Does Foreign Tax Arbitrage Promote Innovation?*

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Abstract

I identify a new category of fiscal policy instruments – those regulating profit shifting activity – as an important determinant of corporate innovation. Using confidential microdata on the foreign and domestic operations of U.S. multinational firms, I document that after an unexpected policy shock that facilitated foreign tax arbitrage, U.S. multinationals shifted more of their taxable income and intellectual property to low tax countries. This increased the after-tax return to innovative activity. In response, U.S. multinationals increased their innovation in the U.S., whether measured using R&D expenditures, patent applications, or patent citations.

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Multinational firms perform almost all U.S. business research and development (R&D). For example, in 2010, the parent companies of US. multinationals undertook more than 70% of U.S. business R&D, as seen in Figure 1. This striking fact reveals that technological progress in the U.S. is highly exposed to the innovative activities of multinational firms.

This paper is the first to document that policies regulating multinationals' profit shifting may have a significant impact on their innovative activities. These activities often produce intellectual property (IP), such as patents and trade secrets. If firms are able to locate IP - and its associated income - in low tax jurisdictions, the after-tax return to producing IP rises. Hence, loosened restrictions on firms' profit shifting may promote innovation.

Two principal challenges have complicated investigating the link between tax arbitrage and innovation, however. First, such an analysis requires a shock to firms' tax arbitrage activities. Second, the publicly available data on firms' unconsolidated operations are not sufficiently detailed to investigate this topic empirically.

To address the first challenge, I focus on the U.S. Treasury's 1997 "Check-the-Box" (CTB) policy decision. CTB was intended to simplify the federal tax filing process for small, domestic U.S. firms. In doing so, it also unexpectedly granted U.S. multinationals greater discretion over where to locate their foreign IP-derived income. As a consequence, multinationals moved this income to relatively low tax jurisdictions, increasing the after-tax return to innovative activity.

To address the second challenge, I use confidential data on the operations of U.S. multinational firms collected by the Bureau of Economic Analysis (BEA). The data include information on U.S. multinationals' foreign operations, such as balance sheet and income statement items, as well as intra-firm transactions, such as royalty payments and license receipts. In addition, BEA collects separate balance sheet and income statement items on U.S. multinationals' domestic activities, including information on domestically performed R&D. These data allow me to evaluate whether multinationals altered their innovative activities in the U.S. following CTB.[1]

The manner by which CTB facilitated tax arbitrage by U.S. multinationals can be illustrated with an example. Consider a hypothetical U.S.-based software company that sells its software to customers around the world from the U.S. In this case, all resulting income would be reported in the

[1]The focus on U.S. innovation results from the fact that U.S. multinational firms perform almost all their innovative activity in the U.S. A further discussion is contained in Section 4.1.3.

U.S. and subject to contemporaneous U.S. federal taxation. Alternatively, the firm could license the software to a subsidiary in another country with a relatively low tax rate, like Bermuda. The Bermudian subsidiary could, in turn, sell the software to users outside the U.S.[2] The U.S. tax code stipulates that the Bermudian subsidiary must make a substantive contribution to the software's development in order to benefit from Bermuda's lower tax rate.[3] I will refer to this provision of the tax code as the "co-development requirement." The co-development requirement is one of the central challenges in international tax planning, since many of the countries with the lowest corporate income tax rates do not also have a local workforce to plausibly claim such a contribution. Continuing the example, the labor pool in Bermuda capable of making a substantive contribution to the development of a U.S. multinational's software is likely very small or nonexistent. CTB effectively eliminated the co-development requirement. After CTB, the software company could shift from the U.S. to Bermuda the sale of its software to foreign customers. Instead of paying the U.S. tax rate of 35% on these sales, it could pay the 0% Bermudian rate.

This paper focuses on two related aspects of the CTB policy shock on U.S. multinationals' activities. First, I present evidence that after CTB U.S. multinationals allocated significantly more of their foreign taxable income to subsidiaries in countries with relatively low corporate income tax rates. As this income was shifted, the firms' foreign tax rates fell. Second, I show that the more firms benefited from CTB the more they increased their innovative activity in the US.

I conduct the profit shifting analysis at the firm-country-year level. I find that after CTB the operations of a multinational firm in a country with a 1 standard deviation (8 percentage point) lower tax rate reports roughly $27 million more taxable income. This is economically significant. It represents about 18% of the standard deviation of taxable income at the firm-country-year level. In short, U.S. multinationals indeed increased their profit shifting activities after CTB.

This baseline profit shifting result is highly robust. It holds regardless of the inclusion of controls or fixed effects. It is not driven by the recent emergence of patent box[4] regimes. It is reflected in increased profit shifting to tax havens, particularly those with the lowest tax rates. Relying on a proxy used previously in the literature (Branstetter, Fisman, and Foley, 2006), I find

[2]Licensing rights for U.S. users are typically retained by a U.S. entity. Appendix A.1 contains additional information.

[3]This point is discussed further in Section 1.

[4]A patent box is a feature of a national tax system that specifies a tax rate lower than the country's standard corporate tax rate for income associated with the use of patents.

that firms shift their IP in parallel with their taxable income.

Having demonstrated the link between CTB and profit shifting, I turn to its implications for innovative activity. In shifting income to lower tax jurisdictions, the after-tax return to the projects that generated this income increases, providing an incentive for firms to undertake marginal projects previously forgone. Following this line of reasoning, firms benefiting from CTB may undertake more projects that produce IP.

Since CTB applied to all multinationals, I rely on heterogeneity in the degree to which firms benefited from CTB. Specifically, I calculate the drop in their average foreign tax rate between the years just before and after CTB. The greater the reduction in the tax rates firms faced on their IP income, the greater the increase in the after-tax return to projects that produce IP.

A possible concern with this approach is that it relies on where firms choose to locate their profits. As a result, the reduction in their foreign tax rate may correlate with firm characteristics that in turn relate to innovative activity. Endogeneity of this type may yield biased point estimates. In addition, reverse causality may be a concern. Post-CTB increases in R&D may cause firms to report more of their foreign IP-derived income in low tax countries.

To address potential concerns of this nature, I implement an instrumental variables regression analysis. Specifically, I instrument a firm's tax reduction following CTB with the average tax rate it faced before CTB in the countries where it reported labor expenses. The reduction in firms' foreign tax rates due to CTB and their pre-CTB labor-weighted tax rates are intuitively related. The higher a firm's pre-CTB tax rate, the more it stands to benefit from the policy shock. Moreover, numerous economically substantive considerations constrain where firms locate their foreign labor forces. For example, a firm requiring expertise in mechanical engineering may establish operations in Germany, while a firm requiring expertise in fashion design may set up a subsidiary in Italy. I rely on variation of this kind – the difference in pre-CTB tax rates between Italy and Germany – in the main innovation analysis.

In the baseline innovation specification, I find that a 1 standard deviation larger reduction in a firm's foreign tax rate is associated with a 0.19 standard deviation higher R&D intensity. This positive relation holds irrespective of the presence of controls or fixed effects. It is not driven by firms' exposure to patent boxes. It also holds if firms' tax reductions are measured over various time horizons or using IP-weighted instead of taxable income-weighted tax rates. An unistru-

mented specification also suggests a positive and statistically significant relation between firms' tax reductions and their innovative activity, although endogeneity appears to bias the point estimate downward.

Next I isolate the intensive and extensive margins of the response in R&D activity. I find that the degree to which firms benefit from CTB relates most strongly to their decision to continue and scale up existing R&D activities. In this sense, foreign tax arbitrage may be seen as a countervailing force in firms' recent trend toward abandoning their R&D operations.

I also consider firms' patenting activity. For patenting data I rely on PATSTAT, which is comprised of information from patenting authorities worldwide, including the U.S. Patent and Trademark Office. I find that patenting activity is also positively associated with firms' CTB related tax reductions. In particular, a one standard deviation larger drop in firms' foreign tax rates is associated with a 28% increase in patent applications. Citations of firms' patents also increase, suggesting the patented ideas are genuinely innovative.

I also consider the geographic distribution of firms' patenting activity. While CTB may induce firms to file patents abroad for IP already protected in the U.S., the R&D and citations results suggest CTB spurred true innovation. If firms are undertaking new projects to produce IP, patenting activity to protect the new IP would plausibly increase both domestically and abroad. I find that patenting increased in both the U.S. and foreign countries, consistent with this notion.

Having presented evidence suggesting that firms' CTB-linked tax reductions are associated with genuinely innovative activity, I turn to the associated innovation spillovers. I measure spillovers by tracking the geographic distribution of the patents that cite the multinational firms' patent applications. The existing results suggest that, since the innovation merits protection in the U.S., domestic innovators may benefit. Its impact on the work of researchers in foreign countries is less clear for two reasons. First, foreign patents filed by U.S. firms may be intended to simply extend legal protections for existing IP to target countries. Second, informational frictions may inhibit foreign researchers' use of new ideas generated in the U.S. Empirically, I find economically and statistically significant increases in citation activity by patents filed in the U.S. Citation activity also increases abroad, but the effect is economically modest and statistically insignificant. Hence, it appears the U.S. accrues two benefits from U.S. multinational firms' arbitrage of foreign tax policy. First, it supports R&D activity. Second, this innovation supports follow-on technological progress

domestically.

A potential concern may be that an R&D efficiency shock occurred at the same time as CTB, lowering the cost of undertaking the marginal unit of R&D. I perform a falsification test to evaluate this possibility. BEA's data on R&D expenditures can be disaggregated into two components: R&D performed for a parent company's own account and R&D performed for the Federal Government. R&D for a parent's own account may be sensitive to taxes, while an efficiency shock may impact both types of R&D expenditures. The data indicate own account R&D increased at firms benefiting from reduced taxes, while R&D performed for the Federal Government did not respond. This suggests it is unlikely that a contemporaneous efficiency shock confounds the results.

The paper's principal contributions can be organized into three categories. First, the paper contributes to the literature on the relationship between fiscal policy and innovative activity. This literature itself comprises two groups. The first group focuses on the association between corporate tax rates and innovation.[5] The second group focuses on estimating the elasticity of R&D to R&D tax credits.[6] Both these groups of the literature are important because they document the roles of major categories of fiscal policies – corporate tax rates and R&D tax credits – in influencing innovative activity. The main contribution of this paper is in identifying a new third category of fiscal policy instruments – those that regulate profit shifting activity – as an important determinant of firms' innovation. The core message of this paper is that since multinationals undertake a significant fraction of innovative activity (as noted above), and they also often rely on sophisticated profit shifting techniques to avoid taxes, policies that regulate profit shifting activity may have important consequences for innovation.

Second, the paper extends the literature on tax avoidance.[7] I find that firms have become

[5]For example, Mukherjee, Singh, and Žaldokas (2017) show that corporate tax increases are negatively associated with innovation while Atanassov and Liu (2016) confirm this result and also show that corporate tax cuts are positively associated with innovation. In distinct but related work preceding both these papers, Djankov, Ganser, McLiesh, Ramalho, and Shleifer (2010) show that corporate tax rates and entrepreneurship are negatively associated.

[6]This group includes Mansfield (1986), Bloom, Griffith, and Van Reenen (2002), Wilson (2009), and Rao (2016), among others. One challenge inherent in estimating the elasticity of R&D to R&D tax credits is that firms have an incentive to "relabel" other expenses as R&D expenditures to capture additional tax benefits (Hall and Van Reenen, 2000; Chen, Liu, Serrato, and Xu, 2017). The empirical setting in this paper sidesteps this issue since firms benefit from increasing R&D only to the extent that the R&D generates income. I find that a $1 reduction in a firm's foreign tax bill corresponds to a $1.10 increase in R&D expenditures, which is toward the upper end of R&D tax elasticity estimates. This is consistent with the notion that multinationals engage in relatively little relabeling.

[7]This large literature includes Hines Jr. and Rice (1994), Desai, Foley, and Hines Jr. (2004), Desai and Dharmapala (2006), Foley, Hartzell, Titman, and Twite (2007), Huizinga and Laeven (2008), Desai and Dharmapala (2009), Hanlon, Lester, and Verdi (2015), Faulkender, Hankins, and Petersen (2017), Zwick and Mahon (2017), Xu and Zwick (2017), Liu, Schmidt-Eisenlohr, and Guo (2017), and Albertus (2018), among many others. See Dharmapala

more sensitive to tax rates in the allocation of their taxable income in recent years, a point of ongoing debate (Dharmapala, 2014; Clausing, 2016). I also find that IP and taxable income are comparable in their responsiveness to taxes, a fact absent from the current literature.[8] This result is particularly relevant given the growing role IP is thought to play in economic activity generally (Corrado, Hulten, and Sichel, 2009).[9,10]

Finally, the results are also linked to the literature on corporate cash holdings. U.S. multinationals have accumulated large stocks of cash and other financial securities abroad (Foley, Hartzell, Titman, and Twite, 2007; Duchin, Gilbert, Harford, and Hrdlicka, 2017; Gu, 2017; Faulkender, Hankins, and Petersen, 2017; Albertus, Glover, and Levine, 2018). This is particularly true of R&D intensive firms (Bates, Kahle, and Stulz, 2009; Pinkowitz, Stulz, and Williamson, 2015). My findings are consistent with the notion that taxes play an important role in firms' growing reserves of financial assets abroad, particularly for multinationals with significant intellectual property.

1 Illustration of Check-the-Box

The practical consequences of CTB are illustrated in the following hypothetical example, which has been constructed from Darby and Lemaster (2007), Drucker (October 21, 2010), Kleinbard (2011), United States Senate Permanent Subcommittee on Investigations (2012), and United States Senate Permanent Subcommittee on Investigations (2014).[11] It is presented schematically in Figure 2. Figure 2a presents a typical organizational structure prior to CTB, while Figure 2b presents a typical structure after CTB.

Consider a U.S.-based multinational software company with a foreign subsidiary in Germany, a relatively high tax country, that sells to German customers, as in Figure 2a. Let the German subsidiary be designated as a corporation for U.S. federal tax purposes. Note the sub-

(2014) for a recent overview.

[8] Dischinger and Riedel (2011) also find that the location of intangible capital within the firm is responsive to taxation. However, the elasticities of intangibles and taxable income to tax rates are not compared.

[9] In broader terms, the paper also relates to a recent stream of research on the opacity of the countries that most intensively attract corporate profits and the other corporate activities this opacity facilitates, including bribery (Zeume, 2017), shareholder expropriation (Bennedsen and Zeume, 2018), and corruption (O'Donovan, Wagner, and Zeume, 2017).

[10] Several other papers also study CTB in the context of multinational firms' profit shifting activities (Altshuler and Grubert, 2005; Desai and Dharmapala, 2009; Guvenen, Mataloni Jr., Rassier, and Ruhl, 2017; Wright and Zucman, 2018). However, they do not consider the consequences of CTB for innovative activity, the primary focus of this paper.

[11] Appendix A discusses the principles underlying U.S. international taxation and CTB in more general terms.

sidiary has access to a meaningful supply of the factors of production, particularly the German workforce. Suppose the multinational's parent company partially develops new software. When the software nears completion, the parent enters into a co-development agreement with the subsidiary. To compensate the parent for its earlier development work, the subsidiary makes royalty payments to the parent. To the extent necessary, the subsidiary relies on its German employees to complete the software's development.[12]

Prior to CTB, income associated with the U.S. multinational's software held abroad would be taxed at the German rate. The U.S. tax obligation on this income would be deferred since the subsidiary contributed to the software's completion. In terms of selecting a country in which to realize this foreign income, the software firm is constrained by foreign countries' supplies of the factors of production and tax rates, as well as other efficiency considerations.

Now consider the setting in which CTB has been implemented. To reduce its foreign taxes while still satisfying the criteria for U.S. deferral, the software firm must have a second subsidiary, as in Figure 2b. This subsidiary is typically located in a low tax jurisdiction, such as Bermuda. It is designated as a disregarded entity under CTB and associated with the German subsidiary for U.S. tax filing purposes. The German subsidiary will continue to sell to German customers and retain the workforce it employed before CTB was implemented. The software is licensed by the U.S. parent company to the Bermudian subsidiary, which in turn sublicenses it to the German subsidiary. Because the licensing and sublicensing agreements are between related entities within the same corporate group, the associated royalty payments can be set so the majority of the income from the ultimate sale of the software accrues at the Bermudian subsidiary.

With respect to foreign taxes, the multinational now pays the Bermudian tax rate instead of the German tax rate. With respect to U.S. taxes, the German and Bermudian subsidiaries report to the IRS on a consolidated basis. The IRS will observe substantial foreign income reported by the German subsidiary (which from the German and Bermudian perspectives was realized in Bermuda). In addition, by virtue of its workforce, the German subsidiary will be positioned to credibly contribute to the software's development. Since from the perspective of the IRS the German subsidiary both realizes the income and plausibly makes an active contribution to the

[12]The co-development requirement is an example of a regulatory cost that discourages firms from shifting all their income to low tax jurisdictions, a point addressed more generally in Klassen and Laplante (2012).

software's development, the associated income is eligible for U.S. tax deferral.[13]

2 Data, Sample, and Summary Statistics

This Section first describes the data, then discusses sample selection, and concludes by presenting summary statistics.

2.1 Data Description

I construct a panel on the direct investment activities of U.S. multinationals using data collected through BEA's annual surveys on U.S. Direct Investment Abroad.[14] For the purposes of BEA's surveys, and consistent with international conventions, direct investment is defined as the ownership or control, direct or indirect, by a legal person of 10 percent or more of the voting securities of an incorporated foreign business enterprise, or an equivalent interest in an unincorporated foreign business enterprise. A multinational enterprise (MNE) is the combination of a single legal entity that undertakes the direct investment, termed the parent company, and at least one foreign business enterprise, termed by BEA as the foreign affiliate.

BEA's surveys are conducted pursuant to the International Investment and Trade in Services Survey Act (hereafter the Act). The Act stipulates that the "use of an individual company's data for tax, investigative, or regulatory purposes is prohibited." Willful noncompliance with the Act may result in imprisonment for up to one year. For these reasons, in addition to their monitoring of corporate actions and a system of internal data integrity checks, BEA believes the surveys accurately capture virtually complete data on the universe of all U.S. direct investment abroad.

The surveys provide detailed data on respondents' financial and operating characteristics. Among other items, these include information on the balance sheet and income statement of the respondent.[15] More detailed data are collected for majority-owned affiliates, which are commonly referred to as "subsidiaries," the term used in this paper. Data are reported in accordance with

[13] Additional details add complexity but leave this basic outcome intact. More complex structures are discussed by, for example, Darby and Lemaster (2007), Kleinbard (2011), and Zucman (2014).

[14] These data are collected for the purpose of producing publicly available aggregate statistics on the activities of multinational enterprises.

[15] BEA imputes values for some data items of some affiliates to calculate direct investment universe totals. Imputed data comprise a minuscule portion of direct investment activity. For example, in the 2004 data, 99.8% of affiliate net income was reported. Nevertheless, to rule out concerns related to the data estimated by BEA, the analysis in this paper relies only on the reported data.

U.S. Generally Accepted Accounting Principles and any currency translation adjustments are made consistent with Financial Accounting Standard 52 (Foreign Currency Translation).[16]

To obtain as comprehensive a set of corporate income tax rates as possible, I combine data from several sources. For OECD countries, I obtain tax rates for 1994-2010 from The Tax Foundation (2014). For non-OECD countries, I begin with tax rates from KPMG's Corporate and Indirect Tax Rate Surveys from 1999-2010 (KPMG, Various years). For these countries prior to 1999, and for countries neither in the OECD nor surveyed by KPMG, I draw tax data from the University of Michigan's World Tax Database (Various years). When combined, these sources offer nearly complete coverage over the sample period.

Finally, for information on patenting activity I rely on PATSTAT, a dataset assembled by the European Patent Office. PATSTAT incorporates data from patent authorities worldwide. In particular, it subsumes the patent data available from the U.S. Patent and Trademark Office. With these data I can track patenting activity by U.S. multinationals in both the U.S. and abroad. I can also explore innovation spillovers by tracking the global geographic distribution of patent citations.

2.2 Sample Selection

I argue that CTB facilitated profit shifting and prompted increased innovative activity by U.S. multinational firms. A firm is not likely to engage in profit shifting at a foreign entity in which it does not have a controlling stake. Hence I limit the sample of foreign affiliates to subsidiaries, that is, affiliates in which the U.S. parent's equity stake exceeds 50%. Since financial firms (SIC 6000-6499) and utilities (4900-4999) are often subject to unique regulatory regimes, I omit them from the analysis. I also omit public administration firms (SIC 9000-9999). The analysis begins in 1994 and ends in 2010. The sample for the profit shifting analysis is comprised of 84,383 observations at the MNE-country-year level representing 11,402 unique MNE-country pairs. The innovation analysis relies on 12,229 parent-year observations associated with 1,016 unique parent companies.

In several cases the main sample is restricted due to data limitations. The measure of intellectual property uses data on royalty payments and license fees from BEA's BE-577 survey. This survey was conducted from 1994 through 2006. Hence the IP analysis concludes in 2006. The

[16] A further discussion of BEA's data on multinational firms can be found in Mataloni (1995). More detailed information is included in the methodology sections of BEA's various benchmark data reports; BEA (2013) is the most recent finalized version.

decomposition of aggregate R&D expenditures into R&D expenditures for a parent company's own account and for the Federal Government is available in BEA's 1994, 1999, 2004, and 2009 surveys, restricting use of these variable to these years.

2.3 Summary Statistics

I present a full set of MNE-country-year and parent company-year summary statistics in Table 1. All financial figures are adjusted for inflation using the GDP deflator. They are recorded in millions of 2009 U.S. dollars. Each variable has been winsorized at the 1% and 99% thresholds of its empirical distribution to mitigate the influence of outliers.

Observations in Panel A reflect aggregations of foreign subsidiary-year level data for each MNE to the country-year level. On average, U.S. multinationals have assets worth roughly $545 million in each foreign country in which they have operations. The standard deviation is substantially larger, at $1,690 million, suggesting the distribution of this variable is right skewed. On average, a U.S. multinational's taxable income in a foreign country is $41 million. Employee compensation is of a similar magnitude, averaging $39 million. The average foreign statutory corporate income tax rate faced by U.S. multinationals is 30%.

I present summary statistics on the parents of U.S. multinational firms in Panel B. The unit of observation is the parent company-year. These figures consolidate all U.S. activity on an annual basis. Unsurprisingly, the parent companies in the sample are much larger than their foreign subsidiaries. The average and standard deviation of assets amount to $6,390 million and $14,682 million, respectively. Hence the ratio of average parent company assets to average parent company-country assets is roughly 12.[17] Average sales is of a similar order of magnitude as assets, at $4,426 million. R&D expenditures average $153 million annually and have a standard deviation of $507 million.[18] R&D intensity, measured as the ratio of R&D expenditures to sales averages 5%. On average, sample firms submit 17 patent applications globally each year.

The firms comprising the sample are large. By comparison, firms in the Compustat North America Fundamentals Annual database satisfying similar selection criteria have average assets of

[17] The calculation is $\frac{6{,}390.26}{545.05} \approx 12$.

[18] R&D by U.S. multinationals occurs largely within the United States. Sample MNEs spend $18 million on R&D annually across their foreign operations, on average. Hence domestic R&D comprises roughly 89% of their global total ($\frac{153}{18+153} \approx 0.89$).

$5,736 million. By this measure, the parent companies in BEA's data are about 11 percent larger than a typical Compustat firm.[19] In fact, this comparison somewhat understates the degree to which the multinationals in BEA's data are larger, as the multinational data presented in Panel B correspond only to U.S. activity, while the Compustat data reflect consolidated global activity.

3 Check-the-Box and Profit Shifting

In this Section I present the results on U.S. multinational firms' allocation of taxable income. First I lay out the empirical strategy. Then I discuss the baseline findings and robustness checks.

3.1 Empirical Strategy for Profit Shifting Analysis

To explore how the association between tax rates and taxable income changed after CTB, I estimate the following specification.

$$\begin{aligned} \frac{TaxableIncome_{i,c,t}}{Wages_{i,c,t}} &= \beta_1 \times (PolicyShock_t \times TaxRate_{c,t}) + \beta_2 \times TaxRate_{c,t} \\ &\quad + \alpha_t + \gamma' X_{i,c,t} + \varepsilon_{i,c,t} \end{aligned} \tag{1}$$

The raw data are recorded at the subsidiary-year level. The focus of this analysis is the allocation of a multinational firm's taxable income across countries, not the allocation of taxable income across its subsidiaries located in the same country. For this reason, I aggregate subsidiary-year observations for each MNE to the country-year level. MNEs, countries, and years are indexed by i, c, and t, respectively. I winsorize each variable at the 1st and 99th percentiles of its empirical distribution to mitigate the influence of outliers. The dependent variable is the ratio of $TaxableIncome_{i,c,t}$ to $Wages_{i,c,t}$, which I discuss in detail in the next paragraph. $TaxableIncome_{i,c,t}$ is the sum of net income and taxes paid. $Wages_{i,c,t}$ is employee compensation. $PolicyShock_t$ is an indicator variable that equals 1 starting in 1997, the year CTB went into effect. $TaxRate_{c,t}$ is the statutory corporate income tax rate.[20] $X_{i,c,t}$ is a vector of control variables consisting of the natural logarithm of 1 plus $Assets_{i,c,t}$ and the natural logarithm of 1 plus $Age_{i,c,t}$. $Assets_{i,c,t}$ is total assets. $Age_{i,c,t}$ is the

[19] The calculation is $\frac{6390.26}{5736} \approx 1.11$.

[20] I rely on statutory tax rates instead of effective tax rates since the latter are partly determined by firms' policies, potentially generating endogeneity concerns. For this reason, the use of statutory tax rates is standard in the literature (Dharmapala, 2014).

average number of years since subsidiaries of MNE i first appear in country c, as weighted by the subsidiaries' total assets. α_t are year fixed effects, which I discuss below. $\varepsilon_{i,c,t}$ is the usual error term. Standard errors are clustered by MNE-country. A stand alone $PolicyShock_t$ term is omitted in the baseline specification due to its collinearity with the year fixed effects. β_1 is the coefficient of interest.

Using $\frac{TaxableIncome_{i,c,t}}{Wages_{i,c,t}}$ to measure profit shifting activity offers several advantages.[21] First, unlike $ln\left(TaxableIncome_{i,c,t}\right)$, it does not eliminate from the sample observations with negative taxable income. Instances of negative taxable income are arguably of particular interest in the context of profit shifting, when taxable income is actively reduced in high tax countries. Second, a more conventional measure of profitability, the ratio of net income to total assets, presents several downsides. Net income is mechanically related to tax rates. As a result, a negative association between these variables cannot be taken as evidence of profit shifting. Moreover, total assets includes components such as cash that may present challenges. For example, if cash balances at subsidiaries in low tax countries tend to grow with profit shifting activity (Faulkender, Hankins, and Petersen, 2017), the estimated magnitude of the profit shifting activity may be biased downward. While using $\frac{TaxableIncome_{i,c,t}}{Wages_{i,c,t}}$ avoids these issues, I also show in Table 3 that the baseline profit shifting result is robust to alternative measures of the dependent variable.

The year fixed effects serve to restrict comparison of pre-tax profitability in countries with different tax rates within the same year. The influence of broad-based but difficult to measure changes varying across years – such as increased marketing of tax avoidance strategies to U.S. multinationals by professional services firms (United States Senate Permanent Subcommittee on Investigations, 2014) – is mitigated with these fixed effects in place.[22]

3.2 Taxable Income Moved to Low Tax Countries

In Table 2 I present estimates of the association between taxable income and corporate income tax rates. In column 1 I omit the fixed effects and control variables (and hence include a

[21] It also follows the existing literature (Tørsløv, Wier, and Zucman, 2018).

[22] In untabulated results I find that countries' macroeconomic conditions, political cycles, and debt burdens do not systematically vary with their corporate income tax rates. On the other hand, I find that tax competition is a key determinant of tax policy. These results are consistent with Devereux, Lockwood, and Redoano (2008) and Heider and Ljungqvist (2015) and further circumscribe the set of variables potentially confounding the analysis. For example, since local macroeconomic conditions are not strongly related to tax policy, they are unlikely to underpin the association between tax rates and taxable income.

stand alone term for $PolicyShock_t$). $\hat{\beta}_1$, the estimated coefficient associated with $PolicyShock_t \times TaxRate_{c,t}$, is negative and statistically significant at the 1% level. This suggests taxable income is more negatively related to tax rates after CTB, highlighting the potential importance of this policy for U.S. multinational firms' foreign profit shifting activities. The inclusion of control variables for size and age, as in column 2, leaves the point and standard error estimates little changed.

In column 3 I again omit the control variables, but now include the fixed effects. Since $PolicyShock_t$ is collinear with the fixed effects, it drops from the analysis. The point and standard error estimates are not meaningfully different from those in columns 1 and 2. In column 4 I include both the controls and the fixed effects, which I take as the baseline profit shifting result. The point estimate is again similar in magnitude relative to the other columns and remains statistically significant at the 1% level.

The positive and significant coefficients on $PolicyShock_t$ in columns 1 and 2 suggest firms' foreign operations were more profitable after CTB relative to before, as measured by $\frac{TaxableIncome_{i,c,t}}{Wages_{i,c,t}}$. The negative and significant coefficients on $TaxRate_{c,t}$ in columns 1 through 4 indicate firms were sensitive to tax considerations in where they reported their income even prior to CTB. In the baseline specification, the coefficient associated with $PolicyShock_t \times TaxRate_{c,t}$ is more than twice as large in magnitude as the coefficient associated with $TaxRate_{c,t}$, further highlighting the role of CTB in firms' foreign tax planning.[23]

The baseline result also suggests CTB was an economically important policy change with respect to profit shifting activity. Relative to before CTB, a 1 standard deviation (8 percentage point) lower tax rate is associated with a roughly 0.69 higher value of $\frac{TaxableIncome_{i,c,t}}{Wages_{i,c,t}}$.[24] With $Wages_{i,c,t}$ averaging roughly $39 million, this corresponds to approximately $27 million in shifted taxable income.[25] This $27 million, in turn, represents about 18% of a standard deviation of taxable income for the MNE-country-year level observations that comprise the sample.[26] Taken together, the results in Table 2 suggest U.S. multinationals became more sensitive to taxes in where they allocated their taxable income after CTB.[27]

[23] The calculation is $\frac{-8.64}{-3.91} > 2$.

[24] The calculation is $-0.08 \cdot -8.64 \approx 0.69$.

[25] The calculation is $0.69 \cdot 38.50 \approx 26.57$.

[26] The calculation is $\frac{26.57}{148.25} \approx 0.18$.

[27] $\hat{\beta}_1$ remains negative and statistically significant with the inclusion of MNE-country fixed effects. I omit these fixed effects from the analysis since they remove much of the interesting variation in $TaxRate_{c,t}$. For example, with these fixed effects in place, the influence of countries with constant tax rates over the sample period, such as Bermuda,

3.3 Profit Shifting Result is Robust

In Table 3 I present estimates exploring the robustness of the baseline profit shifting result. The baseline dependent variable uses wages in the denominator. The appeal of this variable is that it is relatively unlikely to be influenced by tax planning itself, particularly in comparison with an alternative such as assets. Like those for labor, location decisions for property, plant, and equipment are likely subject to numerous economically substantive considerations. As a result, it is also relatively unlikely to be influenced by tax planning and consequently may serve as an alternative denominator in the calculation of the dependent variable. Hence in column 1 I use $\frac{TaxableIncome_{i,c,t}}{NetPPE_{i,c,t}}$ as the dependent variable. $NetPPE_{i,c,t}$ is net property, plant, and equipment. The point estimate remains negative and is statistically significant at the 1 percent level.

As I describe in Section 1, CTB facilitated a particular type of profit shifting, namely that accomplished through the use of royalty payments and license fees associated with intellectual property. Hence after CTB, firms may have shifted intellectual property to low tax jurisdictions, allowing the associated income to accrue there. To explore this possibility, in column 2 I replace the numerator of the baseline dependent variable with a measure of intellectual property, $IP_{i,c,t}$. Following Branstetter, Fisman, and Foley (2006), I proxy intellectual property with royalty payments and license fees made to a parent company from its foreign subsidiaries. The point estimate is negative and again remains statistically significant at the 1% level. Firms indeed appear to shift intellectual property across their foreign operations toward relatively low tax jurisdictions after CTB.

The dependent variable in the baseline profit shifting specification is a ratio, $\frac{TaxableIncome_{i,c,t}}{Wages_{i,c,t}}$. Although the denominator, $Wages_{i,c,t}$, was selected due to its relative insensitivity to tax planning, the negative association of $\frac{TaxableIncome_{i,c,t}}{Wages_{i,c,t}}$ with tax rates could in principle result from variation in the numerator, the denominator, or both. To explore this possibility, I set the denominator equal to its average value in the 3 years prior to CTB, 1994-1996. I present the results in column 3. The association with tax rates after CTB remains negative and is statistically significant at the 1% level. This suggests variation in $TaxableIncome_{i,c,t}$ indeed drives the baseline profit shifting result.

Another potential concern may be that firms are responding to the introduction of patent

would not enter into the estimation of β_1. For further discussion of the role of fixed effects in studies of profit shifting activity using panel data, see Dharmapala (2014) and Clausing (2016).

boxes instead of the implementation of CTB. In general, when a country introduces a patent box, a company's income derived from patents in that country is taxed at a rate below the country's standard corporate income tax rate. To explore the role of patent boxes in firms' profit shifting activity, I rely on patent box enactment data from PwC (2015). I include an indicator variable for the presence of a patent box, $PatentBox_{c,t}$, in the baseline specification and present the results in column 4. I find that a patent box is indeed positively associated with $\frac{TaxableIncome_{i,c,t}}{Wages_{i,c,t}}$, although the point estimate is neither statistically nor economically significant. $\hat{\beta}$ remains statistically significant at the 1% level and is comparable in magnitude to the baseline point estimate. The change in the sensitivity of taxable income to tax rates after CTB does not appear attributable to the introduction of patent boxes.

Congressional testimony and practitioner accounts suggest that after CTB U.S. multinationals disregarded the availability of local factors of production and shifted profits to countries with robust legal systems and very low corporate income tax rates (Darby and Lemaster, 2007; Kleinbard, 2011; United States Senate Permanent Subcommittee on Investigations, 2012). Tax havens such as Ireland and Bermuda closely capture these qualities. Hines Jr. (2010) compiles a comprehensive list of tax haven countries, and designates a subset of geographically very small countries as "dot" tax havens. On average, dot tax havens have tax rates even lower than the full set of tax havens. For example, Bermuda is a dot tax haven and has a corporate income tax rate of 0% while Ireland falls only under the broader definition of tax havens and has a corporate income tax rate of 12.5%. I denote the full set of tax haven countries with the indicator variable $Haven_c$ and dot tax havens with the indicator variable $DotHaven_c$. As a final robustness check I explore whether taxable income indeed rose in these countries after CTB.[28] The results are contained in columns 5 and 6. After CTB, tax haven countries exhibit a roughly 1.14 increase in $\frac{TaxableIncome_{i,c,t}}{Wages_{i,c,t}}$. This point estimate is statistically significant at the 1% level. For dot tax havens, the effect is roughly 5 times stronger in economic terms, with a 5.19 increase in the same ratio.[29] This point estimate is also statistically significant. In summary, the results in Table 3 suggest the increased sensitivity of taxable income to taxes after CTB is robust.

[28] In recent work on the importance of tax havens in profit shifting activity, Suárez Serrato (2018) highlights the role of Puerto Rico – a U.S. territory often regarded as a tax haven – as a destination of corporate profits.

[29] The calculation is $\frac{5.19}{1.14} \approx 5$.

4 Innovative Activity Rises

As described in Section 1, after CTB U.S. multinationals faced reduced restrictions on their tax planning activities abroad, particularly those related to their IP-generated income. As documented in Section 3, firms became more sensitive to taxes in the allocation of their taxable income post-CTB. By shifting foreign income to lower tax jurisdictions, the after-tax return to projects generating that income increased, providing firms the incentive to pursue marginal projects previously forgone. This line of reasoning suggests the hypothesis that, post-CTB, firms may undertake more projects that produce intellectual property. I test this hypothesis by examining firms' R&D and patenting activities.

In this Section I first discuss possible endogeneity concerns, describe my approach to addressing them, and present the baseline results in the process. Then I consider robustness checks and alternative measures of innovation. Finally, I include further analyses of innovation on the intensive and extensive margins, the geography of the innovation spillovers, and a falsification test.

4.1 R&D Intensity Increased

4.1.1 Measuring the Benefits of CTB and Identification Strategy

CTB impacted all firms subject to taxation by the United States, including all U.S. multinationals and their foreign subsidiaries. As a result, throughout the innovation analysis I rely on heterogeneity in the degree to which firms benefited from CTB. I capture the extent to which firms benefited from CTB in a variable I denote $TaxDrop_i$. I measure $TaxDrop_i$ by first calculating a firm's foreign taxable income-weighted average tax rate during 1994-1996 and 2002-2004. The 2002-2004 average is then subtracted from the 1994-1996 average. (As discussed in Section 4.2, the innovation results are robust to alternative definitions of $TaxDrop_i$.) The idea is that the more taxable income a firm was able to shift from high tax to low tax jurisdictions after CTB, the more it benefited from the shock. Hence the measurement of the degree to which firms benefited from CTB is closely linked to the analysis on profit shifting contained in Section 3.

A potential concern inherent in this approach is that the calculation of $TaxDrop_i$ relies on where firms *chose* to locate their taxable income. There are two aspects to this concern. First, $TaxDrop_i$ may correlate with firm characteristics that in turn relate to innovative activity. If

present, this endogeneity would preclude a causal interpretation of the estimated association between $TaxDrop_i$ and firms' innovative activity. Moreover, controls and fixed effects may only partially capture this potentially confounding variation. Second, it raises the prospect of reverse causality. Firms that increase their innovative activity after CTB may also report more of their foreign taxable income in low tax jurisdictions.[30]

To address these potential issues, I rely on an instrumental variables regression strategy. I instrument $TaxDrop_i$ with firms' pre-CTB foreign average tax rate, as weighted by their labor costs. The intuition behind this identification strategy can be illustrated as follows. Prior to CTB, U.S. multinationals had an incentive to locate the income associated with their intellectual property in countries where they also had real economic operations, as described in Section 1. Each firm optimally located its foreign operations subject to a broad set of considerations. For example, a luxury goods firm requiring a workforce with expertise in fashion design may establish operations in Italy. Similarly, a manufacturing firm requiring a workforce with engineering expertise may establish operations in Germany. Because Italy and Germany had different tax rates prior to CTB, and because these firms had an incentive to realize their IP-generated taxable income in the countries where they had real operations, these firms' IP-generated taxable income faced different tax rates prior to CTB. After CTB was implemented, both of these firms could shift their IP-generated taxable income to Bermuda (or any other country), reducing the tax rate on this income. Hence the reduction in each firm's foreign tax burden – $TaxDrop_i$ – is related to its pre-CTB foreign tax rate. Moreover, estimates obtained through this approach are generated only through variation in firms' pre-CTB tax exposures, addressing reverse causality concerns. Finally, identification is obtained through variation in the location of each firm's foreign labor force, which is constrained by substantive economic considerations.

4.1.2 First Stage Results Indicate Instrument Is Strong

Specifically, I obtain fitted values of $TaxDrop_{i,t}$ by estimating the following specification.

$$TaxDrop_i = \beta_2 \times TaxRate_i^{9496Wages} + \gamma' X_{i,t} + \varepsilon_{i,t} \tag{2}$$

[30] Indeed, as described in Section 4.2, I find that the ordinary least squares estimate of the hypothesized positive relation between $TaxDrop_{i,t}$ and firms' innovative activity appears to be biased downward.

The unit of observation is the parent-year. As before, i and t index parent companies and years and each variable is winsorized at the 1st and 99th percentiles of its empirical distribution to mitigate the influence of outliers. $TaxDrop_i$ is calculated according to the description in Section 4.1.1. $TaxRate_i^{9496Wages}$ is the average tax rate faced by a parent company's foreign subsidiaries from 1994-1996, the 3 years preceding CTB, as weighted by the subsidiaries' employee compensation. The controls, $X_{i,t}$, are the natural logarithm of 1 plus $Assets_{i,t}$ and the natural logarithm of 1 plus $Age_{i,t}$. $Assets_{i,t}$ is total assets. $Age_{i,t}$ is the number of years since the parent company first appears in the data. Standard errors are clustered by parent company. $\varepsilon_{i,t}$ is the usual error term.

I present the estimates in Table 4. The estimated value of β_2 is positive, as expected; the higher the pre-CTB taxable income-weighted average foreign tax rate the further it has to fall, and pre-CTB taxable income- and wage-weighted average foreign tax rates are positively related. In economic terms, a 1 percentage point higher value of $TaxRate_i^{9496Wages}$ is associated with a 58 basis point higher value of $TaxDrop_i$. Moreover, this association is statistically significant at the 1 percent level. The inclusion of control variables does not alter the results.

For $TaxRate_i^{9496Wages}$ to be a valid instrument for $TaxDrop_i$, two conditions must be satisfied. First, the instrument must satisfy the relevance condition, which requires that $TaxDrop_i$ and $TaxRate_i^{9496Wages}$ be strongly statistically related. With a t-statistic greater than 5, this condition is satisfied.[31] Second, the instrument must satisfy the exclusion restriction. The exclusion restriction requires that $TaxRate_i^{9496Wages}$ relate to the second stage dependent variable – measures of innovative activity such as R&D – only by way of $TaxDrop_i$. It is not possible to formally test the exclusion restriction. However, results from a falsification test – discussed in Section 4.6 – are consistent with the notion that this condition is satisfied.

Since I am focused on the association between $TaxDrop_i$ and the innovation response after CTB, in the second stage analyses I will use fitted values of $TaxDrop_i \times PolicyShock_t$ as the independent variable. The instrument will therefore change in parallel, to $TaxRate_i^{9496Wages} \times PolicyShock_t$. Since the impact of CTB on multinational firms was unanticipated, the interaction does not introduce endogeneity. The inclusion of stand-alone lower order terms (i.e. $PolicyShock_t$) is dictated by the fixed effects.

[31] First stage F-statistics are included and discussed below.

4.1.3 Second Stage and Baseline Innovation Results

I now proceed to the baseline instrumented relationship between tax relief due to CTB and innovation. Specifically, I estimate the following second stage regression.

$$RDIntensity_{i,t} = \beta_3 \times \left(TaxDrop_i \times \widehat{PolicyShock_t}\right) + \alpha_i + \alpha_t + \gamma' X_{i,t} + \varepsilon_{i,t} \tag{3}$$

The subscripts and controls are the same as in equation 2. The dependent variable, $RDIntensity_{i,t}$, is measured as the ratio of $RD_{i,t}$ to $Sales_{i,t}$, following Aboody and Lev (2000). (As discussed in Section 4.2, the results are robust to alternative measures of the dependent variable.)
$TaxDrop_i \times \widehat{PolicyShock_t}$ represents the fitted values from the first stage regression. α_i and α_t are parent and year fixed effects. The inclusion of fixed effects serves to circumscribe the control group, mitigating potentially confounding sources of variation difficult to fully capture with control variables. Standard errors are clustered by parent company. β_3 is the coefficient of interest.

I focus on R&D intensity at the parent companies (i.e. in the U.S.) for three reasons. First, as noted in Section 2.3, U.S. multinationals perform almost all of their R&D in the U.S. Second, R&D expenses are generally deductible from revenues in the calculation of taxable income, providing firms an incentive to perform this activity in a high tax jurisdiction such as the U.S. Third, there is no country-level prediction for where this activity should take place abroad. It need not, for example, take place in the countries to which firms also shift their taxable income. And, as an empirical matter, I find no relation between a firm's tax reduction associated with CTB and its R&D intensity abroad, either at the MNE-country level or on a consolidated foreign basis.

I present the estimates in Table 5. Column 1, which omits fixed effects and control variables, indicates that there is a positive association between a parent's tax reduction and its R&D intensity following CTB, as hypothesized. The point estimate suggests a one percentage point larger reduction in a firm's foreign tax rate is associated with a 16 basis point higher post-CTB R&D intensity. It is statistically significant at the 5% level.

Without fixed effects, I include both $TaxDrop_i \times PolicyShock_t$ and $TaxDrop_i$ as endogenous regressors, and instrument them with $TaxRate_i^{9496Wages} \times PolicyShock_t$ and $TaxRate_i^{9496Wages}$. The Angrist and Pischke (2009) first stage F-statistics for $TaxRate_i^{9496Wages} \times PolicyShock_t$ and

$TaxDrop_i$ are 26.88 and 40.55, respectively, indicating the instruments are strong. The Cragg-Donald statistic testing the joint strength of the instruments, at 227.49, also indicates they are strong. In column 2 I include the controls. The estimates are virtually unchanged.

In column 3 I again omit the controls but include parent and year fixed effects. The point estimate is again positive and statistical significance remains at the 5% level. Relative to columns 1 and 2, the magnitude of the point estimate is somewhat reduced. The parent company fixed effects are collinear with $TaxDrop_i$, leaving only $TaxDrop_i \times PolicyShock_t$. Hence I rely on only one instrument, $TaxRate_i^{9496Wages} \times PolicyShock_t$. The first stage F-statistic is 33.96, exceeding the conventional threshold of 10 for a strong instrument provided in Staiger and Stock (1997).

Column 4 includes both the controls and the parent and year fixed effects, which I take as the baseline R&D intensity specification. The estimates are virtually unchanged relative to column 3. In particular, the point estimate is significant at the 5% level (p-value: 0.015) and the first stage F-statistic exceeds 10. A 1 standard deviation larger $TaxDrop_i$ is associated with a 0.19 standard deviation increase in $RDIntensity_{i,t}$, indicating the effect is economically substantial.[32]

The responsiveness of R&D to tax incentives is typically studied in the context of R&D tax credits. Since the magnitude of the tax benefit is commensurate with the amount of R&D reported by the firm, R&D tax credits provide firms the incentive to overstate the amount of R&D they perform. Hence, while there is a consensus that R&D tax credits and reported R&D are positively associated, there is an ongoing debate regarding the portion of the reported R&D response that reflects genuine R&D activity versus "relabeling" (Hall and Van Reenen, 2000; Chen, Liu, Serrato, and Xu, 2017). In contrast, CTB provided a tax incentive for firms to increase, but not misreport, their R&D expenditures. In this sense, the elasticity of R&D with respect to taxes in the context of CTB isolates the real component from the relabeling component of the responsiveness of R&D to tax policy. The current setting suggests a \$1 reduction in a firm's foreign tax bill corresponds to a \$1.10 increase in R&D expenditures.[33] While this figure should be interpreted as suggestive, it is toward the high end of the range of the response of reported R&D (i.e. the sum of real R&D

[32]The calculation is $0.10 \cdot 0.17 = 0.017$ and $\frac{0.017}{0.09} \approx 0.19$.

[33]Aggregate foreign taxable income averages \$332 million. Hence a 1% $TaxDrop_i$ increases the average firm's net income by \$3.3 million, assuming this has no impact on the firm's U.S. tax payments. A 1% $TaxDrop_i$ is associated with a 0.001 increase in $RDIntensity_{i,t}$. This translates into a \$4.4 million increase in R&D expenditures ($0.001 \cdot 4425.79 \approx 4.4$). Hence a \$1 reduction in a firm's foreign tax bill corresponds to a \$1.10 increase in R&D expenditures ($\frac{4.4}{3.3} = 1.1$).

and relabeling) to taxes found in the existing literature (Bloom, Griffith, and Van Reenen, 2002). Multinational firms' innovation policies may be particularly tax sensitive or they may engage in relatively little relabeling activity.

4.2 Innovation Result is Robust

In Table 6 I present estimates exploring the robustness of the baseline R&D results contained in column 4 of Table 5.

Since $RDIntensity_{i,t}$ is a fraction, I confirm it is indeed variation in the numerator, $RD_{i,t}$, and not the denominator, $Sales_{i,t}$, that underpins its association with the independent variable. Paralleling the robustness check in Section 3.3, I replace the denominator with its average value over the 3 years preceding CTB, 1994-1996. I present the results using this alternative dependent variable, $RDIntensity_{i,t}^{Sales9496}$, in column 1. The point estimate remains positive and statistically significant. The first stage F-statistic, at 34.23, indicates the instrument remains strong. This suggests variation in $Sales_{i,t}$ does not drive the baseline innovation result.

In column 2 I check whether the increase in R&D intensity is associated with a parent company's exposure to a patent box. Here $PatentBox_{i,t}$ is an indicator variable that equals 1 if a parent company has a foreign subsidiary in a country with a patent box in place. The coefficient on $PatentBox_{i,t}$ is neither statistically nor economically significant. The point estimate associated with $TaxDrop_i \times \widehat{PolicyShock_t}$ remains statistically significant at the 5% level and is virtually unchanged. Patent boxes do not appear to confound the innovation analysis.

In column 3 I consider whether the baseline result is sensitive to the windows for which the tax reduction is calculated. Specifically, I change the independent variable to be $TaxDrop_i^{0002} \widehat{\times} PolicyShock_t$. Here, the measurement of $TaxDrop_i^{0002}$ is analogous to the measurement of $TaxDrop_i$, except the 2000-2002 average (instead of the 2002-2004 average) is calculated and then subtracted from the 1994-1996 average. The point estimate remains positive, statistically significant at the 5% level, and is similar in magnitude to the baseline point estimate.

In column 4, I use an $IP_{i,c,t}$-weighted average foreign tax rate instead of a $TaxableIncome_{i,c,t}$-weighted average foreign tax rate to calculate $TaxDrop_i$. Due to the relatively restricted availability of the $IP_{i,c,t}$ data, the sample size is substantially reduced. The point estimate remains statistically significant however, and is somewhat larger in magnitude relative to the baseline.

In column 5, I estimate the reduced form version of equation 3. That is, I rely directly on the instrument, $TaxRate_i^{9496Wages}$, not fitted values from the first stage regression. The point estimate is again positive, and is statistically significant at the 1% level. Its magnitude is somewhat reduced, to 0.06. This is expected, as the first stage coefficient on the instrument is positive but less than 1.

In column 6 I estimate the uninstrumented analog of equation 3. The coefficient on $TaxDrop_i \times PolicyShock_t$, although statistically significant, is reduced in magnitude. While the precise source of this bias is difficult to identify with certainty, one plausible explanation is as follows. It is possible that U.S. multinationals coincidentally planning to increase their R&D may have developed more sophisticated tax planning strategies in anticipation of the associated increase in IP income, thereby allowing them to shift more of their income to low tax countries prior to CTB. In this scenario, low pre-CTB taxable income-weighted foreign average tax rates would be associated with high values of post-CTB R&D, biasing the ordinary least squares point estimate downward. This bias would be eliminated by instrumenting $TaxDrop_i$ with the pre-CTB average foreign tax rate weighted by wages, as in the baseline specification.

Overall, the results in Table 6 suggest the positive association between $TaxDrop_i \times \widehat{PolicyShock}_t$ and $RDIntensity_{i,t}$ is robust.

4.3 Innovation on the Intensive and Extensive Margins

The baseline innovation result does not distinguish between effects on the intensive and extensive margins. It may, for example, reflect either the initiation of R&D programs by firms that previously had none or the expansion of firms' existing R&D programs. This distinction is noteworthy given the recent trend among public U.S. companies of ending their R&D operations, as seen in the dashed line in Figure 3. In contrast, the fraction of U.S. multinationals that perform R&D has remained relatively stable in recent years. In Table 7 I explore the effects of CTB on the intensive and extensive margins of R&D activity separately.

I begin with the intensive margin by reestimating the baseline specification and limiting the sample to parents that performed R&D during 1994-1996, the 3 years prior to CTB. As seen in column 1 of Table 7, I find that firms already performing R&D increase their R&D intensity. The point estimate is statistically significant and of the same magnitude as that in the baseline

specification. In column 2 I restrict the sample to parents that did not perform R&D during 1994-1996. For these firms, I find no effect on R&D intensity in either economic or statistical terms. This result indicates that if a firm did not perform R&D before CTB, the intensity with which it performed R&D after CTB is unrelated to $TaxDrop_i$.

I consider the extensive margin in columns 3 and 4. I estimate a linear probability model using ordinary least squares (Angrist and Pischke, 2009). The dependent variable is $\mathbb{1}_{i,t}^{RD}$, an indicator variable that equals 1 if a parent reports positive R&D expenditures. In column 3, as in column 1, I restrict the sample to parents that performed R&D during 1994-1996. I find that treatment is positively associated with parents continuing to perform R&D. The point estimate is positive and statistically significant at the 5% level. In economic terms, a 1 standard deviation larger $TaxDrop_i$ is associated with a 14% increase in the likelihood a parent company undertakes R&D after CTB, conditional on having undertaken R&D in the 3 years prior to CTB.[34] In column 4 I consider whether CTB relates to a parent company's decision to initiate R&D activities. I rerun the same specification as in column 3, but instead limit the sample to parent companies that did not perform R&D during 1994-1996, as in column 2. The coefficient on $TaxDrop_i \times \widehat{PolicyShock}_t$ is not statistically significant and is roughly a sixth of the magnitude of the coefficient in column 3.[35]

In combination, the results in Table 7 suggest CTB was particularly important in supporting the existing R&D activities of U.S. multinationals. In this sense, foreign tax arbitrage appears to be working against the recent general trend of firms eliminating their R&D programs.

4.4 Alternative Measures of Innovation: Patents and Citations

In Table 8 I further explore the robustness of the baseline R&D result by considering two additional measures of innovative activity, namely patent applications and patent citations. The latter reflects whether a firm's patents are used in the research or development of other ideas and helps in evaluating whether a firm's patents genuinely advance the technological frontier. I obtain patent and citation data from PATSTAT, a dataset assembled by the European Patent Office. PATSTAT incorporates data from patent authorities worldwide, including the U.S. Patent

[34] The calculation is $0.17 \cdot 0.81 \approx 0.14$.
[35] The calculation is $\frac{0.14}{0.81} \approx 0.17$.

and Trademark Office. I manually match parent companies in BEA's data to PATSTAT patent assignees by name.

In column 1, I replace the dependent variable in the baseline specification with the natural logarithm of 1 plus the number of patent applications submitted worldwide by a firm. I use a worldwide measure since the same innovation generated in the U.S. can be patented in both the U.S. and other countries. (I consider the geographic composition of firms' patenting activity in Table 9.) I find that $TaxDrop_i \times \widehat{PolicyShock_t}$ is positively related to patenting activity. A 1 standard deviation larger tax drop is associated with a roughly 28% increase in patent applications.[36] The result is statistically significant at the 10% level.

In column 2 the dependent variable is the natural logarithm of 1 plus the number of citations a parent company's patents receive in the current and 3 subsequent years. The point estimate is again positive. Statistical significance rises to the 5% level. It is also stronger in economic terms; a 1 standard deviation larger tax drop is associated with a roughly 42% increase in patent citations.[37]

Together, these results indicate that in broad terms innovative activity increased at firms benefiting from CTB.

4.5 The Geography of Innovation Spillovers

The results in Table 8 can be interpreted as suggesting CTB prompted an increase in patenting activity, and that these patents prompted further innovation, as reflected in their citation by other patents. A natural question is whether these innovation spillovers accrue primarily to the U.S. or to other countries. I explore this issue in Table 9 by relying on geographic decompositions of global patenting activity recorded in the PATSTAT data.

In columns 1 and 2 I focus on patenting itself. In column 1 the dependent variable is the natural logarithm of 1 plus the number of patent applications a firm submits to the U.S. Patent and Trademark Office, while in column 2 it is the natural logarithm of 1 plus the number of patent applications a firm submits to foreign patent authorities. I find that both are positively related to $TaxDrop_i \times \widehat{PolicyShock_t}$, and both are statistically significant. Economically, the effect on U.S. patenting is stronger by roughly 19%.[38] Much of the increase in patenting activity appears directed

[36] The calculation is $0.17 \cdot 1.63 \approx 0.28$.
[37] The calculation is $0.17 \cdot 2.48 \approx 0.42$.
[38] The calculation is $\frac{1.41}{1.18} \approx 1.19$.

toward innovation for the U.S. market.

In columns 3 and 4 I consider the geographic distribution of the patents that cite a firm's patent applications. In column 3 the dependent variable is the natural logarithm of 1 plus the number of citations of a firm's patents in the current and 3 subsequent years by U.S. patents. In column 4 the dependent variable is analogously constructed, but for citations by foreign patents. $TaxDrop_i \times \widehat{PolicyShock}_t$ is much more strongly related to the former than the latter, although in both cases the association is positive. The relation between $TaxDrop_i \times \widehat{PolicyShock}_t$ and U.S. citations is statistically significant at the 5% level. In contrast, for citations by foreign patents, the association is not statistically significant at any conventional threshold. In economic terms, the effect for U.S. citations is nearly 3 times stronger than that for foreign citations.[39] The innovation spillovers associated with CTB appear to accrue largely in the U.S.

The innovation spurred by CTB appears to be high quality from the U.S. perspective, but not particularly different from previous innovation from the foreign perspective. Overall, the results in Table 9 suggest that the technological progress associated with CTB was realized largely within the U.S.

4.6 Falsification Test: Types of R&D

Businesses typically perform R&D for themselves. However, since some R&D projects are short term, and maintaining a research staff and the necessary facilities is expensive, some organizations complete certain projects by contracting with firms that have established R&D programs. For example, government entities may contract R&D out to firms. For 1994, 1999, 2004, and 2009, BEA's R&D expenditures data are available for R&D performed for a parent company's own account, as well as that performed for the Federal Government. Tax incentives may be expected to impact the former but are plausibly unrelated to the latter.

An alternative explanation for the increase in R&D activities undertaken by parent companies consistent with the results presented so far is that firms with large values of $TaxDrop_i \times \widehat{PolicyShock}_t$ experienced a shock coincident with CTB that increased the efficiency with which they performed R&D. A shock of this nature may be expected to lead to an increase in R&D expenditures both on behalf of a parent company's own account and on behalf of other

[39] The calculation is $\frac{2.37}{0.83} \approx 2.9$.

groups, such as the Federal Government. I investigate this alternative explanation by modifying the dependent variable in specification 3. I replace the numerator, (total) R&D expenditures, with R&D expenditures for the parent's own account ($RD_{i,t}^{Self}$) and R&D expenditures on behalf of the Federal Government ($RD_{i,t}^{Gov}$).

I present the estimates in Table 10. The point estimate in column 1, corresponding to expenditures on R&D performed for a parent company's own account, is very similar to the baseline estimate. Despite a reduction in the sample size by more than a factor of 4, the estimate is also statistically significant. In contrast, the point estimate in column 2, representing the effect of CTB on R&D expenditures linked to the Federal Government, is indistinguishable from zero in both economic and statistical terms.

Of course, R&D performed for the government and for businesses may not be perfectly comparable. Subject to this caution however, the estimates provide suggestive evidence supporting the paper's core message on innovation. Specifically, a shock correlated with firms' values of $TaxDrop_i \times \widehat{PolicyShock_t}$ and coincident with CTB that lowered the cost of undertaking domestic R&D in general does not appear to underpin the innovation results.

5 Conclusion

The central message of this paper is that policies regulating firms' profit shifting may have a significant impact on their innovation. When firms shift taxable income – particularly the highly mobile taxable income associated with IP – to lower tax jurisdictions, the after-tax return to generating IP increases. As a result, firms have an incentive to create new IP through innovation.

I use the U.S. Treasury's unexpected 1997 "Check-the-Box" policy decision as a shock to firms' profit shifting activities. I present evidence that after 1997, U.S. multinationals became significantly more sensitive to taxes in where they located their taxable income and intellectual property. I find a positive association between the degree to which U.S. multinationals benefited from CTB and their innovative activities in the U.S. Specifically, I document increases in R&D, patent applications, and patent citations. Moreover, the spillovers associated with this innovation also accrued primarily in the U.S.

Tax arbitrage is often associated with its "dark sides," such as the dissipation of resources in

the process of minimizing firms' tax payments. The results in this paper suggest a "bright side." Tax avoidance with the highly mobile income associated with intellectual property appears to support innovative activity.

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Figure 1: Multinational Firms Perform Almost All U.S. Business R&D

In this figure I present the share of U.S. business R&D performed by the parent companies of U.S. multinational firms. The data are from Moris (2012) and Moris (2016).

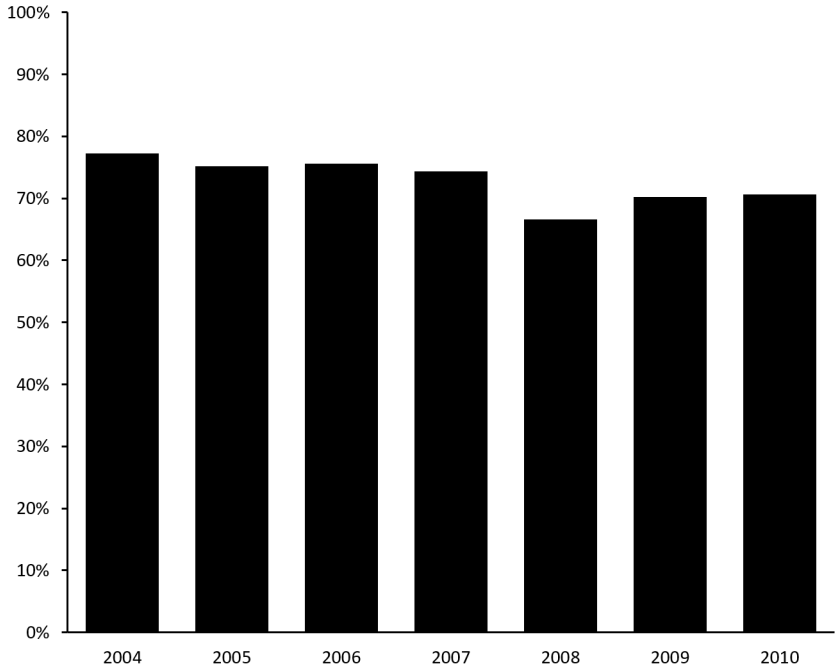
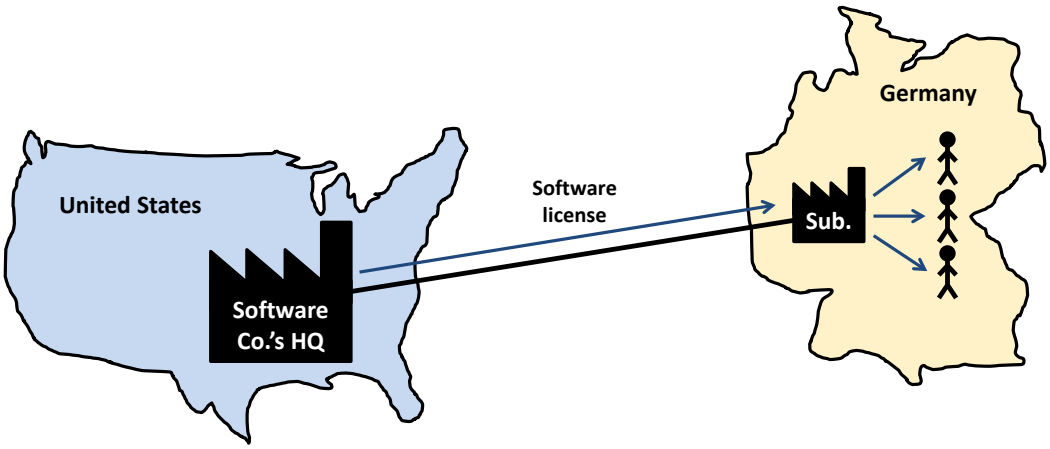


Figure 2: Illustration of the Policy Shock

In this figure I illustrate the role of the Check-the-Box policy shock in U.S. international taxation. The discussion of the figure is contained Section 1.

(a) Multinational Structure Before the Policy Shock



(b) Multinational Structure After the Policy Shock

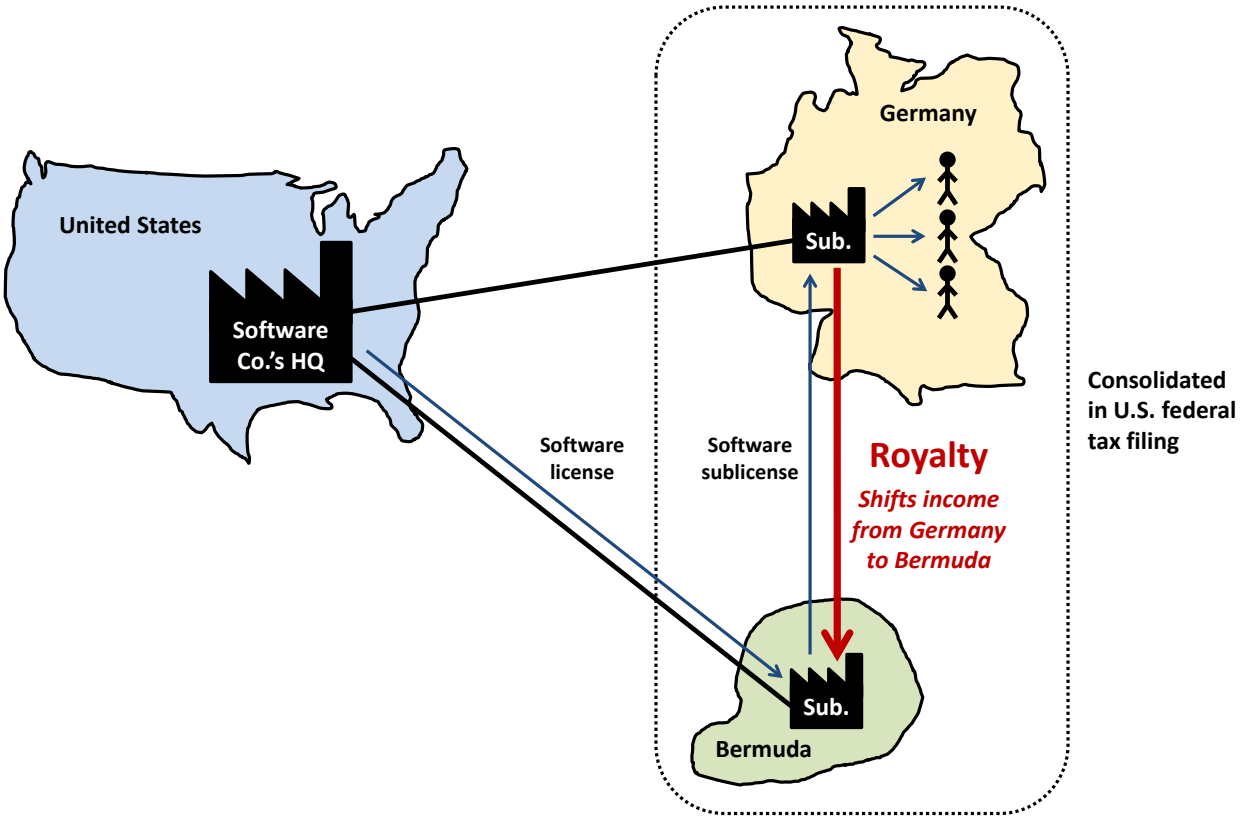


Figure 3: Proportion of BEA and Compustat Firms Performing R&D

In this figure I present the proportion of BEA and Compustat firms that report positive R&D by year. Sample BEA firms are represented by the solid line and are plotted against the left axis. Compustat firms are represented by the dashed line and plotted against the right axis.

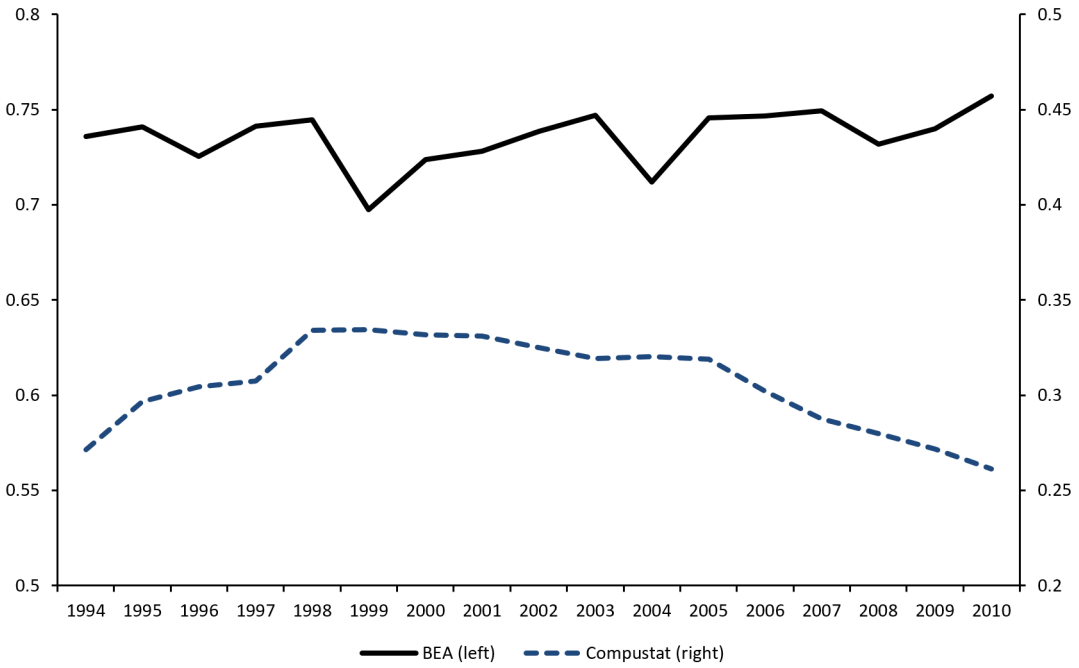


Table 1: Summary Statistics

In this table I present summary statistics on the U.S. parent companies and their foreign operations that comprise the sample. Observations in Panel A reflect aggregations of foreign subsidiary-year level data for each MNE to the country-year level. $Assets_{i,c,t}$ is total assets. $Age_{i,c,t}$ is the average number of years since subsidiaries of MNE i first appear in country c, as weighted by the subsidiaries' total assets. $TaxRate_{c,t}$ is the statutory tax rate recorded as a decimal. $TaxableIncome_{i,c,t}$ is the sum of net income and taxes paid. $Wages_{i,c,t}$ is employee compensation. $IP_{i,c,t}$ (in the numerator of $\frac{IP_{i,c,t}}{Wages_{i,c,t}}$) is royalty payments to a parent company from its foreign subsidiaries, following Branstetter, Fisman, and Foley (2006). Observations in Panel B are at the parent-year level. As before, $Assets_{i,t}$ is total assets. $Age_{i,t}$ is the number of years since the parent company first appears in the data. $TaxDrop_{i,t}$ is measured by first calculating a firm's foreign taxable income-weighted average tax rate over 1994-1996 and 2002-2004. The 2002-2004 average is then subtracted from the 1994-1996 average. $RD_{i,t}$ is R&D expenditures. $RD_{i,t}^{Self}$ is R&D expenditures undertaken for a parent company's own account. $RD_{i,t}^{Gov}$ is R&D expenditures undertaken on behalf of the Federal Government. $Sales_{i,t}$ is sales. $RDIntensity_{i,t}$ is the ratio of $RD_{i,t}$ to $Sales_{i,t}$. $Patents_{i,t}$ is the number of patent applications. $TotCites_{i,t}$ is the total number of citations of a parent company's patents in the current and three subsequent years. $AvgCites_{i,t}$ is the average number of citations per patent of a parent company's patents in the current and three subsequent years. All financial figures are adjusted for inflation using the GDP deflator and recorded in millions of 2009 U.S. dollars. Each variable has been winsorized at the 1% and 99% thresholds of its empirical distribution to mitigate the influence of outliers.

Panel A: MNE-country-year level observations			
	Observations	Mean	Std. dev.
$Assets_{i,c,t}$	84,383	545.05	1,690.45
$Age_{i,c,t}$	84,383	9.81	6.67
$TaxRate_{c,t}$	84,383	0.30	0.08
$TaxableIncome_{i,c,t}$	84,383	40.75	148.25
$Wages_{i,c,t}$	84,383	38.50	75.45
$\frac{TaxableIncome_{i,c,t}}{Wages_{i,c,t}}$	84,383	1.96	7.45
$\frac{IP_{i,c,t}}{Wages_{i,c,t}}$	71,101	0.08	0.27
Panel B: Parent-year level observations			
	Observations	Mean	Std. dev.
$Assets_{i,t}$	12,229	6,390.26	14,681.51
$Age_{i,t}$	12,229	15.13	6.77
$TaxDrop_{i,t}$	12,229	0.04	0.17
$RD_{i,t}$	12,229	152.93	506.69
$RD_{i,t}^{Self}$	2,888	119.92	382.08
$RD_{i,t}^{Gov}$	2,888	4.85	35.56
$Sales_{i,t}$	12,229	4,425.79	9,940.93
$RDIntensity_{i,t}$	12,229	0.05	0.09
$Patents_{i,t}$	12,229	17.35	63.15
$TotCites_{i,t}$	12,229	41.31	165.36
$AvgCites_{i,t}$	12,229	0.76	1.88

Table 2: Profit Shifting Increased After the Policy Shock

In this table I present estimates of the association between foreign taxes and the location of U.S. multinational firms' foreign taxable income. Observations reflect aggregations of foreign subsidiary-year level data for each MNE to the country-year level. The dependent variable is the ratio of $TaxableIncome_{i,c,t}$ to $Wages_{i,c,t}$. $TaxableIncome_{i,c,t}$ is the sum of net income and taxes paid. $Wages_{i,c,t}$ is employee compensation. $PolicyShock_t$ is an indicator variable that equals one starting in 1997, the year the Check-the-Box policy went into effect. $TaxRate_{c,t}$ is the statutory tax rate. Controls are the natural logarithm of 1 plus $Assets_{i,c,t}$ and the natural logarithm of 1 plus $Age_{i,c,t}$. $Assets_{i,c,t}$ is total assets. $Age_{i,c,t}$ is the average number of years since subsidiaries of MNE i first appear in country c, as weighted by the subsidiaries' total assets. I take the estimates in column 4 as the baseline profit shifting results. Standard errors clustered by MNE-country are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	$\frac{TaxableIncome_{i,c,t}}{Wages_{i,c,t}}$			
	(1)	(2)	(3)	(4)
$PolicyShock_t \times TaxRate_{c,t}$	-10.99***	-8.36***	-10.48***	-8.64***
	(1.71)	(1.58)	(1.83)	(1.70)
$TaxRate_{c,t}$	-2.77***	-3.91***	-2.86***	-3.91***
	(1.04)	(1.01)	(1.05)	(1.01)
$PolicyShock_t$	3.81***	2.65***		
	(0.54)	(0.50)		
Controls	No	Yes	No	Yes
Year fixed effects	No	No	Yes	Yes
R^2	0.02	0.07	0.02	0.07
Observations	84,383	84,383	84,383	84,383

Table 3: Results on Increased Profit Shifting After the Policy Shock Are Robust

In this table I present estimates exploring the robustness of the association between taxes and the location of U.S. multinational firms' foreign taxable income following the Check-the-Box policy shock. Observations reflect aggregations of foreign subsidiary-year level data for each MNE to the country-year level. All changes are relative to the baseline profit shifting results presented in column 4 of Table 2. In column 1 the dependent variable is the ratio of $TaxableIncome_{i,c,t}$ to $NetPPE_{i,c,t}$. $TaxableIncome_{i,c,t}$ is the sum of net income and taxes paid. $NetPPE_{i,c,t}$ is net property, plant, and equipment. In column 2 the dependent variable is the ratio of $IP_{i,c,t}$ to $Wages_{i,c,t}$. $IP_{i,c,t}$ is royalty payments to a parent company from its foreign subsidiaries, following Branstetter, Fisman, and Foley (2006). $Wages_{i,c,t}$ is employee compensation. In column 3 the dependent variable is the ratio of $TaxableIncome_{i,c,t}$ to $Wages^{9496}_{i,c,t}$. $Wages^{9496}_{i,c,t}$ is the average value of employee compensation over 1994-1996, the three years prior to the Check-the-Box policy shock. In columns 4 through 6 the dependent variable is the ratio of $TaxableIncome_{i,c,t}$ to $Wages_{i,c,t}$. $PolicyShock_t$ is an indicator variable that equals 1 starting in 1997, the year the Check-the-Box policy went into effect. $TaxRate_{c,t}$ is the statutory tax rate. $PatentBox_{c,t}$ is an indicator variable that equals 1 if a country has a patent box policy in place. $Haven_c$ and $DotHaven_c$ are indicator variables that equal 1 when a country is a tax haven or a "dot" (geographically very small) tax haven, following the classification in Hines Jr. and Rice (1994). Controls are the natural logarithm of 1 plus $Assets_{i,c,t}$ and the natural logarithm of 1 plus $Age_{i,c,t}$. $Assets_{i,c,t}$ is total assets. $Age_{i,c,t}$ is the average number of years since subsidiaries of MNE i first appear in country c, as weighted by the subsidiaries' total assets. Standard errors clustered by MNE-country are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	$\frac{TaxableIncome_{i,c,t}}{NetPPE_{i,c,t}}$	$\frac{IP_{i,c,t}}{Wages_{i,c,t}}$	$\frac{TaxableIncome_{i,c,t}}{Wages^{9496}_{i,c,t}}$	$\frac{TaxableIncome_{i,c,t}}{Wages_{i,c,t}}$		
	(1)	(2)	(3)	(4)	(5)	(6)
$PolicyShock_t \times TaxRate_{c,t}$	-25.74***	-0.19***	-18.32***	-8.74***		
	(5.52)	(0.06)	(3.42)	(1.71)		
$PolicyShock_t \times Haven_c$					1.14***	
					(0.40)	
$PolicyShock_t \times DotHaven_c$						5.19*
						(3.01)
$TaxRate_{c,t}$	-29.28***	-0.08*	-6.07**	-3.90***		
	(4.43)	(0.05)	(1.17)	(1.01)		
$Haven_c$					3.44***	
					(0.40)	
$DotHaven_c$						14.99***
						(3.05)
$PatentBox_{c,t}$				0.18		
				(0.20)		
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.02	0.11	0.01	0.07	0.09	0.12
Observations	83,240	67,382	57,572	84,383	84,383	84,383

Table 4: Instrument and Endogenous Regressor Are Strongly Related

In this table I present results on the association between $TaxDrop_i$, an endogenous regressor in the innovation analysis, and $TaxRate_i^{9496Wages}$, its instrument. The unit of observation is the parent company-year. $TaxDrop_i$ is measured by first calculating a firm's foreign taxable income-weighted average tax rate during 1994-1996 and 2002-2004. The 2002-2004 average is then subtracted from the 1994-1996 average. $TaxRate_i^{9496Wages}$ is the average tax rate faced by a parent company's subsidiaries from 1994-1996, the three years preceding the Check-the-Box policy shock, as weighted by the subsidiaries' employee compensation. Controls are the natural logarithm of 1 plus $Assets_{i,t}$ and the natural logarithm of 1 plus $Age_{i,t}$. $Assets_{i,t}$ is total assets. $Age_{i,t}$ is the number of years since the parent company first appears in the data. Standard errors clustered by parent company are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	$TaxDrop_i$	
	(1)	(2)
$TaxRate_i^{9496Wages}$	0.58***	0.58***
	(0.10)	(0.11)
Controls	No	Yes
R^2	0.04	0.04
Observations	12,229	12,229

Table 5: Innovation Increased at Firms Benefiting from Policy Shock

In this table I present the second stage results from the instrumental variables analysis of the association between the reduction in foreign taxes U.S. multinationals experienced following the Check-the-Box policy shock and their innovative activity. The unit of observation is the parent company-year. The dependent variable, $RDIntensity_{i,t}$, is the ratio of $RD_{i,t}$ to $Sales_{i,t}$. $RD_{i,t}$ is R&D expenditures. $Sales_{i,t}$ is sales. $TaxDrop_i \times \widehat{PolicyShock_t}$ and $\widehat{TaxDrop_i}$ take fitted values obtained from first stage regressions. $TaxDrop_i$ is measured by first calculating a firm's foreign taxable income-weighted average tax rate during 1994-1996 and 2002-2004. The 2002-2004 average is then subtracted from the 1994-1996 average. $PolicyShock_t$ is an indicator variable that equals one starting in 1997, the year the Check-the-Box policy went into effect. Controls are the natural logarithm of 1 plus $Assets_{i,t}$ and the natural logarithm of 1 plus $Age_{i,t}$. $Assets_{i,t}$ is total assets. $Age_{i,t}$ is the number of years since the parent company first appears in the data. I take the estimates in column 4 as the baseline R&D results. Standard errors clustered by parent company are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	$RDIntensity_{i,t}$			
	(1)	(2)	(3)	(4)
$TaxDrop_i \times \widehat{PolicyShock_t}$	0.16**	0.16**	0.10**	0.10**
	(0.07)	(0.07)	(0.04)	(0.04)
$\widehat{TaxDrop_i}$	0.28***	0.28***		
	(0.07)	(0.07)		
$PolicyShock_t$	0.00	0.00		
	(0.00)	(0.01)		
Controls	No	Yes	No	Yes
Fixed effects:				
Parent company	No	No	Yes	Yes
Year	No	No	Yes	Yes
Angrist-Pishke F-statistics				
$TaxRate_i^{9496Wages} \times PolicyShock_t$	26.88	26.30	33.96	34.23
$TaxRate_i^{9496Wages}$	40.55	41.45		
Cragg-Donald statistic	227.49	228.40		
Observations	12,229	12,229	12,229	12,229

Table 6: Results on Increased Innovation After the Policy Shock Are Robust

In this table I present estimates exploring the robustness of the association between the reduction in foreign taxes U.S. multinationals experienced following the Check-the-Box policy shock and their innovative activity. The unit of observation is the parent company-year. All changes are relative to the baseline innovation results presented in column 4 of Table 5. In column 1 the dependent variable, $RDIntensity_{i,t}^{Sales9496}$, is the ratio of $RD_{i,t}$ to $Sales_{i,t}^{9496}$. $RD_{i,t}$ is R&D expenditures. $Sales_{i,t}^{9496}$ is the average value of sales over 1994-1996, the three years prior to the Check-the-Box policy shock. In columns 2 through 6 the dependent variable is $RDIntensity_{i,t}$, the ratio of $RD_{i,t}$ to $Sales_{i,t}$. $Sales_{i,t}$ is sales. $TaxDrop_i \times \widehat{PolicyShock_t}$, $TaxDrop_i^{0002} \widehat{\times PolicyShock_t}$, and $TaxDrop_i^{IP} \widehat{\times PolicyShock_t}$ take fitted values obtained from first stage regressions. $TaxDrop_i$ is measured by first calculating a firm's foreign taxable income-weighted average tax rate during 1994-1996 and 2002-2004. The 2002-2004 average is then subtracted from the 1994-1996 average. $TaxDrop_i^{0002}$ is measured analogously, except the 2000-2002 average is calculated and then subtracted from the 1994-1996 average. $TaxDrop_i^{IP}$ is measured analogously with $TaxDrop_i$, except the firm's foreign tax rate exposure is weighted by $IP_{i,c,t}$ instead of taxable income. $IP_{i,c,t}$ is royalty payments to a parent company from its foreign subsidiaries, following Branstetter, Fisman, and Foley (2006). $PolicyShock_t$ is an indicator variable that equals one starting in 1997, the year the Check-the-Box policy went into effect. $TaxRate_i^{9496Wages} \times PolicyShock_t$ is the instrument for $TaxDrop_i \times PolicyShock_t$. $TaxRate_i^{9496Wages}$ is the average tax rate faced by a parent company's subsidiaries from 1994-1996, as weighted by the subsidiaries' employee compensation. $TaxDrop_i \times PolicyShock_t$ is the uninstrumented version of $TaxDrop_i \times \widehat{PolicyShock_t}$. $PatentBox_{i,t}$ is an indicator variable that equals 1 if a parent company has at least one subsidiary in a country that has a patent box policy in place. Controls are the natural logarithm of 1 plus $Assets_{i,t}$ and the natural logarithm of 1 plus $Age_{i,t}$. $Assets_{i,t}$ is total assets. $Age_{i,t}$ is the number of years since the parent company first appears in the data. Standard errors clustered by parent company are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	$RDIntensity_{i,t}^{Sales9496}$	$RDIntensity_{i,t}$				
	(1)	(2)	(3)	(4)	(5)	(6)
$TaxDrop_i \times \widehat{PolicyShock_t}$	0.29***	0.09**				
	(0.08)	(0.04)				
$TaxDrop_i^{0002} \widehat{\times PolicyShock_t}$			0.12**			
			(0.06)			
$TaxDrop_i^{IP} \widehat{\times PolicyShock_t}$				0.14*		
				(0.08)		
$TaxRate_i^{9496Wages} \times PolicyShock_t$					0.06***	
					(0.02)	
$TaxDrop_i \times PolicyShock_t$						0.01*
						(0.01)
$PatentBox_{i,t}$		0.00				
		(0.00)				
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effects:						
Parent company	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
R^2					0.78	0.78
F-statistic	34.23	34.00	15.06	26.85		
Observations	12,220	12,229	11,514	4,177	12,229	12,229

Table 7: Innovation Responses on the Intensive and Extensive Margins

In this table I present estimates on the reduction in foreign taxes U.S. multinationals experienced following the Check-the-Box policy shock and their innovative activity on the intensive and extensive margins. The unit of observation is the parent company-year. In columns 1 and 3 the sample is restricted to observations for which the parent company undertakes R&D during 1994-1996, the three years prior to the Check-the-Box policy shock. In columns 2 and 4 the sample is restricted to observations for which the parent company does not perform R&D during 1994-1996. The dependent variable in columns 1 and 2, $RDIntensity_{i,t}$, is the ratio of $RD_{i,t}$ to $Sales_{i,t}$. $RD_{i,t}$ is R&D expenditures. $Sales_{i,t}$ is sales. The dependent variable in columns 3 and 4, $\mathbb{1}_{i,t}^{RD}$, is an indicator variable that equals 1 if a parent undertakes R&D. The independent variable, $TaxDrop_i \times \widehat{PolicyShock}_t$, takes fitted values obtained from first stage regressions. $TaxDrop_i$ is measured by first calculating a firm's foreign taxable income-weighted average tax rate during 1994-1996 and 2002-2004. The 2002-2004 average is then subtracted from the 1994-1996 average. $PolicyShock_t$ is an indicator variable that equals one starting in 1997, the year the Check-the-Box policy went into effect. Controls are the natural logarithm of 1 plus $Assets_{i,t}$ and the natural logarithm of 1 plus $Age_{i,t}$. $Assets_{i,t}$ is total assets. $Age_{i,t}$ is the number of years since the parent company first appears in the data. Standard errors clustered by parent company are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	$RDIntensity_{i,t}$		$\mathbb{1}_{i,t}^{RD}$	
	(1)	(2)	(3)	(4)
$TaxDrop_i \times \widehat{PolicyShock}_t$	0.10*	0.01	0.81**	-0.14
	(0.05)	(0.01)	(0.33)	(0.42)
Controls	Yes	Yes	Yes	Yes
Fixed effects:				
Parent	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
R&D before policy shock	Yes	No	Yes	No
F-statistic	23.74	8.26	23.74	8.26
Observations	9,246	2,983	9,246	2,983

Table 8: Alternative Measures of Innovation Also Increase at Firms Benefiting from Policy Shock

In this table I present estimates on the association between the reduction in foreign taxes U.S. multinationals experienced following the Check-the-Box policy shock and alternative measures of their innovative activity. The unit of observation is the parent company-year. The dependent variable in column 1, $ln\left(Patents_{i,t}\right)$, is the natural logarithm of 1 plus the number of patent applications. The dependent variable in column 2, $ln\left(TotCites_{i,t}\right)$ is the natural logarithm of 1 plus the number of citations of a parent company's patents in the current and three subsequent years. The independent variable, $TaxDrop_i \times \widehat{PolicyShock}_t$, takes fitted values obtained from first stage regressions. $TaxDrop_i$ is measured by first calculating a firm's foreign taxable income-weighted average tax rate during 1994-1996 and 2002-2004. The 2002-2004 average is then subtracted from the 1994-1996 average. $PolicyShock_t$ is an indicator variable that equals one starting in 1997, the year the Check-the-Box policy went into effect. Controls are the natural logarithm of 1 plus $Assets_{i,t}$ and the natural logarithm of 1 plus $Age_{i,t}$. $Assets_{i,t}$ is total assets. $Age_{i,t}$ is the number of years since the parent company first appears in the data. Standard errors clustered by parent company are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	$ln\left(Patents_{i,t}\right)$	$ln\left(TotCites_{i,t}\right)$
	(1)	(2)
$TaxDrop_i \times \widehat{PolicyShock}_t$	1.63*	2.48**
	(0.88)	(1.05)
Controls	Yes	Yes
Fixed effects:		
Parent	Yes	Yes
Year	Yes	Yes
F-statistic	34.23	34.23
Observations	12,229	12,229

Table 9: Innovation Spillovers Further Benefit the U.S.

In this table I present estimates on the association between the reduction in foreign taxes U.S. multinationals experienced following the Check-the-Box policy shock and the geographic breakdown of innovative activity. The unit of observation is the parent company-year. The dependent variable in column 1, $ln\left(Patents_{i,t}^{US}\right)$ is the natural logarithm of 1 plus the number of U.S. patent applications. The dependent variable in column 2, $ln\left(Patents_{i,t}^{For}\right)$ is the natural logarithm of 1 plus the number of foreign patent applications. The dependent variable in column 3, $ln\left(TotCites_{i,t}^{US}\right)$ is the natural logarithm of 1 plus the number of citations by U.S. patents of a parent company's patents in the current and three subsequent years. The dependent variable in column 4, $ln\left(TotCites_{i,t}^{For}\right)$ is the natural logarithm of 1 plus the number of citations by foreign patents of a parent company's patents in the current and three subsequent years. The independent variable, $TaxDrop_i \times \widehat{PolicyShock}_t$, takes fitted values obtained from first stage regressions. $TaxDrop_i$ is measured by first calculating a firm's foreign taxable income-weighted average tax rate during 1994-1996 and 2002-2004. The 2002-2004 average is then subtracted from the 1994-1996 average. $PolicyShock_t$ is an indicator variable that equals one starting in 1997, the year the Check-the-Box policy went into effect. Controls are the natural logarithm of 1 plus $Assets_{i,t}$ and the natural logarithm of 1 plus $Age_{i,t}$. $Assets_{i,t}$ is total assets. $Age_{i,t}$ is the number of years since the parent company first appears in the data. Standard errors clustered by parent company are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	$ln\left(Patent_{i,t}^{US}\right)$	$ln\left(Patent_{i,t}^{For}\right)$	$ln\left(TotCites_{i,t}^{US}\right)$	$ln\left(TotCites_{i,t}^{For}\right)$
	(1)	(2)	(3)	(4)
$TaxDrop_i \times \widehat{PolicyShock}_t$	1.41*	1.18*	2.37**	0.83
	(0.76)	(0.68)	(1.03)	(0.51)
Controls	Yes	Yes	Yes	Yes
Fixed effects:				
Parent	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
F-statistic	34.23	34.23	34.23	34.23
Observations	12,229	12,229	12,229	12,229

Table 10: R&D Response by Account Type Restricts Potential Role of Confounding Shock

In this table I present estimates on the association between the reduction in foreign taxes U.S. multinationals experienced following the Check-the-Box policy shock and their R&D expenditures by account type. The unit of observation is the parent company-year. The sample is limited to the years for which data on R&D expenditures by account type are available, namely 1994, 1999, 2004, and 2009. The dependent variable in column 1, $RDIntensity_{i,t}^{Self}$, is the ratio of $RD_{i,t}^{Self}$ to $Sales_{i,t}$. $RD_{i,t}^{Self}$ is R&D expenditures undertaken for a parent company's own account. $Sales_{i,t}$ is sales. The dependent variable in column 2, $RDIntensity_{i,t}^{Gov}$, is the ratio of $RD_{i,t}^{Gov}$ to $Sales_{i,t}$. $RD_{i,t}^{Gov}$ is R&D expenditures undertaken on behalf of the Federal Government. The independent variable, $TaxDrop_i \times \widehat{PolicyShock}_t$, takes fitted values obtained from first stage regressions. $TaxDrop_i$ is measured by first calculating a firm's foreign taxable income-weighted average tax rate during 1994-1996 and 2002-2004. The 2002-2004 average is then subtracted from the 1994-1996 average. $PolicyShock_t$ is an indicator variable that equals one starting in 1997, the year the Check-the-Box policy went into effect. Controls are the natural logarithm of 1 plus $Assets_{i,t}$ and the natural logarithm of 1 plus $Age_{i,t}$. $Assets_{i,t}$ is total assets. $Age_{i,t}$ is the number of years since the parent company first appears in the data. Standard errors clustered by parent company are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	$RDIntensity_{i,t}^{Self}$	$RDIntensity_{i,t}^{Gov}$
	(1)	(2)
$TaxDrop_i \times \widehat{PolicyShock}_t$	0.09*	0.00
	(0.05)	(0.00)
Controls	Yes	Yes
Fixed effects:		
Parent	Yes	Yes
Year	Yes	Yes
F-statistic	26.29	26.29
Observations	2,888	2,888

A U.S. International Taxation

In this appendix I provide general background on how the U.S. taxes U.S. multinational firms' foreign income and the U.S. Treasury's CTB policy decision. I also discuss how firms can permanently avoid taxes on deferred income. For a concrete illustration of the incentive effects of CTB, see Section 1.

A.1 U.S. Taxation of Foreign Income

The U.S. operates a worldwide tax system. This means the income of U.S. persons, including U.S. resident multinationals, realized in foreign jurisdictions (known as "foreign source income") is subject to U.S. federal income taxation.[40]

The avoidance of double taxation has been one of the organizing principles of U.S. tax policy since the 1920s (Coates, 1924). To this end, U.S. companies receive tax credits for foreign taxes paid. Credits may not exceed a firm's tax obligation in a given year, but excess credits may be carried forward or back across several years.

A second organizing principle of U.S. tax policy is that income is subject to taxation only when recognized by the taxpayer. In the case of U.S. multinationals, this principle presents the opportunity to defer income realized by a foreign subsidiary but not remitted (for example, in the form of a dividend) to the U.S. parent. However, to limit the use of abusive tax strategies, a set of anti-deferral rules circumscribe the situations in which income is eligible for deferral.

"Subpart F" of the U.S. tax code contains some of these anti-deferral rules. Importantly, it specifies some of the conditions under which the income of a subsidiary is ineligible for deferral. In general, Subpart F rules stipulate that "passive" income, such as that from intra-company royalty payments, trigger an immediate U.S. tax liability. Income from sales involving a related party, such as a corporate parent, in which the subsidiary did not actively participate in generating the underlying good or service is also subject to immediate taxation.

One common strategy employed by a subsidiary of a U.S. multinational to satisfy the deferral requirements for passive income associated with IP is to enter into a "co-development agreement"[41] with its parent. In following this strategy, the parent will nearly complete the development of

[40] Unlike the Federal Government, U.S. states do not tax foreign source income.

[41] This is also sometimes termed a "cost sharing arrangement."

some IP. The subsidiary will then purchase the right to use this IP abroad[42] and complete the IP's development. Under this scenario, multinationals have an incentive to realize passive income associated with IP in foreign countries that meet two criteria. First, the necessary factors of production, such as a skilled labor force, must be locally available. Even if these factors are not relied on intensively, their absence may prompt scrutiny by U.S. tax authorities. Second, in the interest of limiting a subsidiary's local tax obligation, the country should have a relatively low corporate income tax rate. Through the use of such strategies, U.S. multinationals have been successful in satisfying the criteria to defer U.S. taxes on their foreign source income.

A.2 The Check-the-Box Policy Shock

Prior to 1997, the U.S. Treasury used a four factor test to determine the tax rules to apply to unincorporated business entities. The test was burdensome, especially for small businesses, such as partnerships. CTB was intended to reduce the burden on these small domestic firms by allowing them to elect their tax designation by simply checking a box on IRS form 8832. Its consequences for U.S.-based multinational firms were unanticipated.

CTB, formally known as Treasury Decision 8697, was implemented on January 1, 1997. From the perspective of a U.S. multinational, it permits foreign subsidiaries to elect their organizational designation, for example as a corporation or a branch, for U.S. federal tax purposes. This has no effect on the subsidiary's designation for tax purposes in other countries. For example, a subsidiary recognized as a corporation by a foreign country may elect to be taxed as a disregarded entity (equivalent for tax purposes to a branch affiliate) for U.S. federal tax purposes. A disregarded entity reports on a consolidated basis with its immediate parent under U.S. federal tax regulations. Consequently, income resulting from transactions between a disregarded entity and its immediate parent – including passive income such as royalty payments – is not separately reported to U.S. tax authorities. From the perspective of the IRS, this income appears to be generated by the disregarded entity's immediate parent.

In effect, CTB allowed U.S. multinationals to reduce their foreign tax obligations while still meeting the requirements to defer passive foreign source income. From the perspective of the

[42] In practice, co-development agreements typically stipulate that the rights to use the IP in the U.S. are retained by the U.S. parent, although they may be transferred to a subsidiary in Puerto Rico, a U.S. territory (Grubert and Slemrod, 1998).

IRS, but not foreign tax authorities, IP could be co-developed by a U.S. multinational's subsidiary in a country with readily available factors of production, meeting the conditions for deferral of U.S. taxes on foreign source income. Under this arrangement before CTB's implementation, the resulting income would trigger a tax obligation only in the foreign country. Since 1997, however, U.S. deferral rules can be satisfied and a reduced foreign tax obligation can be achieved by shifting the associated income to a disregarded entity tax resident in a country with a lower tax rate, despite the fact that no meaningful economic activity takes place there. Since the IRS would not separately observe this second subsidiary, eligibility for U.S. tax deferral remains intact. In this sense, CTB broke the link between where foreign factors of production are located (the country where co-development ostensibly occurs) and where the resulting income is ultimately reported (the country where the disregarded entity is located). Summarizing, CTB reduced U.S. multinationals' foreign tax obligations while leaving deferral of U.S. taxes intact by allowing them to shift passive income from countries where they could plausibly claim co-development to countries of their choosing, typically those with very low corporate income tax rates.[43]

A.3 Accessing Deferred Foreign Earnings

Suppose after CTB a firm shifts its IP-generated foreign income to a disregarded entity in a country with a 0% corporate tax rate. The firm would pay no foreign taxes and defer U.S. taxes. If the firm were to repatriate the foreign income to the U.S. parent the following year, it would have to pay the 35% U.S. corporate income tax rate on the foreign earnings, as described in Section A.1. If the firm is ultimately obligated to pay taxes on the foreign income, CTB may not have a meaningful impact on the firm's decision to undertake projects.[44] However, there are several ways the firm could gain access to the foreign income without paying U.S. taxes. First, it could simply wait for a tax holiday, repatriating the foreign income at a reduced rate. For example, the 2004 Homeland Investment Act allowed firms to repatriate untaxed foreign profits at a rate of 5.25% instead of 35% (Dharmapala, Foley, and Forbes, 2011; Faulkender and Petersen, 2012). Policy discussions of a second similar tax holiday have been ongoing since the expiration of the

[43] Although the impact of CTB on U.S. tax revenue is difficult to assess, it may be positive. As noted above, U.S. multinationals receive tax credits for foreign taxes paid. Income shifted to lower tax foreign jurisdictions will result in fewer such credits. If the foreign income is repatriated to the U.S. under standard conditions (i.e. absent a tax holiday), the resulting tax payment to the U.S. Treasury would be higher.

[44] Nevertheless, deferred taxes would still be reduced in present value terms due to discounting.

first. Second, the firm could invert, switching its tax residence from the U.S. to a foreign country and gaining access to its unrepatriated foreign profits without paying additional taxes (Desai and Hines Jr., 2002; Babkin, Glover, and Levine, 2017).[45] Third, the firm could use domestic losses to offset repatriated foreign earnings. Alternative methods are also available. In short, CTB indeed plausibly changed the after-tax return to projects creating IP.

[45]This option was available to firms throughout the sample period. Its use has subsequently been restricted.