251	24.8%	15.3%
UK MNC headquarter or subsidiary	7,194	38.5%	13.3%

Notes: This table shows the number of companies in each ownership category and their share of exports and total assets in the merged FAME-CT600-Trade dataset.
Source: Authors' calculation based on the merged FAME-CT600-Trade dataset.

The third database, also provided by the HMRC, consists of firm-level corporation tax records that provide detailed information on the tax position of each company and how it is determined. A lookup table that cross references the trader IDs and taxpayer identifiers allows us to merge the two databases. We exploit information from this database to test for differential transfer pricing behavior across firms with different R&D intensities and to assess the magnitude of tax-revenue loss from transfer mispricing relative to total CIT revenue collected from UK MNCs in manufacturing.

Focus on UK Multinationals We restrict our comparison to pricing differences between UK multinationals in group (4), as our data are best suited to study their transfer pricing

information on companies' subsidiaries up to 10 levels.

[26]Domestic companies include (a) stand-alone companies, (b) parent companies of a domestic group with all subsidiaries in the UK, (c) subsidiaries of a domestic group, and (d) firms with no match in FAME.

behavior. Domestic firms do not set transfer prices for cross-border transactions. As the typical domestic firm differs substantially from the typical MNC, their arm's length export prices are also less comparable to those charged by MNCs. Subsidiaries of foreign parents set transfer prices, but have to solve a very different tax planning problem. Their transfer pricing decisions in the UK likely depend not only on the tax rate in the country that they are exporting to but also on the tax rate and tax system in their parent country.

Proxying Related-Party Trade We use the location of foreign affiliates as a proxy for related-party trade, similar to Vicard (2015), Hebous and Johannesen (2015), and Cristea and Nguyen (2016). By definition, a UK MNC can only have related-party trade with countries where it has an affiliate. Of course, it may also trade with unrelated parties in these countries. Therefore, the price we observe for an MNC that has an affiliate in a given country is the weighted average of the prices charged in all intra-firm and arm's length transactions. Importantly, this measurement error biases results against us finding any effects, as it makes it harder to identify systematic differences between pure arm's length prices and our related-party price proxy.[27]

The FAME database provides a snapshot of the ownership structure of UK firms in 2015. A potential caveat of using the static information to define the location of foreign affiliates is that it assumes that the affiliate status of firms has remained constant over the sample period for UK companies that experienced expansion abroad, for example through mergers and acquisitions (M&A). In particular, the static definition of foreign affiliates location does not reflect changes in destination countries in which UK MNCs established their *first* affiliate between 2005 and 2015. To address this limitation, we complement the FAME data on the network of foreign affiliate locations with information on M&As by all UK companies between 2005 and 2015 from the Zephyr database, which is also provided by Bureau Van Dijck.[28]. The detailed procedure for updating the location of foreign affiliates for all company-years

[27]Interestingly, for France, Davies et al. (2018), using data with direct information on related-party trade, found very similar results to Vicard (2015), who proxied related-party trade through affiliate information.

[28]The Zephyr dataset uses the same company identifier and can be linked with FAME.

recursively between 2005 and 2015 is described in Appendix B. Overall, 102 UK MNCs established a first affiliate in a new country during our sample period across more than 30 different countries. After merging in the information from Zephyr, we create a new time-varying dummy indicator (Aff_{ijt}) that takes the value of 1 if company i has an affiliate in country j in year t.

Other Data Sources We augment the data set with additional data on destination country characteristics and statutory corporate tax rates.[29] We obtain information on country-level variables from the World Bank (World Databank, World Development Indicators) and the PennWorld Table 8.1. The statutory tax rates are headline corporation tax rates drawn from KPMG Corporate Tax Rate Tables.[30]

Definitions and Descriptive Statistics Define $\Delta\tau_{jt} \equiv |\tau_{jt} - \tau_{UK,t}|$ as the absolute value of the difference in the statutory tax rate between the UK ($\tau_{UK,t}$) and the destination country (τ_{jt}). Furthermore, define a country as a low-tax destination if its statutory corporate tax rate is lower than the UK rate ($\tau_{jt} < \tau_{UK,t}$) and as a high-tax country if its statutory tax rate is equal to or higher than the UK rate ($\tau_{jt} \geq \tau_{UK,t}$). Following this definition, a destination country can switch from a low-tax to a high-tax country when the tax rate in the foreign country or in the UK changes over time. Figure A.1 Panel B shows the number of countries classified as low tax and high tax, respectively, over the sample period of 2005 to 2011.

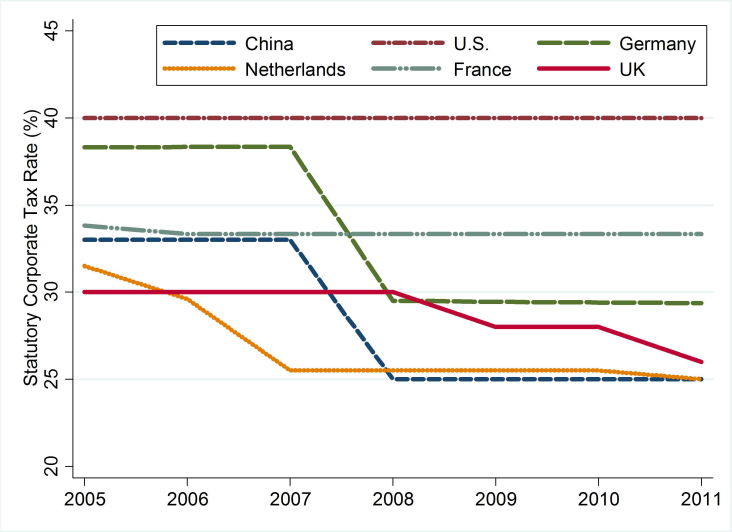
Figure 1 further illustrates variation in the tax rates. Panel A shows the time trend in the statutory tax rate in the UK and in its top five export destination markets in 2005 to 2011. Panel B shows the histogram of the corporate tax differential for the estimation sample. As these figures show, there is substantial variation in corporate tax rates, both in the time series and the cross section.

[29] Given that we include an extensive set of fixed effects in the baseline regression, we utilize the firm and destination country characteristics mainly to replicate and compare with specifications in existing studies on transfer pricing in section 5.4.

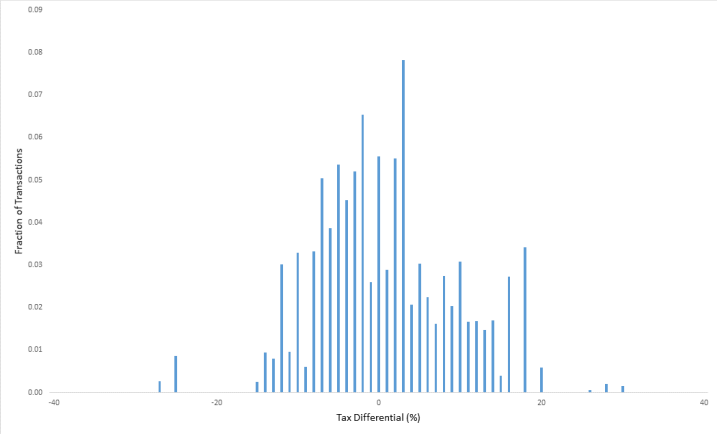
[30] The corporate tax rates from 2006 to 2011 are drawn from KPMG Corporate Tax Rate Table (2006 to 2014). The rates for 2005 are from KPMG (2006).

Figure 1. Tax Incentives for Profit Shifting

(a) Statutory Tax Rate (%)



(b) Distribution of Tax Differential



Notes: Panel A shows the statutory tax rate in the UK and in its top-5 exporting partners during 2005-2011. Panel B shows a histogram distribution of the tax differential during the same time period.
Source: Panel A: Office for National Statistics (ONS) and KPMG Corporate Tax Rate Tables. Panel B: Authors' calculations using the estimation sample.

The final data set includes 931,773 observations at the firm–product–year level for 1,256 unique companies in manufacturing during 2005 to 2011. Figure A.2 reports the overall

annual exports as well as the share of MNC exports that are to countries where the respective MNC has a majority-owned affiliate - on average around 39 percent of MNC exports fall in this category.[31] Table 2 provides summary statistics for the baseline estimation data set, which includes 387,709 observations after inclusion of the full set of fixed effects.[32]

Table 2. Summary Statistics

	Mean	Std. Dev	P25	P50	P75	Obs
	(1)	(2)	(3)	(4)	(5)	(6)
Product Characteristics						
Export Value (GBP)	181,507	601,514	1,140	8,083	57,627	387,709
Net Mass (in kilogram)	24,498	104,324	12	132	2,280	387,709
Average Value (per kilogram)	337	930	8.0	34.8	199	387,709
Firm Characteristics						
Log Sales	16.6	1.8	15.4	16.4	17.5	7,420
Intra-firm Trade	0.72	0.45	0	1	1	7,420
Profit Making	0.39	0.49	0	0	1	7,420
Country Characteristics						
Low Tax Country Dummy	0.54	0.50	0	1	1	686
Low Tax Wedge ($\tau_{UK} - \tau j, \%$)	7.44	5.68	2.5	6	11.5	187,795
High Tax Wedge ($\tau j - \tau_{UK}, \%$)	5.36	4.16	2	5	7.25	199,914

Notes: This table lists the summary statistics for the key variables in this paper's main estimation sample in years 2005-2011.
Source: Authors' calculation based on the main estimation sample.

5 Main Empirical Results

This section presents results from our baseline fixed effects regression, results on the 2009 UK tax reform, and on trade creation. We then quantify the results in terms of foregone tax revenues, present a set of robustness checks and compare our findings to previous studies. Finally, we look at heterogeneity of effects in destination country tax rates, destination

[31] Note that this share represents an upper-bound of the actual share of related-party trade as MNCs may also be selling at arm's length to destinations where they have a majority-owned affiliate.
[32] Table B.1 in Appendix B reports summary statistics for the full data set.

country tax haven status and firms' R&D intensities.

5.1 Baseline Results

Table 3 presents our baseline regression results based on equation (1).[33] Column (1) shows that the coefficient on the triple interaction for low-tax destinations is negative and highly significant, indicating that MNCs shift profits out of the UK by underpricing related-party exports to low-tax countries. In contrast, the triple interaction for high-tax destinations is insignificant. That is, there is no evidence that MNCs shift profits into the UK from higher-tax countries through transfer prices. Column (2) controls for pricing-to-market by including an interaction term between destination country per-capita GDP and the related-party dummy indicator. The results are very similar. Column (3) checks the robustness of the results to potential mismeasurement in the time-invariant ownership indicator by dropping observations with changing ownership. Column (4) uses the dynamic affiliate indicator. The results remain almost identical in both columns.

Effects for low-tax destinations are large. A one percentage point larger tax difference, on average, reduces related-party export prices relative to arm's length export prices by around three percent. Figure 2 illustrates the size of our main estimate relative to those found in previous studies: the magnitude of the tax effect is substantially larger than the effects found in Vicard (2015), Cristea and Nguyen (2016), and Davies et al. (2018) which report price responses between 0.12 and 0.6 percent. It is more comparable to Clausing (2003) and Bernard et al. (2006), the latter reporting effects between 0.4 and 4.2 percent depending on the specification.

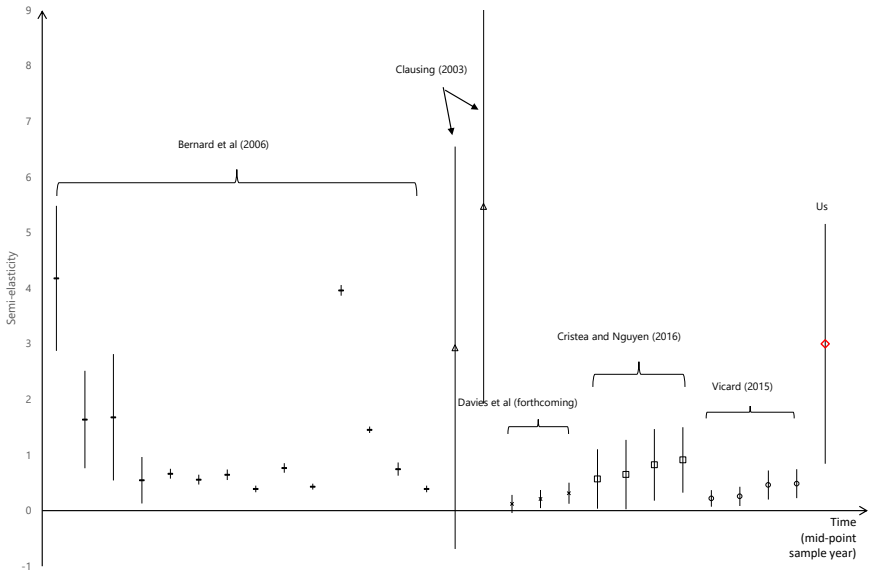
[33] As pointed out by one anonymous referee, a case can be made to employ one-sided tests for statistical significance as the null hypothesis is that transfer prices are not significantly lower for affiliates in low-tax countries. We followed the suggestion and performed one-sided tests for results in Table 3, for which the results are also highly significant (and available from the authors upon request).

Table 3. Effect of the Tax Differentials on Transfer Pricing by UK MNCs: Baseline Results

$AFF_{ij(t)}\times$	(1)	(2)	(3)	(4)
$\Delta_{\tau_{jt}} \times I_{low,t}$	-0.030***	-0.029***	-0.029***	-0.030***
	(0.011)	(0.011)	(0.011)	(0.011)
$\Delta_{\tau_{jt}} \times I_{high,t}$	-0.007	-0.007	-0.007	-0.007
	(0.006)	(0.006)	(0.006)	(0.006)
$lnGDP\ PC_{jt}$		-0.058	-0.059	-0.005
		(0.133)	(0.133)	(0.088)
Adjusted R^2	0.91	0.91	0.91	0.91
N	387,709	384,525	312,174	384,525

Notes: This table presents regression results on the causal effect of the tax differential on transfer prices of exports by UK multinational, based on equation (1). The dependent variable, lnp_{ijkt}, is the average unit price of exports of product k to country j by firm i in year t. $\Delta\tau_{jt}$ is the absolute difference in statutory corporate tax rates between the destination country j and the UK in year t. $I_{low,t}$ ($I_{high,t}$) are indicators that take the value of one if the destination country has a lower (higher) statutory tax rate than the UK in year t, and zero otherwise. $AFF_{ij(t)}$ is a dummy indicator that takes a value of one if the MNC firm i has at least one affiliate in country j, and zero otherwise. $lnGDP\ PC_{jt}$ is the log of GDP per capita in destination country j in year t. The main variables of interests are the three-way interaction terms $AFF_{ij(t)} \times \Delta\tau_{jt} \times I_{low,t}$ and $AFF_{ij(t)} \times \Delta\tau_{jt} \times I_{high,t}$. The regression includes a full set of firm–market–product (α_{ijk}), product–market–year (α_{jkt}), and firm–product–year (α_{ikt}) fixed effects. Standard errors clustered by country-year pairs are in parentheses. ***,**,* denotes significance at 1%, 5%, and 10% level, respectively.
Source: Authors' calculation based on the main estimation sample.

Figure 2. Effect sizes in the literature



Notes: This figures plots coefficients and confidence bands of the semi-elasticity of log unit price for intra-group exports for past studies and our sample. The studies are ordered on the x-axis by the mid-year of their sample period.
Source: Author's calculation based on studies cited in online appendix Table A.3.

There are many differences that could explain the heterogeneity in estimates across the studies. First, it is important to note that for a given firm, the semi-elasticity of intra-group prices (and more generally, the semi-elasticity of reported profits) is not an immutable parameter but depends critically on the tax system. Features of the tax system, including the corporate tax base, taxation of foreign profits, the extent of integration between the corporate and personal tax base, and the strength of anti-avoidance regulations would all play a role in determining the net benefit from transfer mispricing. For example, credits on corporate income taxes are only passed through to shareholders if a domestic tax has been paid at the corporate level, which would provide French firms with an incentive to incur domestic income and alleviate outward profit shifting from France (Clausing, 2003). Given that existing papers cover several countries (France, Denmark, U.S. and U.K.), one reason for the relatively wide range of estimates may be genuine differences in the tax sensitivity

of transfer pricing across MNCs from these countries, reflecting differences in the underlying corporate and overall tax systems.

Another potential explanation can be omitted variable bias due to differences in specifications across papers. We study this in detail in section 5.4, showing that this channel can account for some but not all of the differences in estimates. As a preview, Online Appendix Table A.6 shows coefficients obtained for our baseline estimation when gradually adding more fixed effects that controls for alternative confounding factors of the tax effect. Doing so varies our main coefficient of interest between 0.7 and 6.1 percent.

Differences in the empirical approach used in different studies, including the way that related-party trade is measured, the type of variation exploited (cross-section versus time-series), and the tax rate variable used to measure incentive for profit shifting, can each lead to differences in the estimates. For example, Davies et al. (2018) use a precise measure of related party trade but rely on a cross-section of French firms in one single year for identification. Our paper follows Cristea and Nguyen (2016) and proxies related-party trade by the presence of a majority-owned affiliate. Despite the differences in the data employed, our estimates are quite comparable with the preferred estimates in Bernard et al. (2006) Table 5, which shows price effects between 1.6 and 4.2 percent per percentage point of tax rate difference.[34] Moreover, with the same specification, estimates based on an effective tax rate measure is often two to three times smaller than those based on the statutory tax rate in Bernard et al. (2006). This also highlights the importance of using the latter for profit-shifting analysis: effective tax rates in part reflect endogenous choices made by firms, including the amount of profit shifted. In contrast, statutory tax rates are determined by governments and are thus generally exogenous to the firm's decisions, making them a more credible source of identification for profit shifting analysis (Dharmapala, 2014; Beer et al., 2018).

To summarize, our coefficient estimates are substantially larger than those estimated for

[34]When adding more controls and product-fixed effects, their coefficient estimates decline to values between 0.6 and 0.7 percent.

France and Denmark in the studies cited above and, depending on the interpretation, are more comparable with those estimated by Clausing (2003) and Bernard et al. (2006) for the U.S. Future research will hopefully shed more light on the question how much of this heterogeneity in coefficients is driven by genuine differences in the aggressiveness of transfer pricing across countries of varying tax systems and how much of it can be explained by the empirical methods employed in earlier studies.

5.2 The Territorial Tax Reform

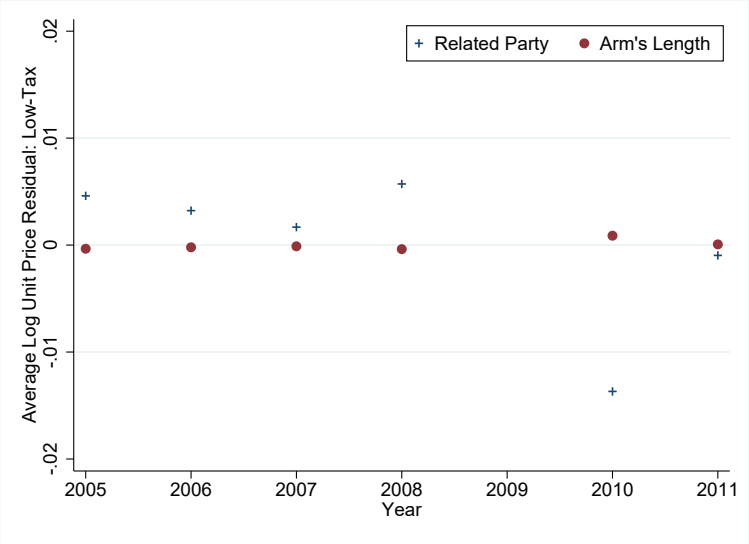
Graphical evidence Figure 3 provides graphical evidence on the effects of the tax reform on average unit price residuals.[35] Figure 3 Panel A depicts mean residual prices over time for low tax destinations, separately for related party and arm's length trade transactions. Before the tax reform, these residual prices trend very similarly. In 2010, the average related-party price residual drops substantially whereas the average arm's length residual is unaffected. In 2011, the related-party residual rebounds but is still below its pre-reform level. A similar pattern holds in Figure 3 Panel B, which compares price residuals for related-party exports between low-tax and high-tax countries. While the pattern is a bit less clear-cut than in Panel A, there is a strong drop in residual prices in 2010 with a partial recovery in 2011. This graphical evidence suggests a positive impact of the tax reform on transfer mispricing by UK MNCs. In the following, we test this relationship more formally by estimating equation (2).

Main Results Table 4 presents our regression results on the territorial tax reform. Column (1) shows that the extent of profit shifting through transfer mispricing is larger under the territorial tax system. Before the reform, on average, a one percentage point increase in the tax difference led to a 2.7 percent decrease in the price of related-party exports relative to the price of arm's-length exports. After 2009, the tax effect is more pronounced, reducing

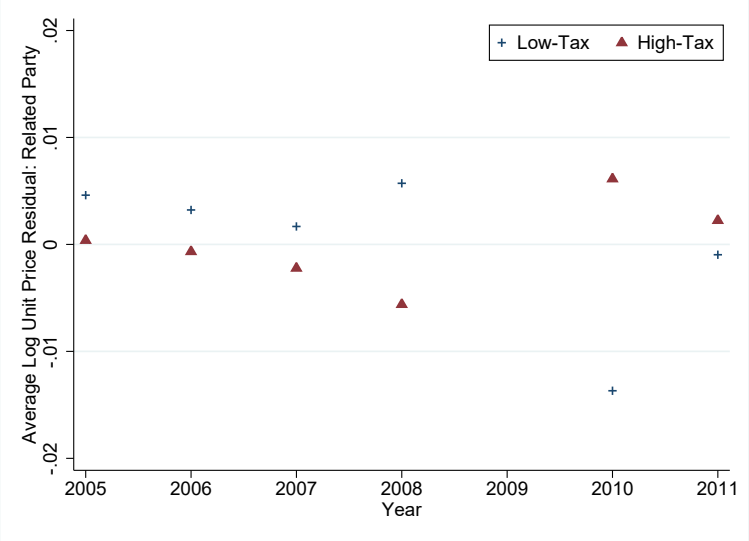
[35] As the raw price data is very noisy and there are many sources of price heterogeneity across firms, products, destination and time, controls include all three-way fixed effects from equation (2).

Figure 3. Log Unit Price Residuals and the Tax Reform

(a) Low tax destinations



(b) Related-party trade



Notes: This figure shows mean log unit price residuals by year. Panel A shows mean residuals for low tax destinations separately for related party and arm's length transactions. Panel B shows mean residuals for related-party trade separately for low-tax and high-tax destinations.
Source: Author's calculations based on the main estimation sample.

the relative export price for low-tax destinations by another 1.5 percent per one percentage point lower tax rate difference. The increase in the strength of transfer pricing following the UK tax reform is significant at the 1 percent level.[36] Column (2) adds the interaction term between destination country Per-Capita GDP and the related-party dummy indicator. Column (3) tests the robustness of the results by replacing AFF_{ij} with the time-varying ownership indicator Aff_{ijt}. The results remain very similar.

Table 4. Effect of the Tax Differentials on Transfer Pricing by UK MNCs: Tax Reform

$AFF_{ij(t)}\times$	(1)	(2)	(3)
$\Delta_{\tau_{jt}} \times I_{low,t}$	-0.027**	-0.027**	-0.028**
	(0.011)	(0.011)	(0.011)
$\Delta_{\tau_{jt}} \times I_{high,t}$	-0.000	-0.001	-0.000
	(0.006)	(0.006)	(0.006)
$Post_t$	0.132***	0.130***	0.131***
	(0.043)	(0.043)	(0.044)
$\Delta_{\tau_{jt}} \times I_{low,t} \times Post_t$	-0.015***	-0.015***	-0.015***
	(0.005)	(0.005)	(0.005)
$\Delta_{\tau_{jt}} \times I_{high,t} \times Post_t$	-0.008	-0.008	-0.008
	(0.007)	(0.007)	(0.007)
$lnGDP\ PC_{jt}$		-0.046	0.004
		(0.135)	(0.090)
Adjusted R^2	0.91	0.91	0.91
N	315,330	312,274	312,274

Notes: This table presents regression results on the causal effect of the tax differential on transfer prices of exports by UK multinational, based on equation (2). The main variables of interests are the four-way interaction terms $AFF_{ij(t)} \times \Delta\tau_{jt} \times I_{low,t} \times Post_t$ and $AFF_{ij(t)} \times \Delta\tau_{jt} \times I_{high,t} \times Post_t$. $Post_t$ is a dummy indicator that equal to zero until 2008 and equal to one from 2010 onward. All other variables are as previously defined in Table 3. Standard errors clustered by country-year pairs are in parentheses. ***,**,* denotes significance at 1%, 5%, and 10% level, respectively.
Source: Authors' calculation based on the main estimation sample.

[36]This finding is consistent with existing studies based on OECD countries that establish that firms with worldwide parents tend to shift less income than firms with territorial parents (Markle, 2016). Given that we only have two years of post-reform data, we are unable to examine in-depth the dynamics of transfer mispricing under the territorial tax regime.

Placebo Test The identification for the effect of the territorial tax reform on transfer mispricing rests critically on the assumption that there are no differential changes in the pricing behavior between the two comparison groups prior to the reform, other than the main supply and demand factors that are already controlled for with the full set of fixed effects. We perform a placebo test to check this assumption, restricting the data sample to the pre-reform period of 2005-2009.[37] We assume a counterfactual year for the switch in the tax regime, which is captured in the $Post_t$ dummy indicator that takes the value of one for all years post 2006, 2007, and 2008 in Columns (1)-(3) of Table 5, respectively. We estimate equation (2) on this restricted sample and report the results in Table 5. The estimated coefficients concerning the effect of the tax reform (β_3 and β_4) are not statistically different from zero.

This placebo test also helps us to assess the potential bias that the time-invariant ownership status imposes on the triple interaction term with the tax policy change indicator. The misrepresentation of arm's-length pricing as being related-party pricing should be a more frequent occurrence in the first part of the sample compared to the later sample years, given that the network of foreign affiliates observed in the later periods is more likely to resemble to network observed in 2015. To rule out that the estimated effect of the tax reform merely reflects a gradual improvement in the measurement of related-party trade over time, the estimated coefficients should be zero in any of the pre-reform period. This is indeed the case in Table 5.

5.3 Trade Creation and Quantification

Trade Creation Table 6 examines the effect of the tax differential on the quantity and value of exports by UK MNCs. The dependent variable in Columns (1) and (2) of Table 6 is the quantity of exports measured by weight, whereas Columns (3)-(4) and (5)-(6) focus on

[37] We thank one anonymous referee for this suggestion.

Table 5. Effect of the Tax Differentials on Transfer Pricing by UK MNCs: Placebo Tests

Post Year:	2006	2007	2008
$AFF_{ij}\times$	(1)	(2)	(3)
$\Delta_{\tau_{jt}} \times I_{low,t}$	-0.030**	-0.023*	-0.030**
	(0.012)	(0.012)	(0.012)
$\Delta_{\tau_{jt}} \times I_{high,t}$	-0.008	-0.014	-0.011
	(0.011)	(0.008)	(0.010)
$Post_t$	0.026	-0.053	-0.037
	(0.077)	(0.061)	(0.062)
$\Delta_{\tau_{jt}} \times I_{low,t} \times Post_t$	0.004	0.006	0.000
	(0.006)	(0.005)	(0.006)
$\Delta_{\tau_{jt}} \times I_{high,t} \times Post_t$	0.004	0.010	0.014
	(0.010)	(0.008)	(0.009)
Adjusted R^2	0.91	0.91	0.91
N	254,431	254,431	254,431

Notes: This table presents results of the placebo test for the territorial tax reform. The main variables of interests are the four-way interaction terms $AFF_{ij(t)} \times \Delta\tau_{jt} \times I_{low,t} \times Post_t$ and $AFF_{ij(t)} \times \Delta\tau_{jt} \times I_{high,t} \times Post_t$. All other variables are as previously defined in Table 3. Standard errors clustered by country-year pairs are in parentheses. ***,**,* denotes significance at 1%, 5%, and 10% level, respectively.
Source: Authors' calculation based on the main estimation sample.

the unit price and the total value of transactions, respectively.

Column (1) shows that overall there is a weak negative effect of the tax differential interacted with affiliate status on export quantities, which is significant at the 10 percent level. While this negative correlation goes against the trade creation channel (Prediction 3), results concerning the tax reform in Column (2) provides some evidence in favor of the trade creation mechanism: the interaction with the post-reform dummy is positive and highly significant. That is, UK MNCs increased their related-party export quantities to low-tax countries, in line with their profit-shifting incentives, following the reform. For ease of comparison, columns (3) and (4) reproduce the main results on transfer prices in Table 3 column (4) and Table 4 column (2), respectively.

Due to the offsetting price and quantity effects on total export value, columns (5) shows that overall the effect of the tax differential on the value of related-party exports is negative. Column (6) disentangles the effect before and after the tax reform, showing that a one percentage point increase in the tax differential on average depresses the value of intra-firm exports to low-tax countries by 4.3 percent relative to arm's length exports prior to the reform. The effect of the tax differential on total related-party export values to low-tax countries did not change significantly after the tax reform. In summary, while we find mixed evidence on the trade creation channel, the effect is quite intriguing and merits further study.

Quantification of Effects We now discuss the quantitative importance of our findings, computing estimates of total shifted profits and foregone tax revenues to the UK based on our preferred estimated coefficients for transfer mispricing in Table 4 column (3). Specifically, We calculate total shifted profits as

$$\sum_{c=1}^{C}(\hat{\beta}_1 + \hat{\beta}_3) \times I_{low,c} \times \Delta\tau_c \times exp_c, \tag{3}$$

Table 6. Effect of the Tax Differentials on Trade Diversion by UK Multinationals

Dependent variable:	$ln(Weight)$		$ln(UnitPrice)$		$ln(TotalValue)$	
$AFF_{ij}\times$	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta_{\tau_{jt}} \times I_{low,t}$	-0.034*	-0.016	-0.029***	-0.027**	-0.063***	-0.043**
	(0.020)	(0.020)	(0.011)	(0.011)	(0.023)	(0.022)
$\Delta_{\tau_{jt}} \times I_{high,t}$	-0.010	-0.004	-0.007	-0.001	-0.018*	-0.005
	(0.009)	(0.011)	(0.006)	(0.006)	(0.010)	(0.012)
$Post_t$		0.120		0.130***		0.249**
		(0.101)		(0.043)		(0.102)
$\Delta_{\tau_{jt}} \times I_{low,t} \times Post_t$		0.018**		-0.015***		0.003
		(0.009)		(0.005)		(0.010)
$\Delta_{\tau_{jt}} \times I_{high,t} \times Post_t$		-0.001		-0.008		-0.009
		(0.013)		(0.007)		(0.013)
$lnGDP\ PC_{jt}$	0.381	0.465	-0.058	-0.046	0.323	0.420
	(0.292)	(0.291)	(0.133)	(0.135)	(0.304)	(0.292)
Adjusted R^2	0.92	0.92	0.91	0.91	0.89	0.89
N	384,525	312,274	384,525	312,274	384,525	312,274

Notes: This table presents regression results on the effect of the tax differential on the quantity of exports (Columns (1)-(2)), the transfer prices (Columns (3)-(4)), and the total value of exports (Columns (5)-(6)) by UK multinationals, respectively. All other variables are as previously defined in Table 3. Standard errors clustered by country-year pairs are in parentheses. ***, **, * denotes significance at 1%, 5%, and 10% level, respectively.
Source: Authors' calculation based on the main estimation sample.

where $\hat{\beta}_1$ and $\hat{\beta}_3$ are the coefficient estimates from equation (2) (and take the value of 0.028 and 0.015, respectively), exp_c is the volume of related-party exports to country c, and $\Delta\tau_c$ is the tax difference between the UK and country c.

We estimate that in 2010, UK multinationals shifted about 840.97 million GBP toward low-tax jurisdictions via transfer mispricing, where Ireland ranks the top country to which such transfer mispricing took place. At the 2010 tax rate of 28 percent, this finding implies foregone tax revenues of £235.5 million due to transfer mispricing in exports by UK MNCs in manufacturing. The foregone tax revenues represent about 7.8 percent of the total corporate tax revenue collected from the UK MNCs in manufacturing in 2010. As a share of total corporate income tax revenues, our estimates are comparable to Davies et al. (2018), who calculate that French firms would have paid about 1 percent (333 million Euro out of 36 billion Euro) more corporate income tax in the absence of tax-motivated transfer mispricing.

5.4 Comparison to Previous Studies

Several previous studies estimate the extent of the price wedge between arm's length and intra-firm trade with respect to the statutory corporate tax in the destination country relative to the home country. These studies all find significant responses of the price wedge to the tax rate differential in a baseline regression of log unit price on a measure of the tax wedge.

A key challenge for the literature to credibly identify the effect of taxes on transfer prices is the large heterogeneity in the sets of fixed effects employed in these studies.[38] The large variation in the sets of fixed effects employed make it difficult to compare results across papers. In the following exercise, we show how our results change when employing the less

[38]These studies also differ in the data employed. They covered different countries and years and had different levels of aggregation. Clausing (2003) uses monthly US data in 1997 to 1999. Bernard et al. (2006) uses annual data on US exports in 1993 to 2000. Davies et al. (2018) uses cross-sectional data for a set of French exporters in 1999, and Vicard (2015) uses French data in 2000, 2007 to 2009, and 2014. Cristea and Nguyen (2016) analyzes trade data by foreign-owned multinationals in Denmark in 1999 to 2006. Finally, Bernard et al. (2006) and Flaaen (2016) both employ U.S. Census data and look at the price wedges within U.S. multinational firms between related-party sales and arm's-length sales. While this leads to a clean identification of effects in some dimensions, it also creates an additional endogeneity concern, as discussed by Cristea and Nguyen (2016).

comprehensive fixed-effect specifications used in some of the previous papers.

Table 7 reports the results based on four specifications of equation (1). Column (1) includes no fixed effects and reports a negative and highly significant coefficient estimate on $\Delta\tau_{jt} \times I_{low,t} \times Aff_{ij}$ ($\widehat{\beta}_1$) and a positive and statistically insignificant coefficient estimate on $\Delta\tau_{jt} \times I_{high,t} \times Aff_{ij}$ ($\widehat{\beta}_2$). Column (2) follows the main specification in Vicard (2015) by including a set of firm-product-year fixed effects and country-product-year fixed effects. Column (3) uses the main specification in Cristea and Nguyen (2016) and includes a set of country-firm-product fixed effects, and year fixed effects interacted with the low-tax country dummy indicator $I_{low,t}$. Column (4) adds firm-level and country-level controls, as in Cristea and Nguyen (2016).

Columns (2)-(4) show that results are highly sensitive to the inclusion of different fixed effects, with the coefficient on high-tax countries even having the opposite sign in one specification from that predicted by the theory. To make sure that the varying results in Panel A are not an artifact of using different regression samples, Panel B repeats the analysis by including observations that are used in the most comprehensive specification of equation (1). $\widehat{\beta}_1$ is negative and significant in all specifications, though the coefficient size varies substantially. $\widehat{\beta}_2$ is yet more sensitive to inclusion of different fixed effects. We conclude that even when looking at the exact same sample, failing to include the full set of fixed effects leads to substantially biased estimates.

6 Heterogeneous Effects in Transfer Mispricing

This section presents evidence for heterogeneity in transfer mispricing in destination country tax haven status, destination country tax rate and firms' R&D intensity.

Table 7. Comparison to Existing Studies

Specification:	No FE	Davies et al (2018), year 2007				Vicard (2015)		Cristea & Nguyen (2016)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A:									
$\Delta\tau_{jt} \times AFF_{ij} \times I_{low,t}$	-0.061***	0.015***	0.013***			-0.007***		-0.012	-0.005
	(0.001)	(0.004)	(0.004)			(0.002)		(0.011)	(0.012)
$\Delta\tau_{jt} \times AFF_{ij} \times I_{high,t}$	0.002	0.028**	0.026**			-0.008***		-0.006	-0.011
	(0.001)	(0.012)	(0.013)			(0.002)		(0.005)	(0.008)
$\log(1-\tau)$				-0.068					
				(0.077)					
$\log(1-\tau) \times AFF_{ij}$				-0.167	-0.949				
				(0.427)	(0.602)				
$\Delta\tau \times AFF_{ij}$							0.001		
							(0.002)		
Adjusted R^2		0.81	0.81	0.81	0.82	0.88	0.88	0.85	0.85
N	941,358	102,133	102,132	102,133	98,687	550,252	550,252	673,436	568,333
Panel B:									
$\Delta\tau_{jt} \times AFF_{ij} \times I_{low,t}$	-0.054***	0.010**	0.011***			-0.007***		-0.026***	-0.025*
	(0.003)	(0.005)	(0.004)			(0.002)		(0.010)	(0.013)
$\Delta\tau_{jt} \times AFF_{ij} \times I_{high,t}$	-0.001	0.018*	0.018*			-0.009***		-0.007	-0.014**
	(0.003)	(0.010)	(0.011)			(0.002)		(0.006)	(0.007)
$\log(1-\tau)$				-0.124					
				(0.097)					
$\log(1-\tau) \times AFF_{ij}$				-0.053	-0.405				
				(0.409)	(0.387)				
$\Delta\tau \times AFF_{ij}$							0.001		
							(0.002)		
Adjusted R^2		0.83	0.83	0.83	0.83	0.89	0.89	0.85	0.85
N	387,709	55,283	55,283	55,283	53,855	387,709	387,709	387,709	326,816
Both panels include:									
Fixed Effects	None	F-P-C	F-P-C C	F-P-C	F-P-C C	Y-F-P Y-C-P	Y-F-P Y-C-P	F-P-C Low-tax C-Y	F-P-C L-tax C-Y
Controls					Aff×Haven, Aff×lnDist Aff×lnGDPPC				lnSales, lnEmp. lnGDPPC ln Ex. Rate

Notes: This table presents regression results on the effect of taxes on transfer prices of exports by UK multinational, following specifications in a number of previous studies. Panel A uses the full sample of UK MNCs in manufacturing, whereas Panel B uses the main estimation sample with fewer observations due to inclusion of fixed effects based on equation (1). Y-C-P denotes product–market–year fixed effect, Y-F-P denotes firm–product–year fixed effect, and F-P-C denotes firm–market–product fixed effect. All other variables are as previously defined in Table 3. Standard errors clustered by country-year pairs are in parentheses. ***, **, * denotes significance at 1%, 5%, and 10% level, respectively.
Source: Authors' calculation based on the main estimation sample.

6.1 Transfer mispricing and the Destination Country

Tax Haven Status A recent study on transfer mispricing, Davies et al. (2018), found that price manipulation by French firms is concentrated in trade with tax havens and very low-tax countries. We test to what extent the same patterns hold for UK MNCs by splitting the sample into tax havens and countries that are not tax havens following the classification in Hines (2005).[39] Results are presented in Columns (1) and (2) of Table 8. Interestingly, we find significant effects for non-haven countries but no significant effects for the tax-haven-only sample. These results remain unchanged when pooling the data and interacting the variable of interest with the tax haven indicator (Column (3)).

The fact that we do not find any effects for tax havens is not necessarily inconsistent with Davies et al. (2018), due to the different empirical strategies that are used to identify the effects of taxes. Our empirical strategy relies on variation in the tax rates over time. Given that tax rates were already quite low in most tax havens at the beginning of our sample (and has remained low during our sample period), there was limited variation in the tax differential within that set of countries, making it difficult to identify our coefficient of interest for these countries. In fact, 67 percent of countries that were classified as tax havens in Hines (2005) did not experience any change in their statutory CIT rate throughout our sample period, while only 32 percent of non-haven countries had no change in their CIT rate (online appendix Table A.4). Davies et al. (2018), in contrast, exploited cross-sectional variation in France, allowing them to identify effects even for countries with no change in their tax rates in recent years.[40] Columns (4)-(9) verify that our results are mainly driven

[39] This is the same classification used in Davies et al. (2018). Online appendix Table A.1 lists the countries that are classified as tax havens in Hines (2005), Dharmapala and Hines (2009), OECD (2000), whereas Online appendix Table A.2 lists the tax haven countries that are included in our estimation sample under the various definitions of tax havens.

[40] An economic factor limiting transfer pricing to tax havens is that trade volumes with tax havens are not that large (they have declined substantially in our sample period and represent slightly over 10 percent of UK exports in manufacturing since 2008). To the extent that there is sizable profit shifting to tax havens, it must therefore happen through other channels than transfer mispricing in real goods, e.g., transfer mispricing on service trade and intangibles.

Table 8. Effect of the Tax Differentials on Transfer Pricing by UK Multinationals in Tax Havens

	Hines (2005)			Dharmapala and Hines (2009)			OECD (2000)			Davies et al. (2018)
	Tax Havens	Non-Tax Havens	Full Sample	Tax Havens	Non-Tax Havens	Full Sample	Tax Havens	Non-Tax Havens	Full Sample	Tax Havens
$AFF_{ij}\times$	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$\Delta_{\tau_{jt}} \times I_{low,t}$	0.002	-0.026**	-0.028**	0.002	-0.026**	-0.028**	-0.039	-0.031***	-0.031***	0.002
	(0.026)	(0.013)	(0.013)	(0.027)	(0.013)	(0.013)	(0.076)	(0.011)	(0.011)	(0.027)
$\Delta_{\tau_{jt}} \times I_{high,t}$	-0.004	-0.009*	-0.007	-0.004	-0.009*	-0.007	0.000	-0.007	-0.007	-0.001
	(0.130)	(0.005)	(0.006)	(0.131)	(0.005)	(0.006)	(.)	(0.006)	(0.006)	(0.134)
$\Delta_{\tau_{jt}} \times I_{low,t} \times Haven_j$			-0.002			-0.001			0.105	
			(0.022)			(0.022)			(0.064)	
$\Delta_{\tau_{jt}} \times I_{high,t} \times Haven_j$			0.079			0.079			0.099	
			(0.200)			(0.200)			(0.214)	
$lnGDP\ PC_{jt}$	1.127*	-0.152	-0.059	1.125*	-0.152	-0.059	-3.520	-0.056	-0.055	1.048
	(0.635)	(0.149)	(0.136)	(0.642)	(0.149)	(0.136)	(2.351)	(0.134)	(0.133)	(0.645)
Adjusted R^2	0.89	0.91	0.91	0.88	0.91	0.91	0.26	0.91	0.91	0.85
N	22,891	329,140	384,525	22,324	329,709	384,525	4,873	372,449	384,525	20,001

Notes: This table presents regression results on the effect of the tax differential on transfer prices of exports by UK multinational in tax havens and non-haven countries, based on equation (1). The list of countries that are regarded as tax havens varies in Hines(2005), Dharmapala and Hines (2009), and the OECD list of Uncooperative Tax Havens. All other variables are as previously defined in Table 3. Standard errors clustered by country-year pairs are in parentheses. ***, **, * denotes significance at 1%, 5%, and 10% level, respectively.

Source: Authors' calculation based on the main estimation sample.

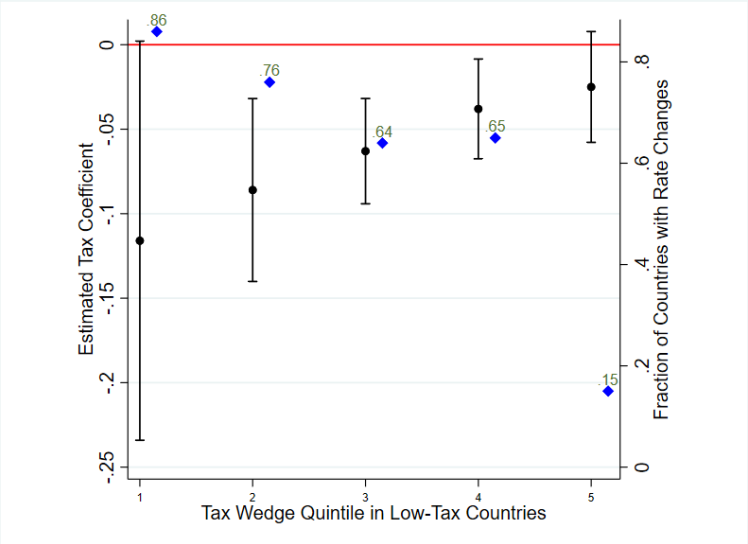
by transfer mispricing in non-haven countries, using alternative lists of tax havens as in Dharmapala and Hines (2009) and as suggested in OECD (2000), and using the exact set of tax haven countries as in Davies et al. (2018).

Tax Rate Groups In a related exercise, we study whether transfer mispricing is concentrated in the lowest-tax destinations. For this analysis, We split the estimation sample into quintile bins based on the level of tax rate difference between the UK and the destination country. We then replace our main explanatory variable ($\Delta\tau_{jt} \times I_{low,t}$) by its interactions with dummy indicators of each quintile. Results are presented in Figure 4 Panel A. The left y-axis shows the estimated coefficients with the corresponding 90% confidence interval. The right y-axis shows the fraction of countries that changed their CIT rate at least once within each quintile. Panel B splits countries into tax havens and non-tax havens and shows that the extent of transfer price manipulation is roughly proportional to the tax difference. However, for countries with the largest tax wedge, the standard error is large and the tax effect is not statistically different from zero. Again, we only find significant effects for non-haven countries. For tax havens, there is so little variation (i.e. changes in tax rates) in the data that we are not able to estimate coefficients for the two groups with the highest tax rate differences.

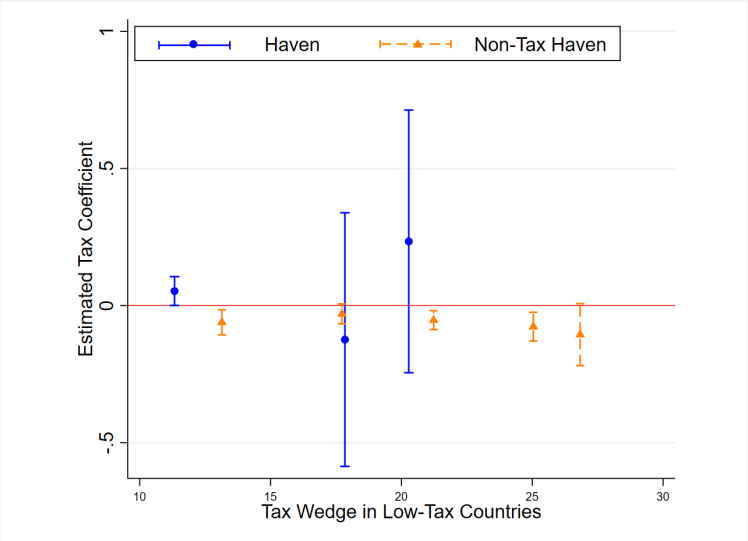
To summarize, our results show substantial transfer price manipulation by UK MNCs in exports to non-tax-haven countries with low to intermediate CIT rates.

Figure 4. Non-linear Transfer Mispricing in Low-Tax Countries

(a) All Countries



(b) Haven vs. Non-Haven



Notes: This figure plots the point estimate of the tax coefficient β_1 as in equation (1) and the corresponding 90% confidence intervals at each quintile of tax wedge $\Delta\tau_{jt}$ in the low-tax countries. Panel A illustrates the fraction of countries that changed tax rates at least once on the right y-axis, Panel B shows the results separately for haven and non-haven countries. The x-axis denotes the average value of the tax wedge in each quintile.
Source: Author's calculations.

6.2 Transfer Mispricing and R&D Intensity

Do firms that undertake more investment in R&D engage in more transfer price manipulation? A priori, the relation could go either way. On the one hand, R&D increases the intangible capital of a firm, some of which can be allocated to low-tax jurisdictions to facilitate profit shifting. On the other hand, R&D can make a firm's products more specialized, which makes finding comparable prices harder and in turn makes it easier to shift profits through transfer mispricing.

Table 9 Column (1) presents the results from a regression that interacts $\Delta\tau_{jt} \times I_{low,t} \times AFF_{ij}$ with three indicators of R&D intensity based on the average firm-level R&D spending in the sample.[41] The results suggest that transfer mispricing is concentrated in firms with the highest R&D intensity. Their coefficient is highly significant and has double the size of the average baseline effect estimated earlier. In contrast, there is no evidence for any systematic transfer price manipulations of firms outside the highest R&D group. On the other hand, given the large standard errors for the other two coefficients, we can not reject the null hypothesis that the three coefficients are statistically equal to one another. The findings are suggestive that R&D makes goods more specific, facilitating profit shifting through mispricing.

It is plausible that large companies are more likely to invest in R&D so that indicators of R&D intensity may be highly correlated with firm size. Column (2) therefore includes both sets of interaction terms, and shows that, controlling for firm size, companies with the highest R&D intensity strongly manipulate their transfer prices.[42] Column (3) instead controls for the type of goods based on the classification in Rauch (1999), by adding an interaction term between a dummy indicator that distinguishes between homogeneous and

[41] Specifically, we compute a time-invariant measure of firm-level R&D intensity as the ratio between total qualifying R&D expenditure and total turnover during the sample period. We then group firms by their R&D intensity into the low, medium, and high categories.

[42] Indicators of firm size are defined based on the tercile of the distribution of firm-level fixed assets in the sample. The correlation between the levels of R&D intensity and fixed assets is -0.01, suggesting that collinearity should not be a major concern here. This low correlation between R&D intensity and firm size is in line with U.S. evidence in Cohen et al. (1987).

Table 9. Heterogeneous Transfer Mispricing in R&D

Dependent variable: $AFF_{ij}\times$	(1)	(2)	(3)	(4)
$\Delta_{\tau_{jt}} \times I_{low,t}$			-0.032	-0.034
			(0.028)	(0.030)
$\Delta_{\tau_{jt}} \times I_{low,t} \times R\&D_{low,i}$	-0.009	-0.031*		
	(0.015)	(0.018)		
$\Delta_{\tau_{jt}} \times I_{low,t} \times R\&D_{medium,i}$	0.000	-0.023	0.014	0.016
	(0.017)	(0.019)	(0.015)	(0.015)
$\Delta_{\tau_{jt}} \times I_{low,t} \times R\&D_{high,i}$	-0.063***	-0.086***	-0.043*	-0.040*
	(0.017)	(0.023)	(0.024)	(0.023)
$\Delta_{\tau_{jt}} \times I_{low,t} \times Size_{medium,i}$		0.034**		-0.021
		(0.017)		(0.026)
$\Delta_{\tau_{jt}} \times I_{low,t} \times Size_{large,i}$		0.024		-0.015
		(0.022)		(0.022)
$\Delta_{\tau_{jt}} \times I_{low,t} \times Diff_i$			0.019	0.033
			(0.034)	(0.032)
$\Delta_{\tau_{jt}} \times I_{high,t}$	-0.007	-0.007	-0.009	-0.009
	(0.006)	(0.006)	(0.006)	(0.007)
$lnGDP\ PC_{jt}$	-0.023	-0.023	-0.020	-0.022
	(0.136)	(0.136)	(0.140)	(0.141)
Adjusted R^2	0.91	0.91	0.91	0.91
N	384,525	384,525	328,941	318,484

Notes: This table presents regression results on the heterogeneous effect of the tax differential on transfer prices of exports by UK multinational with low, medium, and high R&D intensity, based on equation (1). The R&D intensity indicators are defined in reference to the quartiles of the distribution of average firm-level R&D expenses relative to total sales. The size indicators are defined in reference to the quartiles of the distribution of average firm-level fixed assets. The indicator for differentiated products is based on Rauch (1999). All other variables are as previously defined in Table 3. Standard errors clustered by country-year pairs are in parentheses. ***, **, * denotes significance at 1%, 5%, and 10% level, respectively. *Source*: Authors' calculation based on the main estimation sample.

differentiated goods and the main variable of interest $\Delta\tau_{jt} \times I_{low,t} \times AFF_{ij}$ to the regression. Column (4) includes both the firm size and the goods type interactions as controls. The basic finding that the most R&D-intensive firms manipulate their transfer prices more remains unchanged in these alternative specifications.

7 Conclusions

In this paper, we use linked trade-tax administrative records on UK multinationals in manufacturing to estimate the extent of tax-motivated transfer mispricing in exports of real goods. Our findings suggest that, on average, a 1 percentage point tax difference reduces related-party export prices to low-tax countries by 3 percent relative to the prices charged at arm's length. The extent of tax-motivated transfer mispricing has increased in the post-2009 territorial tax regime, is present in non-tax havens with relatively low and medium tax rates, and is substantially larger in R&D-intensive firms. The new evidence on transfer mispricing has several implications for policy and future research.

First, we document compelling evidence that transfer mispricing takes place in exports of real goods in addition to any shifting based on intra-firm loans or royalty and license fee payments for the use of intellectual property. This result points out another area of revenue leakage risk and calls for tax authorities to keep paying attention to transfer pricing issues in tangible goods. Moreover, transfer mispricing is not uniform across firms but concentrated in the most R&D-intensive ones. This finding provides tax authorities with useful guidance on where to look for mispricing activities. Second, the UK's shift from a worldwide to a more territorial tax regime in 2009 has increased the extent of transfer mispricing. This result is consistent with the view that, compared to a worldwide system, the territorial tax regime creates more incentives for profit shifting. It is also in line with previous studies that document more profit shifting by MNCs under the territorial tax system (Markle, 2016). The revenue costs associated with increased transfer pricing under the territorial tax reform hence

represent another important aspect for consideration in the ongoing debate on international tax policy.[43]

Finally, in contrast to earlier research on France by Davies et al. (2018), we find evidence for transfer mispricing in exports to countries that are not tax havens. Our results imply that policy-makers should not focus on tax havens alone but should also pay attention to other non-haven, low-tax and medium-tax countries as destinations for profit shifting.

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[43]This finding does not necessarily imply that worldwide taxation is preferable to territorial taxation, as the latter may have other desirable effects such as increasing the efficiency of outbound investment allocation.

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A Conceptual Framework

This section develops a simple model that shows how tax differences motivate MNCs to manipulate transfer prices. It also shows how a shift from a worldwide tax system to a territorial tax system increases incentives for transfer price manipulation. We start from a modified version of the model in Cristea and Nguyen (2016), which is based on Bernard et al. (2006) and Hyde and Choe (2005).

There are three differences to the setup in Cristea and Nguyen (2016). The most important is a new parameter γ, which captures the aspect that deferred profits abroad may be worth less to an MNC than profits at home — a key innovation to study the difference in incentives to shift profits between worldwide and territorial taxation. Secondly, to focus the analysis, we drop the incentive price p_i. This change is without loss of generality, as all questions that we are interested in are independent of that variable. Finally, we modify the penalty function for transfer mispricing. The change in the penalty function is not essential but arguably makes the model more realistic.

Basic setup There is a multinational firm that sells to another country in two ways. It sells directly to an unrelated party at the arm's length price p_a, and it sells through its subsidiary abroad at the final sales price p_f. For this related-party transaction, the MNC also needs to set an internal transfer price p_t. We assume that arm's length sales and related-party sales target independent sets of consumers, so there is no competition across these two modes of selling abroad.[44] Profits of the parent π_h and subsidiary π_f are given by:

$$\begin{aligned} \pi_h &= (1-\tau_h)[(p_a - c)q_a + (p_t - c)q_f)], \\ \pi_f &= (1-\tau_f)(p_f - p_t)q_f, \end{aligned} \tag{A.1}$$

[44]This assumption greatly simplifies the analysis but does not drive the results. All mechanisms and results should persist when allowing for some degree of competition across modes of exporting.

where τ_h and τ_f are the corporate income tax rates in countries where the headquarters and the subsidiary are located, respectively; c is marginal cost of production per unit of output; and q_a and q_f are quantities sold at arm's length and through the affiliate, respectively. Assume that differences between the transfer price and the arm's length price imply a penalty given by:[45]

$$\frac{\lambda}{2}(p_a - p_t)^2 q_f, \tag{A.2}$$

where λ captures the strength of tax enforcement. The penalty is linear in the trade volume, q_f, and quadratic in the difference between the arm's length price and the transfer price, $p_a - p_t$.

MNCs have to decide where to report their book profits. Importantly, they can only pay out dividends to their equity holders or reinvest at home if profits have been repatriated to the headquarters. Under worldwide taxation, firms pay dividend taxes on any current or deferred after-tax profits that are brought home. To capture this aspect, let $\gamma \in \{\gamma_W, \gamma_T\}$ be the relative value of a pound of after-tax profit in a low-tax country compared to a pound of after-tax profit at home. In a worldwide system with deferral, after-tax profits abroad are less valuable to the firm, because they are still taxed upon repatriation and therefore $\gamma_W < 1$. In a territorial system, there are no additional taxes on foreign repatriations, so $\gamma_T = 1$.[46] Assume that penalties are paid at home and are not tax deductible. An MNC

[45] While Cristea and Nguyen (2016) assume the penalty function is quadratic in q_f, in our specification the penalty is linear in the quantity sold abroad through the affiliate. A penalty that is proportional to the value of trade is consistent with HMRC rules. See Deloitte (2015), page 229: "penalties are linked to the behavior that gives rise to the error: if reasonable care was taken – no penalty; careless behavior – minimum 0 percent and maximum 30 percent; deliberate careless behavior – minimum 20 percent and maximum 70 percent; and deliberate and concealed error – minimum 30 percent and maximum 100 percent." Thus, we assume that the punishment is convex in the extent of mispricing $(p_a - p_t)$ but proportional to the trade volume. With this assumption, the model still gives rise to a manipulated arm's length price, as emphasized in Cristea and Nguyen (2016).

[46] Of course, there may still be some costs involved in moving profits back to the headquarters. The key point is that these costs should be strictly smaller under territorial taxation than under worldwide taxation — that is, $\gamma_W < \gamma_T$.

therefore maximizes its overall weighted profits:

$$\Pi = (1-\tau_h)[(p_a - c)q_a + (p_t - c)q_f] - \frac{\lambda}{2}(p_a - p_t)^2 q_f + \gamma(1-\tau_f)(p_f - p_t)q_f. \tag{A.3}$$

The transfer price Taking the first-order condition with respect to p_t, we can derive

$$p_t = p_a - \frac{(\gamma - 1 + \tau_h - \gamma\tau_f)}{\lambda}. \tag{A.4}$$

The optimal transfer price is equal to the arm's length price minus a correction for taxes. The lower the tax rate abroad relative to the home rate, the lower is the optimal transfer price.[47]

Proposition 1 (Transfer Price Manipulation, Prediction 1) *Relative to the arm's length price p_a,*

(i) under a territorial tax system, the optimal transfer price decreases in the tax difference $\tau_h - \tau_f$,

(ii) under a worldwide tax system, the optimal transfer price decreases in the adjusted tax difference $\tau_h - \gamma_W \tau_f$.

Proof. *Follows directly from equation* (A.4). ■

Leaving profits abroad is costly to the MNC under worldwide taxation and the optimal transfer price is hence less distorted than under territorial taxation. This effect can easily be seen by noting that p_t decreases in γ.

Proposition 2 (Tax Reform, Prediction 2) *Transfer price manipulation is stronger under a territorial tax system than under a worldwide tax system ($\partial(p_a - p_t)/\partial\gamma > 0$).* ***Proof.*** *Follows directly from equation* (A.4). ■

[47] Note that in Cristea and Nguyen (2016), the optimal transfer price also depends on q_f. Our change to the penalty function makes this non-intuitive result disappear.

In equilibrium, the optimal arm's length price p_a is also a function of the tax rates at home and abroad. As the full model is not solvable in closed form, we show that the results in Propositions 1 and 2 on the transfer price (relative to p_a) generalize to the absolute transfer price p_t by simulating the model.

It is interesting to note that there is a cutoff value $\bar{\gamma}$ at which a firm no longer wants to manipulate its transfer price for tax reasons. This can be seen by solving equation (A.4) for $\bar{\gamma}$ for the case $p_t = p_a$. This delivers:

$$\bar{\gamma} = \frac{1 - \tau_h}{1 - \tau_f}. \tag{A.5}$$

If $\gamma < \bar{\gamma}$, it is not worthwhile for an MNC to shift profits into a low-tax jurisdiction for tax reasons.[48]

Trade Creation Plugging the optimal transfer price into the profits and defining $\widetilde{\Delta\tau} = \gamma - 1 + \tau_h - \gamma\tau_f$ to get:

$$\Pi = (1 - \tau_h)(p_a - c)q_a + \gamma(1 - \tau_f)(p_f - c)q_f - \left[(p_t - c)\widetilde{\Delta\tau} + \frac{\left(\widetilde{\Delta\tau}\right)^2}{2\lambda}\right] q_f \tag{A.6}$$

We can than derive:

Proposition 3 (Trade Creation, Prediction 3) *If $p_t < c - \frac{\widetilde{\Delta\tau}}{2\lambda}$. Then the MNC increases its related-party exports from a profit-shifting motive.*

Proof. *Suppose $p_t = c - \frac{\widetilde{\Delta\tau}}{2\lambda}$. Then, the last term in equation* (A.6) *is zero and the MNC sells the standard first-best quantity abroad. As $p_t < c - \frac{\widetilde{\Delta\tau}}{2\lambda}$, the last term in equation* (A.6) *becomes positive and the exporter optimally sells a larger quantity as long as $\widetilde{\Delta\tau} > 0$.* ■

That is, the MNC has an incentive to increase trade for tax reasons if the optimal transfer price is sufficiently low. An interesting necessary condition is that the transfer price charged

[48] We thank an anonymous referee for raising this point.

is below the marginal production cost c. For further intuition, consider the simplified case where $\lambda = 0$ and $\gamma = 1$. Then $p_t = 0$ and profits are:

$$\Pi = (1 - \tau_h)(p_a - c)q_a + q_f[p_f - c + \tau_h c - \tau_f p_f] \tag{A.7}$$

Then, the two pricing decisions become independent and the FOC for p_f implies:

$$R' = \frac{1 - \tau_h}{1 - \tau_f} c, \tag{A.8}$$

This leads to a straightforward corollary:

Corollary 1 (Trade Creation when $\lambda = 0$ and $\gamma = 1$) *Suppose $\lambda = 0$ and $\gamma = 1$. Then, the firm increases (decreases) its related-party export quantities for profit-shifting reasons if and only if the foreign tax rate τ_f is lower (higher) than the home tax rate τ_h.*

The arm's length price Now, assume that there is a standard CES demand given by

$$q_a = p_a^{-\sigma} A. \tag{A.9}$$

Then, we can derive the first-order condition with respect to p_a and solve for[49]

$$p_a = p_x \frac{1}{1 + \kappa(\Delta\tau)}, \tag{A.10}$$

$$\text{with } p_x = \frac{\sigma}{\sigma - 1} c, \tag{A.11}$$

$$\text{and } \kappa(\Delta\tau) = \frac{\gamma - 1 + \tau_h - \gamma\tau_f}{(1 - \tau_h)(\sigma - 1)} \left(\frac{q_f}{q_a} \right), \tag{A.12}$$

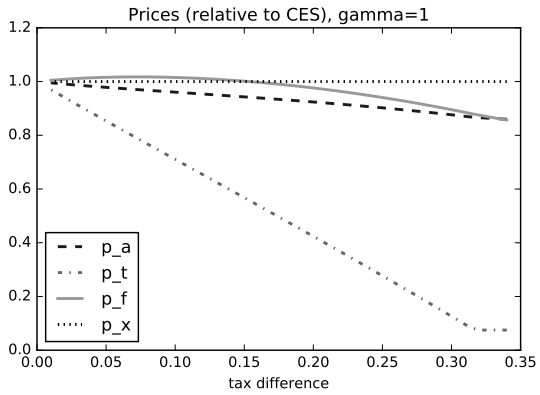
where p_x is the standard optimal price under CES preferences and monopolistic competition in the absence of transfer pricing. As pointed out by Cristea and Nguyen (2016), multinational firms have an incentive to not only manipulate their transfer price with a related

[49]For $\gamma = 1$, this result is the same as in Cristea and Nguyen (2016), despite the change to the penalty function.

party but also their arm's length prices to unrelated parties. Equation (A.10) implies that the arm's length price increases with the destination country's tax rate. Arm's length prices and transfer prices hence move in the same direction in response to tax rates, which keeps them closer together and thereby limits the effectiveness of transfer pricing regulation and tax penalty.

Simulation results Figure A.1 shows how optimal prices change with the tax difference. While the figure shows results for a specific set of parameters, the patterns in the figure discussed below are general features of the model. First, note that the transfer price, p_t, strictly decreases in the tax difference, as should be expected. In addition, the firm has an incentive to charge an arm's length price, p_a, that is strictly below the standard CES price p_x, as discussed in detail in Cristea and Nguyen (2016). In line with prediction 3, the optimal related-party final sales price p_f is below the standard CES price for a large enough tax difference $\Delta\tau$, representing tax-motivated trade creation.

Figure A.1. Simulated Prices in response to Tax Differential

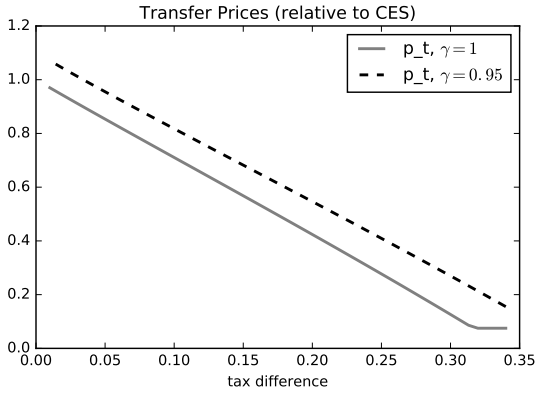


Notes: This figures shows simulated paths of standard CES price (p_x), final sales price ($p_(f)$), optimal arm's length price (p_a), and optimal transfer price (p_t), for different values of tax difference and $\gamma = 1$.

Next, Figure A.2 illustrates how the transfer price changes with γ, by plotting the optimal transfer price against the tax difference for $\gamma = 1$ and $\gamma = 0.95$. The optimal transfer price

is clearly decreasing in γ, in line with the result in Proposition 1.

Figure A.2. Optimal transfer prices for different γ



Notes: This figures shows the simulated path of optimal transfer price (p_t) under different values of tax difference, for $\gamma = 1$ and $\gamma = 0.95$, respectively.

B Data Appendix

B.1 Data Sources

The HMRC Custom Dataset The primary data on exports of UK companies comes from the HMRC custom dataset, which provides transaction-level export data during 2005-2011. We utilize for each record-year the information on the firm's trader ID (anonymized), the product code (15-digit HMRC Integrated Trade Tariff Code[50], Standard International Trade Classification (SITC) 4-digit code of goods, the destination country, date of export, the export value in British pounds, and the weight in kilograms. The transaction-level export

[50]The breakdown of the 15-digit HMRC Integrated Trade Tariff Code is as following: Digits 1-6 – refer to the Harmonized Commodity Description and Coding System (HS); Digits 7-8 – refer to the Combined Nomenclature (CN) for classifying goods, set up to meet the requirements both of the Common Customs Tariff and of the EU's external trade statistics; Digit 9 – National Statistics (each EU member state can apply their own 9th digit breakdown) The UK no longer use this so the digit will always be 0 (zero); Digits 10-11 – refer to the TARIC code designed to show the various EU rules applying to specific products when imported into the EU. This is an extract from Official Journal C103/2003. Digit 12-15 – refer to an additional code which is alphanumeric and used to provide for: complex anti-dumping and countervailing duties, agricultural components, pharmaceutical substances listed in part three, section II of the CN, CITES products (Washington Convention), reference prices for fish, and certain other import or export measures for which a subdivision of the CN/TARIC code is required.

data includes additional information on the custom clearance procedure and documents, which we do not utilize in this paper. We collapse the transaction data to firm-product-destination-year level, computing total export value, total quantity, number of shipments, and average unit price.

We compare the aggregate trade volume with the Office of National Statistics (ONS) aggregate statistics for each country to make sure that our data represents the bulk of UK trade. For most countries the two aggregate series are very similar. However, this is not the case for Switzerland because the aggregated trade volume trends in opposite direction compared to the record from ONS statistics. We dropped exports to Switzerland from the baseline estimation sample, but include these observations to check the robustness of our results. Online appendix Table A.7 reports the results, which remain unchanged to our main results.

The CT600-FAME Dataset The CT600 corporate tax records contain detailed information on the tax position of each company and how it is determined. We utilize qualifying R&D expenditure and CIT tax liability in the CT600 dataset. The UK requires every incorporated firm to file annual financial statement with Company House regardless of their size. The FAME accounting dataset therefore provides detailed financial information such as sales, fixed assets, and total assets for the population of UK companies. With the assistance of the HMRC datalab staff, we match each company-year in the CT600 corporate tax record with their FAME accounting record. The matching is based on a HMRC lookup table that cross links the unique company registration number (in FAME) with their unique taxpayer number (in the CT600). The latter is ANOMYNIZED, replaced with a unique pseudo-taxpayer number in the lookup table. The lookup relies on the common pseudo-identifier and is done by the HMRC datalab staff. This step matched 90 percent of companies in the corporate tax records.

FAME Ownership Dataset The FAME ownership dataset provides information, for each company in the UK, the ultimate parent company (if applicable) and its location, industry,

and basic financial characteristics; its subsidiaries up to ten level in the ownership chain (if applicable) and their location, industry, and basic financial characteristics.

Time-varying network of foreign affiliates The FAME database provides a snapshot of the ownership structure of UK firms in 2015. To reflect developments in the network of foreign affiliates due to foreign mergers and acquisitions (M&A) during our sample period, we download all M&A deals that are acquired by a UK company during 2005-2015 from the Zephyr database, which is also provided by Bureau Van Dijck. We then record for each acquiring company, all the target countries in each year where the M&A took place, the number of deals in each year, and the unique company identifier for all the target companies as well as the acquiring firm. For each UK company, changes in its network of foreign affiliates can be due to direct M&A, or any M&As by other affiliates in the same MNC group. We update the ownership network of foreign affiliates backward, starting from 2015. For each company-year, if (1) there is at least one M&A in country j in year $t-1$, and (2) the number of deals in year $t-1$ is larger than the number of affiliates in t, we consider that these deals lead to an expansion of the network into country j in year t, updating the ownership information in year $t-1$ accordingly. We apply this algorithm to all company-years recursively between 2005 and 2015. We then define a new dummy indicator (Aff_{ijt}) that takes the value of 1 if company i has an affiliate in country j in year t based on the dynamic ownership structure. The new time-varying affiliate dummy indicator therefore addresses the potential measurement issue that for the subset of UK MNCs that established a foreign affiliate in a *new* destination country, trade transactions that may have been arm's length at the beginning of the sample period are treated as intra-firm in the estimation.

B.2 Matching Process

We are able to link across different data sources thanks to the HMRC lookup table, prepared by the HMRC datalab staff. Each company has a unique identifier in the trade statistics (trader ID), the CT600 tax records (taxpayer identifier), and FAME accounting and own-

ership datasets (company registration number). The trader ID and taxpayer identifier are confidential, and are already replaced with a masked version in the HMRC datalab that are available for research purposes. The HMRC lookup table generates a common pseudo company ID for each unique trader ID (Trade), taxpayer identifier (CT600), and company registration number (FAME).

Linking ownership information to the CT600-FAME dataset We start by matching, for each company in the CT600-FAME dataset, information on their ownership structure including their ownership category and the static and time-varying affiliate dummy indicators with respect to all countries in the world (for UK and foreign MNCs only). The ownership variable allows us to group the population of UK companies into four categories: (1) domestic or unknown; (2) parent companies of an MNC group with at least one subsidiary outside the UK; (3) subsidiaries of a UK MNC group; and (4) subsidiaries of a foreign parent company. As the accounting and ownership datasets are both from the FAME database, the matching quality is identical to that for the linked CT600-FAME dataset, that is, we matched 90% of companies in the corporate tax records with their accounting and ownership information.

Matching Trade Statistics with the augmented CT600-FAME Dataset We match, for each company in the CT600-FAME dataset augmented with their ownership structure, information on their exports per product-destination-year in the trade dataset, using the HMRC lookup table that cross references the trader IDs and taxpayer identifiers. Our estimation sample focuses on exports within manufacturing. The matching rate is 100%, that is, within manufacturing, all UK MNCs in the CT600-FAME dataset have a correspondence in the trade statistics.

B.3 Summary Statistics

The final data set includes 931,773 observations at the firm–product–year level for 1,256 unique companies in manufacturing during 2005 to 2011. Table B.1 reports the summary

statistics of the full sample without dropping any observations due to the inclusion of various fixed effects in equation (1).

Table B.1. Summary Statistics: Full Sample

	Mean	Std. Dev	P25	P50	P75	Obs
	(1)	(2)	(3)	(4)	(5)	(6)
Product Characteristics						
Export Value (GBP)	119,791	482,403	970	4,661	29,242	941,358
Net Mass (in kilogram)	17,170	87,118	9	83	1,157	941,358
Average Value (per kilogram)	317	897	8.6	35.5	184.1	941,358
Firm Characteristics						
Log Sales	16.3	2.0	15.1	16.3	17.4	10,091
Intra-firm Trade	0.39	0.49	0	0	1	10,091
Profit Making	0.71	0.45	0	1	1	10,091
Country Characteristics						
Low Tax Country Dummy	0.55	0.50	0	1	1	705
Low Tax Wedge ($\tau_{UK} - \tau j, \%$)	7.67	5.71	3	6	11.5	450,005
High Tax Wedge ($\tau j - \tau_{UK}, \%$)	5.85	4.68	2	5	8.31	491,353

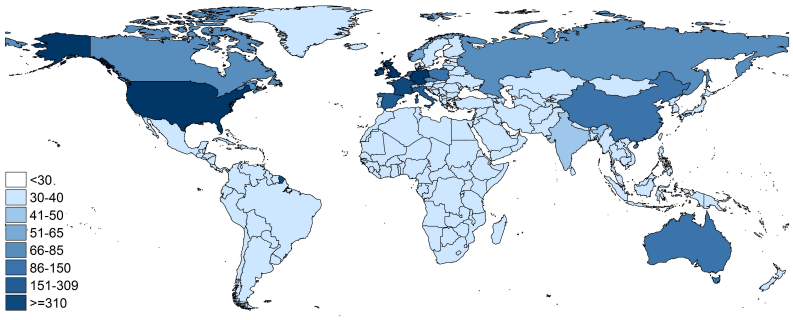
Notes: This table lists the summary statistics for the key variables in this paper's full sample without dropping any observations due to the inclusion of various fixed effects.

Online Appendix

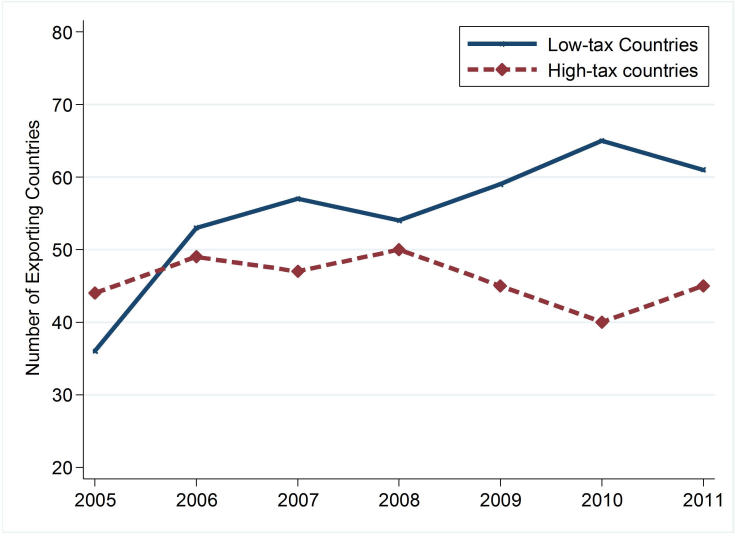
A Additional Exhibits

Figure A.1. Distribution of Affiliates

(a) Location of UK MNC Affiliates



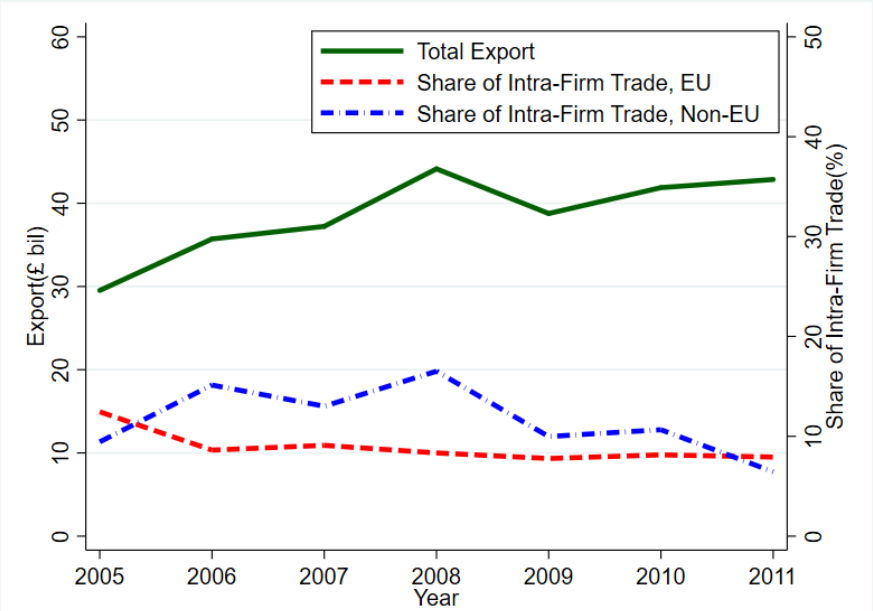
(b) Number of Low/High Tax Countries



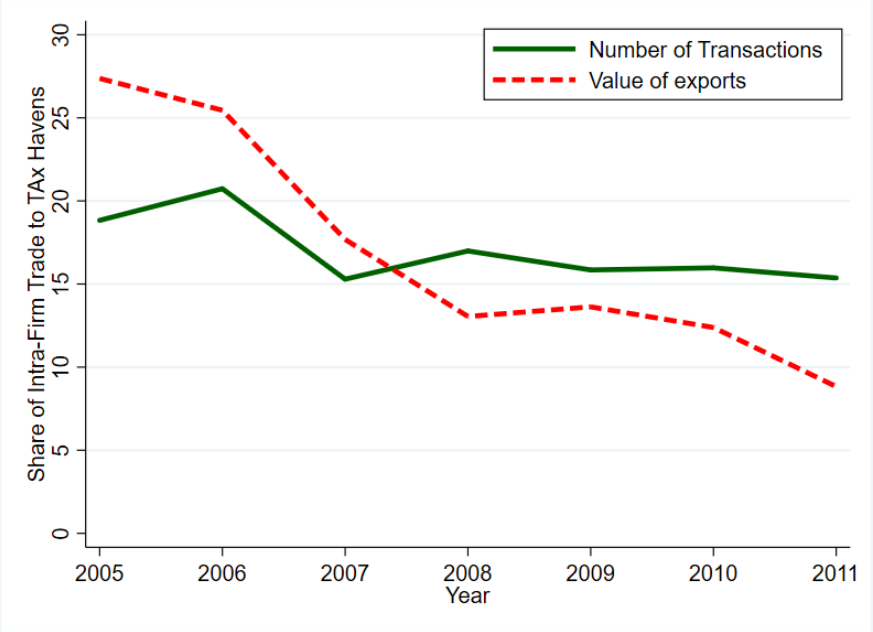
Notes: Panel A shows the worldwide location of UK MNC affiliates in 2011, the last year in our sample period. Panel B shows the number of countries with statutory tax rate lower than the UK rate (low-tax) and higher than the UK rate (high-tax), respectively, during 2005-2011.
Source: FAME, KPMG Corporate Tax Rate Tables, and authors' calculations.

Figure A.2. Time-Series Export Values and the Share of Intra-Firm Trade

(a) Time-Series



(b) Share of Intra-firm Exports to Tax Havens



Notes: Panel A shows the value of total exports in the final dataset during 2005-2011 (on the left y-axis), and the share of intra-firm trade in total exports within/outside the EU (on the right y-axis), respectively. Intra-firm trade refers to trade with destination countries with at least one related party. Panel B shows the share of intra-firm trade to tax havens in total intra-firm trade, measured by total number of transactions (solid line) and value of exports (dashed line). The list of countries in our main estimation sample that are considered as tax havens in Hines (2005) includes: Bahamas. Bahrain, Barbados, Costa Rica, Cyprus, Hong Kong, Ireland, Jordan, Luxembourg, Malta, Mauritius, Panama, Samoa, Singapore, and Vanuatu.
Source: Both panels: Authors' calculations using the estimation sample.

Table A.1. List of Tax Havens

Country	Hines (2005)	Dharmapala and Hines (2009)	OECD List of Uncooperative Tax Havens (2000)
Andorra	1	1	1
Anguilla	1	1	1
Antigua and Barbuda	1	1	1
Aruba	1	0	1
Bahamas	1	1	1
Bahrain	1	1	1
Barbados	1	1	1
Belize	1	1	1
Bermuda	1	1	1
British Virgin Islands	1	1	1
Cayman Islands	1	1	1
Channel Islands	0	1	1
Cook Islands	1	1	1
Costa Rica	1	0	0
Cyprus	1	1	1
Djibouti	1	0	0
Dominica	1	1	1
Gibraltar	1	1	1
Grenada	1	1	1
Guernsey	1	0	0
Hong Kong	1	1	0
Ireland	1	1	0
Isle of Man	1	1	1
Jersey	1	0	0
Jordan	1	1	0
Lebanon	1	1	0
Liberia	1	1	1
Liechtenstein	1	1	1
Luxembourg	1	1	0
Macao	1	1	0
Maldives	1	1	1
Malta	1	1	1
Marshall Islands	1	1	1
Mauritius	1	0	1
Micronesia	1	0	0
Monaco	1	1	1
Montserrat	1	1	1
Nauru	1	0	1
Netherlands Antilles	1	1	1
Niue	1	0	1
Panama	1	1	1
Saint Kitts and Nevis	1	1	1
Saint Lucia	1	1	1
St. Martin	1	0	0
Saint Vincent and the Grenadines	1	1	1
Samoa	1	0	1
San Marino	1	0	1
Seychelles	1	0	1
Singapore	1	1	0
Switzerland	1	1	0
Tonga	1	0	1
Turks and Caicos Islands	1	1	1
Vanuatu	1	1	1

Notes: This table lists the countries that are regarded as tax havens in three different publications. The tax haven dummy indicator takes the value of one if the country was regarded as a tax haven under the corresponding publication, and zero otherwise.

Table A.2. List of Tax Havens in Estimation Sample

Hines (2005)	Dharmapala and Hines (2009)	OECD (2000)	Davies et al (2018)
Bahamas (the)	Bahamas (the)	Bahamas (the)	Bahamas (the)
Bahrain	Bahrain	Bahrain	Cyprus
Barbados	Barbados	Barbados	Hong Kong
Costa Rica	Cyprus	Cyprus	Ireland
Cyprus	Hong Kong	Malta	Luxembourg
Hong Kong	Ireland	Mauritius	Malta
Ireland	Jordan	Panama	Singapore
Jordan	Luxembourg	Vanuatu	
Luxembourg	Malta		
Malta	Panama		
Mauritius	Singapore		
Panama	Vanuatu		
Samoa			
Singapore			
Vanuatu			

Notes: This table lists the countries that are regarded as tax havens in three different publications in our estimation sample.

Table A.3. Past Transfer Pricing Semi-elasticity Estimates

Paper	Semi-elasticity	Std Error	Trade	Tax Rate	Country	Period	Mid-Point Sample Year
Clausing (2003)	2.93	1.85	Export	Effective	US	1997-1999	1998
Clausing (2003)	5.47	1.81	Export	Statutory	US	1997-1999	1998
Bernard et al (2006)	4.18	0.67	Export	Statutory	US	1993-2000	1996.5
Bernard et al (2006)	1.64	0.45	Export	Statutory	US	1993-2000	1996.5
Bernard et al (2006)	1.68	0.58	Export	Effective	US	1993-2000	1996.5
Bernard et al (2006)	0.55	0.21	Export	Effective	US	1993-2000	1996.5
Bernard et al (2006)	0.66	0.05	Export	Statutory	US	1993-2000	1996.5
Bernard et al (2006)	0.56	0.05	Export	Statutory	US	1993-2000	1996.5
Bernard et al (2006)	0.65	0.05	Export	Statutory	US	1993-2000	1996.5
Bernard et al (2006)	0.39	0.03	Export	Effective	US	1993-2000	1996.5
Bernard et al (2006)	0.77	0.04	Export	Statutory	US	1993-2000	1996.5
Bernard et al (2006)	0.43	0.03	Export	Effective	US	1993-2000	1996.5
Bernard et al (2006)	3.96	0.05	Export	Statutory	US	1993-2000	1996.5
Bernard et al (2006)	1.46	0.03	Export	Effective	US	1993-2000	1996.5
Bernard et al (2006)	0.75	0.06	Export	Statutory	US	1993-2000	1996.5
Bernard et al (2006)	0.39	0.03	Export	Effective	US	1993-2000	1996.5
Davies et al (2018)	0.12	0.08	Export	Effective, marginal	France	1999	1999
Davies et al (2018)	0.21	0.08	Export	Effective	France	1999	1999
Davies et al (2018)	0.31	0.10	Export	Effective, marginal	France	1999	1999
Vicard (2015)	0.22	0.08	Export	Statutory	France	2000-2014	2007
Vicard (2015)	0.26	0.09	Export	Statutory	France	2000-2014	2007
Vicard (2015)	0.46	0.13	Export	Statutory	France	2000-2014	2007
Vicard (2015)	0.49	0.13	Export	Statutory	France	2000-2014	2007
Cristea and Nguyen (2016)	0.57	0.27	Export	Statutory	Denmark	1999-2006	2002.5
Cristea and Nguyen (2016)	0.65	0.32	Export	Statutory	Denmark	1999-2006	2002.5
Cristea and Nguyen (2016)	0.82	0.33	Export	Statutory	Denmark	1999-2006	2002.5
Cristea and Nguyen (2016)	0.91	0.30	Export	Statutory	Denmark	1999-2006	2002.5

Table A.4. Frequency of CIT Rate Changes

Estimation Sample:	All Countries		Tax Haven		Non-Tax Haven	
Number of CIT Rate Change	Frequency	Percent (%)	Frequency	Percent (%)	Frequency	Percent (%)
0	139,273	35.9%	32,626	67.0%	106,647	31.5%
1	112,055	28.9%	6,473	13.3%	105,582	31.1%
2	45,403	11.7%	7,847	16.1%	37,556	11.1%
3	34,845	9.0%	1,721	3.5%	33,124	9.8%
4	24,890	6.4%	-	0.0%	24,890	7.3%
6	31,243	8.1%	-	0.0%	31,243	9.2%
Total	387,709	100%	48,667	100.00%	339,042	100%

Notes: This table lists the frequency of CIT rate changes in all countries in our main estimation sample, and separately in tax havens and non-haven countries, respectively.

Table A.5. Frequency of CIT Rate Changes across Tax Wedge Quintile

Frequency of change in Δ_j	Quintile 1 (with highest τ_j)	Quintile 2	Quintile 3	Quintile 4	Quintile 5 (with lowest τ_j)
0	14%	24%	36%	35%	85%
1	42%	41%	29%	37%	13%
2	6%	7%	3%	25%	2%
3	32%	13%	4%	3%	0%
4	2%	0%	29%	0%	0%
6	3%	0%	0%	0%	0%
Total	100%	100%	100%	100%	100%

Notes: This table lists the frequency of CIT rate changes within each quintile of CIT rate differential in the estimation sample, respectively.

Table A.6. Baseline with step-wise introduction of fixed effects

$\Delta_{\tau_{jt}}\times$	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$I_{low,t}$	-0.012***	0.002								
	(0.001)	(0.002)								
$I_{high,t}$	0.020***	0.016***								
	(0.001)	(0.004)								
$I_{low,t} \times AFF_{ij}$	-0.061***	-0.017***	-0.010***	-0.018***	-0.009***	-0.026***	-0.007***	-0.010	-0.022	-0.030***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.008)	(0.002)	(0.006)	(0.016)	(0.011)
$I_{high,t} \times AFF_{ij}$	0.002	0.000	-0.012***	-0.000	-0.006***	-0.006	-0.008***	-0.015***	0.005	-0.007
	(0.001)	(0.004)	(0.003)	(0.006)	(0.001)	(0.010)	(0.002)	(0.004)	(0.005)	(0.006)
R^2	0.01	0.515	0.680	0.746	0.842	0.893	0.934	0.930	0.952	0.973
N	941,358	941,308	939,715	695,778	780,092	673,436	550,252	584,210	466,749	387,709
$I_{low,t}$	-0.013***	0.001								
	(0.001)	(0.002)								
$I_{high,t}$	0.011***	0.013***								
	(0.001)	(0.003)								
$I_{low,t} \times AFF_{ij}$	-0.054***	-0.012***	-0.008***	-0.017***	-0.007***	-0.037***	-0.007***	-0.021**	-0.032**	-0.030***
	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.010)	(0.002)	(0.009)	(0.014)	(0.011)
$I_{high,t} \times AFF_{ij}$	-0.001	0.005	-0.009***	0.003	-0.007***	-0.009	-0.009***	-0.019***	0.002	-0.007
	(0.003)	(0.005)	(0.002)	(0.005)	(0.002)	(0.008)	(0.002)	(0.004)	(0.007)	(0.006)
Adjust R^2		0.595	0.75	0.782	0.861	0.896	0.942	0.932	0.956	0.973
N	387,709	387,709	387,709	387,709	387,709	387,709	387,709	387,709	387,709	387,709
FE Included:	None	Firm FE Year FE	Firm FE Year FE Product FE	Y-C-P	Y-F-P	F-P-C	Y-F-P Y-C-P	F-P-C Y-F-P	F-P-C Y-C-P	F-P-C Y-C-P Y-F-P

Notes: This table presents regression results on the effect of the tax differential on transfer prices of exports by UK multinational, based on equation (1) by adding different fixed effects. The dependent variable, lnp_{ijkt}, is the average unit price of exports of product k to country j by firm i in year t. $\Delta\tau_{jt}$ is the absolute difference in statutory corporate tax rates between the destination country j and the UK in year t. $I_{low,t}$ ($I_{high,t}$) are indicators that take the value of one if the destination country has a lower (higher) statutory tax rate than the UK in year t, and zero otherwise. $AFF_{ij(t)}$ is a dummy indicator that takes a value of one if the MNC firm i has at least one affiliate in country j, and zero otherwise. $lnGDP\ PC_{jt}$ is the log of GDP per capita in destination country j in year t. The main variables of interests are the three-way interaction terms $AFF_{ij(t)} \times \Delta\tau_{jt} \times I_{low,t}$ and $AFF_{ij(t)} \times \Delta\tau_{jt} \times I_{high,t}$. Y-C-P denotes product–market–year fixed effect, Y-F-P denotes firm–product–year fixed effect, and F-P-C denotes firm–market–product fixed effect. Standard errors clustered by country-year pairs are in parentheses. ***,**,* denotes significance at 1%, 5%, and 10% level, respectively.

Table A.7. Additional Robustness Check: Including Exports to Switzerland

Sample:	Including Switzerland	
$AFF_{ij}\times$	(1)	(2)
$\Delta_{\tau_{jt}} \times I_{low,t}$	-0.029***	-0.027**
	(0.011)	(0.011)
$\Delta_{\tau_{jt}} \times I_{high,t}$	-0.007	-0.001
	(0.006)	(0.006)
$Post_t$		0.130***
		(0.043)
$\Delta_{\tau_{jt}} \times I_{low,t} \times Post_t$		-0.015***
		(0.005)
$\Delta_{\tau_{jt}} \times I_{high,t} \times Post_t$		-0.008
		(0.007)
$lnGDP\ PC_{jt}$	-0.058	-0.046
	(0.133)	(0.135)
Adjusted R^2	0.91	0.91
N	384,525	312,274

Notes: This table presents regression results on the effect of the tax differential on transfer prices of exports by UK multinational, based on equations (1) and (2) by expanding the sample to include exports to Switzerland. The dependent variable, lnp_{ijkt}, is the average unit price of exports of product k to country j by firm i in year t. $\Delta\tau_{jt}$ is the absolute difference in statutory corporate tax rates between the destination country j and the UK in year t. $I_{low,t}$ ($I_{high,t}$) are indicators that take the value of one if the destination country has a lower (higher) statutory tax rate than the UK in year t, and zero otherwise. $AFF_{ij(t)}$ is a dummy indicator that takes a value of one if the MNC firm i has at least one affiliate in country j, and zero otherwise. $lnGDP\ PC_{jt}$ is the log of GDP per capita in destination country j in year t. The main variables of interests are the interaction terms $AFF_{ij} \times \Delta\tau_{jt} \times I_{low,t}$ and $AFF_{ij} \times \Delta_{\tau_{jt}} \times I_{low,t} \times Post_t$. Standard errors clustered by country-year pairs are in parentheses. ***,**,* denotes significance at 1%, 5%, and 10% level, respectively.