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UNIVERSITY OF CALIFORNIA,
IRVINE

Patent Collateralization and Tax-motivated Outbound Income Shifting

DISSERTATION

submitted in partial satisfaction of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

in Management

by

Ruimin Shaphan Harun Ng

Dissertation Committee:
Professor Terry Shevlin, Chair
Professor Mort Pincus
Professor Siew Hong Teoh

2021

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DEDICATION

To God be the Glory!

To my parents: Thank you for always encouraging me to do my best and inspiring me to be an accounting academic

To my dearest Kristal Yang: Thank you for always being there for me, even when we were oceans apart

If I have seen further, it is by standing on the shoulders of giants

Isaac Newton

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ABSTRACT OF THE DISSERTATION

Patent Collateralization and Tax-motivated Outbound Income Shifting

by

Ruimin Shaphan Harun Ng

Doctor of Philosophy in Management

University of California, Irvine, 2021

Professor Terry Shevlin, Chair

I study whether patents pledged as collateral for debt financing constrain US multinationals' (MNCs) tax-motivated outbound income shifting (TMOIS). US MNCs generally prefer high patent valuations when collateralizing their patents but low patent valuations when using patents for TMOIS. Tax authorities can rely on patent collateral valuations to constrain US MNCs' ability to artificially depress patent values for TMOIS. Moreover, banks often restrict US MNCs from relocating collateralized patents in lending contracts. Therefore, US MNCs that collateralize patents face increased costs of using those patents to engage in TMOIS. I provide evidence that the number of collateralized patents is negatively associated with US MNCs' TMOIS. The negative association between patent collateralization and TMOIS is more pronounced for US MNCs with strong debt financing needs and when tax authorities' resources are constrained. My study sheds light on a source of information that tax authorities can rely on to detect and deter aggressive income shifting strategies.

1. INTRODUCTION

In this paper, I study whether the pledging of patents as collateral for debt financing affects US multinationals' (MNCs) tax-motivated US outbound income shifting strategies (TMOIS). US MNCs commonly transfer patents out of the US to subsidiaries in low-tax jurisdictions such as Ireland and Singapore at artificially low values (i.e., transfer prices) (Avi-Yonah 2012). To obtain the benefits of TMOIS, US MNCs have strong incentive to artificially depress the values of their patents for transfer pricing purposes to avoid income taxes in the high-tax US. To mitigate tax-motivated transfer pricing, tax authorities require that transfer prices be at arm's length, or comparable to prices charged between unrelated parties (Section 482, IRC). However, identifying arm's length or comparable values in patent transactions is challenging for tax authorities as patents are unique and complex to value (IMF et al. 2017).

Tax authorities could rely on patent collateral valuations as benchmarks for the arm's length transfer prices of collateralized patents. US MNCs, especially innovative MNCs, increasingly pledge patents as collateral to obtain debt financing. As of 2017, 62% of patenting US MNCs have pledged patents as collateral at some point. Before issuing a patent-secured loan, the bank typically appoints an independent appraiser to formally value the borrowing MNC's pledged patent portfolio (Nowotarski 2012). The appraised values of the collateralized patents are made available to the borrowing MNC at the loan origination date.[1] These values satisfy the "arm's length" definition as the appraiser and the bank are unrelated to the borrowing MNC. During an audit, the IRS can make an information document request to gain access to pertinent information

[1] The borrower uses the independent appraiser's valuation to prepare a borrowing base report for the bank. A borrowing base report is a report that details the values of all the borrower's pledged collaterals. Throughout the tenure of the loan, borrowers are required to frequently prepare a borrowing base report for the bank to provide assurance that the total collateral values are sufficient to support the loan.

such as the loan agreement documents.[2] As a result, tax authorities can rely on patent collateral valuations to benchmark transfer prices of collateralized patents. Tax authorities could thus constrain the ability of borrowing US MNCs to set artificially low transfer prices on the same patents that are used for TMOIS. Therefore, I expect patent collateralization to constrain US MNCs' TMOIS.

Moreover, banks can directly restrict US MNCs from transferring collateralized patents out of the US to facilitate the collection of collateral. In lending contracts, banks typically state the location of the collaterals and include clauses that restrict the relocation of collaterals (See Appendix A). As a result, US MNCS with collateralized patents likely face difficulty undertaking TMOIS for their collateralized patents. Thus, I hypothesize that the number of collateralized patents is negatively associated with the extent of TMOIS.

I use records from the United States Patent and Trademark Office (USPTO) to identify patents pledged as collateral. I match these records to Compustat and examine the characteristics of US MNCs that collateralize patents. I find that US MNCs that have high innovation (i.e., US MNCs that hold more patents) and US MNCs in industries with low tangible assets tend to collateralize more patents. I also find that firm characteristics that are traditionally associated with debt use (low market-to-book ratios, high debt reliance measured using one-period lagged leverage ratio, low cash holdings, and non-dividend payers) are positively associated with the number of patents collateralized.

[2] My conversation with a former tax practitioner at a Big Four accounting firm suggests that tax authorities usually set their own benchmarks for patent transfer prices based on 1) proprietary databases that record comparable patent sale and licensing transactions and 2) data they obtain from the taxpayer (i.e. the corporation shifting its patents). The taxpayer's data can include loan agreement documents and documentation containing the appraised value of patents (e.g., borrowing base report).

I next examine whether patent collateralization constrains TMOIS by adapting Klassen and Laplante's (2012) multi-period outbound income shifting model. My sample spans 1995-2013 and I measure tax-motivated outbound income shifting through 2017.[3] I develop two measures of patent collateralization: 1) the natural logarithm of 1 plus the number of patents that are held by lenders of the US MNC for security interest in a given year and 2) the natural logarithm of 1 plus the number of patents pledged by the US MNC as collateral in the last two years. I interact these two measures with the outbound tax incentive of the US MNC to test whether the number of collateralized patents is negatively associated with TMOIS. I measure US MNCs' outbound tax incentive by using the five-year average of difference between the US statutory tax rate and weighted foreign tax rate. My results are consistent with the number of collateralized patents constraining US MNCs' TMOIS. I find that moving from the bottom to top quartile of the number of collateralized patents is associated with approximately an 8% reduction in TMOIS. In dollar terms, moving from the bottom to top quartile of the number of collateralized patents is associated with approximately a $3.1mil decrease in the average company's TMOIS per year.

Next, I examine whether US MNCs with stronger debt financing needs are more likely to trade off patent-based TMOIS in favor of meeting their debt financing needs. US MNCs that have stronger debt financing needs are more likely to pledge more valuable patents as collateral to secure bank loan financing.[4] Hence, tax authorities could constrain the ability of these US MNCs to set lower transfer prices for their valuable collateralized patents that are used for TMOIS. I use leverage ratios and operating cash flows scaled by lagged assets to measure US MNCs' debt financing needs. Consistent with my expectation, I find that the negative association between

[3] Most variables in the outbound income shifting model are measured from *t* to *t+4*.

[4] As patent collateral values are proprietary information, this information is not available to me. To address this data limitation, I use the debt financing needs of US MNCs as a proxy for higher patent collateral values.

patent collateralization and TMOIS is more pronounced for US MNCs with stronger debt financing needs.

I next provide support for the two channels through which patent collateralization constrains TMOIS. First, banks can contractually restrict borrowing MNCs from relocating collateralized patents to low-tax countries. I call this the "contracting channel." I identify cross-sectional variation in banks' willingness to approve US MNCs' relocation of collateralized patents.[5] Banks are less likely to be concerned about collateral collection when borrowing MNCs have low default risk. Hence, I expect banks to be more amenable to US MNCs relocating their collateralized patents when default risk is low. US MNCs with low default risk are thus more likely to implement their TMOIS strategies. I use two measures of default risk: 1) the probability of a US MNC violating its loan covenants, taken from Demerjian and Owens (2016), and 2) Altman's (1968) Z-score. Consistent with my expectation, I find that the negative association between patent collateralization and TMOIS is less pronounced for US MNCs with lower default risk.

Second, tax authorities can rely on patent valuation information in loan contracts to constrain US MNCs' TMOIS. I call this the "information channel." I perform two tests to examine whether patent collateralization constrains TMOIS through the information channel. First, I identify cross-sectional variation in the number of firm peers to proxy for tax authorities' reliance on information other than patent collateral valuations to benchmark transfer prices. US MNCs with more peers are likely to have more comparable patents for tax authorities to benchmark against. Tax authorities are likely to place more weight on comparable patent transactions and less weight

[5] It is empirically challenging to identify cross-sectional variation in collateral agreements that contain clauses that limit the relocation of collateralized patents and agreements that do not. US MNCs have discretion over the documents they disclose on the USPTO Patent Assignment website and most US MNCs only disclose the security agreements, which outline key terms of the arrangement and are not as detailed as the collateral agreements.

on the patent collateral valuations when benchmarking transfer prices for US MNCs with more peers. Hence, US MNCs with more peers are less constrained and more able to set lower transfer prices for collateralized patents and engage in TMOIS. To measure the number of peers, I use two proxies based on Hoberg and Phillips' (2010) product market peers database: 1) the number of product market peers and 2) the similarity-score weighted number of product market peers.[6] Consistent with my expectation, I find that the negative association between patent collateralization and TMOIS is less pronounced for US MNCs with a greater number of product market peers.

Second, I examine whether tax authorities' reliance on patent collateral valuations to benchmark transfer prices are affected by the amount of resources available to them. As determining the arm's length transfer prices of patents can be resource-consuming for tax authorities, tax authorities are more likely to rely on patent collateral valuations as benchmarks when resources are constrained. Hence, US MNCs are less able to set lower transfer prices for collateralized patents and engage in TMOIS when tax authorities are resource-constrained. I use the inflation-adjusted IRS enforcement budget scaled by the total number of tax returns filed to measure tax authorities' resources (Nessa, Schwab, Stomberg, and Towery 2020). Consistent with my expectation, I find that the negative association between patent collateralization and TMOIS is more pronounced in years when tax authorities are resource-constrained.

Next, I also examine whether collateralized patents are less likely to be shifted overseas. This analysis seeks to provide further validation that patent collateralization constrains US MNCs'

[6] The similarity-score weighted number of product market peers is based on the notion that not all product market peers are equally similar to the focal US MNC. Each peer firm is assigned a score (between 0 and 1) based on how similar the peers' products are to the focal US MNC's. The similarity-score weighted number of product market peers for a given focal US MNC is essentially the sum of the similarity scores between the focal US MNC and all its peers. I provide more details in Section 6.4.3.

ability to use collateralized patents for TMOIS. Through the contracting and information channel, US MNCs face increased costs of transferring collateralized patents out of the US for the purpose of TMOIS. Therefore, I expect collateralized patents held by US MNCs to have a lower likelihood of being transferred out of the US. Performing a patent-level analysis, I find evidence consistent with collateralized patents having a lower likelihood of being transferred out of the US and to tax haven countries.

Finally, to address endogeneity concerns stemming from unobservable motivations that could be driving both patent collateralization and TMOIS decisions, I employ two alternative identification strategies. First, I rely on the federal court decision in *Rhone-Poulenc Agro v DeKalb Genetics Corp. (2002)* concerning the applicability of patent law to Delaware's Asset-backed Securities Facilitation Act (ABSFA) to exploit plausibly exogenous variation in US MNCs' incentives to collateralize patents. Property rights are largely similar across most states (Mann 2018). However, Delaware's ABSFA protects creditor rights by allowing borrowers to "sell" collateral such that in the event of a bankruptcy, assets that have been pledged as security by the borrowers are not deemed to be part of the borrowers' assets for liquidation and distribution. There was, however, uncertainty on whether ABSFA applied to patent-secured loans because ABSFA is a state law and courts could rule that federal patent law implicitly pre-empts state law. In *Rhone-Poulenc*, the court recognized that state laws have authority over contracts for rights under patents, which include patent security contracts. The court decision indirectly acknowledged the applicability of ABSFA to patent-secured loans, reinforcing the rights of creditors that issue patent-secured loans to Delaware-incorporated borrowers. Consequently, the court decision "exogenously" raised the collateral values of patents for Delaware-incorporated borrowers via strengthened creditor rights, incentivizing Delaware-incorporated borrowers' to collateralize patents. I employ a generalized difference-in-differences design as my identification strategy.[7] I continue to find results consistent with patent collateralization constraining TMOIS.

Second, I employ the Heckman selection correction procedure to mitigate bias from US MNCs' self-selecting into patent collateralization. I rely on the *Rhone-Poulenc* event as my exclusion restriction in the first stage selection model. My main results are robust to the inclusion of the inverse Mills ratio derived from the first stage model. Overall, my main results are robust to alternative identification strategies.

My study contributes to several strands of literature. First, the literature on patent collateralization is relatively scarce. Only a few studies examine the effect of patent collateralization on firm decisions (e.g., Mann 2018). My study is one of the first to examine how patent collateralization for debt financing affects US MNCs' incentives to shift income overseas. Studies on TMOIS are still relevant even after the passage of the 2017 Tax Cut and Jobs Act (TCJA). The transition from a worldwide corporate income tax system to a hybrid territorial system continues to provide US MNCs with the incentive to shift income out of the US to lower tax jurisdictions. While there are provisions in TCJA that aim to prevent base-erosion and income shifting (e.g., Base-Erosion and Anti-abuse Tax (BEAT) and Global Intangible Low-Taxed Income (GILTI)), the effectiveness of these policies is not yet known.

Second, my study extends De Simone (2016) by exploring information sources provided by external parties that influence MNCs' TMOIS. De Simone (2016) finds that MNCs with more comparable financial reporting have greater flexibility in setting transfer prices as they have a larger set of comparable firms to benchmark against. I, on the other hand, find evidence consistent

[7] Exploiting a plausibly exogenous shock to MNCs' incentive to collateralize patents in a generalized difference-in-differences design also allows me to mitigate concerns about simultaneity bias coming from patent collateralization and tax-motivated outbound income shifting being jointly determined.

with patent collateral values from patent-secured loans providing tax authorities with a benchmark for patent transfer prices. In fact, information from patent collateral valuations could be important to tax authorities, in light of the IRS facing budget cuts. Over the past 10 years, the IRS budget has been reduced by approximately 20%, stifling the agency's investments in staff training and new technology (Snell 2020). As determining the arm's length transfer prices of patents can be a time- and resource-consuming activity, tax authorities could rely more on patent collateral valuations as benchmarks for transfer prices when resources are constrained.

Third, my study adds to the literature on the role banks play in corporate tax avoidance. While banks have been known to facilitate tax planning for firms (Gallemore, Gipper, and Maydew 2019), there is little empirical evidence that supports whether contracting terms and patent valuation information in loan contracts can have negative externalities on borrowing firms' tax planning. My study sheds light on whether banks 1) restrict the relocation of collateralized patents to low-tax countries through collateral contracts and 2) provide an arm's length valuation of assets, which tax authorities can rely on to benchmark transfer prices.

Last, because patent collateralization for debt financing could constrain US MNCs' ability to shift income overseas, there is a trade-off between the US MNCs' debt financing needs and tax planning. My study contributes to the literature on the cost of tax planning and tax avoidance. My study extends Dyreng and Markle (2016) by providing alternative channels through which firms' debt financing needs and financial constraints restrict TMOIS. In my study, I provide evidence consistent with patent collateralization constraining TMOIS through the contracting and information channel.

2. INSTITUTIONAL BACKGROUND AND PRIOR LITERATURE

2.1. Tax-motivated Income Shifting

MNCs shift income in response to tax incentives via the strategic valuation of intracompany sale of goods, services, and intangibles such as patents. Patent-based income shifting is a major strategy employed by US MNCs in their tax-motivated income shifting endeavors (De Simone, Huang, and Krull 2020; De Simone, Mills, and Stomberg 2019; Grubert 2003; Grubert and Mutti 1991). Using patents, US MNCs can 1) shift income out of the high-tax US to low-tax subsidiaries (i.e., tax-motivated outbound income shifting; TMOIS) and 2) shift income from high-tax subsidiaries (e.g., French subsidiary) to low-tax subsidiaries. Relating to TMOIS, De Simone et al. (2019) use IRS data and find that US MNCs in high tech industries report net outbound payments to their foreign controlled subsidiaries. Regarding income shifting between high-tax and low-tax subsidiaries, Grubert (2003) provides evidence that approximately half of the income shifted from high-tax to low-tax countries is attributed to income derived from R&D-based intangibles. While patent collateralization is likely to affect both forms of tax-motivated income shifting, I focus on TMOIS in my study as my research design is only equipped to capture this type of income shifting.

There are typically three types of intra-company transactions US MNCs can undertake to engage in patent-based TMOIS. These intra-company transactions include patent licensing, patent sales, and cost sharing agreements (CSAs). For patent licensing or sales, the US parent can transfer the economic rights of the domestically developed patents to foreign affiliates in low-tax countries at an artificially low transfer price. After the patents are transferred to the low-tax foreign subsidiaries, future profits generated by the patents (e.g., royalty payments from other foreign subsidiaries for the use of the patents) are relocated to these low-tax jurisdictions (Blair-Stanek

2015; Avi-Yonah 2012).[8] For CSAs, the US parent can enter into a cost-sharing contractual agreement with its low-tax foreign subsidiaries to jointly develop new patents. Under this agreement, the US parent would contribute its domestically developed patent in return for an artificially low "buy-in" payment from the low-tax foreign affiliate. Collectively, these three strategies allow US MNCs to transfer their domestically developed patents to foreign affiliates at an artificially low price, resulting in the shifting of future income to low-tax foreign jurisdictions.

To mitigate tax-motivated transfer pricing, tax authorities require that transfer prices be at arm's length, or comparable to prices charged between unrelated parties (Section 482, IRC). Furthermore, beginning in 2013, the OECD and G20 countries adopted the Base Erosion and Profit Shifting (BEPS) initiative. With the goal of targeting intangible-related income shifting, the BEPS initiative developed Actions 8-10 to "align transfer pricing outcomes with value creation" (OECD 2015). The premise of the OECD's approach is that all affiliates of a MNC should receive appropriate compensation, at arm's length, for the functions they perform, the assets they use and the risks they assume in connection with the intangibles (Subramanian 2017). Despite stricter regulations, MNCs continue to engage in patent-based TMOIS. This is because identifying comparable patent transactions that are in line with OECD's "value creation" approach to benchmark transfer prices can be challenging for tax authorities, because patents, by nature, are unique and complex to value (IMF et al. 2017).

[8] Royalty payments made by a foreign subsidiary to another give rise to subpart F income. Subpart F income is taxed immediately at the US statutory tax rate even if the royalty income has not been repatriated to the US. To prevent such royalty payments from being classified as subpart F income, US MNCs typically create a foreign holding company that owns the low-tax subsidiary holding the patents and other foreign subsidiaries that use the patents for their operations. The patent-owning subsidiary and the other foreign operational subsidiaries make check-the-box elections to be treated as passthrough entities such that the intra-company royalty payments are eliminated for US tax purposes and not deemed as subpart F income.

However, US MNCs could decide not to artificially deflate their patents' transfer prices for a few reasons. The need to protect intellectual property value could disincentivize US MNCs from lowering transfer prices of patents, thereby constraining TMOIS. Lower patent transfer prices may harm the MNC's ability to support the value of its patents in an infringement case, causing the MNC to recover damages that are lower than what it is actually entitled. Gallemore, Huang, and Wentland (2019) find US MNCs that engage a greater number of patent expert law firms are more likely to reduce the extent of their TMOIS. These legal experts are more likely to advise their client firms against employing aggressive patent transfer pricing strategies in order to protect the US MNCs' intellectual property value.

Another reason that US MNCs do not deflate patent transfer prices is that arm's length values of patents could be made available to tax authorities. One source of information tax authorities can rely on to benchmark transfer prices for patents is patent-secured loan agreements.[9] Before issuing a patent-secured loan to the borrowing MNC, the bank will appoint an independent appraiser to formally value the pledged patent portfolio to determine how much of a loan the patent portfolio can support (Nowotarski 2012).[10] This valuation satisfies the "arm's length" definition as the appraiser and the bank are unrelated to the borrowing MNC. Given that tax authorities can avail themselves access to the valuation of collateralized patents through information document requests, US MNCs' ability to set low transfer prices for these patents could then be constrained by tax authorities.

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[9] Corporations can expect to furnish loan documents, among other documents, when they are being audited by the IRS.

[10] I assume that the patent collateral values do not deviate too far from the fundamental values of the patents. The independent appraisers are experts in valuing patents and are expected to provide an unbiased assessment about the fair value of the collateralized patents. Moreover, to the extent that the bank lending market is competitive, US MNCs, on average, should borrow from banks that provide patent valuations that are equal to or above the MNCs' reservation price. This assumption may not be true and provides tension for my hypothesis.

Moreover, banks can directly restrict borrowing MNCs from transferring patents out of the US. Banks are likely to face difficulty enforcing their security interests in collateralized patents if the borrowing MNCs transfer their collateralized patents to overseas subsidiaries and subsequently default on their loans. Hence, banks can contractually restrict borrowing MNCs from relocating collateralized patents to overseas affiliates. In Appendix A, I provide an example of a clause in a collateral agreement that restricts the borrower from relocating its collaterals (collateralized patents included) unless approval is granted by the bank.

2.2.Banking and Tax Avoidance

Prior studies find that banks play two different roles in corporate tax avoidance. On one hand, banks serve as a tax-planning intermediary for firms, designing, promoting, and facilitating financial arrangements that reduce client firms' tax burdens (Gallemore et al. 2019). On the other hand, banks perceive corporate tax avoidance as a risky activity, charging higher loan spreads to firms with greater tax avoidance (Hasan, Hoi, Wu, and Zhang 2014; Shevlin, Urcan, and Vasvari 2020). However, banks can affect firms' tax avoidance activities in other ways such as 1) restricting the relocation of collateralized patents to low-tax countries through collateral contracts and 2) providing an arm's length valuation of assets used for transfer pricing, which tax authorities can rely on to benchmark transfer prices. My study sheds light on these other channels through which banks constrain US MNCs' tax avoidance activities involving patent-based TMOIS.

2.3.Patent Collateralization

Patents are a growing source of collateral for debt financing. As of 2017, 53% of patenting US corporations that have filed a patent since 1995[11] have pledged patents as collateral at some point. In 2017, 27% of these firms were in a patent-secured loan agreement. The percentage is

[11] The patent assignment and collateralization data are collected for patents filed since 1995. More details are provided in Section 5.

even higher for MNCs with 62% of patenting US MNCs[12] pledging patents as collateral at some point, as of 2017 (see Fig. 1).

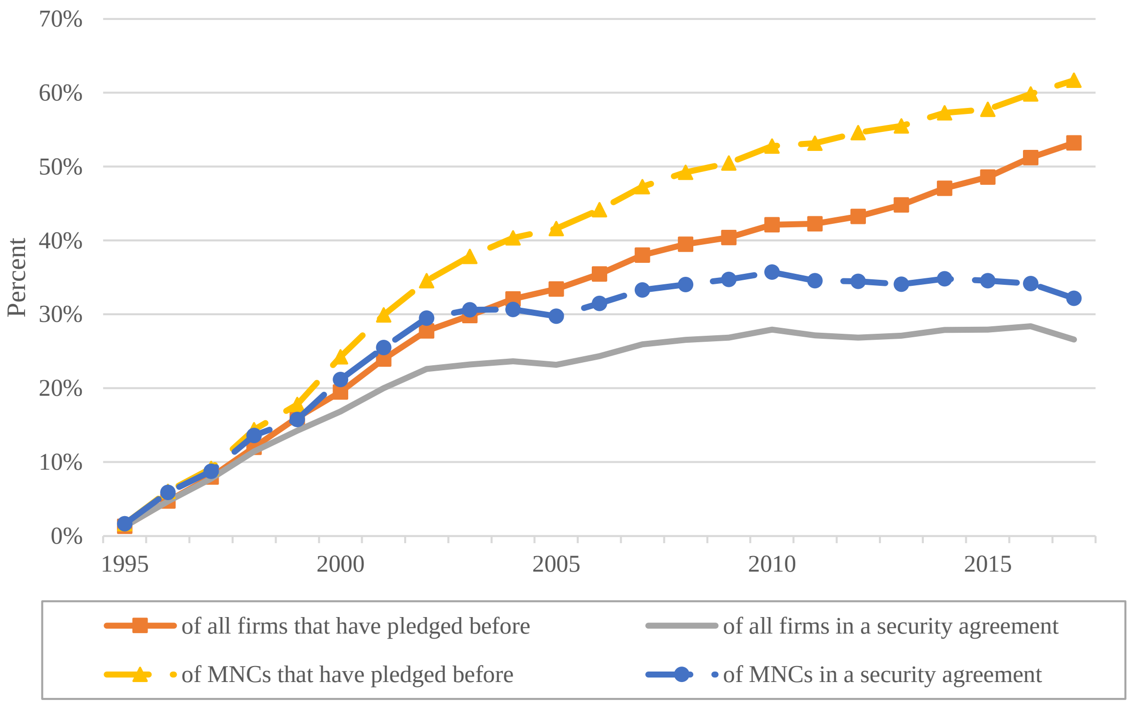

Figure 1. Percentage of Patenting Firms that Pledged their Patents as Collateral

Notes: Patents used in the figures and subsequent analyses refer to patents filed since 1995. The extremely low percentage of patenting firms pledging patents as collateral in the early years could be that firms need time to collateralize patents that are recently filed. In later years, the percentages are similar to Mann's (2018) estimates. For example, in 2013, 38% (Mann 2018) vs. 45% (my estimate) of US patenting firms had pledged their patents as collateral at some point.

In fact, innovative US MNCs, well known for their aggressive tax avoidance activities and the focus of the study, are more likely to collateralize patents. Fig. 2 presents the top ten industries of US MNCs that collateralize patents, as of 2017. These industries mainly consist of the IT/internet and pharmaceutical industries (industries traditionally viewed as high-tech industries). In addition, patents with higher forward citations and generality are more likely to be collateralized

[12] I define MNCs as firms with non-zero or non-missing values of pre-tax foreign earnings (PIFO) or foreign tax expense (TXFO, TXDFO).

since such patents are more redeployable and are expected to limit creditors' downside risk (Mann 2018). These patents are also more likely to be used for TMOIS (Baumann, Bohm, Knoll, and Riedel 2018). As higher valued patents generate higher income in the form of royalty/ licensing fees, US MNCs have strong incentives to relocate higher valued patents to low-tax countries so as to shift greater amounts of income out of the US to low-tax countries. Hence, US MNCs face a trade-off between pledging patents as collateral for debt financing and using the same patents for TMOIS.

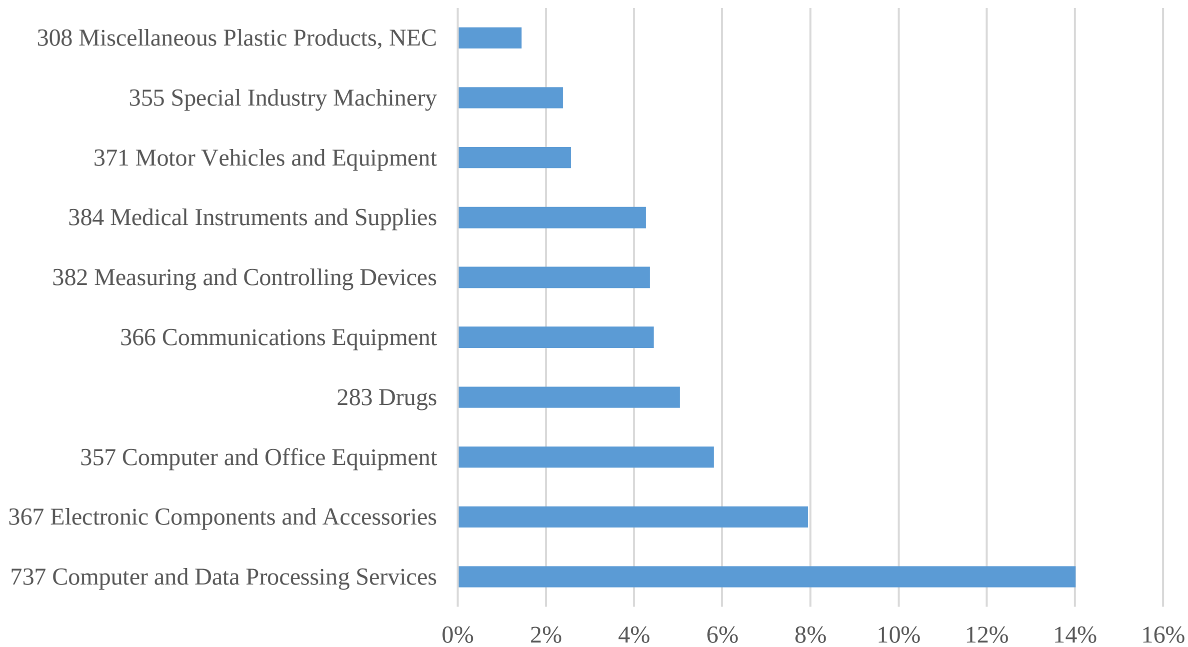

Figure 2. Top Ten Industries of Patenting MNCs that Collateralize Patents

For patent collateralization to constrain TMOIS of US MNCs, a key assumption is that the collateralized patents are located in the US at the time of collateralization. To validate my assumption, I focus on patents held by US MNCs (and their affiliates) and examine the legal residence of the patent holders that assign security interests of their patents to banks. In Table 1, I present the top ten countries to which the patent holders that collateralize patents belong. Almost all the patent holders reside in the US when they assign the security interests of their patents to banks. This finding gives me assurance that almost all patents are located in the US at the time of collateralization. While the proportion of patent holders located in tax havens is very small, it is interesting to note that four out of the top ten countries where patent holders are located are listed as tax havens (United Kingdom, Netherlands, Luxembourg, and Switzerland).[13] Moreover, patent holders residing in tax haven countries make up a sizeable proportion (~16%) of patent holders residing outside of the US.

Table 1. Top Ten Countries of Patent Holders that Pledge Patents as Collateral

Country	%
USA	98.79%
Germany	0.52%
Canada	0.38%
United Kingdom	0.12%
Japan	0.06%
France	0.02%
Netherlands	0.02%
Luxembourg	0.02%
Israel	0.02%
Switzerland	0.02%
Tax Havens	0.19%

Notes: This table presents the top ten countries where patent assignees that pledge their patents as collateral are located. Tax havens refer to countries that are listed in Hine's (2010) and Garcia-Bernardo et al.'s (2017) list of tax haven countries.

3. HYPOTHESIS DEVELOPMENT

3.1.Main Hypothesis

I hypothesize that patent collateralization constrains US MNCs' TMOIS through two channels. First, banks can restrict borrowing MNCs from relocating collateralized patents to

[13] I classify countries as tax havens based on Hine's (2010) and Garcia-Bernardo et al.'s (2017) list of tax haven countries. Following the restructuring of its tax code in 2009 – 2013, the United Kingdom has gained the reputation of a rising corporate tax haven (Bloomberg News 2017; The Economist 2015; Garcia-Bernardo et al. 2017).

overseas low-tax affiliates. In the event that borrowing MNCs default on their loans, banks have the right to enforce their security interests in the collateralized patents and repossess these patents to offset against the borrowing MNCs' debt obligations. To facilitate the collection of collaterals in the event of a default, banks clearly stipulate the location of the collaterals and include clauses that restrict the relocation of collaterals in the collateral agreement. See Appendix A for an example. Given that banks can contractually restrict US MNCs from relocating collateralized patents to low-tax subsidiaries, these MNCs will have difficulty undertaking patent-based TMOIS for their collateralized patents.

Second, banks typically appoint independent appraisers to formally value the collateralized patents. These valuations of patents are likely to be informative of the arm's length values, as the appraisers, banks, and borrowing MNC are unrelated.[14] Given that tax authorities can access the collateralized patent valuations by auditing the US MNCs' loan documents, tax authorities could use the collateral valuations to benchmark transfer prices for the collateralized patents. Hence, tax authorities are likely to constrain US MNCs' TMOIS because US MNCs are less able to set artificially low transfer prices for collateralized patents. As a result, I expect US MNCs to reduce the extent of their TMOIS as they collateralize more patents. Thus,

H1: I hypothesize that the number of collateralized patents is negatively associated with the extent of TMOIS.

[14] I assume that US MNCs do not or cannot influence the independent appraisers to understate the values of collateralized patents so that the US MNCs can engage in TMOIS. The independent appraisers have to be unrelated to both the bank and the borrowing MNCs. They are thus expected to provide an unbiased assessment about the fair value of the collateralized patents. Moreover, deflating collateral values is costly to the borrowing MNC as the MNC will either obtain a smaller loan or be charged higher interests when collateral values are deflated. Hence, I expect MNCs not to influence appraisers to deflate patent collateral values, especially when they have strong debt financing needs. Consistent with this line of argument, I hypothesize that patent collateralization constrains TMOIS to a larger extent when MNCs have stronger debt financing needs because these MNCs are likely to seek favorable collateral valuations for their collateralized patents to secure larger bank loans (see Hypothesis *H2*).

However, my hypothesis is not without tension. While collateral agreements may contain clauses that restrict the relocation of collateralized patents to overseas low-tax jurisdictions, the degree to which banks enforce these clauses is an empirical question. To the extent that these clauses are boilerplate and banks are amenable to US MNCs' relocating their collateralized patents overseas, patent collateralization may not effectively restrict US MNCs' intracompany patent transfer arrangements, on average. In addition, I assume that the patent collateral valuations do not deviate too far from the fundamental values of the patents. If banks and appraisers are conservative in their valuations, tax authorities may rely less on the patent collateral valuations as benchmarks since these valuations may not be informative of the arm's length values of the collateralized patents. Given these reasons, the relation between patent collateralization and TMOIS is an empirical question.

Next, I examine whether US MNCs trade off patent-based TMOIS in favor of meeting their debt financing needs.[15] US MNCs that have stronger debt financing needs are more likely to pledge their more high-valued patents as collateral to secure a greater amount of bank loan financing. However, these high-valued patents could be contractually restricted from being relocated to low-tax countries for TMOIS. As a result, US MNCs forgo shifting substantial amounts of income out of US to low-tax countries, where the high-valued patents could have been relocated.

Furthermore, US MNCs with strong debt financing needs are likely to seek favorable collateral valuations for their collateralized patents to secure larger bank loans. As a result, the higher patent collateral valuations can be used as benchmarks by tax authorities. Consequently,

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[15] It is possible that US MNCs needing debt financing to fund their domestic operations face high cost of external financing and are less likely to shift income out of the US (Dyreng and Markle 2016). However, the purpose of this cross-sectional analysis is not to examine whether debt financing needs affect TMOIS but to examine whether debt financing needs affect the constraining effect of patent collateralization on TMOIS.

tax authorities are more likely to constrain the TMOIS of US MNCs with strong debt financing as these MNCs are less able to set low transfer prices for their collateralized patents. I hence expect the extent of TMOIS in US MNCs with stronger debt financing to be decreasing more drastically in the number of patents collateralized. Thus,

H2: I hypothesize that the negative association between patent collateralization and TMOIS is more pronounced for US MNCs with stronger debt financing needs than for those with weaker debt financing needs.

3.2.Contracting Channel

Next, I provide evidence that banks have the contractual right to restrict US MNCs from relocating collateralized patents to low-tax countries. I identify cross-sectional variation in banks' willingness to approve US MNCs' relocation of collateralized patents.[16] As banks are less likely to be concerned about collateral collection when the borrowing MNCs have low default risk, I expect banks to be more amenable to US MNCs relocating their collateralized patents when default risk is low. Hence, I expect TMOIS of US MNCs with low default risk to be less constrained.[17] Thus,

H3: I hypothesize that the negative association between patent collateralization and TMOIS is less pronounced for US MNCs that are less likely to default on loans than for other US MNCs.

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[16] Most US MNCs do not disclose collateral agreements and instead disclose the security agreements, which outline key terms of the arrangement and are not as detailed as the collateral agreements. It is an empirical challenge to discern whether lenders include contractual clauses that restrict the relocation of collateralized patents in most secured transactions. To address this issue, I use borrowing MNCs' default risk to proxy for banks' willingness to allow borrowing MNCs to relocate their collateralized patents.

[17] To the extent that the default risk of the US MNC affects the valuation of the collateralized patents, US MNCs with lower default risk are likely to have higher patent collateral valuations. US MNCs would then be less able to set low transfer prices for collateralized patents if tax authorities use the higher patent collateral valuations to benchmark transfer prices. If this argument is true, I expect the negative association between patent collateralization and TMOIS to be *more* pronounced for US MNCs that are less likely to default on loans than for others.

3.3.Information Channel

Next, I provide support that patent collateralization provides tax authorities with an informative signal of the arm's length values of patents through the appraised values of collateralized patents. First, I identify cross-sectional variation in tax authorities' reliance on patent collateral valuations as benchmarks for transfer prices. My conversation with a former tax practitioner suggests that tax authorities typically set their own benchmarks for patent transfer prices based on 1) proprietary databases that record comparable patent sale and licensing transactions and 2) data they obtain from the US MNC (e.g., loan documents). US MNCs with a greater number of peers are likely to have more comparable patent sale and licensing transactions for tax authorities to benchmark against. Tax authorities are hence likely to place more weight on these comparable patent transactions and less weight on the patent collateral valuations when determining benchmark prices of collateralized patents for US MNCs with more peers.

Moreover, US MNCs with more peers have a larger set of comparable benchmark patents that likely provides a wider range of benchmark prices. Even if the collateral valuations of collateralized patents can be made available to tax authorities, US MNCs with more peers can justify the lower transfer prices of their collateralized patents more easily. These lower transfer prices are likely to fall within the wider benchmark price ranges. As a result, these MNCs have greater flexibility in setting lower transfer prices for their collateralized patents. My argument is in the same vein as the argument in De Simone (2016) where she finds that the increase in the number of economically comparable peers, as a result of cross-country IFRS adoption, provides focal MNCs with a larger set of potential benchmark firms, affording MNCs more flexibility to set tax-advantaged transfer prices.

As US MNCs with more peers are less constrained by tax authorities' reliance on patent collateral valuations to benchmark transfer prices, I expect these MNCs to reduce their TMOIS to a smaller extent as they collateralize more patents. Thus,

H4a: I hypothesize that the negative association between patent collateralization and TMOIS is less pronounced for US MNCs with more peers than for those with fewer peers.

That said, US MNCs with greater number of peers could operate in a more transparent environment. Tax authorities could rely on more external comparable information, coupled with patent collateral valuations, to constrain US MNCs' TMOIS activities (Amberger and Osswald 2020). This argument is a source of tension for my cross-sectional hypothesis *H4a*.

Second, I examine whether the resources of tax authorities affect the constraining effect of patent collateralization on TMOIS. Determining the arm's length values of patents can be a resource-consuming activity for tax authorities. The uniqueness of patents makes identifying comparable patent transactions to benchmark patent transfer prices challenging. In a resource-constrained environment, tax authorities are more likely to rely on readily available valuation information when benchmarking patent transfer prices. Patent collateral valuations, which can be made readily available to tax authorities, provide tax authorities with an informative signal of the arm's length values of the collateralized patents. Tax authorities are hence likely to place more weight on patent collateral valuations in determining the arm's length values of collateralized patents when resources are constrained. Consequently, US MNCs are less able to set low transfer prices for collateralized patents and engage in TMOIS when tax authorities' resources are constrained. I expect US MNCs to reduce their TMOIS to a greater extent as they collateralize more patents when tax authorities' resources are constrained. Thus, *H4b: I hypothesize that the negative association between patent collateralization and TMOIS is more pronounced in years when tax authorities are resource-constrained than in other years.*

4. RESEARCH DESIGN

To test the effect of patent collateralization on TMOIS, I adapt Klassen and Laplante (2012) multi-period outbound income shifting model and estimate the following OLS panel regression.

$$FRoS_{i(t,t+4)} = \beta_0 + \beta_1 FTR_{i(t,t+4)} + \beta_2 \#ColPatents_{it} + \beta_3 \#ColPatents_{it} * FTR_{i(t,t+4)} + \beta_4 RoS_{i(t,t+4)} + \beta_k X'_{i(t,t+4)} + IndustryFE + YearFE + \epsilon_{i(t,t+4)} \quad (1)$$

The dependent variable $FRoS_{(t,t+4)}$ represents the profit margin of a US MNC's foreign operations and is measured using the five-year sum of foreign pre-tax income (PIFO) over the five-year sum of foreign sales. $FTR_{(t,t+4)}$ represents the TMOIS incentive and is calculated using the five-year average of difference between the US statutory tax rate and weighted foreign tax rate. The weighted foreign tax rate is calculated using the foreign tax expense (TXFO plus TXDFO) scaled by foreign pre-tax income (PIFO). A higher FTR implies a higher outbound tax incentive to shift US income overseas. Hence, I expect β_1 to be positive as the profitability of the US MNC's foreign operations is expected to increase as FTR increases. I use a five-year multi-period model to smooth yearly fluctuations in the outbound tax incentive measure that are unrelated to TMOIS (e.g., net operating losses in foreign operations), reducing measurement error in the outbound tax incentive measure (Klassen and Laplante 2012).

$\#ColPatents$ represents the number of patents collateralized by the US MNC. I use two measures of $\#ColPatents$: 1) the natural logarithm of 1 plus the number of patents that are held by lenders of the US MNC *i* for security interest in year *t* (*Ln(ColPat)*) and 2) natural logarithm of 1 plus the number of patents pledged by the US MNC *i* as collateral in the last two years (*t-2, t*)

(*Ln(ColPatInit2)*).[18] For example, if a US MNC pledges 5 patents as collateral in 2005 and does not pledge any more patents after, the *Ln(ColPatInit2)* variable will be coded to log(1+5) in 2005 to 2007 and 0 after. The difference between the two measures is subtle yet important. To illustrate the difference, if a US MNC assigns 10 patents to a bank in 2000 for security interest (i.e., pledges 10 patents as collateral in 2000) and the bank releases the security interest in 2004, the *Ln(ColPat)* variable will be coded to log(1+10) from 2000 to 2004. On the other hand, the *Ln(ColPatInit2)* variable will be coded to log(1+10) from 2000 to 2002 and 0 from 2003 to 2004. Please refer to Appendix B for a graphical representation of the construction of the two measures. For patent collateral valuations to be relevant to the tax authorities for benchmarking, the valuations should be timely. Patents that have been pledged as collateral for a long time could have valuations that deviate from the appraised values undertaken at the loan origination date. *Ln(ColPatInit2)* captures the number of collateralized patents with timely patent collateral valuations that could be relevant to tax authorities.[19]

The variable of interest in the regression is the interaction of the number of collateralized patents and the TMOIS incentive of the US MNC, $\#ColPatents_{it} * FTR_{i(t,t+4)}$. Given my hypothesis that the number of collateralized patents is negatively associated with the extent of TMOIS, I expect β_3 to be negative. $RoS_{(t,t+4)}$ is the five-year sum of worldwide pre-tax income (PI) over five-year sum of worldwide sales (SALE) and is used to control for cross-sectional variation in US MNCs' overall profitability. I also include a vector of controls X that are correlated with US MNCs' incentives to collateralize patents (and use debt financing) and shift income

[18] Given the skewness of the data, I choose to take the natural logarithm rather than the raw count of the number of collateralized patents. Nevertheless, my results are robust to using the count of the number of collateralized patents.

[19] In robustness tests, I reduce the window to 1 year instead of 2 and find very similar results (see Table 13 Panel C).

overseas. Controls include firm size (*ln(Assets)*$_{(t,t+4)}$), leverage (*Lev*$_{(t,t+4)}$), market-to-book ratio (*MB*$_{(t,t+4)}$), cash scaled by lagged assets (*Cash* $_{(t,t+4)}$), tangibility of assets (net PPE scaled by total assets; *Tangible*$_{(t,t+4)}$), dummy variable indicating whether the US MNC pays dividends (*DivPayer*$_{(t,t+4)}$), the marginal tax rates (*MTR*$_{(t,t+4)}$) and the five-year standard deviation of operating cash flow scaled by lagged assets (*5Yrσ(CFO)*) (Dyreng and Markle 2016; Lester 2019; Lemmon, Roberts, and Zender 2008; Titman and Wessels 1988). Dyreng and Markle (2016) find that US MNCs with greater financial constraints (i.e., less ability to raise external financing) are less likely to shift income out of the US as these MNCs have to pay taxes on the repatriated foreign income that is used to fund domestic operations. To the extent that financially constrained US MNCs are more likely to collateralize patents, the inclusion of *Lev*$_{(t,t+4)}$, *Cash* $_{(t,t+4)}$, and the determinants of debt financing (e.g., *MB*$_{(t,t+4)}$, *Tangible*$_{(t,t+4)}$, *DivPayer*$_{(t,t+4)}$, *MTR*$_{(t,t+4)}$, and *5Yrσ(CFO)*) as control variables helps to rule out financial constraints as an alternative explanation for the negative β_3 coefficient. Also, another reason for including *Lev*$_{(t,t+4)}$ as a control is that patent collateralization can affect TMOIS via the bank financing channel. Banks could either 1) facilitate US MNC's tax avoidance strategies (Gallemore et al. 2019) or 2) deter tax avoidance by charging high loan spreads (Hasan et al. 2014). Controlling for leverage controls for the bank financing channel. Refer to Appendix C for variable definitions.

I also include total patents (*Ln(Patents)*) and the interaction *Ln(Patents)* $* FTR_{i(t,t+4)}$. *Ln(Patents)* refers to the natural logarithm of 1 plus the number of patents and pending patents held by a US MNC.[20] Controlling for *Ln(Patents)* and the interaction *Ln(Patents)* $* FTR_{i(t,t+4)}$

[20] Pending patents refer to filed patent applications that have not been granted but will eventually be granted. I include pending patents in the total patent count because US MNCs can collateralize them and assign them to new assignees. This measure of total patents should be comparable to the $\#ColPatents$ measures and could also capture patent-based TMOIS.

controls for patents that are not collateralized and are used for TMOIS. Hence, I expect the coefficient on *Ln(Patents)* $* FTR_{i(t,t+4)}$ to be positive. I also control for the quality of patents in the US MNC's patent portfolio by including the natural logarithm of 1 plus the average number of forward citations a US MNC's patents receive (*Ln(AvgCites)*). I include industry and year fixed effects and cluster standard errors at the US MNC level to correct for autocorrelation in the MNC's incentive to shift income overseas and the rolling 5-year average measures of some of the variables in Eq (1).[21]

5. DATA AND SAMPLE SELECTION

I collect innovation data from the Global Corporate Patent Database hosted by the University of Virginia's Darden School of Business (Bena, Ferreira, Matos, and Pedro Pires 2017). I supplement the innovation data with patent assignment data by webscraping the USPTO Patent Assignment website. To obtain the total number of patents held by a US MNC, I first determine whether the patent is still owned by the US MNC (original patent assignee) since the granting of the patent. I track each assignment event posted on the USPTO Patent Assignment website and check whether the patent was transferred to an assignee with a distinct name. If the new assignee's name is distinct from the original assignee, I consider the patent no longer held by the US MNC from the transfer date onwards.[22] I also remove expired patents from the total patent count. A patent typically expires 20 years after its filing date.

[21] My main results are robust to using Newey-West standard errors, which is another method to correct for serial correlation in the error term and independent variables.
[22] New assignees that share a common name with the original assignee (e.g., Abbott Laboratories Vascular Enterprises Limited (Irish Subsidiary) and Abbott Laboratories (US Parent)) or have a similar name to the original assignee (using fuzzy-matching) are considered affiliates of the original assignee. I acknowledge that some foreign subsidiaries could have names very different from their parents. The number of patents and the number of collateralized patents the US MNC has could hence be mismeasured. To the extent that the measurement error is not associated with the US MNC's incentive to perform TMOIS (i.e., US MNC's choice of name for foreign subsidiary is not related to their TMOIS propensity), this source of measurement error attenuates my results.

The USPTO Patent Assignment website also contains information on patent collateralization. Lenders that accept patents as collateral can file a record of the patent collateralization arrangement with the USPTO.[23] This record serves as a public notice so that a third party cannot purchase the patent and subsequently claim ignorance of the security interest. I identify patent assignments with the conveyance containing the keywords (e.g., "security" for "Security Interest" and "Patent Security Agreement") as patents pledged as collateral. See Appendix D for an example. The patent assignment and collateralization information I obtained from USPTO are for patents filed in and after 1995.[24] Hence, the total patents and the number of collateralized patents variables are based on patents filed since 1995.

Next, I obtain US MNCs' financial information from Compustat. Following Klassen and Laplante (2012), I (1) limit my sample to US incorporated firms with foreign sales, pretax earnings, and tax information for the period 1995-2017 [25] [26], (2) exclude observations that do not have five years of data with which to compute some of the variables in Eq (1), (3) exclude observations with negative five-year summed pretax domestic or foreign income (loss firms), and (4) exclude firm years with an average foreign tax rate incentive less than negative one or greater than one. To focus on the TMOIS incentives of innovative US MNCs, I further restrict the sample to observations

[23] While filing with the USPTO does not guarantee perfecting the security interest, rulings from case laws (e.g., *In re Transportation Design & Technology, Inc.*) suggest that secured creditors can benefit from complete protection by filing the patent collateralization agreement under both the federal USPTO and the state Uniform Commercial Code filing systems (Hornick 2003). In fact, the marginal cost of making a USPTO filing is low as there is no USPTO filing fee to record a document against issued patents or pending applications (Criss 2019).

[24] There were ~2mil patents filed by Compustat firms from 1995 to 2017. Extending the collection period to the year in which the first patent was filed would be very onerous and time-consuming.

[25] In robustness tests, I drop firm-year observations spanning 2004-2005 to avoid confounds from the American Jobs Creation Act's tax holiday. My results are robust to the exclusion of the AJCA tax holiday period (see Table 13 Panel A).

[26] I end my initial sample in 2017- the year before TCJA came into effect. The reduction of corporate tax rate to 21% and the introduction of GILTI could alter US MNCs' incentives to shift income overseas using intangibles and confound my results.

with at least one patent. Because of criterion (2), my final sample spans 1995-2013 but I measure income shifting through 2017.[27] Finally, I winsorize all continuous variables at the 1st and 99th percentile.

6. RESULTS

6.1.Descriptive Statistics

Descriptive statistics and the industry composition of US MNCs in my sample are reported in Table 2. In Panel A, I report descriptive statistics for variables used in my analyses. *FRoS* has a mean (median) value of 12.0% (9.0%) and worldwide *RoS* has a mean (median) value of 12.1% (10.1%).[28] These values indicate that the US MNCs in my sample have positive profit margins on average. *FTR* has a mean (median) value of 0.065 (0.079). The positive values are consistent with the US maintaining a high corporate income tax rate relative to other countries during the sample period. The mean value of *Ln(ColPat)* (*Ln(ColPatInit2)*) is 0.584 (0.558) while the median value is 0 (0). These values suggest that the data are slightly skewed to the right. The average and median US MNCs in my sample hold sizeable patent portfolios with *Ln(Patents)* having a mean and median value of 4.006 and 3.871, respectively. On average, a US MNC's patent has 2.75 forward citations. *Ln(Assets)* has a mean (median) value of 7.714 (7.623), suggesting that US MNCs in my sample are generally mid-large innovative MNCs. *MB* has a mean (median) value of 3.491 (2.716) and *Lev* takes a mean (median) value of .186 (.172). The mean *Cash* is around .183 and median *Cash* is around .117. 66.2% of US MNCs pay dividends and the average US MNC's net property, plant and equipment make up 20.8% of its total assets. The mean and median values of *MTR* are

[27] The income shifting variables are measured from *t* to *t + 4*. As such, these variables cover the period 1995-2017.

[28] While it is surprising that the mean and median values of *FRoS* are smaller than those of the worldwide *RoS*, studies using more recent sample periods and studies focusing on innovative US MNCs have descriptive statistics that imply similar findings of worldwide *RoS* being larger (smaller) than foreign (domestic) *RoS* (De Simone et al. 2020; Gallemore et al. 2019; Lester 2019).

Table 2. Income Shifting Sample Characteristics

Panel A: Summary statistics of regression variables						
VARIABLES	**N**	**Mean**	**Median**	**SD**	**25th**	**75th**
FRoS (t, t+4)	7382	0.120	0.090	0.104	0.051	0.151
Ln(ColPat) t	7382	0.584	0.000	1.140	0.000	0.693
Ln(ColPatInit) t	7382	0.558	0.000	1.109	0.000	0.693
Ln(Patent) t	7382	4.006	3.871	2.189	2.197	5.595
Ln(AvgCites) t	7382	1.105	1.145	0.621	0.693	1.511
RoS (t, t+4)	7382	0.121	0.101	0.082	0.063	0.158
FTR (t, t+4)	7382	0.065	0.079	0.163	-0.004	0.163
Ln(Assets) (t, t+4)	7382	7.714	7.623	1.770	6.495	8.864
MB (t, t+4)	7382	3.491	2.716	3.189	1.841	4.086
Lev (t, t+4)	7382	0.186	0.172	0.150	0.064	0.271
Cash (t, t+4)	7382	0.183	0.117	0.174	0.055	0.261
DivPayer (t, t+4)	7382	0.662	1.000	0.473	0.000	1.000
Tangible (t, t+4)	7382	0.208	0.167	0.152	0.096	0.282
MTR (t, t+4)	7382	0.331	0.350	0.041	0.324	0.352
5Yrσ(CFO) t	7382	0.056	0.041	0.048	0.026	0.067

Table 2. Income Shifting Sample Characteristics (continued)

Panel B: Industry composition

	All sample US MNCs		MNCs that have collateralized patents		
	(a)		(b)		(b)/(a)
Fama-French 12 Industries	**# unique MNCs**	**% of total**	**# unique MNCs**	**% of total**	**% of all MNCs**
Consumer Durables	61	6%	25	6%	41%
Consumer Non-Durables	65	6%	26	6%	40%
Manufacturing	238	21%	116	26%	49%
Oil, Gas, and Coal Extraction	29	3%	7	2%	24%
Chemicals and Allied Products	62	5%	33	6%	53%
Business Equipment	339	32%	156	35%	46%
Telephone and TV Transmission	7	1%	4	1%	57%
Utilities	1	0%	0	0%	0%
Wholesale and Retail	53	5%	15	3%	28%
Healthcare and Drugs	94	9%	40	9%	43%
Finance	33	3%	9	2%	27%
Other	71	7%	17	4%	24%
Total	**1053**		**448**		

Notes: This table presents the characteristics of US MNCs in the income-shifting sample, following Klassen and Laplante's (2012) sample selection method. In Panel A, I provide descriptive statistics of variables used in the income-shifting regression. All variables are defined in Appendix C. All variables are winsorized at the 1st and 99th percentiles. In Panel B, I provide the industry composition of all sample US MNCs and US MNCs that have collateralized patents in my sample. The industries are based on the Fama-French 12 industry classification.

33.1% and 35%. These values suggest that the average and median US MNCs in my sample have marginal tax rates similar to the US statutory tax rate.[29] *5Yrσ(CFO)* has a mean (median) value of 0.056 (0.041).

In Panel B, I report the industry composition of US MNCs and MNCs that collateralize patents in my sample. Using Fama-French 12 industry classification, I find that the industry composition of MNCs that collateralize patents are very similar to that of US MNCs in the entire sample. The two industries to which the largest proportion of US MNCs belong are business equipment (~32%) and manufacturing (~21%). US MNCs in high tech industries such as pharmaceutical, business equipment, chemicals, and telecommunication/media are slightly over-represented in the sample of US MNCs that collateralize patents. This finding is consistent with high-tech US MNCs being more likely to collateralize their patents (see Fig. 2 and Table 3).

6.2.Determinants of Patent Collateralization

Before estimating the effect of patent collateralization on TMOIS, I seek to understand patenting US MNC's decision to collateralize patents. I regress *Ln(ColPat)* and *Ln(ColPatInit2)* on a number of firm characteristics that, based on prior studies, are likely to be correlated with debt use and patent collateralization (size of patent portfolio (*Ln(Patents)*), average citation of patents (*Ln(AvgCites)*), firm size (*Ln(Assets)*), market-to-book (*MB*), profitability (*ROA*), debt-reliance (one-period lagged *Lev*), liquidity(*Cash*), whether the US MNC pays dividends (*DivPayer*), tangibility (*Tangible*), marginal tax rates (*MTR*)[30], and operating risk (*5Yrσ(CFO)*)).[31] These variables are measured contemporaneously except for the debt-reliance measure.

[29] This is unsurprising as I limit my sample to profitable MNCs, following Klassen and Laplante (2012). Hence, MNCs in my sample are unlikely to have net operating losses that can reduce their marginal tax rates.
[30] Marginal tax rates are obtained from John Graham's website (Graham 1996). Missing values are replaced with calculated MTR values using the estimated coefficients from Graham and Mills (2008).
[31] Refer to Appendix C for variable definitions.

Table 3. Determinants of Patent Collateralization

VARIABLES	Pred.	(1) *Ln(ColPat)* *t*	(2) *Ln(ColPatInit2)* *t*	(3) *Ln(ColPat)* *t*	(4) *Ln(ColPatInit2)* *t*
Ln(Patents) t	+	0.232***	0.216***	0.228***	0.209***
		(16.04)	(16.40)	(12.70)	(13.36)
Ln(AvgCites) t		-0.033	-0.042	-0.026	-0.041
		(-0.83)	(-1.16)	(-0.62)	(-1.12)
Ln(Assets) t		0.005	0.022	0.004	0.025
		(0.33)	(1.51)	(0.21)	(1.37)
MB t		-0.012**	-0.009*	-0.013**	-0.011**
		(-2.34)	(-1.75)	(-2.52)	(-2.01)
ROA t	-	0.114	0.136	0.174	0.210
		(0.42)	(0.53)	(0.62)	(0.82)
Lev t-1	+	0.367***	0.400***	0.369***	0.382***
		(3.75)	(4.02)	(3.52)	(3.71)
Cash t	-	-0.541***	-0.502***	-0.495***	-0.454***
		(-4.24)	(-4.22)	(-3.73)	(-3.74)
DivPayer t	-	-0.244***	-0.254***	-0.273***	-0.284***
		(-4.09)	(-4.72)	(-4.35)	(-4.99)
Tangible t		-0.312*	-0.297*	-0.164	-0.116
		(-1.93)	(-1.89)	(-0.73)	(-0.56)
MTR t		-1.335***	-1.573***	-1.242***	-1.460***
		(-3.80)	(-4.47)	(-3.58)	(-4.21)
5Yrσ(CFO) t		1.363***	1.139**	1.239**	1.036**
		(2.63)	(2.26)	(2.38)	(2.07)
Observations		7,363	7,363	7,363	7,363
Adjusted R-squared		0.232	0.228	0.248	0.247
Industry FE		No	No	Yes	Yes
Year FE		Yes	Yes	Yes	Yes

Notes: This table presents the determinants regression of US MNCs' decision to pledge patents. In columns (1) and (3), I use *Ln(ColPat)* as my dependent variable while I use *Ln(ColPatInit2)* as my dependent variable in column (2) and (4). All variables are defined in Appendix C. All variables are winsorized at the 1st and 99th percentiles. Standard errors are clustered at the MNC level. I perform two-sided t-tests on all coefficients. *** denotes significance at the 1% level, ** denotes significance at the 5% level and * denotes significance at the 10% level.

I present my results in Table 3.[32] In both columns 1 and 2, I include year fixed effects but do not include industry fixed effects to allow for cross-industry variation. In columns 3 and 4, I include industry and year fixed effects, following the fixed effects structure in Eq (1). First, I find that the size of patent portfolio is positively associated with the number of patents collateralized, consistent with innovative US MNCs being more likely to collateralize patents. While I do not find a significant relation between the average patent citation counts and the number of collateralized patents, the lack of significance could be attributable to noise from averaging patent citations over both collateralized and uncollateralized patents. For example, a US MNC that has few highly cited patents that can be pledged as collateral can have a relatively high average patent citation count but low number of collateralized patents. To provide more conclusive evidence that patent citations affect a patent's propensity of being collateralized, I perform firm-patent-year level untabulated analyses to estimate whether patents with higher forward citations have a higher likelihood of being pledged as collateral. Consistent with Mann (2018), I find evidence that patents with higher forward citations are more likely to be pledged as collateral.

[32] In Section 6.7.2., I estimate a Heckman first-stage probit regression, which is similar to the determinants OLS regression in this section. Both tests provide consistent insights into US MNCs' decision to collateralize patents. The main differences between the Heckman first-stage test and the determinants test are 1) the patent collateralization dependent variables in the Heckman first-stage model are indicator variables while the dependent variables in the determinants are continuous variables; 2) I include an exclusion restriction in the Heckman first-stage model, as recommended by Lennox, Francis, and Wang (2012), in addition to firm characteristics; 3) firm characteristics used in the determinants tests are measured contemporaneously except for the debt-reliance measure, which is one-period lagged, whereas firm characteristics used in the Heckman first-stage regression are measured over a five-year period, as per the control variables in the second-stage (main) regression; and 4) I also include incorporation state fixed effects in the Heckman first-stage model to control for state-invariant characteristics that could be correlated with US MNCs' incentives to collateralize patents and the exclusion restriction, which is measured at the incorporation state. Even with the slight differences in model specification between the Heckman first-stage test and determinants test, inferences from the determinants test are largely similar to those from the first-stage test (See Table 12 Panel A).

Next, I find that the signs on the coefficients of the other firm characteristics generally conform with standard empirical predictions of higher leverage ratios. US MNCs that have high market-to-book ratio are less likely to collateralize patents as these MNCs traditionally tend not to rely on debt in their capital structure (Myers 1977) and hence are less likely to collateralize patents for debt financing. US MNCs that have high cash balances and MNCs that pay dividends are less likely to borrow and collateralize patents as these MNCs have sufficient internal cash flows to finance their operations or have lower investment needs (Fama and French 2002; Myers 1984).

Interestingly, I find some evidence that the tangibility of the US MNC is negatively associated with the number of patents collateralized, contrary to the conventional prediction that firms with higher tangibility are more likely to use debt financing by selling secured debt (Myers and Majluf 1984; Lemmon et al. 2008). The coefficient on *Tangible* is negative and significant at the 10% level in both columns 1 and 2. However, the results are weaker and insignificant after the inclusion of industry fixed effects, suggesting that this result is driven by cross-industry variation. This finding is consistent with the fact that the top ten industries in which patent collaterals are used are industries that tend to have low tangibility (see Fig. 2). Consistent with Mann's (2018) findings[33], I provide some corroborating evidence that US MNCs in low tangibility industries can instead pledge their patents as collateral to secure bank loans.

Moreover, I find evidence that marginal tax rates are negatively associated with the number collateralized patents. US MNCs with high marginal tax rates are likely to use unsecured debt financing to benefit from interest tax shield, given that unsecured debt typically charges higher

[33] Mann (2018) also finds that, without the inclusion of industry fixed effects, firms are more likely to collateralize patents when tangibility is low. However, after the inclusion of industry fixed effects, the negative relation becomes statistically insignificant at conventional levels.

interests than secured debt, all things being equal. Thus, US MNCs with high marginal tax rates are less likely to collateralize patents.[34]

Another interesting result is that US MNCs that have higher operating risks are more likely to collateralize patents. Given that innovative MNCs are characterized by the risky R&D projects they undertake, this result is consistent with innovative MNCs being more likely to collateralize patents. Furthermore, banks may require these risky US MNCs to pledge patents as collateral to limit the banks' downside risk.

6.3.Main Results

Table 4 reports estimates of Eq (1). In columns 1 and 2, I use *Ln(ColPat)* and *Ln(ColPatInit2)* as measures of the number of collateralized patents, respectively. First, I find that the coefficient on *FTR* is positive and significant at the 1% level across both columns, consistent with US MNCs shifting more profits overseas as the outbound tax incentive increase (Klassen and Laplante 2012). Second, consistent with my prediction, I find that the coefficients on *Ln(ColPat)*FTR* and *Ln(ColPatInit2)*FTR* are negative and significant at the 5% level across both columns. In terms of economic magnitude, moving from the bottom to top quartile of the number of collateralized patents is associated with approximately an 8% reduction in TMOIS.[35] Moreover, based on the average outbound tax incentive and foreign sales in my sample, moving from the bottom to top quartile of the number of collateralized patents is associated with

[34] A potential alternative explanation is that MNCs with high marginal tax rates are more likely to shift income overseas and hence less likely to collateralize patents. In untabulated analysis, I include the five-year averaged outbound tax incentive FTR in the regression and find that the coefficient on the outbound tax incentive variable is insignificant at conventional levels but the coefficient on marginal tax rates continues to be negative and significant.

[35] The expression of the sensitivity of foreign profitability to tax incentive is as follows: $\beta_1 + \beta_3 * \#ColPatents + \beta_i * \overline{ln(Patents)}$. For the bottom quartile of collateralized patents, the sensitivity of foreign profitability to tax incentive is 0.173 (0.089 - 0.02*0 + 0.021*4.006). For the top quartile of collateralized patents, the sensitivity of foreign profitability to tax incentive is 0.159 (0.089 - 0.02*0.693 + 0.021*4.006). The percentage difference = 0.159/0.173 -1 = ~-8%

Table 4. Main Test

VARIABLES	Pred.	(1) *FRoS (t, t+4)*	(2) *FRoS (t, t+4)*
FTR (t, t+4)	+	0.089***	0.089***
		(3.70)	(3.71)
Ln(ColPat) t		-0.002	
		(-0.96)	
*Ln(ColPat) t * FTR (t, t+4)*	-	-0.020**	
		(-2.27)	
Ln(ColPatInit2) t			0.000
			(0.13)
*Ln(ColPatInit2) t * FTR (t, t+4)*	-		-0.021**
			(-2.48)
Ln(Patents) t		-0.005***	-0.006***
		(-2.94)	(-3.18)
*Ln(Patents) t * FTR (t, t+4)*	+	0.021***	0.021***
		(3.15)	(3.17)
Observations		7,382	7,382
Adjusted R-squared		0.509	0.508
Controls		Yes	Yes
Industry FE		Yes	Yes
Year FE		Yes	Yes

Notes: This table reports the effect of patent collateralization on tax-motivated outbound income shifting. I use *Ln(ColPat)* and *Ln(ColPatInit2)* as my measures of the number of collateralized patents in columns (1) and (2), respectively. All variables are defined in Appendix C. All variables are winsorized at the 1st and 99th percentiles. Standard errors are clustered at the MNC level. I perform two-sided t-tests on all coefficients. *** denotes significance at the 1% level, ** denotes significance at the 5% level and * denotes significance at the 10% level.

approximately a $3.1mil (-0.02*0.693*0.065*$3,400mil) decrease in the average company's TMOIS per year.

On a separate note, the coefficients on the interaction term, *Ln(Patents) * FTR*, in both columns are positive and significant at the 1% level. This result is consistent with innovative US MNCs using patents as a means to implement their TMOIS strategies.

6.4.Cross-sectional Analysis: Debt Financing Needs

Next, I test whether the negative association between patent collateralization and TMOIS is more pronounced for US MNCs with stronger debt financing needs than for those with weaker debt financing needs (*H2*). US MNCs with stronger debt financing needs are more likely to pledge more valuable patents as collateral to secure bank loan financing. Hence, tax authorities could constrain the ability of these US MNCs to set lower transfer prices for their valuable collateralized patents that are used for TMOIS. I expect the extent of TMOIS in US MNCs with stronger debt financing needs to be decreasing more drastically in the number of patents collateralized.

I first use leverage ratios to measure US MNCs' debt financing needs. US MNCs with higher leverage ratios rely more on debt as a source of financing. Hence, I expect highly levered US MNCs' TMOIS to be more negatively associated with patent collateralization relative to other MNCs. To test this cross-sectional prediction, I interact the cross-sectional variable *HighLev* with my variables of interest, *Ln(ColPat)*FTR* and *Ln(ColPatInit2)*FTR*. *HighLev* is a binary variable that equals 1 if a US MNC's long-term debt scaled by lagged total assets in a given year is in the top quartile and 0 otherwise.[36] Based on my cross-sectional hypothesis (*H2*), I expect the coefficient on the interaction term between the cross-sectional variables and the variables of

[36] I exclude *Lev (t, t+4)* from the control variables as it is highly correlated with the *HighLev* cross-sectional variable.

Table 5. Cross-sectional Test: Debt Financing Needs

VARIABLES		X = / CP = / Pred.	(1) HighLev ColPat FRoS (t, t+4)	(2) HighLev ColPatInit2 FRoS (t, t+4)	(3) LowCFO ColPat FRoS (t, t+4)	(4) LowCFO ColPatInit2 FRoS (t, t+4)
FTR (t, t+4)		+	0.079***	0.080***	0.114***	0.115***
			(3.12)	(3.15)	(4.52)	(4.56)
X			0.010***	0.010***	0.003	0.003
			(2.83)	(2.69)	(0.98)	(1.17)
*X * FTR (t, t+4)*			0.035	0.033	-0.058***	-0.061***
			(1.44)	(1.38)	(-3.28)	(-3.46)
Ln(CP) t			-0.001	0.001	-0.002	-0.000
			(-0.48)	(0.32)	(-1.12)	(-0.04)
*X * Ln(CP) t*			-0.001	-0.001	0.000	-0.001
			(-0.38)	(-0.32)	(0.02)	(-0.48)
*Ln(CP) t * FTR (t, t+4)*	β_a	-	-0.015	-0.017*	-0.006	-0.009
			(-1.45)	(-1.65)	(-0.50)	(-0.83)
*X * Ln(CP) t * FTR (t, t+4)*	β_b	-	-0.028*	-0.024	-0.027**	-0.023*
			(-1.88)	(-1.58)	(-2.01)	(-1.72)
$\beta_a + \beta_b$			-0.044***	-0.041***	-0.033***	-0.032***
			(-3.48)	(-3.28)	(-3.45)	(-3.30)
Observations			7,382	7,382	7,382	7,382
Adjusted R-squared			0.507	0.507	0.512	0.512
Controls			Yes	Yes	Yes	Yes
Industry FE			Yes	Yes	Yes	Yes
Year FE			Yes	Yes	Yes	Yes

Notes: This table reports the heterogenous effect of patent collateralization on tax-motivated outbound income shifting based on the US MNCs' debt financing needs. In columns (1) and (2), I measure debt financing needs using leverage ratios. *HighLev* is a binary variable coded to 1 if the US MNC's leverage ratio is in the highest quartile and 0 otherwise. In columns (3) and (4), I measure debt financing needs using operating cash flows scaled by lagged assets. *LowCFO* is a binary variable coded to 1 if the US MNC's operating cash flows scaled by lagged assets is in the lowest quartile and 0 otherwise. In columns (1) and (3) (columns (2) and (4)), I use *Ln(ColPat)* (*Ln(ColPatInit2)*) as my measure of the number of collateralized patents. All variables are defined in Appendix C. All variables are winsorized at the 1st and 99th percentiles. Standard errors are clustered at the MNC level. I perform two-sided t-tests on all coefficients. *** denotes significance at the 1% level, ** denotes significance at the 5% level and * denotes significance at the 10% level.

interest to be negative. I report my results in Table 5 columns 1 and 2. Across both columns, the coefficients on the triple interaction terms are negative but only significant at 10% in column 1.

Next, I use operating cash flows scaled by lagged assets to measure US MNCs' debt financing needs. Firms tend to increase leverage through substantial debt issuances to meet operating needs when internally generated cash flow is low (Myers 1984; Denis and McKeon 2012). Hence, US MNCs that generate lower operating cash flows are likely to have stronger debt financing needs to support their operations. I interact the cross-sectional variable *LowCFO* with my variables of interest, *Ln(ColPat)*FTR* and *Ln(ColPatInit2)*FTR*, and expect the coefficient on the interaction terms to be negative. *LowCFO* is a binary variable that equals 1 if a US MNC's operating cash flow scaled by lagged total assets in a given year is in the bottom quartile and 0 otherwise. My results are presented in Table 5 columns 3 and 4. In both columns, I find that the coefficients on the triple interaction terms are negative and significant at conventional levels (5% level in column 3 and 10% level in column 4). Overall, my results provide evidence that the negative association between patent collateralization and TMOIS is more pronounced for US MNCs with stronger debt financing needs.

6.5.Contracting Channel: Risk of Default

I examine whether the negative association between patent collateralization and TMOIS is weaker for US MNCs with lower risk of default (*H3*). Given that banks are more likely to be amenable to US MNCs relocating their collateralized patents to low-tax countries when default risk is low, the TMOIS of US MNCs with low default risk are likely be less constrained.

I use two measures of default risk: the probability of a US MNC violating its loan covenants (*PViol*), taken from Demerjian and Owens (2016), and Altman's (1968) Z-score. *PViol* is a simulation-based measure of the likelihood a firm violates its loan covenants. The calculations are based on the initial covenant slack and the volatility of the borrower's financial metrics on which the loan covenants are based. A high *PViol* value indicates that the US MNC is likely to violate its loan covenants and trigger a technical default on the loan. *PViol* is calculated for each loan package a US MNC borrows. Because identifiable information on the patent-secured loans is scarce (e.g., loan amount, syndicate lenders), I am unable to pinpoint the exact loan packages in the Dealscan database that are patent-secured loans and obtain the *PViol* of these patent-secured loans. To address this issue, I take the average of all the loan packages' *PViol* in a particular firm-year to measure the US MNCs' average default risk.

Altman's Z-score is based on five key financial ratios and is used to predict whether a firm is likely to default and go into bankruptcy. A Z-score of 3 and above signifies that the firm is in a safe zone and unlikely to go bankrupt and default (Altman 1968).

I create two cross-sectional variables, *LowPViol* and *Safe*, based on the two measures of US MNC default risk. *LowPViol* is a binary variable coded to 1 if the average *PViol* is in the lowest quartile and 0 otherwise. *Safe* is a binary variable coded to 1 if Altman's Z-Score is 3 and above, and 0 otherwise. I interact *LowPViol* and *Safe* with my variables of interest, *Ln(ColPat)*FTR* and *Ln(ColPatInit2)*FTR*, to test my cross-sectional hypothesis. I expect the coefficient on the interaction term between the cross-sectional variables and the variables of interest to be positive.

My results are reported in Table 6. In Table 6 columns 1 and 2, I use *LowPViol* as my measure of US MNCs' low default risk. Across both columns, the coefficients on the triple interaction terms are positive and significant at the 5% level. In Table 6 columns 3 and 4, I use *Safe* as my measure of US MNCs' low default risk. I also find that the coefficient on the triple interaction terms is positive and significant at the 5% (10%) level in column 3 (4). Overall, my results provide evidence that the negative association between patent collateralization and TMOIS

Table 6. Cross-sectional Test: Default Risk

VARIABLES		X = / CP = / Pred.	(1) *LowPViol* *ColPat* *FRoS (t, t+4)*	(2) *LowPViol* *ColPatInit2* *FRoS (t, t+4)*	(3) *Safe* *ColPat* *FRoS (t, t+4)*	(4) *Safe* *ColPatInit2* *FRoS (t, t+4)*
FTR (t, t+4)		+	0.107***	0.108***	0.063**	0.062**
			(3.47)	(3.46)	(2.44)	(2.37)
X			-0.014**	-0.014**	-0.008**	-0.008**
			(-2.10)	(-2.12)	(-2.10)	(-2.07)
*X * FTR (t, t+4)*			0.033	0.036	0.044**	0.048**
			(1.05)	(1.15)	(2.27)	(2.43)
Ln(CP) t			-0.001	0.001	-0.002	-0.001
			(-0.43)	(0.77)	(-1.13)	(-0.44)
*X * Ln(CP) t*			-0.007*	-0.007*	-0.000	0.000
			(-1.96)	(-1.81)	(-0.12)	(0.14)
*Ln(CP) t * FTR (t, t+4)*	β_a	-	-0.028**	-0.026**	-0.035***	-0.032***
			(-2.49)	(-2.51)	(-3.64)	(-3.36)
*X * Ln(CP) t * FTR (t, t+4)*	β_b	+	0.065**	0.061**	0.033**	0.028*
			(2.26)	(2.08)	(2.29)	(1.93)
$\beta_a + \beta_b$			0.037	0.035	-0.002	-0.004
			(1.35)	(1.23)	(-0.14)	(-0.30)
Observations			3,543	3,543	7,382	7,382
Adjusted R-squared			0.526	0.525	0.512	0.511
Controls			Yes	Yes	Yes	Yes
Industry FE			Yes	Yes	Yes	Yes
Year FE			Yes	Yes	Yes	Yes

Notes: This table reports the heterogenous effect of patent collateralization on tax-motivated outbound income shifting based on US MNCs' default risk. In columns (1) and (2), I measure default risk using Demerjian and Owen's (2016) probability of violating loan covenants (*PViol*) variable. *LowPViol* is a binary variable coded to 1 if the average probability of a US MNC violating its loan covenants is in the bottom quartile and 0 otherwise. In columns (3) and (4), I measure default risk using Altman (1968) Z-score. *Safe* is a binary variable coded to 1 if the Z-score is equal to or more than 3 and 0 otherwise. In columns (1) and (3) (columns (2) and (4)), I use *Ln(ColPat)* (*Ln(ColPatInit2)*) as my measure of the number of collateralized patents. All variables are defined in Appendix C. All variables are winsorized at the 1st and 99th percentiles. Standard errors are clustered at the MNC level. I perform two-sided t-tests on all coefficients. *** denotes significance at the 1% level, ** denotes significance at the 5% level and * denotes significance at the 10% level.

is less pronounced for US MNCs with low default risk. My results are consistent with US MNCs with low default risks being able to gain the banks' approval to relocate their collateralized patents to low-tax countries so as to undertake TMOIS.

6.6.Information Channel: Number of Peers

I examine whether the negative association between patent collateralization and TMOIS is weaker for US MNCs with more peers than for those with fewer peers (*H4a*). Given that US MNCs with more peers are likely to have a larger set of comparable patents to benchmark against, tax authorities are likely to place more weight on comparable patent transactions and less weight on patent collateral valuations when determining benchmark prices of collateralized patents for US MNCs with more peers. As a result, US MNCs with more peers that collateralize patents are less likely to be constrained by tax authorities and are more able to set low transfer prices for collateralized patents to engage in TMOIS.

I develop two measures of US MNC peers based on Hoberg and Phillips' (2010) product market peers database (*PMP*). *PMP* is based on firm pairwise similarity scores from the text analysis of firm 10K product descriptions (Hoberg and Phillips 2010). Each firm has its own network of product market peers and each peer firm is assigned a similarity score (between 0 and 1) based on how similar the peer firm's products are to the focal firm's products. My first measure of firm peers is *#PMP*, which is a count of the number of product market peers in the focal US MNC's network. My second measure of firm peers is *PMPScore*. This measure takes the sum of the similarity scores between the focal US MNC and all its product market peers.

The difference between the *#PMP* and *PMPScore* is that in the former measure, all peers are assumed to be equally similar to the focal US MNC while in the latter, the number of peers is weighted by each peer's similarity score. Higher values of *#PMP* and *PMPScore* imply that a US MNC has more product market peers.

I create two cross-sectional variables, *High#PMP* and *HighPMPScr*, based on the two measures of firm peers. *High#PMP* (*HighPMPScr*) is a binary variable coded to 1 if *#PMP* (*PMPScore*) is in the highest quartile and 0 otherwise. I interact *High#PMP* and *HighPMPScr* with my variables of interest, *Ln(ColPat)*FTR* and *Ln(ColPatInit2)*FTR*, to test my cross-sectional hypothesis. I expect the coefficient on the interaction term between the cross-sectional variables and the variables of interest to be positive.

My results are reported in Table 7. In Table 7 columns 1 and 2, I use *High#PMP* as my measure of high number of firm peers. The coefficient on the triple interaction terms is positive and significant at the 10% (5%) level in column 1 (2). In Table 7 columns 3 and 4, I use *HighPMPScr* as my measure of high number of firm peers. I find that the coefficients on the triple interaction terms are positive in both columns but significant at the 10% level only in column 4.[37] Across all columns, the overall effect of patent collateralization on TMOIS ($\beta_a + \beta_b$) is not significantly different from zero for US MNCs with a high number of peers. My results are consistent with tax authorities placing less weight on patent collateral values when benchmarking transfer prices for US MNCs with greater number of peers. Overall, my results provide evidence that the negative association between patent collateralization and TMOIS is less pronounced for US MNCs with more peers than for those with fewer peers.

[37] A possible explanation for the weaker results using *HighPMPScr* as the cross-sectional variable is that US MNCs and tax authorities focus more on the raw number of peers than on the similarity-weighted number of peers when benchmarking transfer prices. Patents owned by product market peers, no matter how similar the peers are to the focal US MNC, are likely to be treated as comparable benchmarks.

Table 7. Cross-sectional Test: Number of Peers

VARIABLES		X = CP = Pred.	(1) *High#PMP* *ColPat* *FRoS (t, t+4)*	(2) *ColPatInit2* *FRoS (t, t+4)*	(3) *HighPMPScr* *ColPat* *FRoS (t, t+4)*	(4) *ColPatInit2* *FRoS (t, t+4)*
FTR (t, t+4)		+	0.094***	0.095***	0.094***	0.094***
			(3.52)	(3.55)	(3.48)	(3.50)
X			0.006	0.005	0.004	0.003
			(0.72)	(0.63)	(0.51)	(0.36)
*X * FTR (t, t+4)*			0.019	0.019	0.025	0.025
			(0.60)	(0.61)	(0.77)	(0.79)
Ln(CP) t			0.000	0.002	0.001	0.002
			(0.11)	(0.84)	(0.31)	(1.01)
*X * Ln(CP) t*			-0.009*	-0.007	-0.009**	-0.007*
			(-1.84)	(-1.53)	(-2.02)	(-1.67)
*Ln(CP) t * FTR (t, t+4)*	β_a	-	-0.030***	-0.032***	-0.028***	-0.030***
			(-2.92)	(-3.22)	(-2.85)	(-3.11)
*X * Ln(CP) t * FTR (t, t+4)*	β_b	+	0.042*	0.042**	0.032	0.032*
			(1.94)	(2.11)	(1.60)	(1.74)
$\beta_a + \beta_b$			0.012	0.010	0.004	0.002
			(0.60)	(0.54)	(0.22)	(0.10)
Observations			6,465	6,465	6,465	6,465
Adjusted R-squared			0.521	0.520	0.521	0.520
Controls			Yes	Yes	Yes	Yes
Industry FE			Yes	Yes	Yes	Yes
Year FE			Yes	Yes	Yes	Yes

Notes: This table reports the heterogenous effect of patent collateralization on tax-motivated outbound income shifting based on the number of peers a US MNC has. I measure firm peers using Hoberg and Phillip's (2010) text-based product market peers (*PMP*) variable. In columns (1) and (2), I use *High#PMP* as my cross-sectional variable. *HighPMP* is a binary variable coded to 1 if the number of product market peers a US MNC has is in the highest quartile and 0 otherwise. In columns (3) and (4), I use *HighPMPScr* as my cross-sectional variable. *HighPMPScr* is a binary variable coded to 1 if the sum of the similarity scores of all the peers a US MNC has is in the highest quartile and 0 otherwise. In columns (1) and (3) (columns (2) and (4)), I use *Ln(ColPat)* (*Ln(ColPatInit2)*) as my measure of the number of collateralized patents. All variables are defined in Appendix C. All variables are winsorized at the 1st and 99th percentiles. Standard errors are clustered at the MNC level. I perform two-sided t-tests on all coefficients. *** denotes significance at the 1% level, ** denotes significance at the 5% level and * denotes significance at the 10% level.

6.7.Information Channel: Tax Authorities' Resources

In addition to my cross-sectional analyses, I test whether the negative association between patent collateralization and TMOIS is more pronounced in years when resources of tax authorities are more constrained (*H4b*). Determining the arm's length values of patents can be resource-consuming for tax authorities. When the resources of tax authorities are constrained, tax authorities are more likely to rely on patent collateral valuations as benchmarks because these patent valuations are an informative and readily available signal of the arm's length values of collateralized patents. As a result, US MNCs are less able to set low transfer prices for collateralized patents when the resources of tax authorities are constrained. I expect US MNCs to reduce their TMOIS to a greater extent as they collateralize more patents when tax authorities are more resource-constrained.

I follow Nessa et al. (2020) and use the inflation-adjusted IRS enforcement budget scaled by the total number of tax returns filed to measure tax authorities' resources. A lower value implies that tax authorities are more resource-constrained. To test *H4b*, I interact the variable *LowRes* with my variables of interest, *Ln(ColPat)*FTR* and *Ln(ColPatInit2)*FTR*. *LowRes* is a binary variable that equals 1 if the inflation-adjusted IRS enforcement budget scaled by the total number of tax returns filed in a given year is in the bottom tercile and 0 otherwise.[38] I expect the coefficients on the interaction terms between the *LowRes* variable and the variables of interest to be negative as I hypothesize that the negative association between patent collateralization and TMOIS is more

[38] Unlike prior tests, I use a tercile cutoff instead of a quartile cutoff to partition the IRS resources measure. This is because when I use a quartile cutoff, the amount of IRS resources at the cutoff where *LowRes* equals to 1 ($20.662 per tax return filed) is very similar to the amount of IRS resources at the cutoff where *LowRes* equals to 0 ($20.667 per tax return filed). Having such similar amounts of IRS resources at the cutoffs is likely to introduce noise to the *LowRes* cross-section variable. On the other hand, when I use a tercile cutoff, the amounts of IRS resources at the cutoffs are not so similar. Hence, I prefer to use a tercile cutoff to partition IRS resources.

Table 8. Resources of Tax Authorities

VARIABLES		X = Pred.	(1) LowRes FRoS (t, t+4)	(2) LowRes FRoS (t, t+4)
FTR (t, t+4)		+	0.085***	0.086***
			(3.44)	(3.46)
*X * FTR (t, t+4)*			0.008	0.008
			(0.56)	(0.53)
Ln(ColPat) t			-0.002	
			(-1.03)	
*X * Ln(ColPat) t*			0.000	
			(0.29)	
*Ln(ColPat) t * FTR (t, t+4)*	β_a	-	-0.014	
			(-1.41)	
*X * Ln(ColPat) t * FTR (t, t+4)*	β_b	-	-0.017*	
			(-1.94)	
Ln(ColPatInit2) t				0.000
				(0.09)
*X * Ln(ColPatInit2) t*				-0.000
				(-0.10)
*Ln(ColPatInit2) t * FTR (t, t+4)*	β_a	-		-0.016*
				(-1.67)
*X * Ln(ColPatInit2) t * FTR (t, t+4)*	β_b	-		-0.015*
				(-1.74)
$\beta_a + \beta_b$			-0.031***	-0.031***
			(-3.35)	(-3.27)
Observations			7,382	7,382
Adjusted R-squared			0.509	0.508
Controls			Yes	Yes
Industry FE			Yes	Yes
Year FE			Yes	Yes

Notes: This table reports the effect of tax authorities' resources on the relation between patent collateralization and tax-motivated outbound income shifting. I measure tax authorities' resources using inflation-adjusted IRS enforcement budget scaled by total number of tax returns filed (Nessa et al. 2020). *LowRes* is a binary variable coded to 1 if the inflation-adjusted IRS enforcement budget scaled by total number of tax returns filed is in the lowest tercile and 0 otherwise. In columns (1) and (2), I use *Ln(ColPat)* and *Ln(ColPatInit2)* as my measures of the number of collateralized patents, respectively. All variables are defined in Appendix C. All variables are winsorized at the 1st and 99th percentiles. Standard errors are clustered at the MNC level. I perform two-sided t-tests on all coefficients. *** denotes significance at the 1% level, ** denotes significance at the 5% level and * denotes significance at the 10% level.

pronounced in years when tax authorities are more resource-constrained than in other years. I report my results in Table 8 columns 1 and 2. Across both columns, the coefficients on the triple interaction terms are negative and significant at the 10% level. Note that the *LowRes* main effect is omitted because it is measured annually and is subsumed by the year fixed effects.

6.8.Additional Test: Patent-level Analyses

Next, I examine whether collateralized patents are less likely to be shifted overseas. The availability of patent collateral valuations to tax authorities could constrain US MNCs' transfer pricing strategies. To the extent that US MNCs are less able to set low transfer prices for collateralized patents, the marginal benefit of shifting these patents to lower tax countries diminishes. Thus, I expect collateralized patents to have a lower likelihood of being transferred out of the US to tax haven countries. I estimate the following linear probability model.

$$Foreign_{ijt} = \beta_0 + \beta_1 Collateralized_{ijt} + \beta_k X'_{it} + PatentFE + YearFE + \epsilon_{ijt} \quad (2)$$

The $Foreign$ dependent variable refers to either 1) *Non-US* or 2) *TaxHaven*. *Non-US* is equal to 1 if patent *j* is held by an affiliate that is located outside of the US in year *t* and 0 otherwise. *TaxHaven* is equal to 1 if patent *j* is held by an affiliate that is located in a tax haven country in year *t* and 0 otherwise. I use two measures of $Collateralized$: 1) *ColPat* and 2) *ColPatInit2*. Unlike *Ln(ColPat)* and *Ln(ColPatInit2)* used in Eq (1), which are the natural log of 1 plus the number of collateralized patents, *ColPat* and *ColPatInit2* are dummy variables. *ColPat* is equal to 1 if patent *j* is held by lenders of US MNC *i* for security interest in year *t* and 0 otherwise. *ColPatInit2* is equal to 1 if patent *j* is pledged by US MNC *i* as collateral in years (*t-2*, *t*) and 0 otherwise. The underlying intuition of these two measures is similar to that of *Ln(ColPat)* and *Ln(ColPat2Init)*, respectively. Controls X used are similar to the ones used in the main analyses. The only difference is that the control variables in this test are contemporaneous and not averaged

Table 9. Patent-level Analyses

VARIABLES	Pred.	(1) *Non-US*	(2) *Non-US*	(3) *TaxHaven*	(4) *TaxHaven*
ColPat t	-	-0.005***		-0.002***	
		(-15.51)		(-9.01)	
ColPatInit2 t	-		-0.006***		-0.002***
			(-18.43)		(-12.59)
Ln(Cites) t		0.000**	0.000**	0.001***	0.001***
		(2.30)	(2.33)	(7.19)	(7.23)
Ln(Assets) t		-0.003***	-0.003***	-0.002***	-0.002***
		(-10.82)	(-10.80)	(-15.35)	(-15.31)
MB t		0.000***	0.000***	0.000***	0.000***
		(27.22)	(27.40)	(25.09)	(25.24)
ROA t		0.003***	0.003***	0.002***	0.002***
		(6.38)	(6.29)	(6.52)	(6.47)
Lev t		-0.004***	-0.004***	0.001***	0.001***
		(-7.33)	(-6.93)	(3.00)	(3.37)
Cash t		0.002***	0.001***	-0.001*	-0.001*
		(2.95)	(2.77)	(-1.77)	(-1.90)
DivPayer t		-0.002***	-0.002***	-0.000	-0.000*
		(-6.06)	(-6.58)	(-1.27)	(-1.76)
Tangible t		-0.058***	-0.058***	-0.030***	-0.029***
		(-20.32)	(-20.27)	(-13.37)	(-13.36)
MTR t		-0.006***	-0.006***	-0.005***	-0.005***
		(-7.47)	(-7.58)	(-8.45)	(-8.55)
5Yrσ(CFO) t		0.000	-0.000	-0.000	-0.000
		(0.09)	(-0.08)	(-0.74)	(-0.85)
Observations		5,749,717	5,749,717	5,749,717	5,749,717
Adjusted R-squared		0.826	0.826	0.757	0.757
Patent FE		Yes	Yes	Yes	Yes
Year FE		Yes	Yes	Yes	Yes

Notes: This table reports the likelihood of a collateralized patent being shifted overseas. I use *ColPat* and (*ColPatInit2*) as a measure of whether a patent is pledged as collateral in a given year in columns (1) and (3) (columns (2) and (4)). In columns (1) and (2), I use *Non-US* as my dependent variable. *Non-US* is a binary variable coded to 1 if the patent is held by an affiliate that is located outside of the US in year *t* and 0 otherwise. In columns (3) and (4), I use *TaxHaven* as my dependent variable. *TaxHaven* is a binary variable coded to 1 if the patent is held by an affiliate that is located in a tax haven country in year *t* and 0 otherwise. Control variables are measured contemporaneously. The sample used in the regression comprises US-incorporated MNCs for the period 1995-2017. All variables are defined in Appendix C. All variables are winsorized at the 1st and 99th percentiles. Standard errors are clustered at the patent level. I perform two-sided t-tests on all coefficients. *** denotes significance at the 1% level, ** denotes significance at the 5% level and * denotes significance at the 10% level.

over five years.[39] I include patent fixed effects to control for time-invariant patent characteristics and year fixed effects to control for macroeconomic conditions. I cluster standard errors at the patent level to correct for autocorrelation in patent shifting and collateralization.

In this test, the sample period is from 1995 to 2017. The sample comprises all patenting US incorporated MNCs.[40] Similar to my previous analyses, I define MNCs as firms with non-zero or non-missing values of pre-tax foreign earnings (PIFO) or foreign tax expense (TXFO, TXDFO). I drop observations with missing controls.

My results are presented in Table 9. In columns 1 and 2, I use *Non-US* as my dependent variable, whereas in columns 3 and 4, I use *TaxHaven* as my dependent variable. I report the coefficients on *ColPat* (*ColPatInit2*) in columns 1 and 3 (columns 2 and 4). Across all columns, I find that the coefficients on *ColPat* and *ColPatInit2* are negative and significant at the 1% level. My results are consistent with collateralized patents being less likely to be shifted out of the US and less likely to be shifted to tax haven countries as the availability of patent collateral valuations to tax authorities could constrain US MNCs' TMOIS.

6.9.Alternative Identification Strategies

6.9.1. Generalized Difference-in-Differences Design

Because patent collateralization and TMOIS are firm decisions, there could be unobservables driving both decisions, resulting in a correlated omitted variable problem. To address this concern, I rely on Delaware's ABSFA and a federal court patent law decision that

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[39] This is because I use a single period model in this test and the dependent variable is measured contemporaneously. I use a multi-period model in the main analyses to reduce measurement error in the outbound tax incentive measure (Klassen and Laplante 2012).

[40] As I do not need to create variables that are averaged over five years in this test, I do not have to end the sample in 2013.

reinforces Delaware's ABSFA to exploit plausibly exogenous variation in US MNCs' incentives to collateralize patents.[41]

Enacted in January 2002, Delaware's ABSFA allows borrowers to "sell" collateral such that in the event of a bankruptcy, assets that have been pledged as security by the borrowing firm are not deemed to be part of the borrowing firm's assets for liquidation and distribution. Essentially, ABSFA strengthens the rights of creditors of asset-backed loans. However, the applicability of ABSFA to patent-secured loans was shrouded with uncertainty because ABSFA is a state law and courts could rule that federal patent law implicitly pre-empts state law (Amable, Chatelain, and Ralf 2010; Stevens 2005). In *Rhone-Poulenc*, the court recognized that state laws have authority over contracts for rights under patents, indirectly acknowledging the applicability of ABSFA to patent security contracts and patent-secured loans. As a result, the federal court decision reinforced the rights of creditors that issue patent-secured loans to borrowers incorporated in the state of Delaware. The decision is often cited for the phrase "the interpretation of contracts for rights under patents is generally governed by state law" (e.g., Gibbons 2004, Rosenstock 2005, and Young 2008).

Exploiting *Rhone-Poulenc*'s impact on Delaware's ABSFA limits the threat of policy endogeneity in the form of concurrent state policy changes targeting firms' tax planning strategies. The decision of the courts only concerned patent law and resulted in the strengthening of creditor rights relating to patent-secured loans that are issued to borrowers incorporated in the state of Delaware. The court's decision "exogenously" raised the value of patent collaterals pledged by Delaware incorporated firms via strengthened creditor rights, incentivizing Delaware-incorporated patenting firms to collateralize their patents.

[41] This identification strategy also allows me to mitigate concerns about simultaneity bias coming from patent collateralization and tax-motivated outbound income shifting being jointly determined.

I implement a generalized difference-in-differences design, exploiting Delaware's ABSFA and the *Rhone-Poulenc* federal court ruling on patent law as plausibly exogeneous treatment events in 2002. I limit the event window to 7 years prior to and after the events (i.e., 1995-2009). Following Mann (2018), I remove US MNCs incorporated in other states (Texas, Louisiana, Alabama, South Dakota, Virginia, and Nevada) that have laws similar to Delaware's ABSFA during the event-window.[42] Given that most of the regression variables are computed based on data four years into the future, these variables measured from 1998-2001 (pre-treatment period) could be "tainted" by the treatment effect as the data used to calculate the variables overlap with the post-treatment period. Hence, I exclude the years 1998-2001 from my sample.[43] I modify Eq (1) and estimate the following regression:

$$FRoS_{i(t,t+4)} = \beta_0 + \beta_1 FTR_{i(t,t+4)} + \beta_2 RP_{it} + \beta_3 RP_{it} * FTR_{i(t,t+4)} + \beta_4 RoS_{i(t,t+4)} + \beta_k X'_{i(t,t+4)} + IndustryFE + Inc - StateFE + YearFE + \epsilon_{i(t,t+4)} \quad (3)$$

In this model, I introduce a new variable RP_{it} to measure the impact of the *Rhone-Poulenc* federal court ruling on Delaware's ABSFA. RP_{it} is coded to 1 if a US MNC is incorporated in Delaware and the year is in and after 2002, and 0 otherwise. This variable is equivalent to a *Post* variable interacted with a *Treat* variable in a traditional difference-in-differences design. In a generalized difference-in-differences design, the *Post* and *Treat* variables are omitted because the

[42] In an untabulated robustness test, I include US MNCs incorporated in those states and assign them to the treatment group. As Texas, Louisiana, and Alabama passed the laws before *Rhone-Poulenc*, I assign treatment to MNCs incorporated in these states from 2002 onwards (same as MNCs incorporated in Delaware). For the other states that passed the laws after *Rhone-Poulenc*, I assign treatment to MNCs incorporated in those other states in and after the year the laws were passed. My results are robust to this alternative treatment group.

[43] My results are nonetheless robust to including the years 1998-2001. Alternatively, I replace RP_{it} with a 5-year average treatment variable ($RP_{i(t,t+4)}$) in Eq (3) and estimate the regression on the sample without excluding 1998-2001. My results (untabulated) are also robust to this alternative design.

Treat variable is subsumed by the state of incorporation fixed effects (treatment is at the state of incorporation level) while *Post* is subsumed by year fixed effects. I use the same set of controls as per Eq (1). I cluster standard errors by state of incorporation to allow for dependence across observations within a state across time, following the suggestions in Bertrand, Duflo and Mullainathan (2004).[44] The variable of interest in this regression is $RP_{it} * FTR_{i(t,t+n)}$ and I expect β_3 to be negative.

My results are reported in Table 10 column 1. I find that the coefficient on the interaction term $RP_{it} * FTR_{i(t,t+n)}$ is negative and significant at the 5% level, consistent with my expectation. My result provides evidence that a plausibly exogenous increase in US MNCs' incentive to collateralize patents results in a decrease in TMOIS.

6.9.1.1.Placebo (Parallel Trends) Test

Next, I validate the parallel trends assumption in my generalized difference-in-differences approach by assigning pseudo-treatments to each pre-treatment event-date (i.e., t=-5, t=-6, and t=-7). E.g., for the pseudo-treatment assigned in t-5, the pseudo-treatment variable, *RP{t=-5}*, is coded to 1 in t-5 (1997) for treatment MNCs (MNCs incorporated in Delaware) and in subsequent years. I omit all *actual* treated firm-year observations (i.e., from 2002 onwards) because including *actual* treatment observations in placebo tests could cause the post-pseudo treatment estimate to be significant.

In the absence of an *actual* treatment, I should not expect the TMOIS of the US MNCs in the treatment group to deviate from that of US MNCs in the control group. Hence, I expect the coefficients on the interaction between the pseudo-treatment variables and *FTR* to be not significant. I report my results in Table 10 columns 2 – 4. Across the three columns, the interaction

[44] My results are robust to clustering standard errors at the US MNC level.

Table 10. Generalized Difference-in-Differences Approach

VARIABLES	Pred.	(1) *FRoS (t, t+4)*	(2) *FRoS (t, t+4)*	(3) *FRoS (t, t+4)*	(4) *FRoS (t, t+4)*
FTR (t, t+4)	+	0.088***	0.041	0.035	0.034
		(3.55)	(1.34)	(1.09)	(0.92)
RP		-0.004			
		(-0.81)			
*RP * FTR (t, t+4)*	-	-0.058**			
		(-2.52)			
RP{t=-5}			-0.005		
			(-1.21)		
RP{t=-5} FTR (t, t+4)*	n.s.		0.015		
			(0.58)		
RP{t=-6}				0.006	
				(1.06)	
RP{t=-6} FTR (t, t+4)*	n.s.			0.031	
				(1.29)	
RP{t=-7}					-
RP{t=-7} FTR (t, t+4)*	n.s.				0.022
					(0.75)
Observations		4,081	1,887	1,887	1,887
Adjusted R-squared		0.523	0.581	0.582	0.582
Controls		Yes	Yes	Yes	Yes
Industry FE		Yes	Yes	Yes	Yes
Inc-State FE		Yes	Yes	Yes	Yes
Year FE		Yes	Yes	Yes	Yes

Notes: This table reports the effect of patent collateralization on tax-motivated outbound income shifting, exploiting the impact of *Rhone-Poulenc*'s court ruling on Delaware's ABSFA in 2002 as an exogenous shock to US MNCs' incentive to collateralize patents. In column (1), I report the difference-in-differences estimate of the treatment event on US MNCs' tax-motivated outbound income shifting. In columns (2) – (4), I perform placebo tests by assigning pseudo-treatment events to each pre-treatment event-date. All variables are defined in Appendix C. All variables are winsorized at the 1st and 99th percentiles. Standard errors are clustered at the state of incorporation level. I perform two-sided t-tests on all coefficients. *** denotes significance at the 1% level, ** denotes significance at the 5% level and * denotes significance at the 10% level.

terms are not significant at conventional levels.[45] My results provide evidence that there is no significant deviation between the TMOIS of control MNCs and that of treatment MNCs, in the absence of treatment. Given that both control and treatment US MNCs trend in parallel in the pre-treatment period, there is evidence to support that the control US MNCs are a valid counterfactual to the treatment US MNCs.

6.9.1.2.Treatment Validation

I also provide validation that the treatment event indeed incentivizes US MNCs to collateralize their patents. In this test, the regressors I use are measured contemporaneously (not five-year averages) and hence, I do not omit years from 1998-2001. I present my results in Table 11. In column 1, I use *Ln(ColPat)* as my dependent variable while I use *Ln(ColPatInit2)* as my dependent variable in column 2. Across both columns, the coefficient on *RP* is positive and significant at conventional levels. My results are consistent with the treatment event (the effect of the court ruling in *Rhone-Poulenc* on Delaware's ABSFA) incentivizing Delaware-incorporated US MNCs to collateralize their patents.

6.9.2. Heckman Selection Correction

In addition to the generalized difference-in-differences approach, I perform Heckman selection correction to mitigate coefficient bias arising from the self-selection of patent collateralization in my main model specification Eq (1). I first estimate a selection model in the first stage. For the dependent variables in the first stage, I dichotomize the continuous patent collateralization variables by assigning 1 to firm-year observations with at least one patent collateralized and 0 otherwise. I include *RP* as my exclusion restriction (Lennox, Francis, and

[45] On a side note, the coefficient on *RP{t=-7}* in column (4) is omitted because the pseudo-treatment is assigned in t=-7 (1995), the start of the sample period. *RP{t=-7}* is always coded to 1 for treatment MNCs in the entire sample period and hence, the variable is subsumed by the state of incorporation fixed effect.

Table 11. Effect of Treatment on Patent Collateralization

VARIABLES	Pred.	(1) *Ln(ColPat) t*	(2) *Ln(ColPatInit2) t*
RP t	+	0.239***	0.207**
		(3.15)	(2.38)
Ln(Patents) t	+	0.215***	0.195***
		(19.65)	(21.12)
Ln(AvgCites) t		0.022	0.005
		(0.51)	(0.20)
Ln(Assets) t		-0.000	0.014
		(-0.02)	(0.96)
MB t		-0.012***	-0.007***
		(-7.45)	(-5.32)
ROA t		0.284**	0.280**
		(2.21)	(2.56)
Lev t	+	0.569***	0.521***
		(6.59)	(5.99)
Cash t	-	-0.364***	-0.319***
		(-3.65)	(-5.08)
DivPayer t	-	-0.198***	-0.218***
		(-3.88)	(-3.29)
Tangible t		-0.102	-0.028
		(-0.85)	(-0.16)
MTR t		-1.295***	-1.499***
		(-7.07)	(-8.30)
5Yrσ(CFO) t		1.312***	1.226***
		(5.67)	(6.77)
Observations		5,234	5,234
Adjusted R-squared		0.263	0.258
Industry FE		Yes	Yes
Inc-State FE		Yes	Yes
Year FE		Yes	Yes

Notes: The results in this table provide validation that the plausibly exogenous treatment event in 2002 raises US MNCs' incentive to collateralize patents. In column (1), I use *Ln(ColPat)* as my dependent variable while I use *Ln(ColPatInit2)* as my dependent variable in column (2). Control variables are measured contemporaneously. All variables are defined in Appendix C. All variables are winsorized at the 1st and 99th percentiles. Standard errors are clustered at the state of incorporation level. I perform two-sided t-tests on all coefficients. *** denotes significance at the 1% level, ** denotes significance at the 5% level and * denotes significance at the 10% level.

Wang 2012). As explained above, the *RP* treatment event is unlikely to affect US MNCs' TMOIS directly but through patent collateralization. The other regressors in the model include control variables from Eq (1). I also include incorporation state fixed effects to control for state-invariant characteristics that could be correlated with US MNCs' incentives to collateralize patents and the *RP* exclusion restriction in the first stage regression. Results of the first-stage selection model is reported in Table 12 Panel A.

Consistent with my results in Table 11, I find that the *RP* treatment is positively associated with the likelihood of US MNCs collateralizing patents. The coefficient on *RP* is positive and significant at conventional levels across both columns. This result provides support for the use of *RP* as a valid exclusion restriction. The coefficients on the covariates that are modeled as determinants of patent collateralization largely have the same signs as the coefficients in the determinants model (Table 3).

I next calculate the inverse Mills ratio and include it in the second stage regression of Eq (1). I present my results in Table 12 Panel B.[46] I find that the coefficients on the variables of interest, *Ln(ColPat)*FTR* and *Ln(ColPatInit2)*FTR*, are negative and significant at the 5% level. My results are robust to the Heckman selection correction procedure. It should also be noted that the coefficients on the inverse Mill ratio are negative in both columns, consistent with unobservables driving positive selection into patent collateralization and constraining TMOIS. However, the selection bias seems weak given the statistically insignificant result.

[46] To ensure that the fixed effects structures are consistent across both first and second stage regressions, I include incorporation state fixed effects in the second stage regression. In robustness tests, I omit incorporation state fixed effects, following Eq (1). My results (untabulated) are very similar to those reported in Table 12 Panel B.

Table 12. Heckman Selection Correction

Panel A: First-stage selection model			
		(1)	(2)
VARIABLES	Pred.	*D(#ColPat)*	*D(#ColPatInit2)*
RP	+	0.310**	0.312**
		(2.08)	(2.24)
Ln(Patents) t	+	0.331***	0.301***
		(10.81)	(10.60)
FTR (t, t+4)		-0.370	-0.634
		(-0.77)	(-1.54)
*Ln(Patents) t * FTR (t, t+4)*		0.112	0.197**
		(1.15)	(2.32)
Ln(AvgCites) t		0.067	0.070
		(0.86)	(0.92)
RoS (t, t+4)	-	-0.224	-0.144
		(-0.42)	(-0.29)
Ln(Assets) (t, t+4)		0.022	0.065*
		(0.60)	(1.96)
MB (t, t+4)		-0.012	-0.010
		(-1.22)	(-1.02)
Lev (t, t+4)	+	0.967***	0.681**
		(3.53)	(2.57)
Cash (t, t+4)	-	-0.735**	-0.757***
		(-2.58)	(-2.78)
DivPayer (t, t+4)	-	-0.336***	-0.264***
		(-3.96)	(-3.31)
Tangible (t, t+4)		-0.449	-0.502
		(-1.16)	(-1.29)
MTR (t, t+4)		-1.933**	-2.629***
		(-2.30)	(-3.19)
5Yrσ(CFO) t		1.618**	1.701**
		(2.18)	(2.46)
Observations		7,103	7,081
Pseudo R-squared		0.260	0.262
Industry FE		Yes	Yes
Inc-State FE		Yes	Yes
Year FE		Yes	Yes

Table 12. Heckman Selection Correction (continued)

Panel B: Second-stage regression			
		(1)	(2)
VARIABLES	Pred.	*FRoS (t, t+4)*	*FRoS (t, t+4)*
FTR (t, t+4)	+	0.088***	0.090***
		(3.68)	(3.57)
Ln(ColPat) t		-0.001	
		(-0.95)	
*Ln(ColPat) t * FTR (t, t+4)*	-	-0.020**	
		(-2.22)	
Ln(ColPatInit2) t			0.000
			(0.18)
*Ln(ColPatInit2) t * FTR (t, t+4)*	-		-0.020**
			(-2.37)
IMR		-0.010	-0.009
		(-0.52)	(-0.45)
Observations		7,103	7,081
Adjusted R-squared		0.527	0.527
Controls		Yes	Yes
Industry FE		Yes	Yes
Inc-State FE		Yes	Yes
Year FE		Yes	Yes

Notes: This table reports the effect of patent collateralization on tax-motivated outbound income shifting after correcting for selection bias using the Heckman procedure. In Panel A, I estimate the first-stage selection model. I dichotomize the *Ln(ColPat)* and *Ln(ColPatInit2)* variables to form *D(#ColPat)* and *D(#ColPatInit2)* and use them as my dependent variables in columns (1) and (2), respectively. In Panel B, I re-estimate Eq(1) with the inclusion of the inverse Mills ratio calculated from the first-stage selection model. I use *Ln(ColPat)* and *Ln(ColPatInit2)* as my measures of the number of collateralized patents in columns (1) and (2), respectively. All variables are defined in Appendix C. All variables are winsorized at the 1st and 99th percentiles. Standard errors are clustered at the MNC level. I perform two-sided t-tests on all coefficients. *** denotes significance at the 1% level, ** denotes significance at the 5% level and * denotes significance at the 10% level.

6.10. Robustness Tests

Finally, I perform three robustness tests. My results are reported in Table 13. First, I omit firm-year observations spanning 2004-2005 from my main analysis to avoid the effects of the American Jobs Creation Act's tax holiday. The tax holiday gave US MNCs the option to take an 85 percent dividends received deduction on repatriations in 2004 or 2005. Given that the tax holiday elicited different responses from US MNCs of different characteristics (e.g., US MNCs with lower investment opportunities and higher free cash flows were more likely to repatriate (Blouin and Krull 2009)), the tax holiday not only affected US MNCs' incentives to engage in TMOIS differentially but could also affect US MNCs' incentive to collateralize patents differentially. US MNCs that opt to repatriate may be less likely to seek debt financing to fund domestic operations and hence less likely to collateralize patents. Omitting 2004-2005 limits the confounding effect of the tax holiday. In Table 13 Panel A, I find that the coefficients on the interaction terms of interest remain negative and significant at conventional levels, across both columns.

Second, I use the percentage of patents collateralized as an alternative measure of the number of collateralized patents. Similar to my main measures, I develop two measures: 1) the percent of total patents that are held by lenders of the US MNC *i* for security interest in year *t* and 2) percent of total patents pledged by the US MNC *i* as collateral in the last two years (*t-2, t*). My results are reported in Table 13 Panel B. In both columns, the coefficients on the interaction terms of interest remain negative and significant at conventional levels. I find evidence that my results are robust to alternative measures of the number of collateralized patents.

Third, I narrow the collateral initiation horizon of two years in *Ln(ColPatInit2)* to one year (*Ln(ColPatInit1)*). In Table 13 Panel C, I find that the coefficient on *Ln(ColPatInit1)*FTR* is

Table 13. Robustness Tests

Panel A: Exclude AJCA tax holiday period (2004-2005)

VARIABLES	Pred.	(1) *FRoS (t, t+4)*	(2) *FRoS (t, t+4)*
FTR (t, t+4)	+	0.095***	0.096***
		(3.93)	(3.94)
Ln(ColPat) t		-0.001	
		(-0.74)	
*Ln(ColPat) t * FTR (t, t+4)*	-	-0.024***	
		(-2.68)	
Ln(ColPatInit2) t			0.000
			(0.22)
*Ln(ColPatInit2) t * FTR (t, t+4)*	-		-0.024***
			(-2.79)
Observations		6,558	6,558
Adjusted R-squared		0.508	0.508
Controls		Yes	Yes
Industry FE		Yes	Yes
Year FE		Yes	Yes

Panel B: Alternative measures of patent collateralization

VARIABLES	Pred.	(1) *FRoS (t, t+4)*	(2) *FRoS (t, t+4)*
FTR (t, t+4)	+	0.102***	0.100***
		(4.23)	(4.13)
%ColPat t		-0.010	
		(-1.16)	
*%ColPat t * FTR (t, t+4)*	-	-0.086**	
		(-2.10)	
%ColPatInit2 t			-0.001
			(-0.15)
*%ColPatInit2 t * FTR (t, t+4)*	-		-0.072**
			(-2.17)
Observations		7,382	7,382
Adjusted R-squared		0.508	0.507
Controls		Yes	Yes
Industry FE		Yes	Yes
Year FE		Yes	Yes

Table 13. Robustness Tests (continued)

Panel C: Shorter collateral initiation horizon		
		(1)
VARIABLES	Pred.	*FRoS (t, t+4)*
FTR (t, t+4)	+	0.090***
		(3.76)
Ln(ColPatInit1) t		0.000
		(0.01)
*Ln(ColPatInit1) t * FTR (t, t+4)*	-	-0.021**
		(-2.45)
Observations		7,382
Adjusted R-squared		0.508
Controls		Yes
Industry FE		Yes
Year FE		Yes

Notes: This table presents results of my robustness tests. In Panel A, I exclude 2004-2005 (AJCA tax holiday period) from my sample. In Panel B, I use *%ColPat* and *%ColPatInit2* as alternative measures of patent collateralization. *%ColPat* is the percent of total patents that are held by lenders of US MNC *i* for security interest in year *t*. *%ColPatInit2* is the percent of total patents pledged by US MNC *i* as collateral in the last two years (t-2, t). In Panel C, I use a shorter collateral initiation horizon (1 year) to measure the number of collateralized patents with timely appraised valuations. All variables are defined in Appendix C. All variables are winsorized at the 1st and 99th percentiles. Standard errors are clustered at the MNC level. I perform two-sided t-tests on all coefficients. *** denotes significance at the 1% level, ** denotes significance at the 5% level and * denotes significance at the 10% level.

negative and significant at 5% level. In fact, the magnitude of the coefficient is very similar to that in Table 4 column 2.

7. CONCLUSION

In this study, I examine whether patent collateralization constrains TMOIS. US MNCs that own patents typically employ tax strategies in which they shift income out of the US by understating the value of the patents transferred to subsidiaries in low-tax jurisdictions. My study explores two relatively unexplored channels through which debt financing (in particular, patent-secured loan financing) can constrain US MNCs' TMOIS. First, patent collateralization could hinder US MNCs from transferring collateralized patents out of the US. To facilitate the collection of collateral, banks can restrict borrowing MNCs from relocating collateralized patents to overseas affiliates. These MNCs likely face difficulty undertaking patent-based TMOIS for their collateralized patents. Second, collateral valuations of patents from patent-secured loans could provide tax authorities with benchmarks for arm's length transfer prices. US MNCs typically seek favorable collateral valuations for their patents when pledging them as collateral. However, tax authorities could use these collateral valuations to limit US MNCs' ability to set low transfer prices for collateralized patents, constraining their TMOIS. I find that the number of collateralized patents is negatively associated with the extent of US MNCs' TMOIS.

I next identify cross-sectional variation in the debt financing needs of US MNCs to examine whether MNCs with strong debt financing needs are more likely to trade off patent-based income shifting in favor of meeting their debt financing needs. US MNCs that have stronger debt financing needs are more likely to pledge more valuable patents as collateral to secure bank loan financing. Hence, tax authorities could constrain the ability of these US MNCs to set lower transfer prices for their valuable collateralized patents that are used for TMOIS. I find that the negative association between patent collateralization and TMOIS is stronger for US MNCs with stronger debt financing needs.

To provide validation that banks have the right to agree or disagree to the relocation of collateralized patents, I find evidence consistent with the TMOIS of US MNCs being less constrained when banks are less concerned about US MNCs defaulting on bank loans. I find that the TMOIS of US MNCs with low default risk are less constrained by patent collateralization.

I also provide support that patent collateral valuations are a source of information that tax authorities rely on to constrain US MNCs' TMOIS. First, I find results consistent with tax authorities relying less on patent collateral valuations when other informative signals of patent arm's length values are readily available. I find that the TMOIS of US MNCs with more peers are less constrained by patent collateralization. US MNCs with more peers are likely to have more comparable patents for tax authorities to benchmark against. Tax authorities are expected to place more weight on comparable patent transactions and less weight on patent collateral valuations when determining the benchmark for transfer prices for US MNCs with more peers. US MNCs with more peers thus are more able to set lower transfer prices for collateralized patents.

Second, I find results consistent with tax authorities relying more on patent collateral valuations as benchmarks when tax authorities' resources are constrained. As determining the arm's length values of patents can be resource-consuming for tax authorities, tax authorities are more likely to rely on patent collateral valuations – an informative and readily available signal of the arm's length values of collateralized patents – as benchmarks when resources are constrained. US MNCs thus are less able to set lower transfer prices for collateralized patents when tax authorities' resource are constrained. I find results consistent with the constraining effect of patent collateralization on TMOIS being more pronounced in years when tax authorities are resource-constrained than in other years.

Next, as the availability of patent collateral valuations to tax authorities could constrain US MNCs' transfer pricing strategy, I find that collateralized patents are less likely to be transferred out of the US and less likely to be transferred to tax haven countries.

Finally, to provide robustness for my main results, I employ two alternative identification strategies, generalized difference-in-differences approach and Heckman selection correction. I rely on a federal court decision to exploit plausibly exogenous variation in US MNCs' incentives to collateralize patents. My main results are robust to employing a generalized difference-in-differences approach with the federal court ruling as a treatment event. My main results are also robust to the Heckman selection correction procedure.

Overall, my results provide evidence consistent with patent collateralization 1) restricting US MNCs from relocating patents to low-tax subsidiaries and 2) providing arm's length valuations of assets, which tax authorities can rely on to benchmark transfer prices, thereby constraining TMOIS. My study contributes to the literatures on 1) mechanisms influencing tax-motivated income shifting and 2) banks' role in corporate tax avoidance. In addition, my findings shed light on how tax authorities allocate resources to support their enforcement efforts, given the recent IRS budgets cuts. I find results consistent with tax authorities relying more on an informative and readily available information signal (patent collateral valuations) to detect and deter aggressive TMOIS when resources of tax authorities are constrained.

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APPENDIX A: Excerpt from Collateral Agreement

TECUMSEH PRODUCTS COMPANY (Patent No. 7422422 Reel/Frame: 020995/0940)

(g) Locations. Such Grantor will not (i) maintain any Collateral owned by it at any location other than those locations listed on Exhibit A, (ii) otherwise change, or add to, such locations without the Administrative Agent's prior written consent as required by the Credit Agreement (and if the Administrative Agent gives such consent, the Grantor will concurrently therewith obtain a Collateral Access Agreement for each such location to the extent required by the Credit Agreement), or (iii) change its principal place of business or chief executive office from the location identified on Exhibit A, other than as permitted by the Credit Agreement or Section 4.15 of this Security Agreement.

APPENDIX B: Construction of Patent Collateralization Variables

Firm A pledges 10 patents as collateral to Bank B — Bank B releases the 10 collateralized patents to Firm A

	2000	**2001**	**2002**	**2003**	**2004**
#ColPat	10	10	10	10	10
#ColPatInit2	10	10	10	0	0
Ln(ColPat)	1.041	1.041	1.041	1.041	1.041
Ln(ColPatInit2)	1.041	1.041	1.041	0	0

APPENDIX C: Variable Definitions

Variables used in main test	
FRoS (t, t+4)	Five-year sum of foreign pre-tax income (PIFO; Compustat) scaled by the five-year sum of foreign sales (Compustat Segment).
FTR (t, t+4)	Five-year average of US statutory tax rate minus five-year sum of foreign tax expense (TXFO plus TXDFO) scaled by five-year sum scaled by foreign pre-tax income (PIFO) (Compustat).
Ln(ColPat) t	Natural logarithm of 1 plus the number of patents that are held by lenders for security interest in year *t* (USPTO Patent Assignment).
Ln(ColPatInit2) t	Natural logarithm of 1 plus the number of patents pledged as collateral in the last two years (*t-2, t*) (USPTO Patent Assignment).
Ln(Patents) t	Natural logarithm of 1 plus the number of patents and pending patents held by a US MNC in year *t* (Global Corporate Patenet Database, USPTO Patent Assignment).
Ln(AvgCites) t	Natural logarithm of 1 plus the average number of forward citations a US MNC's patents receive in year *t*. Citation counts are limited to the first five years of the patent's term.
RoS (t, t+4)	Five-year sum of pre-tax income (IB) scaled by the five-year sum of total sales (SALE) (Compustat).
Ln(Assets) (t, t+4)	Natural logarithm of five-year average of total asset (AT) (Compustat).
MB (t, t+4)	Five-year sum of market value of equity (PRCC_F*CSHO) divided by the five-year sum of book value of equity (CEQ) (Compustat).

Lev (t, t+4)	Five-year sum of long-term debt (DLTT) scaled by the five-year sum of lagged assets (AT) (Compustat).
Cash (t, t+4)	Five-year sum of cash holdings (CHE) scaled by the five-year sum of lagged assets (AT) (Compustat).
DivPayer (t, t+4)	Equal 1 if a US MNC pays dividend during years (*t*, *t+4*) and 0 otherwise.
Tangible (t, t+4)	Five-year sum of net property, plant, and equipment (PPENT) scaled by five-year sum of total assets (AT) (Compustat).
MTR (t, t+4)	Five-year average of annual marginal tax rates (MTR) obtained from John Graham's website (Graham 1996). Missing annual MTR values are replaced with calculated MTR values using the estimated coefficients from Graham and Mills (2008).
5Yrσ(CFO) t	The volatility of operating cash flow (OANCF) scaled by lagged assets (AT), measured over five years.
Cross-sectional variables	
HighLev t	Equals 1 if a US MNC's leverage ratio in year *t* is in the highest quartile and 0 otherwise.
LowCFO t	Equals 1 if a US MNC's operating cash flow (OANCF) scaled by lagged assets (AT) in year *t* is in the lowest quartile and 0 otherwise.
LowPViol t	Equals 1 if the average probability of a US MNC violating its loan covenants in year *t* is in the bottom quartile and 0 otherwise.
Safe t	Equals 1 if a US MNC's Altman (1986) Z-score in year *t* is equal to or more than 3 and 0 otherwise.
High#PMP t	Equals 1 if a US MNC's number of product market peers in year *t* (Hoberg and Phillips

	2010) is in the highest quartile and 0 otherwise.
HighPMPScr t	Equals 1 the sum of the similarity scores of all the product market peers in year *t* (Hoberg and Phillips 2010) a US MNC has is in the highest quartile and 0 otherwise.
Variables used in additional tests	
LowRes t	Equals 1 if the IRS' inflation-adjusted enforcement budget scaled by total tax returns filed in year *t* is in the lowest tercile and 0 otherwise (IRS Data Book).
Non-US t	Equals 1 if patent is held by affiliate that is located outside of the US in year *t* and 0 otherwise.
TaxHaven t	Equals 1 if patent is held by affiliate that is located in a tax haven country in year *t* and 0 otherwise.
ColPat t	Equals 1 if patent is held by lenders for security interest in year *t* and 0 otherwise.
ColPatInit2 t	Equals 1 if patent is pledged as collateral in years (*t-2, t*) and 0 otherwise.
D(#ColPat) t	Equals 1 if at least one patent is held by lenders for security interest in year *t* and 0 otherwise.
D(#ColPatInit2) t	Equals 1 if at least one patent is pledged as collateral in the last two years (*t-2, t*) and 0 otherwise.
%ColPat t	Percent of total patents that are held by lenders for security interest in year *t*.
%ColPatInit2 t	Percent of total patents pledged as collateral in the last two years (*t-2, t*).
RP t	Equals 1 if a US MNC is incorporated in Delaware and the year is in and after 2002, and 0 otherwise.

Ln(Cites) t	Natural logarithm of 1 plus the number of forward citations patent *j* receive in year *t*. Citation counts are limited to the first five years of the patent's term.
Ln(Assets) t	Natural logarithm of total asset (AT) (Compustat).
MB t	Market value of equity (PRCC_F*CSHO) divided by book value of equity (CEQ) (Compustat).
ROA t	Pre-tax income (IB) scaled by lagged assets (AT) (Compustat).
Lev t	Long-term debt (DLTT) scaled by lagged assets (Compustat).
Cash t	Cash holdings (CHE) scaled by lagged assets (AT) (Compustat).
DivPayer t	Equal 1 if a US MNC pays dividend in year *t* and 0 otherwise.
Tangible t	Net property, plant, and equipment (PPENT) scaled by total assets (AT) (Compustat).
MTR t	Marginal tax rates (MTR) obtained from John Graham's website (Graham 1996). Missing values are replaced with calculated MTR values using the estimated coefficients from Graham and Mills (2008).

APPENDIX D: Example of Patent Collateralization (Taken from USPTO Patent Assignment Website)

Assignment 2

Reel/frame	Execution date	Date recorded	Properties	Pages
038954/0001	Apr 26, 2016	Jun 2, 2016	18020	961

Conveyance
PATENT SECURITY AGREEMENT

Assignors
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Assignment 1

Reel/frame	Execution date	Date recorded	Properties	Pages
038669/0001	Apr 26, 2016	May 12, 2016	18017	961

Conveyance
SECURITY INTEREST (SEE DOCUMENT FOR DETAILS).

Assignors
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