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Do Firms Do What They Say? The Effect of the American Jobs Creation Act of 2004 on R&D Spending

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ABSTRACT: Prior studies debate whether the temporary tax holiday provided by the American Jobs Creation Act of 2004 (AJCA) increased firm spending on domestic investment. Since internal equity is an important funding source for research and development (R&D), and the AJCA lowered the cost of accessing internal equity through reduced repatriation tax rates, we hypothesize and find that on average, the AJCA led to increased firm spending on R&D. Our results bridge the gap between prior empirical results that do not show an average effect of increased domestic investment under the AJCA and survey results that report increased domestic investment as a common use of funds repatriated under the AJCA.

Keywords: American Jobs Creation Act (AJCA); R&D; tax holiday; repatriation tax; difference-in-differences.

JEL Classifications: G15; G38.

INTRODUCTION

The American Jobs Creation Act of 2004 (AJCA) created a temporary tax holiday that exempted 85 percent of the repatriation tax when U.S. multinational corporations (MNCs) repatriate undistributed foreign earnings back to the United States, effectively reducing the repatriation tax rate from a maximum of 35 percent to 5.25 percent for qualified repatriations defined under the AJCA. The amount of money brought back under this Act—$362 billion[1] as reported by the Internal Revenue Service (IRS) (Redmiles 2008)—demonstrates a partial success of this tax policy, as such funds would have been trapped overseas absent the tax holiday. On the other hand, whether the legislation achieved its policy goal of spurring domestic investment depends on how firms spent the repatriated funds.

The intent of the legislation is to increase domestic investment such as capital expenditures, research and development (R&D), debt repayment, and certain merger and acquisition activities. However, prior studies document that instead of spending the repatriated funds on domestic investment, repatriating firms increased share repurchase, one of the non-approved uses of repatriated funds under the AJCA (Blouin and Krull 2009; Clemons and Kinney 2008; Dharmapala, Foley, and Forbes 2011). For example, Blouin and Krull (2009) estimate that repatriating firms spent approximately 20 percent of the total repatriation amount on share repurchase. Dharmapala et al. (2011) estimate that a $1 increase in repatriation was associated with a $0.60 (60 percent) to $0.92 (92 percent) increase in shareholder payouts. Although researchers generally agree on firms spending repatriated funds on shareholder payouts, none of the prior studies finds that repatriating firms spent *all* repatriated funds on shareholder payouts. This has left the possibility that firms may have spent some of the repatriated funds on domestic investment.

The empirical evidence on whether the increased repatriation led to increased domestic investment is mixed. Two studies document increased domestic investment under the AJCA: Faulkender and Petersen (2012) for a subset of firms that is financially constrained, and Cao, Chen, Clemons, and Kinney (2014) for a subset of firms that lobbied for the passage of the tax

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[1] The $362 billion of repatriated funds includes both a base amount (which is determined by the amount of repatriations made in previous years) and an extraordinary amount (the amount of repatriation in excess of the base amount) for each repatriating firm. Only the extraordinary amount qualifies for the 85 percent exemption under the AJCA. Total qualified repatriation under the AJCA is $312 billion.

policy. Other studies do not find evidence for increased domestic investment under the AJCA, either as an average effect (Blouin and Krull 2009; Clemons and Kinney 2008; Dharmapala et al. 2011), or for the subset of firms that is financially constrained (Dharmapala et al. 2011). On the other hand, although empirical results do not show an average effect of increased domestic investment, survey results suggest that domestic investment is the third most commonly reported use of the repatriated funds (Graham, Hanlon, and Shevlin 2010).

In this study we examine whether the temporary tax holiday created by the AJCA stimulated firm spending on R&D. We focus on R&D in our study for three reasons. First, R&D is a critical driver of the competitiveness of the U.S. economy and therefore a relevant output for policy evaluation. Second, unlike other forms of investment made by U.S. MNCs that could be spread all over the world, R&D expenditure is mostly incurred domestically.[2] Therefore, R&D expense reported in the consolidated financial statements of MNCs is a reasonable proxy for domestic R&D. Third, the two industries with the highest amount of repatriation, as disclosed by the IRS (Redmiles 2008)—pharmaceutical and medicine and computer and electronic equipment—are industries that are heavily reliant on R&D investment.[3] Therefore, whether firms in these industries further strengthen their competitive advantages by spending the repatriated funds on R&D is of particular interest to policymakers and investors.

Prior literature finds that R&D tends to be equity financed (Arrow 1962; Hall and Lerner 2010). Debt is a disfavored source of finance for R&D investment, and firms are either unable or reluctant to use debt financing for R&D investment for two reasons. First, the degree of uncertainty associated with the output of R&D investment makes debt holders reluctant to lend when the project involves R&D rather than physical assets (Alderson and Betker 1996; Williamson 1988). Second, servicing debt requires profitable operations generating a stable source of cash flow, which is hard to sustain with R&D investment. Building on prior findings of a positive relationship between R&D investment and internal finance (Himmelberg and Petersen 1994), we argue that by lowering the cost of accessing internal equity through a reduced repatriation tax rate, the AJCA may change the cost-benefit analysis for firms' investment decisions for R&D spending.

Prior studies show evidence that firms that repatriated under the AJCA have limited investment opportunities both at home and abroad because domestic investment could have been funded through debt financing absent the tax holiday (Blouin and Krull 2009). We argue that this general conclusion may not apply to R&D because R&D is not normally funded with debt financing. Instead, R&D is more commonly funded through internal equity. Thus, we think it is an empirical question whether firms have domestic investment opportunities for R&D.

To examine how firms spent the repatriated funds, we begin with estimating the dollar amount of the increase in total R&D expenditure from the pre-repatriation period to the post-repatriation period for repatriating firms. The amount of increased R&D is $30 billion. This increase represents 11 percent of the total repatriated amount ($268 billion in our final sample). The total increase in R&D expenditure converts into an average increase in R&D of $47 million for each firm. For comparison, the average increase in R&D expenditure is $5 million for nonrepatriating firms during the same period. Therefore, the incremental increase in R&D expenditure for repatriating firms is $42 million.

In this preliminary analysis we have not considered the effect of size and other confounding factors for R&D expenditure, and thus two questions remain: (1) Is the incremental increase in R&D expenditure statistically significant? (2) Is the incremental increase in R&D expenditure associated with the AJCA? We next conduct a formal statistical analysis to answer these questions.

First, without imposing the linear form, we conduct the analysis using propensity score matching (PSM) to show whether the difference in R&D expenditure between repatriating firms and nonrepatriating firms is statistically significant. We find that the increase in R&D from the pre-repatriation period to the post-repatriation period is significantly higher for repatriating firms than nonrepatriating firms when the two groups of firms are matched on size, industry, and pre-repatriation R&D, regardless of whether the change in R&D is measured by dollar value, dollar value scaled by lagged assets, or dollar value scaled by sales.

Second, imposing the linear form, we conduct the analysis using the instrumental variable (IV) regression with the difference-in-differences (hereafter, diff-in-diff) design. We adopt the IV regression because the repatriation decision is endogenous (i.e., firms chose whether to take advantage of the reduced repatriation tax rate under the AJCA). We find that on average, firms that repatriated under the AJCA abnormally increased R&D spending relative to firms that did not repatriate. In particular, our point estimate suggests that a typical firm spent 8.8 percent of the repatriated funds on R&D. This result is consistent with prior literature that finds firms did not spend all repatriated funds on shareholder payouts.[4]

[2] Statistics reported by the Bureau of Economic Analysis show that over the years 1989–2011, around 85 percent of the R&D expenditure by U.S. MNCs is incurred within the U.S.

[3] According to IRS statistics, repatriation made by the pharmaceutical and medicine (computer and electronic equipment) industry accounts for 32 percent (18 percent) of the total qualifying repatriation.

[4] For example, Blouin and Krull (2009) estimate that firms spent 20 percent of the repatriation funds on share repurchase in the first year after the AJCA (2005), and 50 percent in the three years after the AJCA (2005–2007). Dharmapala et al. (2011) estimate that a $1 increase in repatriation was associated with a $0.60 to $0.92 increase in shareholder payouts.

This paper provides two major contributions to the literature on the AJCA. First, with several methodological improvements, the current study provides evidence that the AJCA led to increased firm spending on R&D. The average effect of increased R&D spending is found for the full sample of firms and is not confined to a subset of firms that is financially constrained (Faulkender and Petersen 2012) or that lobbied for the passage of the tax policy (Cao et al. 2014). Therefore, it sheds light on the debate over the efficacy of the tax holiday. Second, this study bridges the gap between (1) prior empirical results that do not find increased firm spending on domestic investment under the AJCA, and (2) survey results that report increased firm spending on domestic investment under the AJCA.

INSTITUTIONAL BACKGROUND OF THE AJCA

The AJCA was signed into law on October 22, 2004. It incentivizes U.S. MNCs to repatriate foreign earnings "trapped" in low tax regions overseas back to the U.S. by allowing firms to elect an 85 percent dividend-received deduction for qualified cash dividends received in one tax year.[5] The deduction effectively reduces the repatriation tax rate from a maximum of 35 percent to 5.25 percent.

A repatriation tax is the difference between the U.S. income tax and the foreign income tax when the U.S. income tax rate is higher than that of the foreign region. Absent the AJCA, firms have to pay the repatriation tax at a maximum rate of 35 percent when they repatriate foreign earnings located in regions with income tax rates lower than that of the U.S. Firms can avoid paying repatriation tax by keeping foreign earnings overseas. The consequence of not paying the repatriation tax is that firms cannot spend the foreign earnings for domestic purposes. In other words, deferring the repatriation tax places a limitation on the use of the foreign funds, while paying the repatriation tax removes the limitation on the use of foreign funds, making them available for domestic uses.

As a result, prior to the AJCA, firms had to pay a higher repatriation tax (maximum of 35 percent) if they needed to use internal equity located in low tax foreign regions for domestic purposes. Under the AJCA, firms could pay a much lower repatriation tax (maximum of 5.25 percent) for accessing internal equity located in low tax foreign regions for domestic purposes. Thus, the AJCA lowered the cost of accessing internal equity for funding domestic investment through a reduced repatriation tax rate.

To serve the policy goal of stimulating the U.S. economy, several conditions need to be met for the repatriation to qualify for the one-time reduced tax rate under the AJCA. The most important conditions include the following. First, the repatriated dividend must be received in cash. Second, the repatriated dividend must be "extraordinary" in the sense that only the excess over the average prior period dividend qualifies. Third, the repatriated funds must be invested in the U.S. pursuant to a domestic investment plan approved by senior management and the board of directors.

The IRS lists approved and non-approved uses of the funds that qualified for the reduced repatriation tax rate. Approved uses are expenditures in the U.S. that include R&D and other domestic investment. Non-approved uses mainly include executive compensation, dividend payment, and share repurchase. Despite the guidance, specific tracing or segregation of the funds is not required. As a result, as observed in prior studies, firms may be able to take advantage of the tax holiday and use the "freed-up" funds for non-approved uses without violating the legal requirement of the law.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

When to Repatriate: Investment Opportunities Overseas and the Repatriation Tax

While the classic theory of repatriation developed in the original Hartman framework (Hartman 1985; Scholes, Wolfson, Erickson, Maydew, and Shevlin 2005) predicts that the repatriation tax does not matter for firms' repatriation decisions, decades of empirical studies find that the repatriation tax does matter for firms' repatriation decisions (Desai, Foley, and Hines 2001; Foley, Hartzell, Titman, and Twite 2007; Grubert 1998; Grubert and Mutti 2001; Hines and Hubbard 1990). The fact that firms responded to the reduced repatriation tax rate under the AJCA by bringing back $312 billion beyond their normal levels of repatriation, confirms prior empirical findings that the repatriation tax matters for firms' repatriation decisions.

As illustrated in later extensions of the Hartman (1985) framework (De Waegenaere and Sansing 2008; Hines and Hubbard 1990), failure of the Hartman prediction is due to violations of its key assumptions. In particular, one key assumption is the abundance of foreign investment opportunities (i.e., all funds kept overseas are assumed to be reinvested at a rate higher than the cost of capital, earning positive net present value [NPV]). When such an assumption holds, the repatriation tax is irrelevant

[5] For calendar year firms, the deduction for a qualified repatriation could be elected in 2004 or 2005. For non-calendar year firms, qualified repatriations could be completed by October 2006. As a result, a qualified repatriation could be made in one of three years: fiscal 2004, 2005, or 2006.

because firms do not need to repatriate the foreign earnings—firms keep foreign earnings overseas and reinvest in business assets earning positive NPV.

When the assumption of the abundance of foreign investment opportunities does not hold however, the repatriation tax may become a binding constraint for firms' repatriation decisions. In this case, firms with limited investment opportunities overseas would have to keep foreign earnings in financial assets earning a return lower than the cost of capital in order to defer payment of the repatriation tax.

To make repatriation decisions, rational firms lacking investment opportunities overseas would then compare the cost of deferring the repatriation tax (negative NPV from reinvestment in financial assets) with the cost of paying the repatriation tax. If the cost of the repatriation tax in place is higher than the cost of holding excess cash, then firms will choose to hold excess cash in order to defer the repatriation tax. For example, Foley et al. (2007) show firms hold excess cash overseas in order to defer the repatriation tax.

When the repatriation tax changes, firms' cost-benefit analysis may change accordingly. Thus, the reduced repatriation tax rate under the AJCA may change repatriation decisions for firms with limited investment opportunities overseas. However, how firms will spend the repatriated funds domestically depends on the availability of domestic investment opportunities, which is unclear *ex ante*.

How to Spend: Investment Opportunities at Home and Alternative Financing

Although firms repatriating under the AJCA probably lack investment opportunities overseas, these firms may or may not lack investment opportunities at home, where the availability of alternative sources of financing may also come into play. In particular, to the extent that firms have domestic investment opportunities, spending some of the repatriated funds on domestic investment would be a sensible option. On the other hand, for any repatriated funds left after making domestic investments, returning the excess funds to investors (shareholders, or debt holders, or both) would be a rational choice to avoid the cost of holding excess cash.

Prior studies show limited evidence on the first possibility (i.e., use of repatriated funds on domestic investment). In particular, increased domestic investment under the AJCA is not found as an average effect, but only for a subset of firms that are financially constrained (Faulkender and Petersen 2012) or that have lobbied for the passage of the tax holiday (Cao et al. 2014). On the other hand, several studies provide evidence on the second possibility (i.e., return of repatriated funds to shareholders in the form of share repurchase) (Blouin and Krull 2009; Clemons and Kinney 2008; Dharmapala et al. 2011).

The AJCA may change firms' investment decision for R&D spending for two reasons. First, alternative financing is not easily available for R&D, since debt is a disfavored financing source for R&D investment, and firms are either unable or reluctant to use debt financing for R&D investment (Arrow 1962; Hall and Lerner 2010). This is so because the degree of uncertainty associated with the output of R&D investment make debt holders reluctant to lend when the project involves R&D rather than physical assets (Alderson and Betker 1996; Williamson 1988). Second, internal equity is a particularly important financing source for R&D (Brown, Fazzari, and Petersen 2009; Hall and Lerner 2010; Himmelberg and Petersen 1994), and the AJCA changed the cost of assessing internal equity for funding R&D through a reduced repatriation tax.[6]

Hypothesis Development

Although empirical studies do not find much evidence for the use of the repatriated funds on domestic investment such as R&D as an average effect, survey results in Graham et al. (2010) show that domestic investment is the third most commonly reported use of repatriated funds (reported by 36 percent of the respondents), ranked after paying down domestic debt (reported by 47.4 percent of the respondents) and repurchasing shares (reported by 40.4 percent of the respondents). Our search of firms' press releases and 10-K disclosures surrounding the AJCA also finds direct evidence of firms reporting R&D as one of the planned uses of funds repatriated under the AJCA: "The amounts repatriated were used for 'qualified expenditures' as defined

[6] The cash windfalls literature examines similar questions in a different setting. For example, Blanchard, Lopez-de-Silanes, and Shleifer (1994) find that R&D investment as a result of the cash windfalls may not be value enhancing. We note the following differences between the cash windfalls literature and the AJCA literature. First, while the cash windfalls are not under the companies' control until they are awarded, overseas earnings that are not repatriated to the U.S. are always controlled by the U.S. parent companies. The U.S. companies can choose to use the unrepatriated foreign earnings in ways they like, as long as they are willing to pay the repatriation tax. Even when the U.S. companies are not willing to pay the repatriation tax, they can still freely use the unrepatriated foreign earnings for overseas purposes; the only restriction on the use of unrepatriated foreign earnings is that without paying the repatriation tax, U.S. companies cannot freely use it for domestic purposes. When U.S. firms choose not to pay the repatriation tax, it is either because they do not need it for domestic uses, or because the cost of the repatriation tax outweighs the benefit of using it domestically. Second, while there is no direct cost for getting the cash windfalls, there is a direct cost of repatriation (i.e., the repatriation tax). Thus while there is no cost-benefit analysis involved for the cash windfalls, firms do need to carefully conduct the cost-benefit analysis for repatriation at the reduced tax rate under the AJCA.

under the Jobs Creation Act such as qualified research and development activities" (see Appendix A for the sample of Medtronic Inc.'s 10-K for 2006). More detailed examples of firm disclosures are provided in Appendix A.

As explained before, although the repatriation decision suggests that repatriating firms may have limited investment opportunities overseas, it is unclear whether such firms have investment opportunities at home.[7] Conceptually, once repatriation is made with the repatriation tax paid, the use of the repatriated cash is no longer restricted. As a result, firms face two rational options for using the repatriated funds, the entire repatriation of which was made in *cash* under the law of the tax holiday: (1) firms can invest the newly released cash to the extent they have investment opportunities available at home, or (2) firms can return cash to domestic investors if no such investment opportunity is available. These two options are not mutually exclusive. It is possible that firms may have investment opportunities up to a certain amount in which they invest the cash, while they return the remaining unused cash to domestic investors through share repurchase and dividend payment.

Empirically, while prior results on the effect of the AJCA on share repurchase are strong and robust across studies, none of these studies finds that firms spent all the repatriated funds on this non-approved use, which leaves it possible that firms may have spent some of the repatriated funds on domestic investment. This conjecture is consistent with survey results in Graham et al. (2010), which report that firms spent some of the repatriated funds on domestic investment. Taken together, it is an empirical question whether the repatriating firms increased their firm spending on R&D after the AJCA. If the AJCA was associated with increased R&D spending, then changes in firm-level R&D expenditure after the AJCA should be higher for repatriating firms than that for nonrepatriating firms. This leads to our hypothesis (stated in alternative form):

H1: Firms that repatriated under the AJCA abnormally increased R&D expenditure relative to firms that did not repatriate under the AJCA.

RESEARCH DESIGN

Preliminary Analysis

To examine how the repatriated cash was spent, we first estimate the dollar amount of the increase in total R&D expenditure from the pre-repatriation period to the post-repatriation period for repatriating firms. The amount of increased R&D is $30 billion. This increase represents 11 percent of the total repatriated amount ($268 billion in our final sample). The total increase in R&D expenditure converts into an average increase in R&D of $47 million for each firm. For comparison, the average increase in R&D expenditure is $5 million for nonrepatriating firms during the same period. Therefore, the incremental increase in R&D expenditure for repatriating firms is $42 million.

In this preliminary analysis we have not considered the effect of size and other confounding factors for R&D expenditure, and thus two questions remain: (1) Is the incremental increase in R&D expenditure statistically significant? (2) Is the incremental increase in R&D expenditure associated with the AJCA? We next conduct a formal statistical analysis to answer these questions. First, without imposing the linear form, we conduct the analysis using propensity score matching to show whether the difference in R&D expenditure between repatriating firms and nonrepatriating firms is statistically significant. Second, imposing the linear form, we conduct the analysis using the IV regression with the diff-in-diff design. We provide details of each analysis below.

Propensity Score Matching

We compare the changes in R&D for repatriating firms with those of a matched sample based on propensity score matching (PSM). Our potential universe of matching companies consists of all nonrepatriating firms. For each repatriating firm, we choose a match with the closest estimated probability of repatriation (i.e., the propensity score). We perform the matching estimation separately for two samples: (1) for the sample of firms that repatriated in 2005, and (2) for the sample of all repatriating firms (i.e., firms that repatriated in 2004, 2005, or 2006).

We conduct the estimation using "teffects psmatch" in Stata 14. The estimated treatment effects of "teffects" take into account that the propensity score is estimated (in the first stage of the matching process) and make corrections to the standard errors in the second stage, which estimates the treatment effect. The adjustment to standard errors by "teffects" builds on recent advancements in econometric theory by Abadie and Imbens (2016).

[7] Blouin and Krull (2009) hypothesize and find that firms that repatriated under the AJCA have limited investment opportunities both at home and abroad, because firms could have borrowed money to fund domestic investment absent the tax holiday. We argue that this general conclusion may not apply to R&D because R&D is a unique form of domestic investment not normally funded with debt financing. Instead, R&D is more commonly funded through internal equity.

For estimations made with both samples, the outcome variable is the change in R&D expenditure from the pre-repatriation period to the post-repatriation period (i.e., average R&D in the post-period minus average R&D in the pre-period), where R&D is alternatively defined as raw R&D (*RD_Diff*), R&D scaled by lagged total assets (*RD_A_Diff*), and R&D scaled by sales (*RD_S_Diff*). The treatment effect compares the change in R&D expenditure after the AJCA between the repatriating firms and matched nonrepatriating firms.

Regression Analysis: Difference-in-Differences Design

The standard diff-in-diff model is a tool to estimate treatment effects comparing the pre- and post-treatment differences in the outcome of a treatment and a control group, and therefore is commonly used for policy evaluation. Following Blouin and Krull (2009), we adopt this standard diff-in-diff design for evaluating the effect of the AJCA on R&D spending in our main regression analysis.

The general model for standard diff-in-diff design takes the following form:

$$RD_{it} = \beta_0 + \beta_1 Repatriation + \beta_2 Post + \beta_3 Repatriation{*}Post + X_{it}\gamma + \mu_i + \delta_t + \varepsilon_{it}, \quad (1)$$

where *RD* is scaled R&D expenditure (scaled by lagged total assets in the main test, and scaled by sales in robustness tests); *Repatriation* is a dummy variable equal to 1 if the firm repatriated under the AJCA, and 0 otherwise; *Post* is a dummy variable equal to 1 if it is in the post-repatriation period, and 0 otherwise; *X* is a set of control variables for R&D expenditure; μ is industry fixed effect; δ is year fixed effect; and ε is the error term.

The coefficient β_1 measures whether R&D expenditure is higher for repatriating firms than nonrepatriating firms in the pre-repatriation period. The coefficient β_2 measures whether R&D expenditure is higher in the post-repatriation period than in the pre-repatriation period for nonrepatriating firms. The interaction term β_3 captures the change in R&D expenditure from the pre-repatriation period to the post-repatriation period for the repatriating firms, relative to the change in R&D expenditure for nonrepatriating firms. Since H1 predicts that repatriating firms increased R&D expenditure more than nonrepatriating firms after the AJCA, we expect a positive coefficient on *Repatriation* $*$ *Post* (β_3).

To implement the standard diff-in-diff design, the policy change needs to happen in one single year to have a clear definition of the pre- and post-period. Since the majority of the repatriations under the AJCA were made in fiscal year 2005 (89 percent of the dollar amount of repatriation in our sample), we include only firms repatriating in 2005 in the treatment group for the main test.[8]

Instrumental Variable and the Endogeneity of the Repatriation Decision

While the AJCA is an exogenous shock, whether to repatriate undistributed foreign earnings at the reduced tax rate under the AJCA is an endogenous choice made by the firms. To address the endogeneity of the repatriation decision, we use the IV regression with the standard diff-in-diff design. We adopt the IV approach for two reasons. First endogeneity in an empirical study is likely due to multiple causes and the IV approach can address all kinds of endogeneity problems, whether the endogeneity is caused by self-selection, omitted variables, or simultaneous decisions (Larcker and Rusticus 2010). Second, the IV approach has advantages over other approaches for addressing endogeneity. In particular, in the setting of the AJCA, the endogeneity of the repatriation decision can be due to self-selection, as firms self-select into repatriating firms and nonrepatriating firms. The IV approach addresses the self-selection problem without requiring two strong assumptions, as in the Heckman (1979) approach. Alternatively, the decision to repatriate under the AJCA and the decision to invest in R&D may be made simultaneously. The IV approach addresses the simultaneous decision problem without requiring an explicit specification of the equations, as required by the simultaneous equation approach. Last but not least, the endogeneity of the repatriation decision may be caused by omitted variables. The IV approach addresses the omitted variable problem without requiring the inclusion of all omitted variables.

We use two instrumental variables in this study: *TaxHaven* and *UDFE*. The first instrumental variable, *TaxHaven,* as in Dharmapala et al. (2011), is a dummy variable indicating the existence of foreign subsidiaries located in tax haven jurisdictions right before the AJCA is enacted. *TaxHaven* meets the two requirements of a good IV. First, the instrument must be correlated with the endogenous explanatory variables, conditional on the other covariates. This requirement is met because *TaxHaven* affects the repatriation decision as MNCs with tax haven existence are more likely to have undistributed foreign earnings trapped overseas in low tax regions, and are thus more likely to take advantage of the reduced tax rate under the AJCA. Second, the instrument cannot be correlated with the error term in the explanatory equation, conditional on the other covariates. This

[8] Firms repatriating in 2004 and 2006 are excluded from both the treatment group and the control group in the main test to minimize measurement errors associated with misclassification. We include all repatriating firms to test the effects of the AJCA on R&D in robustness tests.

requirement is met because there is no obvious reason to expect *TaxHaven* would affect R&D expenditure in ways other than through the repatriation decision.

The second instrumental variable, *UDFE,* is a dummy variable indicating the existence of undistributed foreign earnings right before the AJCA is enacted. Firms are required to disclose undistributed foreign earnings in the 10-K reports when they designate foreign earnings from low tax regions as permanently reinvested. Similar to *TaxHaven, UDFE* meets the two requirements of a good IV: (1) *UDFE* affects the repatriation decision, as MNCs with undistributed foreign earnings trapped overseas in low tax regions are more likely to take advantage of the reduced tax rate under the AJCA, and (2) *UDFE* arguably does not affect R&D expenditure in other ways.[9]

Empirical Model for R&D Expenditure

To estimate the effect of the AJCA on R&D, we need to control for other confounding factors that may affect R&D expenditure. We use the Dharmapala et al. (2011) (DFF) model for determinants of R&D expenditure, where the outcome variable for R&D is R&D expenditure scaled by lagged total assets. The DFF model is specified as follows:

$$\frac{RD_t}{Assets_{t-1}} = \beta_0 + \beta_1 MktLev_{t-1} + \beta_2 Tobin'sQ_{t-1} + \beta_3 \frac{Cash_{t-1}}{Assets_{t-2}} + \beta_4 Profitability_{t-1} + \varepsilon_t, \quad (2)$$

where *MktLev* is market leverage, defined as the ratio of total debt to the sum of total debt and the market value of equity; *Tobin's Q* is the ratio of the market value of total assets to the book value of total assets; and *Profitability* is calculated as net income divided by total assets. Full variable definitions are provided in Appendix B. Lagged market leverage is expected to have a negative sign on R&D, as prior literature suggests that high leverage reduces a firm's ability to finance R&D (Myers 1977). Lagged *Tobin's Q* is expected to have a positive sign, as firms with higher growth potential tend to spend more on R&D (Blundell, Bond, Devereux, and Schiantarelli 1992). Lagged scaled cash is expected to have a positive sign, as firms with more cash are better able to fund R&D investment (Myers 1984). We do not make a prediction for lagged profitability because on the one hand, more profitable firms may spend more on R&D (Fishman and Rob 1999). On the other hand, loss firms may keep investing in R&D (Darrough and Ye 2007; Franzen, Rodgers, and Simin 2007).

We apply the model specification for R&D in the standard diff-in-diff design and examine the effects of the AJCA on R&D expenditure. We also include industry[10] and year fixed effects.

Sample Period

We include firms repatriating in 2005 in the treatment group for the main test. We define 2005 as the event year. Since most repatriating firms report to the IRS that they plan to complete the domestic investment plan in more than one year (Redmiles 2008),[11] we define four years prior to 2005 (2001–2004) as the pre-repatriation period and four years after 2005 (2006–2009) as the post-repatriation period.

SAMPLE SELECTION AND DESCRIPTIVE STATISTICS

Data

Data on repatriation, tax haven, and undistributed foreign earnings are hand collected from firms' 10-K reports. For the repatriation data, we perform the following procedures. First, we retrieve all 10-K reports for the period 2004–2008 that are

[9] Our results do not change when we use the same two IVs as in Dharmapala et al. (2011). We are not able to use our IVs with their data because the BEA data used in their study are not publicly available. With the BEA data, the dollar amount of repatriation is available for both firms that chose to repatriate at the reduced tax rate under the AJCA (by repatriating an abnormal amount of foreign earnings) and for firms that chose not to repatriate at the reduced tax rate under the AJCA (by repatriating the normal amount of foreign earnings, or not repatriating at all). In contrast, we only have data on the dollar amount of repatriation for firms that repatriated at the reduced tax rate under the AJCA (which is only allowed for one year). We do not have data on the dollar amount of repatriation for firms that did not take advantage of the AJCA (which may have repatriated their normal level of foreign earnings). Therefore, the data are noisy if we use a continuous variable for the reported dollar amount of repatriation instead of the dummy variable for repatriating firms. To see why this is the case, suppose Company A repatriated $50 million in 2004, $300 million in 2005 ($250 million of which is taxed at the reduced rate under the AJCA), and $20 million in 2006; Company B repatriated $40 million in 2004, 2005, and 2006. For the repatriation dummy used in our main test, Company A is coded 1, and Company B is coded 0 for all three years; while for the continuous repatriation amount, we will only observe the $300 million in 2005 for Company A, and we will have missing values for the repatriation amount in 2004 and 2006 for Company A, and 2004, 2005, and 2006 for Company B. Setting all missing values to zero may be far from reality, and thus bias the estimated effect.

[10] We use Fama and French's (1997) method to define industry.

[11] In particular, IRS statistics by Redmiles (2008) show that only a third of the firms plan to complete their domestic investment plans in the year immediately after the repatriation, while the remaining firms plan for additional years for the completion.

TABLE 1

Sample Selection

	Firms	Firm-Years
Repatriating Firms		
Identified repatriating firms under the AJCA	498	
Excluding:		
Firms lacking financial data on Compustat	(25)	
Firms not incorporated in the U.S.	(6)	
Financial firms (SIC 6000–6999)	(35)	
Firms with negative book values	(11)	
Firms with missing values for regression variables	(26)	
Repatriating firms in sample	395	4,098
Nonrepatriating Firms		
U.S. incorporated MNCs with financial data on Compustat, excluding financial firms and firms with negative book values	6,247	34,402
Final Sample	6,642	38,500

Table 1 shows the sample selection process. Firm-year observations cover the period 2000–2010. MNCs refer to multinational corporations, defined as firms that have nonmissing foreign pretax income (PIFO) or foreign income taxes (TXFO) on Compustat.

available from the FTP server of the SEC's EDGAR database. Then, we use Python programming language to do a keyword search in all of the 10-K reports and look for discussions in the notes to the financial statements regarding the AJCA and any firm responses.[12] Finally, we read each identified 10-K for data accuracy. We include only firms with actual repatriation (rather than any planned repatriations) under the AJCA and record their repatriation information (e.g., year of actual repatriation, amount of actual repatriation).

To collect data on the variable *TaxHaven,* we search whether Exhibit-21 of each firm's 2003 10-K mentions at least one foreign subsidiary located in a region classified as a tax haven jurisdiction by the Organization for Economic Cooperation and Development (OECD 2000). To collect data on the variable *UDFE*, we search whether each firm's 2003 10-K report contains disclosures on undistributed foreign earnings. All other financial data are obtained from Compustat.

We identify 498 firms with a total repatriation of $317 billion as repatriating firms.[13] Compared with previous studies, our total amount of repatriation identified is closer to the IRS statistics of $362 billion, and our number of identified repatriating firms is larger.[14]

Sample Selection

We follow the procedures in Blouin and Krull (2009) for sample selection. In particular, after merging repatriating firms with financial data from Compustat, we exclude firms that meet any one of the following criteria: (1) firms that are not incorporated in the U.S., (2) financial firms (SIC 6000–6999), (3) firms with negative book values, and (4) non-MNCs, where MNCs are defined as firms with nonmissing foreign pretax income or foreign income taxes. Our final sample includes 395 repatriating firms (treatment group) and 6,247 nonrepatriating firms (control group). Table 1 summarizes the sample selection process.

We present the year and industry distribution of the repatriation under the AJCA for repatriating firms in the final sample in Table 2.

[12] The discussed firm responses to the AJCA include (1) the AJCA is not beneficial to the firm, and thus the firm decides not to take advantage of the AJCA, (2) the impact of the AJCA to the firm is immaterial, (3) the firm plans to repatriate at the reduced rate under the AJCA, with the amount of repatriation still being evaluated, and (4) the firm repatriated at the amount of XXX in year YYYY.

[13] After merging with Compustat data for the regression variables, 395 repatriating firms with a total repatriation of $268 billion are left in the final sample.

[14] To compare with prior studies on the AJCA, Blouin and Krull (2009) identified 357 repatriating firms with a total repatriation of $292 billion, Dharmapala et al. (2011) identified 261 repatriating firms (the total amount of repatriation is not disclosed in their paper), Albring, Mills, and Newberry (2011) identified 220 repatriating firms with a total repatriation of $209 billion (their smaller sample is partly because they limit the sample to U.S. MNCs with permanently reinvested foreign earnings), and Faulkender and Petersen (2012) identified 442 repatriating firms with a total repatriation of $298 billion.

TABLE 2

Year and Industry Distribution of Repatriation

Panel A: Year Distribution of Repatriation

	Total Repatriation		Repatriating Firms		Mean Repatriation	Median Repatriation
Year of Repatriation	Amount	Pct.	No.	Pct.	Amount	Amount
2004	1.31	0.5%	14	3.5%	0.09	0.05
2005	239.76	89.4%	295	74.7%	0.81	0.14
2006	27.00	10.1%	86	21.8%	0.31	0.09
Total	268.07	100.0%	395	100.0%	0.68	0.12

Panel B: Industry Distribution of Repatriation

	Total Repatriation		Repatriating Firms		Mean Repatriation
Industry	Amount	Pct.	No.	Pct.	Amount
Healthcare, Medical Equipment, and Drugs	95.61	36%	46	12%	2.08
Business Equipment—Computers, Software, and Electronic Equipment	70.62	26%	99	25%	0.71
Consumer Nondurables—Food, Tobacco, Textiles, Apparel, Leather, Toys	28.56	11%	39	10%	0.73
Manufacturing—Machinery, Trucks, Planes, Office Furniture, Paper, Commercial Printing	21.99	8%	25	6%	0.88
Chemicals and Allied Products	20.96	8%	73	19%	0.29
Wholesale, Retail, and Some Services (Laundries, Repair Shops)	7.66	3%	29	7%	0.26
Other—Mines, Construction, Building Materials, Transport, Hotels, Business Services, Entertainment	7.22	3%	35	9%	0.21
Oil, Gas, and Coal Extraction and Products	5.99	2%	16	4%	0.37
Consumer Durables—Cars, TVs, Furniture, Household Appliances	4.92	2%	20	5%	0.25
Telephone and Television Transmission	3.25	1%	4	1%	0.81
Utilities	1.30	0%	9	2%	0.14
Total	268.08	100%	395	100%	0.68

Table 2 shows the year and industry distribution of repatriation at the reduced tax rate under the American Jobs Creation Act of 2004 for all repatriating firms in the sample. The amount of repatriation is shown in billions of U.S. dollars. Panel A shows the year distribution of repatriation by all repatriating firms in the sample; Panel B shows the industry distribution of repatriation by all repatriating firms in the sample. We use the Fama-French 12-industry classification to define industry.

Panel A of Table 2 shows that repatriation under the AJCA is concentrated in fiscal year 2005, accounting for 89.4 percent of the total amount of repatriation and 74.7 percent of repatriating firms. Fiscal year 2006 comes next with 10.1 percent of the total amount of repatriation and 21.8 percent of repatriating firms. Fiscal year 2004 has the smallest amount of repatriation with 0.5 percent of the total repatriation and 3.5 percent of repatriating firms.

Consistent with the repatriation statistics revealed by the IRS (Redmiles 2008), Panel B of Table 2 shows that the top two industries with the highest amount of repatriation are the healthcare (pharmaceutical and medicine) industry and business equipment (computer and electronic equipment) industry, even though the number of repatriating firms in these two industries is not necessarily the highest. In particular, the healthcare industry accounts for 36 percent of the total amount of repatriation and 12 percent of the total number of repatriating firms. The business equipment industry accounts for 26 percent of the total amount of repatriation and 25 percent of the total number of repatriating firms.

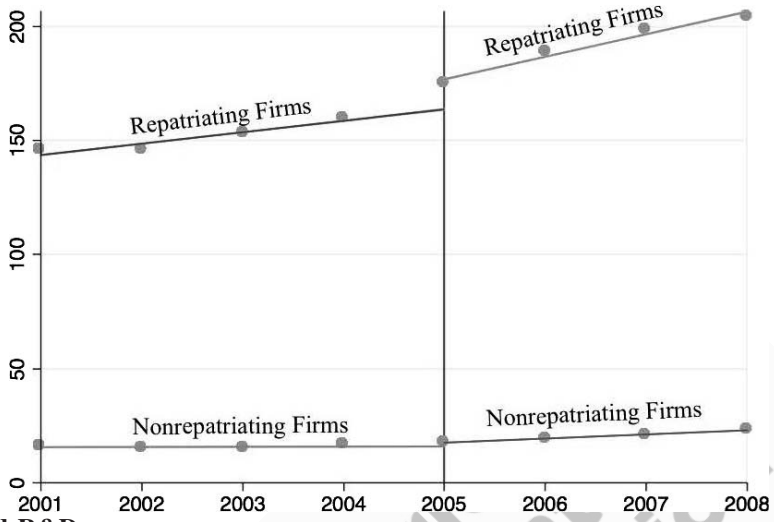
Descriptive Statistics

We depict the mean value of R&D expenditure by repatriating and nonrepatriating firms in the eight years surrounding the AJCA (2001–2008) in Figure 1.

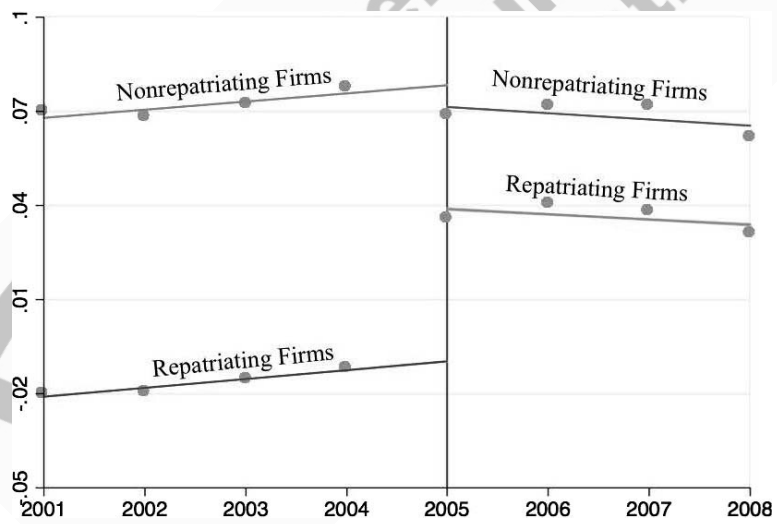
Panel A of Figure 1 depicts mean dollar values of actual R&D expenditure over time. We fitted a linear line for the pre-period (i.e., 2001–2004) and the post-period (i.e., 2005–2008) separately. Fitting the linear lines is more closely aligned with

FIGURE 1
Actual and Predicted Mean R&D Spending

Panel A: Mean R&D Expenditure



Panel B: Mean Predicted R&D



Mean values of R&D expenditure by repatriating and nonrepatriating firms in the period 2001–2008. Repatriating firms are U.S. multinational corporations (MNCs) that repatriated foreign earnings under the American Jobs Creation Act (AJCA) of 2004 in 2005. Nonrepatriating firms are U.S. MNCs that did not repatriate under the AJCA. The pre-repatriation period is 2001–2004; the post-repatriation period is 2005–2008.

Panel A depicts mean dollar values of actual R&D expenditure over time. Values on the y-axis of Panel A are shown in $millions. Panel B depicts mean scaled values of predicted R&D expenditure over time, as estimated in the main regression model in Table 5, where dollar values of R&D are scaled by lagged total assets.

the linear regression we are estimating in the main regression and helps us visually gauge any changes in slope. Based on Figure 1, Panel A, we observe a break in the event year 2005 for repatriating firms but no break for nonrepatriating firms.[15]

[15] Non-MNCs are excluded from our sample and thus are not depicted in the figure, because non-MNCs do not have foreign earnings and thus are not affected by the AJCA. Nonetheless, non-MNCs may serve as a good benchmark for checking the temporal trend during the sample period. We find that non-MNCs show a flat temporal trend in R&D expenditure with no break in 2005, similar to that of nonrepatriating MNCs, and different from that of the repatriating MNCs.

TABLE 3

Descriptive Statistics for Repatriating and Nonrepatriating Firms

Panel A: Repatriating Firms Compared with Nonrepatriating Firms

	Repatriating Firms		Nonrepatriating Firms		Mean Test	
Variable	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Difference**	**t-stat**
Outcome Variables						
RD	173.449	313.372	18.204	74.753	155.245***	(24.93)
RD_A	0.036	0.056	0.067	0.128	−0.031***	(−22.55)
RD_S	0.048	0.085	0.375	1.675	−0.328***	(−32.15)
Instrumental Variables						
TaxHaven	0.429	0.495	0.114	0.318	0.315***	(31.54)
UDFE	0.468	0.499	0.164	0.37	0.304***	(29.96)
Control Variables						
Lagged MktLev	0.216	0.199	0.204	0.257	0.012***	(2.79)
Lagged Tobin's Q	2.064	1.434	2.194	2.216	−0.129***	(−4.12)
Lagged (Cash/Lagged Assets)	0.152	0.202	0.339	0.654	−0.187***	(−33.37)
Lagged Profitability	0.053	0.09	−0.094	0.348	0.148***	(53.65)
No. of Firm-Years	2,545		27,792		30,337	

Panel B: Post-Repatriation Period Compared with Pre-Repatriation Period for Repatriating Firms

	Post-Repatriation Period		Pre-Repatriation Period		Mean Test	
Variable	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Difference**	**t-stat**
Outcome Variables						
RD	198.052	332.846	151.152	292.868	46.900***	(3.53)
RD/Lagged Assets	0.036	0.057	0.037	0.057	−0.001	(−0.47)
RD/Sale	0.048	0.081	0.048	0.090	−0.000	(−0.10)
Control Variables						
Lagged MktLev	0.204	0.187	0.236	0.215	−0.032***	(−3.76)
Lagged Tobin's Q	1.944	1.053	2.165	1.738	−0.220***	(−3.68)
Lagged (Cash/Lagged Assets)	0.140	0.150	0.157	0.243	−0.017**	(−1.99)
Lagged Profitability	0.058	0.103	0.047	0.083	0.011***	(2.66)
No. of Firm-Years	1,061		1,189		2,250	

***, ** Denote a significance level at 0.01 and 0.05, respectively, for two-tailed tests of means.

Table 3 shows descriptive statistics of regression variables for our sample firms in the period 2001–2009. Repatriating firms in this table are firms that repatriated in 2005 at the reduced tax rate under the American Jobs Creation Act of 2004. Panel A presents mean tests for comparing repatriating firms with nonrepatriating firms in the sample period of 2001–2009. Panel B presents mean tests for comparing post-repatriation (2006–2009) results with pre-repatriation (2001–2004) results for firms repatriating in 2005.

Variables are as defined in Appendix B.

Panel B of Figure 1 depicts mean scaled values of predicted R&D expenditure over time, as estimated in the main regression (in Table 5), where the dollar value of R&D is scaled by lagged total assets. We depict predicted values of R&D because it accounts for the covariates identified to be affecting scaled R&D in the literature. In addition, our regression also accounts for the endogeneity of the repatriation decision. Thus depicting the predicted values of R&D presents a full picture of R&D expenditure. Based on Figure 1, Panel B, while nonrepatriating firms decreased predicted R&D in the pre-repatriation period (i.e., 2001–2004) to the post-repatriation period (i.e., 2005–2008), repatriating firms increased predicted R&D in the same time window. Predicted R&D shows a higher value for nonrepatriating firms because these firms are smaller in size and thus have higher values of scaled R&D.

We report descriptive statistics of the regression variables for the sample firms in the period 2001–2009 in Table 3.

Panel A of Table 3 shows that although repatriating firms have much larger R&D expenditures compared with nonrepatriating firms in dollar values (i.e., unscaled R&D), their scaled R&D expenditures are smaller than those of

nonrepatriating firms, reflecting the much larger firm sizes of the repatriating firms. It also shows that repatriating firms differ significantly from nonrepatriating firms on firm characteristics correlated with R&D expenditure. Therefore, in our PSM analysis and the diff-in-diff regression analysis, we control for these differences in firm characteristics between repatriating firms and nonrepatriating firms.

Similarly, Panel B of Table 3 shows that although repatriating firms have larger R&D expenditures in the post-repatriation period compared with pre-repatriation period in dollar values (i.e., unscaled R&D), the difference in scaled R&D is insignificant, possibly due to the increased firm sizes in the post-period.[16] Note that we need to interpret the results with caution for the simple t-test for scaled R&D before and after the AJCA because size alone does not capture the full picture. Our tests using propensity score matching and regression models control for other confounding factors that may affect R&D expenditure and are thus more reliable for identifying the effect of the AJCA on R&D.

RESULTS

Propensity Score Matching

First, without imposing the linear form, we present results from PSM to show whether the difference in R&D expenditure between repatriating firms and nonrepatriating firms is statistically significant in Table 4.

We report the estimated treatment effect for firms repatriating in 2005 in Panel A and all repatriating firms in Panel B of Table 4. Columns (1), (3), and (5) present results when the control group is matched to the treatment group on size and industry; Columns (2), (4), and (6) present results when the control group is matched to the treatment group on size, industry, and pre-repatriation R&D expenditure. The results in Table 4 show that for all specifications, the estimated treatment effect is significantly positive, indicating the increase in R&D expenditure by repatriating firms after the AJCA is significantly higher than that in the matched nonrepatriating sample. These results show that the AJCA was associated with increased firm spending on R&D.

Main Regression Results: Difference-in-Differences with IV Regression

Second, imposing the linear form, we present results from the IV regression for the diff-in-diff estimation in Table 5.

We report the first-stage results of the 2SLS regression for firms repatriating in 2005 in Panel A of Table 5. These results show that both instrumental variables, *TaxHaven* and *UDFE,* are significant determinants of the repatriation decision. The F-statistics for the weak identification test of the instrument are also reported. According to Stock, Wright, and Yogo (2002), F-statistics greater than 10 generally indicate the instrument is strong. Our instruments thus pass the weak identification test. The positive and highly significant coefficients on the instruments imply that firms that have an affiliate located in a tax haven or have undistributed foreign earnings before the tax holiday are more likely to repatriate at the reduced tax rate under the AJCA than other multinational firms. These results are consistent with previous literature (Dharmapala et al. 2011).

We report the second-stage results of the 2SLS regression for firms repatriating in 2005 in Panel B of Table 5. These results show the regression coefficients on the interaction term *Repatriation* $*$ *Post* (β_3) is significantly positive at the 1 percent level (coefficient estimate = 0.054; t-statistic = 2.88), indicating that repatriating firms abnormally increased R&D expenditure after the AJCA, relative to nonrepatriating firms during the same period, consistent with our H1.[17,18]

The estimated increase in R&D expenditure under the AJCA is $60 million for a firm with mean total assets. The effect is estimated by multiplying the estimated coefficient of 0.054 by mean lagged total assets of $1,113 million. Based on this estimate, a typical firm spends 8.8 percent of the repatriated funds on R&D (estimated by dividing the mean increase in R&D expenditure of $60 million by mean repatriation amount of $680 million).

Placebo Tests

We conduct two placebo tests to check the validity of our main results,[19] where we estimate the effect of repatriation on R&D using the IV regression with the diff-in-diff design for firms repatriating in 2005 with the DFF model. In the first placebo

[16] Firm sizes are larger in the post-repatriation period because newly made worldwide profits (revenues minus expenses) are earned and retained (net profits minus dividends) at a higher speed than newly invested R&D expenditures are incurred every year.

[17] Consistent with prior literature, we do not identify increased R&D under the AJCA without addressing the endogeneity of the repatriation decision by using the IVs in the first-stage regression.

[18] We obtain qualitatively similar results when the estimation is made using the reported dollar amount of repatriation instead of the dummy variable for repatriating firms.

[19] We thank an anonymous referee for this helpful suggestion.

TABLE 4

The Effects of Repatriation on R&D: Propensity Score Matching

Panel A: Firms Repatriating in 2005

	RD_Diff		*RD_A_Diff*		*RD_S_Diff*	
Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Treatment Effects						
Coeff.	9.619***	7.942***	0.007**	0.005*	0.150***	0.153***
Std. Err.	2.79	2.82	0.00	0.00	0.04	0.04
p-value	0.001	0.005	0.027	0.061	0.000	0.000
Matched On						
Size	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Pre-Repatriation R&D	No	Yes	No	Yes	No	Yes
No. of Firm-Years	3,028	3,028	3,027	3,027	3,008	3,008

Panel B: All Repatriating Firms

	RD_Diff		*RD_A_Diff*		*RD_S_Diff*	
Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Treatment Effects						
Coeff.	7.844***	6.450***	0.007***	0.008***	0.162***	0.164***
Std. Err.	2.16	1.73	0.00	0.00	0.03	0.03
p-value	0.000	0.000	0.009	0.003	0.000	0.000
Matched On						
Size	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Pre-Repatriation R&D	No	Yes	No	Yes	No	Yes
No. of Firm-Years	8,574	8,574	8,568	8,568	8,514	8,514

***, **, * Denote a significance level at 0.01, 0.05, and 0.10, respectively, for two-tailed tests.

Table 4 shows the effects of repatriation on R&D estimated by Propensity Score Matching (PSM), where the control group (nonrepatriating multinational firms) is matched to the treatment group (repatriating firms) on a one-to-one basis based on the estimated probability of repatriation (i.e., the propensity score). The outcome variable is the difference in R&D expenditure from the pre-repatriation period to the post-repatriation period, where R&D is alternatively defined as raw R&D (*RD_Diff;* Columns (1) and (2)), R&D scaled by lagged total assets (*RD_A_Diff;* Columns (3) and (4)), and R&D scaled by sales (*RD_S_Diff;* Columns (5) and (6)). Panel A shows results for firms repatriating in 2005, and Panel B shows the results for all repatriating firms (firms repatriating in 2004, 2005, or 2006). Columns (1), (3), and (5) present results when the control group is matched to the treatment group on size and industry; Columns (2), (4), and (6) present results when the control group is matched to the treatment group on size, industry, and pre-repatriation R&D expenditure. The estimation is conducted using "teffects psmatch" in Stata 14. The estimated treatment effects of "teffects" adjust standard errors for the first-stage estimation of the matching process.

All other variables are defined in Appendix B.

test, we randomly assign firms in our sample to be repatriating firms; in the second placebo test, we pick three other years in our sample period to be the event year.

For the random assignment of repatriating firms, we randomly assign 395 firms in our sample to be repatriating firms and reestimate our main regression (i.e., the regression in Table 5). We repeat the process 10,000 times and report the results in Panel A of Table 6. For the artificial selection of event years, we define the event year as 2000, 2002, and 2010, respectively, and reestimate our main regression. We report the results in Panel B of Table 6.

Panel A of Table 6 shows that for the random assignment of repatriating firms, *Repatriation* ∗ *Post* is significant 21 out of 10,000 times (0.21 percent) at the 1 percent significance level, 354 out of 10,000 times (3.54 percent) at the 5 percent significance level, and 1,006 out of 10,000 times (10.06 percent) at the 10 percent significance level, suggesting that the randomly assigned "repatriation" does not have any effect on R&D spending. The mean coefficient (−0.031) and t-statistic (−0.06) for *Repatriation* ∗ *Post* from the 10,000 estimates further confirm the null results.

Panel B of Table 6 shows that for the artificial selection of event years, *Repatriation* ∗ *Post* is insignificant when the assigned event year is 2000 (coefficient estimate = 0.005; t-statistic = 0.15), 2002 (coefficient estimate = 0.028; t-statistic =

TABLE 5

The Effects of Repatriation on R&D: Diff-in-Diff with IV for Firms Repatriating in 2005

Panel A: First-Stage Regressions

Variable	Coeff.	t-stat
Instrumental Variables		
TaxHaven	0.086***	(7.59)
UDFE	0.060***	(6.58)
Control Variables		
Lagged MktLev	0.007	(0.90)
Lagged Tobin's Q	0.006***	(6.46)
Lagged (Cash/Lagged Assets)	−0.014***	(−8.41)
Lagged Profitability	0.050***	(11.55)
Intercept	Yes	
Year and Industry Fixed Effects	Yes	
No. of Firm-Years	26,949	
Adj. R^2	50.4%	
F-Statistic for Weak Identification Test	59.28	

Panel B: The Effect of Repatriation on R&D

Variable	Coeff.	t-stat
Test Variables		
Repatriation	−0.064***	(−3.27)
Post	0.001	(0.45)
*Repatriation * Post*	0.054***	(2.88)
Control Variables		
Lagged MktLev	−0.007*	(−1.92)
Lagged Tobin's Q	0.009***	(10.94)
Lagged (Cash/Lagged Assets)	0.021***	(10.49)
Lagged Profitability	−0.101***	(−18.77)
Intercept	Yes	
Year and Industry Fixed Effects	Yes	
No. of Firm-Years	26,949	
Adj. R^2	37.9%	

***, * Denote a significance level at 0.01 and 0.10, respectively, for two-tailed tests.

Table 5 shows the effects of repatriation on R&D estimated by the IV regression with the diff-in-diff design for firms repatriating in 2005. The diff-in-diff design takes the following form: $Y = \beta_0 + \beta_1 Treat + \beta_2 Post + \beta_3 Treat{*}Post + X\gamma + \varepsilon$. For the determinants of R&D expenditure, we follow Dharmapala et al. (2011) for the model specification and the control variables where the outcome variable is R&D scaled by lagged total assets: $\frac{RD_t}{Assets_{t-1}} = \beta_0 + \beta_1 Repatriation + \beta_2 Post + \beta_3 Repatriation{*}Post + \gamma_1 MktLev_{t-1} + \gamma_2 Tobin'sQ_{t-1} + \gamma_3 \frac{Cash_{t-1}}{Assets_{t-2}} + \gamma_4 Profitability_{t-1} + \varepsilon_t$ Panel A shows the first-stage results for the IV regression. The first-stage results check the validity of the instrumental variables. As summarized in Larcker and Rusticus (2010), the dependent variable in the first-stage regression is the endogenous variable in the second-stage regression (i.e., *Repatriation,* a dummy equal to 1 for firms that repatriated under the AJCA, and 0 otherwise). The control variables in the first stage are the same as the control variables in the second stage plus the IVs. The first stage is an OLS. Panel B shows the second-stage results for the IV regression. The second-stage results show the estimated effects of repatriation on R&D expenditure. All models are estimated over the sample period of fiscal 2001–2009, which includes four years before the repatriation (2001–2004) and four years after the repatriation (2006–2009). We include industry and year fixed effects in all models. We define industry using the Fama-French 12-industry classification. Standard errors are robust to firm heterogeneity and serial correlation by clustering at the firm level. t-statistics are shown in parentheses.

All other variables are defined in Appendix B.

0.89), or 2010 (coefficient estimate = 0.015; t-statistic = 0.59), suggesting that the selected year does not show the similar effect of increased R&D spending for repatriating firms.

Robustness Tests

We conduct two robustness tests to further validate our main results. The first robustness test estimates the effect of the AJCA on R&D using alternative empirical models for determinants of R&D expenditure; the second robustness test estimates

TABLE 6

Placebo Tests

Panel A: Random Assignment of Repatriating Firms

	1% Level		5% Level		10% Level	
	No.	**%**	**No.**	**%**	**No.**	**%**
Significant Coefficient on *Repatriation* ∗ *Post*	21	0.21%	354	3.54%	1,006	10.06%
Mean Coefficient on *Repatriation* ∗ *Post*				−0.031		
Mean t-stat on *Repatriation* ∗ *Post*				−0.06		
Intercept				Yes		
Control Variables				Yes		
Year and Industry Fixed Effects				Yes		

Panel B: Artificial Selection of Event Years

	2000		2002		2010	
Variable	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**
Repatriation ∗ *Post*	0.005	0.15	0.028	0.89	0.015	0.59
Intercept				Yes		
Control Variables				Yes		
Year and Industry Fixed Effects				Yes		

Table 6 shows results of the placebo tests for estimating the effect of repatriation on R&D using the IV regression with the diff-in-diff design for firms repatriating in 2005. Model specifications and variables are as defined in Table 5. Panel A presents results for the random assignment of repatriating firms, where we randomly assigned 395 firms in our sample to be repatriating firms, and reestimated our main regression (i.e., the regression in Table 5) 10,000 times. We report the number of times when *Repatriation* ∗ *Post* is significant at the 0.01, 0.05, and 0.10 significance level, respectively. We also report the mean coefficient and t-statistics for *Repatriation* ∗ *Post* from the 10,000 estimates. Panel B presents results for artificial selection of event years, where we selected 2000, 2002, and 2010 to be the event year, and reestimated our main regression (i.e., the regression in Table 5). We include industry and year fixed effects in all models. We define industry using the Fama-French 12-industry classification. Standard errors are robust to firm heterogeneity and serial correlation by clustering at the firm level.
All other variables are defined in Appendix B.

the effect of the AJCA on R&D using alternative designs for diff-in-diff that include all repatriating firms. We report the results of the two robustness tests in Table 7.

In the first robustness check, we use two alternative empirical models for determinants of R&D expenditure: the REM model and the IO model. These model specifications vary in the measurement of the outcome variable (R&D scaled by total assets or by sales) and the choices of the control variables.

The REM model follows the accounting literature in the field of real earnings management. For example, Roychowdhury (2006), Cohen, Dey, and Lys (2008), and Zhang (2012) regress R&D (scaled by lagged total assets) on two size variables. The REM model is specified in Equation (3) below:

$$\frac{RD_t}{Assets_{t-1}} = \beta_0 + \beta_1 \frac{1}{Assets_{t-1}} + \beta_2 \frac{Sales_{t-1}}{Assets_{t-1}} + \varepsilon_t \tag{3}$$

The IO model follows the industrial organization literature, which focuses on the determinants of innovative activities. Cohen (2010) provides a comprehensive review of the empirical work in this field during the last 50 years. The outcome variable used in the IO model is R&D expenditure scaled by sales (termed "R&D intensity"). Specifically, we estimate the IO model as follows:

$$\frac{RD_t}{Sales_t} = \beta_0 + \beta_1 LnAssets_t + \beta_2 BM_t + \beta_3 Ln(FirmAge) + \beta_4 Ln\left(\frac{Cash_t}{Assets_t}\right) + \beta_5 BookLev_t + \beta_6 ROA + \varepsilon_t, \tag{4}$$

where *LnAssets* is the natural log of total assets; *BM* is book-to-market ratio, defined as book value of equity divided by market value of equity; *BookLev* is book leverage, defined as total debt divided by total assets; and *ROA* is return on assets, the ratio of income before extraordinary items to total assets.

TABLE 7
Robustness Tests

Panel A: Alternative Model Specifications for Determinants of R&D

	REM		IO	
Variable	**Coeff. (1)**	**t-stat (2)**	**Coeff. (3)**	**t-stat (4)**
Test Variables				
Repatriation	−0.162***	(−6.21)	−1.959***	(−3.58)
Post	−0.013***	(−4.55)	−0.214***	(−3.27)
Repatriation ∗ *Post*	0.139***	(5.45)	1.651***	(3.35)
REM Controls				
1/*Lagged Assets*	0.176***	(8.16)		
(*Lagged Sale*)/(*Lagged Assets*)	−0.020***	(−12.68)		
IO Controls				
LnAssets			0.085***	(5.51)
BM			−0.068***	(−5.45)
Ln(*FirmAge*)			−0.003	(−0.14)
Ln(*Cash*/*Assets*)			0.137***	(12.76)
BookLev			−0.022	(−0.29)
ROA			−1.647***	(−17.94)
Intercept	Yes		Yes	
Year and Industry Fixed Effects	Yes		Yes	
No. of Firm-Years	26,949		26,949	
Adj. R^2	23.6%		18.3%	

Panel B: Alternative Designs for Diff-in-Diff

	Same Cutoff for Pre and Post		Actual Cutoff for Pre and Post	
Variable	**Coeff. (1)**	**t-stat (2)**	**Coeff. (3)**	**t-stat (4)**
Test Variables				
Repatriation	−0.044***	(−3.01)	−0.048***	(−3.06)
Post	−0.016***	(−5.43)		
Repatriation ∗ *Post*	0.037***	(2.59)	0.041***	(2.69)
Control Variables				
Lagged MktLev	0.002	(0.41)	0.006	(1.61)
Lagged Tobin's Q	0.010***	(13.72)	0.009***	(13.24)
Lagged (*Cash*/*Lagged Assets*)	0.014***	(8.11)	0.017***	(10.44)
Lagged Profitability	−0.114***	(−21.90)	−0.117***	(−22.60)
Intercept	Yes		Yes	
Year and Industry Fixed Effects	Yes		Yes	
No. of Firm-Years	28,065		38,105	
Adj. R^2	40.3%		40.4%	

*** Denote a significance level at 0.01 for two-tailed tests.

Table 7 shows robustness tests for the effect of repatriation on R&D using alternative research designs. Panel A presents results using alternative model specifications for determinants of R&D. Two alternative models are used: (1) the REM model, and (2) the IO model. The REM model follows Roychowdhury (2006), Cohen et al. (2008), and Zhang (2012) in the accounting literature for the model specification and the control variables where the outcome variable is R&D scaled by lagged total assets: $\frac{RD_t}{Assets_{t-1}} = \beta_0 + \beta_1 Repatriation + \beta_2 Post + \beta_3 Repatriation{*}Post + \gamma_1 \frac{1}{Assets_{t-1}} + \gamma_2 \frac{Sales_{t-1}}{Assets_{t-1}} + \varepsilon_t$ The IO model follows Cohen (2010) in the industrial organization literature for the model specification and the control variables where the outcome variable is R&D scaled by lagged total assets: $\frac{RD_t}{Sales_t} = \beta_0 + \beta_1 Repatriation + \beta_2 Post + \beta_3 Repatriation{*}Post + \gamma_1 LnAssets_t + \gamma_2 BM_t + \gamma_3 Ln(FirmAge)_t + \gamma_4 Ln\left(\frac{Cash_t}{Assets_t}\right) + \gamma_5 BookLev_t + \gamma_6 ROA + \varepsilon_t$ Panel B presents results using alternative designs for diff-in-diff where all repatriating firms (i.e., firms repatriating in 2004, 2005, or 2006) are used to estimate the IV regression with the diff-in-diff design for the main empirical model defined in Table 5. Columns (1) and

(continued on next page)

TABLE 7 (continued)

(2) show results when the same cutoff is used to define the pre- and post-period for all repatriating and nonrepatriating firms: the pre-period is defined as the four years prior to the first year of repatriation (i.e., 2000–2003), while the post-period is defined as the four years after the last year of repatriation (i.e., 2007–2010). The actual years of repatriation (i.e., 2004–2006) are neither included in the pre-period, nor included in the post-period to avoid misclassification. The diff-in-diff design takes the following form: $Y = \beta_0 + \beta_1 Treat + \beta_2 Post + \beta_3 Treat{*}Post + X\gamma + \varepsilon$ Columns (3) and (4) show results when the actual years of repatriation are used to define the pre- and post-period for repatriating firms: the pre-period is defined as the four years prior to the actual years of repatriation (2000–2003 for firms repatriating in 2004; 2001–2004 for firms repatriating in 2005, and 2002–2005 for firms repatriating in 2006), while the post-period is defined as the four years after the actual year of repatriation (i.e., 2005–2008 for firms repatriating in 2004; 2006–2009 for firms repatriating in 2005; and 2007–2010 for firms repatriating in 2006). The actual years of repatriation (2004–2006) are neither included in the pre-period nor included in the post-period to avoid misclassification. The pre- and post-periods are not defined for firms in the control group (multinational firms that did not repatriate under the AJCA). The diff-in-diff design takes the following form: $Y = \beta_0 + \beta_1 Treat + \beta_2 Treat{*}Post + X\gamma + \varepsilon$. We include industry and year fixed effects in all models. Standard errors are robust to firm heterogeneity and serial correlation by clustering at the firm level. t-statistics are shown in parentheses.
All other variables are defined in Appendix B.

Results of the first robustness test are reported in Panel A of Table 7. Similar to the main results in Table 5, the significantly positive coefficient estimate for the interaction term *Repatriation* ∗ *Post* for both the REM model and the IO model confirms our main finding that repatriating firms increased R&D expenditure relative to nonrepatriating firms after the AJCA.

In the second robustness test, we include all repatriating firms (i.e., firms repatriating in 2004, 2005, or 2006) when testing the effect of repatriation on R&D. We conduct this robustness test in two ways. First, since firms repatriated in one of three years, we define 2004, 2005, and 2006 as the event years. Then, we define 2000–2003 as the pre-repatriation period and 2007–2010 as the post-repatriation period. We report the results in Columns (1) and (2) in Panel B of Table 7 under the heading "Same Cutoff for Pre and Post." Similar to the main results in Table 5, the significantly positive coefficient estimate for the interaction term *Repatriation* ∗ *Post* indicates that the AJCA was associated with an increase in firm spending on R&D.

Second, we define the actual repatriation year of each repatriating firm as the event year and define our pre- and post-periods accordingly. The general model for the multiyear treatment design is specified in Equation (5) below:

$$RD_{it} = \beta_0 + \beta_1 Repatriation + \beta_2 Repatriation{*}Post + X_{it}\gamma + \mu_i + \delta_t + \varepsilon_{it}, \quad (5)$$

where all variables are defined as before. This multiyear treatment design is inferior to our main diff-in-diff design, as the test parameter, β_2, captures the difference in R&D expenditure between the post-repatriation period and the pre-repatriation period for the repatriating firms, but does not take out the common trend in the control group that is possibly caused by other confounding factors during the period. Appendix C provides detailed discussions on the difference between the standard diff-in-diff design and the multiyear treatment design for interpretations of the test parameters.

Results using this approach (i.e., diff-in-diff with multiyear treatment) are reported in Columns (3) and (4) in Panel B of Table 7 under the heading "Actual Cutoff for Pre and Post." The coefficient on the interaction term, *Repatriation* ∗ *Post,* is significantly positive at the 1 percent level, indicating increased firm spending on R&D after the AJCA. Taken together, the two robustness tests in Table 7 suggest our main results in Table 5 are not sensitive to different model specifications for R&D, different sample selection (firms repatriating in 2005 only, or firms repatriating in all three years), different definitions of the pre- and post-period, and whether it is single-year or multiyear treatment design in the diff-in-diff model.

CONCLUSION

In this paper we reexamine the efficacy of the American Jobs Creation Act of 2004 by empirically testing whether repatriating firms increased firm spending on R&D after this temporary tax holiday. We find that on average, the AJCA led to an increase in R&D investment, a result undocumented in prior literature. Our results are consistent with the survey evidence in Graham et al. (2010) that firms spent some of the repatriated funds on domestic investment and our results add to the literature that shows firms did not spend all repatriated funds on share repurchases.

The AJCA provides a unique setting for evaluating the effect of the tax policy on R&D investment because the AJCA changed firms' costs of accessing internal equity through the reduced repatriation tax rate, and internal equity is a particularly important financing source for R&D investment. Given that Congress is considering a major tax reform that may change how U.S. MNCs get taxed on their foreign earnings, our study is of interest to policymakers as it provides additional evidence on the role tax plays in firms' repatriation and investment decisions.

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APPENDIX A[20]

Sample Disclosures on R&D as One of the Planned Uses of Repatriated Funds

Baxter International Inc. (2005 Press Release)

Baxter International Inc. announced today that it intends to repatriate approximately $2.0 billion in unremitted foreign earnings related to the American Jobs Creation Act of 2004. The company expects to record a charge in the third quarter for the related tax expense of approximately 8 percent to 9 percent of the repatriation. Proceeds from the repatriation will be reinvested in its domestic operations consistent with the intent of the legislation. **Potential uses of the repatriated cash may include, among others, debt reduction, contributions to the company's pension fund(s), capital investment and the funding of research and development.**

Blyth Inc. (2006 10-K)

On January 24, 2006, the Board of Directors approved a domestic reinvestment plan for the approximately $130.0 million in foreign earnings, which were previously considered permanently reinvested in non-U.S. legal entities, which the Company repatriated under the American Jobs Creations Act of 2004 (AJCA). Of this amount, $91.0 million qualified for the favorable treatment under the AJCA. The funds were brought back to the U.S. late in the fourth quarter of fiscal 2006. The tax cost of this distribution was $7.6 million. **As part of its repatriation plan, the Company reinvested the repatriated amount domestically in a wide range of initiatives, including the hiring and training of U.S. workers, research and development efforts**, qualified retirement plan funding, capital expenditures to support the U.S. businesses, advertising and marketing with respect to its various trademarks, brand names and rights to intangible property, and acquisitions of U.S.-based businesses, all consistent with the requirements of the legislation.

Medtronic Inc. (2006 10-K)

During the fourth quarter of fiscal year 2006, we repatriated the entire amount eligible under the American Jobs Creation Act of 2004 (Jobs Creation Act), or $934 million. **The amounts repatriated were used for "qualified expenditures" as defined under the Jobs Creation Act such as qualified research and development activities**, construction of a new U.S. facility, and qualified selling and marketing activities.

Monsanto Company (2006 10-K)

In the fourth quarter 2006, after the company's chief executive officer and board of directors approved the company's domestic reinvestment plan, the company repatriated $437 million of foreign earnings under the AJCA. Accordingly, the company recorded income tax expense of $21 million associated with this repatriation. **The repatriated funds were used for research and development, capital expenditures, and other permitted activities.**

[20] This appendix provides examples of firm disclosures on R&D as one of the planned uses of funds repatriated under the AJCA. The bold underlined text reflects our highlighting of relevant passages.

APPENDIX B

Variable Definitions

Variable	Definition
Outcome Variables	
RD	Research and development expense (XRD).
RD_A	Research and development expense (XRD) scaled by beginning-of-period total assets (AT).
RD_S	Research and development expense (XRD) scaled by sales (SALE).
RD_Diff	Difference in *RD* between the post-repatriation period and the pre-repatriation period. Post-repatriation *RD* is calculated as average *RD* in the four years after the year of repatriation (2005–2008 for firms repatriating in 2004; 2006–2009 for firms repatriating in 2005; and 2007–2010 for firms repatriating in 2006); pre-repatriation *RD* is calculated as average *RD* in the four years prior to the year of repatriation (2000–2003 for firms repatriating in 2004; 2001–2004 for firms repatriating in 2005; and 2002–2005 for firms repatriating in 2006).
RD_A_Diff	Difference in *RD*/*Lagged Assets* between the post-repatriation period and the pre-repatriation period. Post-repatriation *RD*/*Lagged Assets* is calculated as average *RD*/*Lagged Assets* in the four years after the year of repatriation (2005–2008 for firms repatriating in 2004; 2006–2009 for firms repatriating in 2005; and 2007–2010 for firms repatriating in 2006); pre-repatriation *RD*/*Lagged Assets* is calculated as average *RD*/*Lagged Assets* in the four years prior to the year of repatriation (2000–2003 for firms repatriating in 2004; 2001–2004 for firms repatriating in 2005; and 2002–2005 for firms repatriating in 2006).
RD_S_Diff	Difference in *RD*/*Sale* between the post-repatriation period and the pre-repatriation period. Post-repatriation *RD*/*Sale* is calculated as average *RD*/*Sale* in the four years after the year of repatriation (2005–2008 for firms repatriating in 2004; 2006–2009 for firms repatriating in 2005; and 2007–2010 for firms repatriating in 2006); pre-repatriation *RD*/*Sale* is calculated as average *RD*/*Sale* in the four years prior to the year of repatriation (2000–2003 for firms repatriating in 2004; 2001–2004 for firms repatriating in 2005; and 2002–2005 for firms repatriating in 2006).
Test Variables	
Repatriation	An indicator variable that equals 1 if the firm repatriates at the reduced tax rate under the American Jobs Creation Act of 2004, and 0 otherwise (from the 10-K).
Post	An indicator variable that equals 1 if year *t* is on or after the year of repatriation, and 0 otherwise (from the 10-K).
Instrumental Variables	
TaxHaven	An indicator variable that equals 1 if a firm has at least one foreign subsidiary located in tax haven jurisdictions as of the end of fiscal 2003, and 0 otherwise (from Exhibit-21 of the 10-K). Tax haven jurisdictions are defined by the OECD (2000) as follows: Andorra, Anguilla, Antigua and Barbuda, Aruba, Bahamas, Bahrain, Barbados, Belize, Bermuda, British Virgin Islands, Cayman Islands, Cook Islands, Cyprus, Dominica, Gibraltar, Grenada, Guernsey, Isle of Man, Jersey, Liberia, Liechtenstein, Maldives, Malta, Marshall Islands, Mauritius, Monaco, Montserrat, Nauru, The Netherlands Antilles, Niue, Panama, Samoa, San Marino, Seychelles, St. Lucia, St. Kitts and Nevis, St. Vincent and the Grenadines, Tonga, Turks and Caicos, U.S. Virgin Islands, Vanuatu.
UDFE	Undistributed foreign earnings. An indicator variable that equals 1 if a firm has undistributed foreign earnings as of the end of fiscal 2003, and 0 otherwise (from the 10-K).
DFF Controls	
MktLev	Market leverage, the ratio of total debt (DLTT + DLC) to the sum of total debt and the market value of equity (CSHO × PRCC_F).
Tobin's Q	Tobin's Q, the ratio of the market value of total assets to the book value of total assets. The market value of total assets is calculated as the book value of assets (AT) plus the difference between the market value of equity (CSHO × PRCC_F) and the book value of equity (CEQ).
Cash/*Lagged Assets*	Cash and short-term investments (CHE) scaled by beginning-of-period total assets (AT).
Profitability	Net income (NI) scaled by lagged total assets (AT).
REM Controls	
1/*Lagged Assets*	One divided by lagged total assets (AT).
Lagged Sale/*Lagged Assets*	Lagged sales revenue (SALE), scaled by lagged total assets (AT).

(continued on next page)

APPENDIX B (continued)

Variable	Definition
IO Controls	
LnAssets	The natural logarithm of total assets (AT), a proxy for firm size.
BM	Book-to-market, the ratio of book value of equity (CEQ) to the market value of equity (CSHO × PRCC_F), a proxy for growth opportunity.
Ln(*FirmAge*)	The natural logarithm of firm age. Firm age is calculated as the current year minus the year of birth plus 1; the year of birth is the earlier of the first year when the company is listed on Compustat or CRSP.
Ln(*Cash*/*Assets*)	The natural logarithm of the ratio of cash and short-term investments (CHE) to total assets (AT).
BookLev	Book leverage, the ratio of total debt (DLTT + DLC) to total assets (AT).
ROA	Return on assets, the ratio of income before extraordinary items (IB) to total assets (AT).

APPENDIX C

Interpretation of the Coefficients

Design	Standard Difference-in-Differences	Multiyear Treatment
Basic Model	$Y = \beta_0 + \beta_1 Treat + \beta_2 Post + \beta_3 Treat{*}Post + \varepsilon$	$Y = \beta_0 + \beta_1 Treat + \beta_2 Treat{*}Post + \varepsilon$
Equations	$E(Y\|T = 1, P = 1) = \beta_0 + \beta_1 + \beta_2 + \beta_3$ (1)	$E(Y\|T = 1, P = 1) = \beta_0 + \beta_1 + \beta_2$ (5)
	$E(Y\|T = 1, P = 0) = \beta_0 + \beta_1$ (2)	$E(Y\|T = 1, P = 0) = \beta_0 + \beta_1$ (6)
	$E(Y\|T = 0, P = 1) = \beta_0 + \beta_2$ (3)	$E(Y\|T = 0, P = 1) = \beta_0$ (7)
	$E(Y\|T = 0, P = 0) = \beta_0$ (4)	$E(Y\|T = 0, P = 0) = \beta_0$ (8)
Test Parameter: β_3 or β_2	[(1) − (2)] − [(3) − (4)] ↠ β_3 represents the difference in *Y* between the post-period and the pre-period for the treatment group, relative to the difference in *Y* between the post-period and the pre-period for the control group (the diff-in-diff parameter).	(5) − (6) ↠ β_2 represents the difference in *Y* between the post-period and the pre-period for the *treatment group* (only).
β_2	(3) − (4) ↠ β_2 represents the difference in *Y* between the post-period and the pre-period for the control group.	
β_1	(2) – (4) ↠ β_1 represents the difference in *Y* between the treatment group and the control group in the pre-period.	(6) − (7) or (6) − (8) ↠ β_1 represents the difference in *Y* between the treatment group in the pre-period and the control group in all periods.
β_0	(4) ↠ β_0 represents the mean value of *Y* in the pre-period for the control group.	(7) − (8) ↠ β_0 represents the mean value of *Y* in all periods for the control group (the mean value is the same in the post- and the pre-periods for the control group, as the two periods cannot be differentiated for the control group).
Extended Model	$Y = \beta_0 + \beta_1 Treat + \beta_2 Post + \beta_3 Treat{*}Post + X\gamma + \varepsilon$	$Y = \beta_0 + \beta_1 Treat + \beta_2 Treat{*}Post + X\gamma + \varepsilon$