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Does carbon risk matter in firm dividend policy? Evidence from a quasi-natural experiment in an imputation environment

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ABSTRACT

We examine the role of carbon risk in dividend policy, and how its effect varies between imputation (paying franked dividends) and classical (paying unfranked dividends) tax environments in the unique experimental setting in Australia. We find that the probability of paying dividend and dividend payout ratio is lower for firms in the highest-emitting industries (polluters) relative to non-polluters, subsequent to ratification of the Kyoto Protocol. While the post-Kyoto reduction in the likelihood of paying dividend is not significantly different, the reduction in payout ratio is smaller in the imputation environment than classical tax system, highlighting the significance of imputation tax environment only on the impact of carbon risk on dividend payout rather than decision to pay. We further document that the post-Kyoto reduction in dividend payout of polluters is driven by their relative increase in earnings uncertainty. The evidence suggests a causal influence of carbon risk on firm dividend policy.

1. Introduction

Given the importance of corporate dividend payout policy to both shareholders and managers, the extant literature has been dedicated to identifying the key determinants of dividend decisions, see for example (Balachandran et al., 2017; Brav et al., 2005; Chay and Suh 2009; DeAngelo et al., 1992; DeAngelo et al., 2006; Denis and Osobov 2008; Fama and French 2001; Hoberg et al., 2014; John et al., 2011; La Porta et al. 2000).[1] However, there is a lack of understanding on the impact of carbon risk on firms' dividend policy and how this effect varies across different tax environments. In this paper, we address these important and interesting issues in the Australian setting which has imputation and traditional tax systems operating contemporaneously, using the ratification of Kyoto Protocol in Australia in 2007 as an experimental exogenous variation in carbon risk.[2]

Our focus on carbon risk to explain dividend policy is motivated by both evidence from the field and empirical research. Lintner (1956), Brav et al. (2005), and Brav et al. (2008) provide survey reports emphasizing that firm managers consider stability in future earnings as the key determinant of dividend policy. These observations are subsequently supported by the internationally consistent evidence of Chay and Suh (2009) who demonstrate the role of cash-flow uncertainty in adversely driving dividend payments. We argue that firms exposed to high levels of carbon risk are likely to experience higher earnings uncertainty, and are, therefore, both less likely to pay dividends and more likely to have lower dividend payouts than other firms.

Firms facing carbon risk are fossil fuel-intensive firms such as those in the material, energy or utility sectors, whose future carbon performance is greatly unstable due to various factors such as

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[1] La Porta *et al.* (2000) show that firms operating in countries with better protection of minority shareholders pay higher dividends. Fama and French (2001) document that firms with high profitability and lower growth rates tend to pay dividends. Brav *et al.* (2005) find that firms with stable and sustainable increases in earnings are the only firms that consider increasing or initiating dividends. DeAngelo *et al.* (2006) show that mature firms are better candidates for paying dividends because they have higher profitability and fewer attractive investment opportunities. Chay and Suh (2009) show that the impact of cash-flow uncertainty on dividends is generally stronger than the impact of other determinants of payout policy—such as the earned/contributed capital mix, agency conflicts, and investment opportunities. Hoberg *et al.* (2014) find that firms' products facing competitive threats have a lower propensity to pay dividends. Balachandran *et al.* (2017) show that both the decision to pay and payout levels are higher for firms within an imputation tax environment than within a traditional tax system.

[2] The ratification of the Kyoto Protocol mandates Australia to reduce carbon emissions, thereby affecting firms in highest-emitting industries.

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the uncertainty in carbon control regulations, the firms' degrees of policy compliance, and managers' views on the importance of carbon reduction (Busch and Hoffmann 2007; Butterworth et al., 2015; Hoffmann and Busch 2008; Oestreich and Tsiakas 2015; Ramiah et al., 2013). Further, the carbon-intensive firms (hereafter, polluters) are likely to incur more carbon-related management and accounting costs such as clean-up costs, research and development (R&D) costs, compliance and litigation costs, and reputation damage costs (Barth and McNichols 1994; Clarkson et al., 2004; Karpoff et al., 2005) than other firms (hereafter, non-polluters). In addition, the high-emitting firms may be subject to higher financing costs due to stricter views imposed by providers of finance such as debt and equity holders (Jung et al., 2016; Matsumura et al., 2013). We argue that the increase in costs related to carbon risk management will affect managers' confidence in future prospects, so rendering cautious financial policies subsequent to ratification of the Kyoto Protocol in Australia. Thus, we predict that polluters are less likely to pay dividend and more likely to have lower dividend payout than non-polluters subsequent to ratification of the Kyoto Protocol in Australia.

The tax environment in Australia is different from the tax environment that operates in the U.S. Since the introduction of the imputation tax system in July 1987, Australian resident shareholders who receive dividends that are paid out of profits earned and taxed in Australia are able to reduce their tax paid on the dividend by an amount equal to the imputation tax credits. Shareholders who receive dividends that are paid out of profits earned and taxed outside Australia pay the normal income tax on the dividend, which corresponds to the classical tax system. Dividend associated with (without) imputation credit is known as franked (unfranked) dividend. The key benefit of the imputation tax environment is avoiding double taxation compared to the classical tax system.[3] Balachandran et al. (2017) argue that the tax incentives that are available to pay franked dividends essentially incentivize dividend payments to be shifted to earlier points in time, since the value of the tax credit will diminish with time. Therefore, we argue that firms following the imputation tax system will be less likely to reduce dividend payout, even if there is a decline in profits due to the carbon-related costs as long as these firms earn profits to pass imputation credits to shareholders. Hence, we predict that the negative impact of carbon risk on dividend policy will be weaker for firms that follow the imputation tax system than the traditional tax system. Given the rapid increase in carbon risk for the foreseeable future, the role of the tax framework on the impact of carbon risk would be of interest not only to policy-makers, but also to managers and shareholders.

Any attempts to investigate the financial impact of carbon risk and the possible moderating role of the tax system are subject to at least three empirical challenges. The first challenge is endogeneity concerns because carbon risk and firm dividend policy may be jointly determined or correlated with other omitted firm characteristics (Al-Tuwaijri et al., 2004; Flammer 2015), which render the parameter estimates biased and inconsistent (Roberts and Whited 2012). The second challenge is the small sample bias due to a shortage of carbon risk data on greenhouse gas emissions or energy consumption at the firm level (Konar and Cohen 2001), which would prevent researchers from drawing valid inferences about the true nature of the population. Even if the emission data were available, they might measure current or past carbon performance, whereas carbon risk – which, by definition, is the uncertainty in future carbon performance – is forward-looking and, thus, hardly observable. The third challenge arises due to the fact that there are very few nations that allow both imputation and traditional tax systems to co-exist (i.e., firms are entitled to pay both franked and unfranked dividends to shareholders), which hinders examination on the moderating role of the tax environment in determining the impact of carbon risk on dividend policy.

In this study, we examine the impact of carbon risk on dividend policy addressing these three issues. First, to alleviate the endogeneity concerns we exploit the ratification of the Kyoto Protocol in Australia as a source of experimental variation.[4] Australia is one of the top ten countries by market capitalization (United States, Japan, United Kingdom, Hong Kong, China, Canada, France, Germany, Australia, and India) and it ratified the Kyoto Protocol in December 2007. The ratification was the first act of the former Prime Minister Kevin Rudd after being sworn in, and was widely regarded as the starting point of an era of stricter environmental regulations for Australia (Ramiah et al., 2013; Subramaniam et al., 2015). In particular, following the Kyoto Protocol ratification, Australia is primarily required to restrict its average annual emissions over the 2008–2012 commitment period to eight percent above its 1990 level.[5]

The United States has never ratified the Kyoto Protocol. Ratification by other countries in the top ten market capitalizations was an automatic step, since these countries had expressed their agreement to join the Protocol since December 1997 when it was adopted in Kyoto, Japan.[6] The anticipated adoption of the Kyoto Protocol may lead firms in these countries to react to the policy well beforehand, which violates the parallel trends assumption for the event to be a valid exogenous shock. In contrast, Australia's ratification came late in December 2007 as a surprise to the market after a great deal of political debate about the pros and cons of the policy for Australia's resource-based economy. Without explicit economic objectives and political anticipation, ratification of the Protocol serves as an exogenous shock that affects polluters. Using this policy variation allows us to establish causal effects of carbon risk on dividend policy as well as other firm financial aspects.

Second, to address the small sample bias concern, we rely on the polluting nature of a firm's industry – that is, the relative industry-based level of carbon emissions and energy consumption – to define polluters. Hence, any firms whose industry classifications are available can be classified as either polluters or non-polluters. In addition, since a polluter is not defined by any of its financial characteristics including dividend policy, using a polluter dummy variable in our analysis allows us to alleviate concerns that a firm's dividend policy may affect its carbon risk and carbon risk may be correlated with other control variables as documented by previous research (Krüger 2015). To account for a possibility that the industry-based classification of polluters and non-polluters may capture some unobserved industry characteristics, such as business risk, other than carbon risk, we control for industry fixed effects and other well-known time-varying determinants of dividend policy in our model specifications. Collectively, this identification strategy allows us to capture carbon risk from its two main sources including the emitting nature of industries and the stringency of carbon policies (Ramiah et al., 2013).

Finally, Australia is not only the most polluting country by greenhouse gas (GHG) emissions per capita in the Organization for Economic Co-operation and Development (OECD) group

[3] See more information on the difference between imputation and traditional tax systems in Cannavan *et al.* (2004) and Balachandran *et al.* (2017).

[4] This Protocol is an internationally binding agreement whereby participating countries commit to reducing carbon emissions to satisfy national reduction targets (UNEP 2006).

[5] Source: http://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/Browse_by_Topic/ClimateChangeold/governance/international/theKyoto.

[6] Source: http://unfccc.int/kyoto_protocol/status_of_ratification/items/2613.php.

(Garnaut, 2011), but it also provides a unique tax setting to test our tax-related hypothesis. In sum, the novel Australian setting that has these two tax systems operating contemporaneously provides insights regarding the effect of carbon risk on dividend decisions and the possible heterogeneity in the effect between imputation (paying franked dividends) and classical (paying unfranked dividends) tax environments.

Adopting a difference-in-differences analysis framework, we find support for our hypotheses. First, we find that both the propensity to pay dividend as well as the level of dividend payout are lower for polluters relative to non-polluters subsequent to ratification of the Kyoto Protocol in Australia. Second, we find that the reduction in the likelihood of paying dividend subsequent to ratification does not differ between imputation and traditional tax environments. However, the reduction in the level of dividend payout subsequent to ratification of the Kyoto Protocol is significantly stronger for the traditional tax environment than for the imputation tax system. In addition, we document that earnings uncertainty increases for both polluters and non-polluters subsequent to ratification. However, this effect is stronger for polluters than non-polluters. Finally, we find that, post ratification, the reduction in the level of dividend payout of polluters is significantly stronger for firms with higher earnings uncertainty than for those with lower earnings uncertainty, supporting the notion that ratification of the Kyoto Protocol increases earnings uncertainty, which, in turn, reduces the level of dividend payout.

For robustness checks, we conduct several additional tests to address identification concerns and alternative measures of the main variables. First, our falsification test on the timing of Kyoto Protocol ratification suggests that the impact of carbon risk on dividend policy prevails only after this event and our main findings are not driven by time trends. Second, we use a firm related approach to define polluters, where a firm is redefined to be a polluter (non-polluter) if its shareholders reacted negatively (insignificantly or positively) to the announcement of Kyoto Protocol ratification in Australia. The intuition is that the Kyoto Protocol ratification could be a bad news for polluting firms (e.g., through increasing operating and financing costs, or restricting some polluting activities), whereas it could not be a bad news for non-polluting firms (e.g., they may even better off through reduced competition or better access to external funds). Using the market reaction-based firm-specific identification of polluters and non-polluters, we document similar results to our industry-based findings, and confirm that our main results are attributable to carbon risk rather than to industry effects.

Third, we rule out the possibility that the Global Financial Crisis that commenced at the same time as Australia's ratification of the Kyoto Protocol may drive the main results. Finally, we replicate our analyses for the U.S. – that is, the biggest nation by market capitalization, but has never adopted the Kyoto Protocol – and find no significant changes in the U.S. polluters' dividend policy after either 2005 or 2007. We also expand our out-of-sample test to the U.K. – that is, the biggest nation in the Europe by the size of both the real economy and stock market, where both the Kyoto Protocol and European Union Emissions Trading System (EU-ETS) policies came into effect in 2005 and the EU-ETS entered the second phase in 2008 – and find significant decreases in the likelihood to pay dividend and the level payout for polluters in the UK for both after 2005 as well as 2007. The out-of-sample tests further confirm that the main results based on Australian data are driven by the nation's Kyoto Protocol ratification, rather than global trends in industry-specific attributes.

This paper contributes to the literature in several ways. First, we add to the debate on the financial effects of carbon risk (Busch and Hoffmann 2007; Hoffmann and Busch 2008; Matsumura et al., 2013; Misani and Pogutz 2015; Nguyen 2018; Oestreich and Tsiakas 2015). Specifically, we show that the tightening in carbon controls results in increases in earnings uncertainty, which in turn leads to a decrease in the dividend payouts. To the best of our knowledge, we are the first to relate carbon risk to this type of firm financial risk, which further unravels the channels of carbon-financial performance relations (Busch and Lewandowski 2018).

Second, the paper contributes to the broad literature on the determinants of firm dividend policy: agency problems, governance and monitoring (Attig et al., 2016; Brockman et al., 2014; De Cesari and Ozkan 2015; Easterbrook 1984; Hail et al., 2014; Jensen 1986; John et al., 2015; La Porta et al. 2000; Short et al., 2002); profitability and growth opportunities (Fama and French 2001); earned/contributed capital mix as a proxy for life cycle theory (DeAngelo et al., 2006); cash-flow uncertainty (Brav et al., 2005; Chay and Suh 2009); internal capital market (Gopalan et al., 2014); external financing conditions (Bliss et al., 2015); stock liquidity (Jiang et al., 2017); and executive overconfidence/risk preference (Caliskan and Doukas 2015; Deshmukh et al., 2013). Our study extends this work by examining the effect of carbon risk on corporate managers' decisions to pay dividends.

Our third contribution is to extend the line of literature on the tax clientele effects on dividend policy (Alzahrani and Lasfer 2012; Brown et al., 2007; Desai and Jin 2011; Hanlon and Hoopes 2014; Henry 2011; Holmen et al., 2008; Jacob and Michaely 2017; Korkeamaki et al., 2010; Li et al., 2017). The prior studies document the relative importance of the imputation tax framework in encouraging firms' managers to increase the likelihood of paying dividend and the level of dividend payout. We are the first to further show the role of the imputation tax environment in attenuating the negative impact of carbon risk on dividend payout.

We organise the remainder of the paper as follows. Section 2 discusses the hypothesis development. Section 3 describes data and summary statistics. Section 4 presents the empirical methodology. Section 5 discusses the empirical results and robustness tests. Section 6 concludes and summarises the paper.

2. Hypothesis development

Fossil fuel-intensive firms such as those in material, energy or utility sectors are exposed to higher carbon risk that is, by definition, instability in future carbon performance (i.e., proxied by volatility in current and past carbon emissions) (Busch and Hoffmann 2007; Hoffmann and Busch 2008; Oestreich and Tsiakas 2015). This carbon risk is expected to be higher when new stringent carbon control regulations are introduced with a certain level of uncertainty in implementation (Butterworth et al., 2015; Ramiah et al., 2013).

As discussed earlier, subsequent to ratification of the Kyoto Protocol, Australia's carbon-intensive firms are likely to incur more carbon-related costs. Subsequent to ratification, carbon risk-induced costs increase earnings uncertainty of polluters compared to non-polluters which, in turn, reduces the confidence of polluters' managers in future prospects, thus rendering more cautious financial policies. Therefore, the carbon risk will adversely affect the likelihood of paying dividend and dividend payout ratio of polluters subsequent to the ratification. The study by Lintner (1956) reports that firm managers identify future earnings stability as the main factor that influences their dividend decisions. Further, survey evidence in Brav et al., (2005); (2008) points out that the stability of future incomes is a key determinant of dividend policy. Indeed, Chay and Suh (2009) provide direct empirical evidence of the negative association between cash-flow uncertainty and both propensity and level of dividend payouts. Hoberg et al. (2014) also show that a firm's dividend decisions are adversely affected by income instability caused by product threats from its competitors. Taking all these factors together, we argue that, subsequent to the ratification of the Kyoto Protocol in Australia, polluters are less likely to pay dividend than non-polluters. We also predict that polluters have lower payout ratios than non-polluters subsequent to Kyoto Protocol ratification. Therefore, we propose following hypotheses:

H1 ((a))**.** Subsequent to Kyoto Protocol ratification, polluters are less likely to pay dividend than non-polluters.

H1 ((b))**.** Subsequent to Kyoto Protocol ratification, polluters have lower dividend payout ratios relative to non-polluters.

Balachandran et al. (2017) argue that the tax incentives that are available in the imputation tax environment incentivize dividend payments to be shifted to earlier points in time, and show that firms in the imputation tax environment are more likely to pay dividend and have higher dividend payout ratios than firms in the traditional tax environment. Pattenden and Twite (2008) document that all dividend initiations, dividend payouts and dividend reinvestment plans increase upon the introduction of dividend imputation. Furthermore, Balachandran et al. (2012) find that the negative market reaction to dividend reductions is stronger for firms that decrease franking credits. Taking all of these factors into consideration, we predict that the reduction in probability of paying dividend and of payout ratio subsequent to ratification of the Kyoto Protocol will be lower for polluters operating in the imputation environment than for those operating in the classical tax environment. Therefore, we develop following hypotheses.

H2 ((a))**.** Post-Kyoto ratification reduction in the probability of paying dividend is lower for polluters operating in the imputation environment than for those operating in traditional tax system.

H2 ((b))**.** Post-Kyoto ratification reduction in the dividend payout ratio is lower for polluters operating in the imputation environment than for those operating in traditional tax system.

As discussed above, we predict that earnings uncertainty is the channel through which polluters relatively decrease their dividend payments after the Kyoto Protocol ratification. Therefore, we develop following hypotheses.

H3 ((a))**.** Subsequent to Kyoto Protocol ratification, earnings uncertainty is higher for polluters than for non-polluters.

H3 ((b))**.** Post-Kyoto ratification reduction in the likelihood to pay dividend is stronger for polluters with higher earnings uncertainty.

H3 ((c))**.** Post-Kyoto ratification reduction in the level of dividend payout ratio is stronger for polluters with higher earnings uncertainty.

3. Data and summary statistics

3.1. Data and variables

We collect yearly cash dividend payments and other financial characteristics of all firms listed in Australia Stock Exchange from Morningstar DatAnalysis database for the period 2002–2013. This sample period is a combination of two six-year long sub-periods: pre-Kyoto 2002–2007 and post-Kyoto 2008–2013. The post-Kyoto period is selected to correspond with the commitment period of Kyoto Protocol ratification by the Australia government.[7] The pre-Kyoto is chosen to be comparable in length with the post-Kyoto period. However, for those variables that require historical data such as earnings uncertainty measures, we extend our data collection period to 1998–2013.

We use GICS industry classification from Morningstar DatAnalysis to classify firms into polluters and non-polluters. We use probability to pay dividends (DIVDUM), and dividends-to-net-incomes ratio (DIVPAYOUT) as the main dependent variables. Control variables are well-documented determinants of corporate dividend policy and all measured in lagged year, including lagged probability or level of dividend payouts (DIVDUM $_{t-1}$ or DIVPAYOUT $_{t-1}$) (Brav et al., 2008), franked dividend dummy (FRANK$_{t-1}$) (Balachandran et al., 2017), log of total assets (SIZE$_{t-1}$) (DeAngelo et al., 2006; Fama and French 2001), return-on-assets ratio (ROA $_{t-1}$) (Denis and Osobov 2008), retained earnings-to-book value of equity ratio (RETAIN $_{t-1}$) (Chay and Suh 2009; DeAngelo et al., 2006), market-to-book value of total assets (TOBINQ $_{t-1}$) (Grullon and Michaely 2002; Hoberg et al., 2014), cash-to-total assets ratio (CASH $_{t-1}$) (Brav et al., 2008; DeAngelo et al., 2006; Fama and French 2001), long-term debt-to-book value of equity ratio (LEV $_{t-1}$), and fixed assets-to-total assets ratio (TANG $_{t-1}$) (John et al., 2011). To minimize the impacts of outliers, we winsorize all continuous variables at the top and bottom one percentiles. We provide detailed definitions of our variables in the Appendix.

3.2. Summary statistics and comparisons

Table 1 reports mean and median of our main variables between polluters and non-polluters for the whole sample period 2002–2013. We use parametric *t* tests and nonparametric Wilcoxon rank-sum tests to report the difference in our main variables between polluters and non-polluters. We find 11.4% of polluters pay dividends compared to 46.4% of non-polluters. Similarly, dividend payout ratio is 6.5% for polluters while this ratio for non-polluters is 28.3%. Median values of these two dividend measures are zero since more than half of either polluters or non-polluters do not pay dividends. Moreover, 6.9% of polluters as opposed to 35.6% of non-polluters pay franked dividends in the lagged year. With regard to other characteristics, polluters are smaller in size, less profitable, have lower earned/contributed capital mix, higher growth opportunities, hold more cash, use lower financial leverage, and invest less in fixed assets. Except for the difference in mean TOBINQL that is significant at 10%, all other variables are significantly different between polluters and non-polluters at least at the 1% level.

4. Methodology

Our primary objective is to examine the effect of carbon risk on firm dividend policy, and how this impact varies between imputation and traditional tax systems. We describe how we classify sample firms into two groups, namely polluters and non-polluters, to capture carbon risk in Section 4.1; explain the identification strategy in Section 4.2; and present empirical models related to hypotheses in Section 4.3.

4.1. Polluters versus non-polluters

First, we classify a firm as either a polluter or a non-polluter based on the emitting nature of the industry in which the firm operates (Nguyen 2018). Polluters are defined as firms in those industries recognized as "carbon intensive", which include the biggest greenhouse gas emitters or energy consumers. "Polluting" firms are more likely to face environmental issues (e.g., climate change) which may have negative financial effects in the form of carbon-related management and accounting costs, clean-up costs, R&D costs, compliance and litigation costs, or reputation damage costs

[7] The original Kyoto Protocol commitment period in Australia is 2008-2012. We add 2013 to account for the fact that for some firms, the 2013 dividend policies are based on 2012 earnings. In an unreported analysis, we define the post-Kyoto period as 2008-2012 and obtain results similar to the main findings.

Table 1
Summary Statistics.

Variable	Polluter (N = 8,539)		Non-polluter (N = 8,305)		*t* test (1) – (3)	Wilcoxon test (2) – (4)
	Mean (1)	Median (2)	Mean (3)	Median (4)		
DIVDUM	0.114	0.000	0.464	0.000	−54.40***	−50.17***
DIVPAYOUT	0.065	0.000	0.283	0.000	−47.75***	−49.82***
$FRANK_{t-1}$	0.069	0.000	0.356	0.000	−48.81***	−45.69***
$SIZE_{t-1}$	16.807	16.369	17.724	17.476	−26.74***	−29.41***
ROA_{t-1}	−0.332	−0.115	−0.195	0.024	−11.43***	−36.92***
$RETAIN_{t-1}$	−0.375	−0.120	−0.258	0.015	−5.97***	−31.79***
$TOBINQ_{t-1}$	2.426	1.496	2.325	1.354	1.93*	5.26***
$CASH_{t-1}$	0.309	0.216	0.210	0.102	24.34***	26.97***
LEV_{t-1}	0.111	0.000	0.262	0.027	−19.66***	−40.11***
$TANG_{t-1}$	0.168	0.028	0.178	0.092	−2.90***	−22.03***

This table presents descriptive statistics on key variables for polluters and non-polluters for the whole sample period 2002–2013. All data are sourced from Morningstar DatAnalysis database. For each variable, we report mean and median. We use parametric t test and nonparametric Wilcoxon rank-sum test to report the difference in our main variables between polluters and non-polluters. Continuous variables are winsorized at 1st and 99th percentiles. We report detailed definitions of all variables in Appendix. * and *** indicate significance at 10% and 1%, respectively.

and so on (Barth and McNichols 1994; Clarkson et al., 2004; Karpoff et al., 2005). In addition, when carbon regulations become more stringent, the financial consequences are expected to be more severe for the polluters. This industry-based classification allows us to overcome the issues of measurement errors and small sample bias identified by previous studies (Konar and Cohen 2001).

The highest carbon-risk industries include those that reportedly emit the most greenhouse gas and/or consume the most energy as described by the Greenhouse Gas Protocol (GHG Protocol).[8] Using a broad classification, among the 10 GICS sectors, three sectors including energy, utilities, and materials are recognized as the largest GHG emitters.[9] For example, according to AMP Capital, energy, utility and materials are the largest contributors to ASX200 GHG emission intensity as of end of August 2015, accounting for 85% of total emissions.[10] With regard to GHG emission investment risk measured by carbon emission cost – which is equal to the estimated equity-based tonne of emissions times the assumed carbon price of US$ 50/tonne CO2-e – the energy, materials and utilities sectors top the list, accounting for 33%, 21% and 19%, respectively, of the total carbon cost of the 10 GICS sectors in the MSCI World Index (AMPCapital 2016).

To address a possible concern that some industries within these three sectors could be less emission intensive, we follow the classification of the Carbon Disclosure Project to identify the most emitting industries within the energy, utilities and materials sectors.[11] To this end, firms in the following nine GICS industries are defined as polluters: ((1) Oil, Gas & Consumable Fuels; (2) Electric Utilities; (3) Gas Utilities; (4) Independent Power Producers and Energy Traders; (5) Multi-Utilities; (6) Chemicals; (7) Construction Materials; (8) Metals and Mining; and (9) Paper and Forest Products (CDP 2012).

4.2. Identification strategy

For identification strategy, we split the sample period into two sub-periods using ratification of the Kyoto Protocol in Australia in December 2007 as the cut-off point. The policy change allows us to compare the difference in dividend policy between polluters and non-polluters in the post-ratification relative to the pre-ratification periods.

For a number of reasons Australia provides a novel setting for examining the linkage between carbon risk and corporate dividend policy. First, according to Climate Change Review Update 2011, based on greenhouse gas emissions per capita, Australia is the most polluting nation in the Organisation for Economic Cooperation and Development group (Garnaut 2011). This fact gives rise to some unique characteristics of the carbon regulatory framework in Australia that have implications for Australian firms. In particular, on the one hand, Australian policy-makers have enacted a large number of new and stringent carbon regulations with which firms have to comply. On the other hand, Australia has been inconsistent in implementing the policies, evidenced by not only delaying in implementing the pollution reduction schemes but also the subsequent abolishment of some of the regulations. Secondly, Australia is among the countries in the world with the greatest awareness by all types of market participants – such as banks, savers, investors, and business managers – of carbon responsibilities (Nguyen 2018). ,[12] [13]

In Australia, ratification of the Kyoto Protocol in December 2007 represents a dramatic shift in the stringency of carbon policies. It is because the Kyoto Protocol ratification was the first act of former Labor Prime Minister Kevin Rudd to fulfil his promises of his election campaign to protect the natural environment (Ramiah et al., 2013). The ratification marked an end to decades of Australia being criticized as a resource-based economy. Indeed, Australia and the U.S. were the only two major industrialized countries that refused to ratify the Kyoto Protocol when it was first introduced in

[8] Source: http://www.ghgprotocol.org/.

[9] Global Industry Classification Standard (GICS) is a joint Standard and Poor's and Morgan Stanley Capital International product aimed at standardising industry definitions worldwide (source: http://www.asx.com.au/products/gics.htm).

[10] AMP Capital is a leading Australian investment house with AU$178.9 billion in funds under management as of 30 June 2017. They were amongst the first to sign on to the Principles for Responsible Investment in 2007 and have broadly considered Environmental, Social and Corporate Governance issues in equity investment strategies and advice (source: https://www.ampcapital.com.au/about-us)

[11] Carbon Disclosure project (CDP) is a not-for-profit charity that runs the global disclosure system for investors, companies, cities, states and regions to manage their environmental impacts (source: https://www.cdp.net/en-US/Pages/About-Us.aspx). Prior studies are found to resort to CDP for environmental information, e.g., Matsumura *et al.* 2013).

[12] The four major Australian banks (Australia and New Zealand Banking Group Limited (ANZ), the Commonwealth Bank of Australia (CBA), the National Australia Bank Limited (NAB) and Westpac Banking Corporation (Westpac)) are signatories to the United Nations Environmental Programme (UNEP) Statement by Financial Institutions and the Equator Principles (EP) (IFC 2013; UNEP 1997).

[13] One notable recent example is the extensive protest involving the petition of over 100,000 Australians asking the CEOs of Australia's Big 4 banks to rule out financing the Abbot Point coal port expansion on the Great Barrier Reef. Financing for this project was refused by some of the world's biggest banks, such as HSBC, Deutsche Bank, The Royal Bank of Scotland, Barclays and Citibank because it is estimated that the project will triple Australia's carbon emissions, locking the country into at least 30 more years of coal-fired power.

1997, and Australia had not taken any decisive action on cutting the national level of emissions prior to the Kyoto Protocol ratification (Subramaniam et al., 2015). By November 2007, whether Australia would ratify the Kyoto Protocol remained unclear and it all depended on which party was going to win the 2007 federal election. If the Liberal party of the then Prime Minister John Howard had won the election, the Protocol might not have been ratified and the Emission Trading Scheme would have been adopted instead.[14] Furthermore, the policy developed was solely aimed at reducing Australia's GHG emission level to no more than eight percent above the 1990 levels for the commitment period 2008–2012. Without explicit economic purposes being attached to the ratification of the Kyoto Protocol, the Australian government has shown its commitment to joining global efforts to protect the environment as a top priority. The Kyoto Protocol ratification, therefore, came as an exogenous shock to firms in carbon-intensive industries, which had long been the main drivers of the Australian economy.

4.3. Testing hypotheses

We present and discuss the empirical models related to hypotheses 1, 2, and 3 in Sections 4.3.1, 4.3.2, and 4.3.3 respectively.

4.3.1. Testing hypothesis 1

To examine the impact of carbon risk on dividend policy, we estimate the following baseline regressions:

$$Y_{it} = \alpha_0 + \alpha_1 POLLUTER_{it} + \sum\nolimits_{j=2}^{n} \alpha_j CONTROL_{jit-1} + \varepsilon_{it} \quad (1)$$

$$\begin{aligned} Y_{it} = {} & \beta_0 + \beta_1 POLLUTER_{it} + \beta_2 POST_{it} + \beta_3 POLLUTER_{it} * POST_{it} \\ & + \sum\nolimits_{j=4}^{n} \beta_j CONTROL_{jit-1} + \varepsilon_{it} \end{aligned} \quad (2)$$

$$\begin{aligned} Y_{it} = {} & \gamma_0 + \gamma_1 POLLUTER_{it} * POST_{it} + \sum\nolimits_{j=2}^{n} \gamma_j CONTROL_{jit-1} \\ & + (\text{Industry \& Year) FE} + \varepsilon_{it} \end{aligned} \quad (3)$$

where Y_{it} is $DIVDUM_t$ ($DIVPAYOUT_t$) for firm i in year t in examining the decision to pay dividend (determinants of dividend payout ratio). $POLLUTER_{it}$ is a dummy variable indicating whether firm i in year t is a polluter, $POST_{it}$ is a dummy variable indicating whether firm i in year t is observed in the post-Kyoto period 2008–2013. $POLLUTER_{it}*POST_{it}$ is an interaction term. $CONTROL_{jit-1}$ is control variable j of firm i in year t-1. For DIVDUM (DIVPAYOUT) as the dependent variable, a list of standard control variables is specified, including $DIVDUM_{t-1}$ ($DIVPAYOUT_{t-1}$), $FRANK_{t-1}$, $SIZE_{t-1}$, ROA_{t-1}, $RETAIN_{t-1}$, $TOBINQ_{t-1}$, $CASH_{t-1}$, LEV_{t-1}, and $TANG_{t-1}$. All *t*-statistics use robust standard errors clustered by firm (Hoberg et al., 2014; John et al., 2011). We provide definitions of all variables in the Appendix.

In Eq. 1, the coefficient of POLLUTER dummy, α_1, captures the mean difference in Y between polluters and non-polluters. For identification, we further include the POST dummy as well as the interaction term POLLUTER*POST to specify difference-in-differences models. In Eq. 2, the coefficient of POLLUTER dummy, β_1, measures the mean difference in Y between polluters and non-polluters in the pre-ratification period, and the coefficient of POST dummy, β_2, captures the change in Y of non-polluters in the post- relative to the pre-ratification period. Of interest in Eq. 2 is the coefficient of the interaction term, β_3, which represents the change in Y of polluters relative to the change in Y of non-polluters subsequent to the ratification of the Kyoto Protocol in Australia. A negative β_3 is consistent with the H1 (a & b).

To control for any possibility that the POLLUTER dummy inadvertently captures industry characteristics other than carbon risk, we include GICS industry fixed effects in Eq. 3. Moreover, as our sample period 2002–2013 covers a relatively long period, we also include year fixed effects to control for macro-economic conditions that may affect the dependent variables Y. In the presence of industry and year fixed effects we do not include industry-based POLLUTER and year-based POST dummies as their explanatory powers over Y are absorbed by those fixed effects. Again, we predict negative coefficient for γ_1 to lend support for H1 (a & b).

4.3.2. Testing hypothesis 2

To investigate the role of the imputation tax system, we augment Eqs. 2 and 3 to specify triple-differences models as follows :[15]

$$\begin{aligned} Y_{it} = {} & \beta_0 + \beta_1 POLLUTER_{it} + \beta_2 POST_{it} + \beta_3 POLLUTER_{it} * POST_{it} \\ & + \beta_4 POLLUTER_{it} * FRANK_{it-1} + \beta_5 POST_{it} * FRANK_{it-1} \\ & + \beta_6 POLLUTER_{it} * POST_{it} * FRANK_{it-1} \\ & + \sum\nolimits_{j=7}^{n} \beta_j CONTROL_{jit-1} + \varepsilon_{it} \end{aligned} \quad (4)$$

$$\begin{aligned} Y_{it} = {} & \gamma_0 + \gamma_1 POLLUTER_{it} * POST_{it} + \gamma_2 POLLUTER_{it} * FRANK_{it-1} \\ & + \gamma_3 POST_{it} * FRANK_{it-1} + \gamma_4 POLLUTER_{it} * POST_{it} * FRANK_{it-1} \\ & + \sum\nolimits_{j=5}^{n} \gamma_j CONTROL_{jit-1} + (\text{Industry \& Year) FE} + \varepsilon_{it} \end{aligned} \quad (5)$$

where Y_{it} is DIVDUM (DIVPAYOUT) for firm i in year t in examining the decision to pay dividend (determinants of dividend payout ratio). $CONTROL_{jit-1}$ consists of the same control variables with Eqs. 2 and 3. The variable of interest in Eqs. 4 and 5 is the triple interaction term POLLUTER*POST*FRANK that captures the difference in the impact of the double interaction term POLLUTER*POST on DIVDUM and DIVPAYOUT between firms that pay franked dividends and other firms. A positive β_6 in Eq. 4 (γ_4 in Eq. 5) is supportive of H2 (a & b).

4.3.2. Testing hypothesis 3

To identify if earnings uncertainty is the channel through which carbon risk negatively affects dividend policy, we employ a two-step approach. First, we examine whether there is any impact of carbon risk on earnings uncertainty by re-estimating Eqs. 2 and 3 with earnings uncertainty (ROAVOL) as the dependent variable. Positive β_3 and $\gamma_1$will confirm H3 (a). Second, we test if the impact of carbon risk on the decision to pay dividend and the level of payout is stronger for firms with higher uncertainty by estimating following equation.

$$\begin{aligned} Y_{it} = {} & \gamma_0 + \gamma_1 POLLUTER_{it} * POST_{it} * HROAVOL_{it} \\ & + \gamma_2 POLLUTER_{it} * POST_{it} * LROAVOL_{it} + \sum\nolimits_{j=3}^{n} \gamma_j CONTROL_{jit-1} \\ & + (\text{Industry \& Year) FE} + \varepsilon_{it} \end{aligned} \quad (6)$$

where, Y_{it} is DIVDUM (DIVPAYOUT) for firm i in year t in examining the decision to pay dividend (determinants of dividend payout ratio). HROAVOL is a dummy variable that takes the value

[14] See the Prime Minister's address on June 3, 2007, to the Liberal Party Federal Council at http://parlinfo.aph.gov.au/parlInfo/search/display/display.w3p;query=Id%3A%22media%2Fpressrel%2FIU9N6%22.

[15] In the case of H2, we opt for triple-differences models over splitting sample into franked and un-franked sub-groups for the following reasons. First, splitting sample will render the sub-samples very uneven with the franked group being much smaller than the un-franked group. Second, the franked group consists of dividend payers, which requires ordinary least square regressions, while the unfranked group includes both payers and non-payers, which works well with tobit regressions. Even though in an unreported test, we find similar results when splitting sample with triple-differences analyses, the apparent differences in sample size and model type render the results relatively less meaningful.

Table 2
Univariate analysis of dividend policy.

	Polluter		Non-polluter		Diff. (1) - (3)	*t*-test	Wilcoxon test
	$N_{pre} = 3,225;\ N_{post} = 5,314$		$N_{pre} = 4,103;\ N_{post} = 4,202$				
	Mean (1)	Median (2)	Mean (3)	Median (4)		t stat.	z stat.
Panel A: DIVDUM							
Pre-Kyoto	0.159	0.000	0.462	0.000	−0.303	−28.95***	−27.42***
Post-Kyoto	0.087	0.000	0.466	0.000	−0.379	−46.69***	−42.11***
Diff. (Post-Pre)	−0.072	0.000	0.004	0.000			
t (or z) stat.	−10.15***	−10.09***	0.35	0.35			
Panel B: DIVPAYOUT							
Pre-Kyoto	0.086	0.000	0.281	0.000	−0.195	−26.70***	−27.63***
Post-Kyoto	0.053	0.000	0.286	0.000	−0.233	−39.64***	−41.55***
Diff. (Post-Pre)	−0.033	0.000	0.004	0.000			
t (or z) stat.	−6.95***	−9.87***	0.55	0.48			

This table presents descriptive statistics on key measures of dividend policy (DIVDUM in Panel A, and DIVPAYOUT in panel B) for polluters and non-polluters in the pre-ratification (2002–2007) and post-ratification (2008–2013) periods. All data are sourced from Morningstar DatAnalysis database. An observation is required to be available for all variables reported in Table 1 to be included in the sample. For each variable, we report mean and median. We use both parametric t test and nonparametric Wilcoxon rank-sum test to report the difference in DIVDUM and DIVPAYOUT between polluters and non-polluters in the pre- and post- ratification periods. Continuous variables are winsorized at 1st and 99th percentiles. We report detailed definitions of all variables in Appendix.
*** indicates significance at 1%.

of 1 for above the cross-sectional median ROAVOL every year, while LROAVOL is one minus HROAVOL. The variables of interest in Eq. 6 is the two triple interaction terms POLLUTER*POST*HROAVOL and POLLUTER*POST*LROAVOL. We predict that the estimated coefficient γ_1 is more negative than the estimated coefficient γ_2 in Eq. 6 to support our hypotheses H3 (b & c).

5. Empirical results

In this section, we report and interpret empirical results for our hypotheses tests. We start with H1 using propensity to pay dividends (DIVDUM) and dividend payout ratio (DIVPAYOUT) to proxy for dividend policy. We then test H2 by examining how the impact of carbon risk on dividend policy (decision to pay and payout) differs between imputation and traditional tax systems. Next, we discuss our robustness checks. Finally, we examine the role of earnings uncertainty on the impact of carbon risk on dividend policy.

5.1. Univariate analysis results

Table 2 reports the univariate results for mean and median differences in the two main measures of dividend policy: DIVDUM (Panel A) and DIVPAYOUT (Panel B). We observe two different trends in the dividend decisions of polluters and non-polluters following the Kyoto Protocol ratification. In particular, the results in Panels A and B show that, for polluters, both mean propensity and mean level of dividend payouts decline subsequent to the ratification of Kyoto Protocol while not changing for non-polluters. For example, there is a 45.3% reduction in the probability of paying dividends for polluters from 15.9% to 8.7% (that is, 45.3% ((8.7–15.9)/15.9)), and 38.4% reduction in the dividend payout ratio from 8.6% to 5.3% (that is, 38.4% ((5.3–8.6)/8.6)) subsequent to the Kyoto Protocol ratification. Consequently, the gaps in both DIVDUM and DIVPAYOUT widen by 25.1% (from 30.3% to 37.9%) and 19.5% (from 19.5% to 23.3%), respectively, in absolute values after the ratification. Similar patterns are observed using tests of median values of DIVDUM and DIVPAYOUT proxies. In short, univariate analysis results are supportive of our hypotheses H1 (a) and H1(b) that both probability of paying dividend and payout level are significantly lower for polluters relative to non-polluters subsequent to the Kyoto Protocol ratification.

5.2. Regression results: determinants of decision to pay dividend and dividend payout ratio

In this section, we estimate probit regressions and tobit regressions to examine the impact of carbon risk on the determinants of decision to pay and dividend payout ratio, respectively. We use DIVDUM as a dependent variable in probit regressions and present the results in Panel A, while DIVPAYOUT is used as dependent variable in the tobit regressions and we present the results in Panel B of Table 3. DIVDUM is a dummy variable that takes value of 1 if a firm pays cash dividend in a particular year, and zero otherwise. We measure DIVPAYOUT as a ratio of cash dividends paid over after-tax earnings in year t. Consistent with Holmen et al. (2008) and Balachandran et al. (2017), the DIVPAYOUT ratio is set to one if (i) dividends are paid but after-tax earnings are negative, or (ii) dividends are larger than after-tax earnings. Our choice of model types and control variables is consistent with prior studies (Balachandran et al., 2012; Chay and Suh 2009).[16]

The negative coefficient of POLLUTER in Panels A and B indicates that, in general, polluters are less likely to pay cash dividends and more likely to have lower dividend payout ratio relative to non-polluters. The significantly negative coefficient of POST in Panels A and B indicates that non-polluters have lower propensity to pay dividends and lower payout ratio during the post-ratification period relative to the pre-ratification period. Further, the significantly negative coefficient of POLLUTER*POST in Panels A and B suggests that reduction in both the probability of paying dividend and in the payout ratio subsequent to the Kyoto Protocol ratification is significantly larger for polluters than non-polluters.[17] These findings support our hypotheses H1(a) and H1(b). Overall, the observations in univariate analyses hold in the multivariate frameworks when we control for other factors, providing support for H1 (a & b).

[16] We also conduct the analyses using logit or linear probability models for DIVDUM (Hoberg *et al.* 2014), with standard errors being clustered by both firm and year. The results are qualitatively similar. These results are available on request.

[17] When we use (i) dividend per share, (ii) dividend yield, and (iii) dividend initiation, as three alternative measures of dividend policy we find qualitatively similar results.

Table 3.
Carbon risk and dividend policy: main results.

Panel A - Decision to Pay Dividend (Dep. Var. = DIVDUM$_t$)							
	1	2	3	4	5	6	7
POLLUTER	−0.596***	−0.470***		−0.479***		−0.472***	
	[−11.71]	[−7.44]		[−6.87]		[−7.51]	
POST		−0.168***		−0.130**		−0.166***	
		[−3.23]		[−2.21]		[−3.23]	
POLLUTER*POST		**−0.214*** **	**−0.211*** **	**−0.250*** **	**−0.252*** **	**−0.232*** **	**−0.224*** **
		[−2.73]	[−2.59]	[−2.85]	[−2.76]	[−2.88]	[−2.66]
POLLUTER*FRANK$_{t-1}$				0.105	0.029		
				[0.45]	[0.13]		
POST*FRANK$_{t-1}$				−0.145	−0.172		
				[−0.97]	[−1.23]		
POLLUTER*POST*FRANK$_{t-1}$				**0.148**	**0.174**	**0.166**	**0.107**
				[0.48]	[0.59]	[0.80]	[0.55]
DIVDUM$_{t-1}$	1.594***	1.585***	1.458***	1.586***	1.458***	1.586***	1.458***
	[23.43]	[23.14]	[22.55]	[23.13]	[22.56]	[23.15]	[22.56]
FRANK$_{t-1}$	1.471***	1.471***	1.508***	1.511***	1.571***	1.451***	1.494***
	[19.91]	[19.85]	[20.29]	[12.68]	[13.98]	[18.72]	[19.26]
SIZE$_{t-1}$	0.228***	0.242***	0.274***	0.241***	0.273***	0.241***	0.274***
	[14.37]	[14.56]	[15.99]	[14.40]	[15.87]	[14.46]	[15.90]
ROA$_{t-1}$	1.371***	1.357***	1.137***	1.355***	1.132***	1.358***	1.136***
	[3.34]	[3.30]	[3.08]	[3.30]	[3.07]	[3.30]	[3.08]
RETAIN$_{t-1}$	0.138	0.128	0.121	0.128	0.121	0.129	0.121
	[1.60]	[1.47]	[1.51]	[1.49]	[1.52]	[1.49]	[1.53]
TOBINQ$_{t-1}$	0.019*	0.019*	0.027***	0.020*	0.027***	0.020*	0.027***
	[1.85]	[1.89]	[2.77]	[1.91]	[2.79]	[1.91]	[2.81]
CASH$_{t-1}$	0.097	0.126	0.225**	0.125	0.225**	0.121	0.222**
	[0.95]	[1.24]	[2.21]	[1.22]	[2.20]	[1.19]	[2.18]
LEV$_{t-1}$	0.023	0.013	−0.062	0.014	−0.061	0.014	−0.061
	[0.54]	[0.28]	[−1.24]	[0.31]	[−1.23]	[0.31]	[−1.23]
TANG$_{t-1}$	0.242**	0.199*	0.249**	0.200*	0.254**	0.198*	0.250**
	[2.37]	[1.93]	[2.35]	[1.95]	[2.39]	[1.93]	[2.35]
Constant	−5.359***	−5.525***	−6.555***	−5.513***	−6.552***	−5.505***	−6.545***
	[−19.08]	[−18.87]	[−16.91]	[−18.62]	[−16.87]	[−18.72]	[−16.84]
Industry FE	No	No	Yes	No	Yes	No	Yes
Year FE	No	No	Yes	No	Yes	No	Yes
Firm Cluster	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	16,855	16,855	16,688	16,855	16,688	16,855	16,688
Pseudo R-squared	0.76	0.76	0.77	0.76	0.77	0.76	0.77
Panel B - Determinants of Payout ratio (Dep. Var. = DIVPAYOUT$_t$)							
	1	2	3	4	5	6	7
POLLUTER	−0.226***	−0.193***		−0.229***		−0.196***	
	[−11.25]	[−9.10]		[−7.40]		[−9.37]	
POST		−0.026**		−0.018		−0.025**	
		[−2.21]		[−0.80]		[−2.16]	
POLLUTER*POST		**−0.060** **	**−0.058** **	**−0.080** **	**−0.083** **	**−0.102*** **	**−0.099*** **
		[−2.44]	[−2.34]	[−2.19]	[−2.27]	[−3.55]	[−3.39]
POLLUTER*FRANK$_{t-1}$				0.095**	0.075*		
				[2.33]	[1.68]		
POST*FRANK$_{t-1}$				−0.012	−0.009		
				[−0.47]	[−0.34]		
POLLUTER*POST*FRANK$_{t-1}$				**0.091** **	**0.096** **	**0.164*** **	**0.149*** **
				[1.96]	[1.99]	[4.23]	[3.57]
DIVPAYOUT$_{t-1}$	0.638***	0.636***	0.566***	0.638***	0.568***	0.637***	0.567***
	[21.83]	[21.75]	[20.47]	[21.75]	[20.58]	[21.74]	[20.54]
FRANK$_{t-1}$	0.403***	0.401***	0.409***	0.375***	0.385***	0.382***	0.392***
	[12.37]	[12.38]	[13.21]	[10.60]	[11.41]	[11.91]	[12.80]
SIZE$_{t-1}$	0.064***	0.066***	0.073***	0.063***	0.071***	0.064***	0.071***
	[12.93]	[13.07]	[12.98]	[12.55]	[12.46]	[12.73]	[12.64]
ROA$_{t-1}$	0.628***	0.625***	0.584***	0.625***	0.583***	0.625***	0.583***
	[2.96]	[2.95]	[2.89]	[2.99]	[2.91]	[2.97]	[2.90]
RETAIN$_{t-1}$	0.047	0.045	0.042	0.047	0.044	0.047	0.044
	[1.48]	[1.45]	[1.35]	[1.55]	[1.44]	[1.52]	[1.41]
TOBINQ$_{t-1}$	−0.004	−0.004	−0.004	−0.004	−0.003	−0.004	−0.003
	[−0.63]	[−0.62]	[−0.50]	[−0.59]	[−0.41]	[−0.59]	[−0.43]
CASH$_{t-1}$	0.020	0.029	0.071**	0.027	0.070**	0.026	0.068**
	[0.61]	[0.88]	[2.15]	[0.83]	[2.11]	[0.78]	[2.07]
LEV$_{t-1}$	0.013	0.012	−0.026*	0.014	−0.024	0.014	−0.024*
	[0.79]	[0.73]	[−1.76]	[0.88]	[−1.61]	[0.83]	[−1.65]
TANG$_{t-1}$	0.134***	0.126***	0.148***	0.116***	0.138***	0.120***	0.142***
	[3.92]	[3.67]	[4.12]	[3.39]	[3.81]	[3.49]	[3.92]
Constant	−1.485***	−1.497***	−1.675***	−1.441***	−1.645***	−1.459***	−1.652***
	[−14.64]	[−14.53]	[−8.64]	[−13.62]	[−8.43]	[−14.05]	[−8.51]
Industry FE	No	No	Yes	No	Yes	No	Yes

(*continued on next page*)

Table 3. (*continued*)

Panel A - Decision to Pay Dividend (Dep. Var. = $DIVDUM_t$)							
	1	2	3	4	5	6	7
Year FE	No	No	Yes	No	Yes	No	Yes
Firm Cluster	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	16,833	16,833	16,795	16,833	16,795	16,834	16,796
Pseudo R-squared	0.61	0.61	0.63	0.62	0.63	0.62	0.63

This table reports the results on the impact of carbon risk on dividend policy. Panel A presents the probit regression results of the impact of carbon risk on decision to pay. Panel B presents the tobit regression results on the impact of carbon risk on the determinants of dividend payout ratio. The t-statistics based on robust standard errors clustered by firm are reported in square brackets. Continuous variables are winsorized at 1st and 99th percentiles. We report detailed definitions of all variables in Appendix. *, **, and *** indicate significance at 10%, 5%, and 1%, respectively.

5.3. The impact of imputation environment

We further examine whether the impact of carbon risk on dividend policy differs between imputation tax system and traditional tax system. We present results for various specifications in Models 4 to 6 in Panels A and B of Table 3 for the decision to pay dividend and the level of dividend payout, respectively. We find that the post-ratification reduction in the probability of paying dividend for polluters does not vary between imputation and classical tax environments, therefore providing no support for H2 (a). However, we find that the post-ratification reduction in the payout level for polluters is significantly lower in the imputation environment than in the classical tax system, yielding support for H2 (b).[18,19]

The coefficients of $DIVDUM_{t-1}$ and $FRANK_{t-1}$ are highly significant and consistently positive, highlighting the importance of these two factors as the determinants of both the decision to pay dividend and the dividend payout ratio, especially in Australian context (Balachandran et al., 2017; Balachandran et al., 2012; Brav et al., 2008). Likewise, the coefficients of $SIZE_{t-1}$ and ROA_{t-1} are positive suggesting that bigger and more profitable firms are more likely to pay dividend (Denis and Osobov 2008; Fama and French 2001) and have higher payout ratio (Balachandran et al., 2017).[20]

5.4. Robustness checks

In this section, we conduct a battery of robustness checks. First, we address the identification concerns about the possible anticipation of the Kyoto Protocol ratification in Australia, and the industry-based definition of polluters which may inadvertently capture industry effects other than carbon risk. Second, we control for the possible confounding impact of the Global Financial Crisis. Finally, we conduct an out-of-sample check using U.S. and U.K. data.

5.4.1. Falsification test on the timing of the kyoto protocol ratification

The central assumption underlying our baseline difference-in-differences models is that in the absence of Kyoto Protocol ratification, polluters' and non-polluters' dividend policy follows parallel trends, thus there should not be any significant difference in dividend policy subsequent to ratification. However, this assumption might be invalid if dividend policies of polluters and non-polluters change and follow different trends, even in the absence of Kyoto Protocol ratification. Alternatively, it is possible that ratification had been anticipated and firms in some industries might have adjusted their dividend policy well before the ratification.

In this section, we adopt the technique of falsification tests as suggested by Roberts and Whited (2012) to help further alleviate the possible endogeneity concerns and rule out time trends as a driver of our findings. In particular, we create three more year-based dummies, $BEFORE^{-1y}$, $CURRENT^{0}$, and $AFTER^{1y+}$ that indicate the years 2007, 2008, and 2009-onwards, respectively. We then include all the newly created dummies together with their interactions with the POLLUTER dummy and exclude the POLLUTER*POST from Eq. 2. Similarly, for Eq. 3 we include the three new interactions only in the specifications that control for industry and year fixed effects. If the change in the polluters' dividend policy is due to time trend rather than Kyoto Protocol ratification or anticipation of ratification, we expect significant and negative coefficients of $POLLUTER*BEFORE^{-1y}$ interaction terms.

The results of these tests reported in Table 4 indicate that the coefficients of $POLLUTER*BEFORE^{-1y}$ are statistically insignificant in all regressions, suggesting that there are no changes in dividend policies (both decision to pay and dividend payout) of polluters and non-polluters prior to Kyoto Protocol ratification. More importantly, the coefficients of the interactions $POLLUTER*CURRENT^{0}$, and $POLLUTER*AFTER^{1y+}$ remain negative and highly significant, indicating that the reduction in both propensity to pay and in the level of dividend payouts are significantly stronger for polluters than non-polluters only after actual Kyoto Protocol ratification. In short, the falsification test results rule out the possibility that our findings are driven by time trends or anticipation of Kyoto Protocol ratification.

5.4.2. A firm-based definition of polluters and non-polluters

Using an industry-based classification of polluters and non-polluters in the main tests may raise a concern that the POLLUTER dummy variable simply captures the effects of industry characteristics rather than the impact of carbon risk on dividend policy. Therefore, we have controlled for industry fixed effects in the regression models to validate the industry-level identification of polluters. Nonetheless, a firm-based classification of polluters and non-polluters may better account for the variation in the firm carbon risk. Therefore, in this section, we construct one additional firm-specific polluter dummy variable for this purpose.

Specifically, a firm is considered to be a polluter (non-polluter) if its shareholders reacted negatively (insignificantly or positively) to the announcement of Kyoto Protocol ratification in Australia. The

[18] Our baseline results also hold when we use only large firms in our sample. We define large firms using each of four following criteria: (i) top 500 firms by market capitalization, or market capitalization of above (ii) $10M, (iii) $20M, or (iv) $30M in at least one year during the period 2002-2013. Results based on large firms are consistent those based on all firms reported in Table 3, suggesting that our baseline findings are not driven by small or micro-cap firms. We do not report these results to conserve space.

[19] Our baseline results related to dividend payout ratios also hold when we use only dividend payers in our sample. That is, we still find that polluters have lower dividend payout ratios subsequent to the ratification of Kyoto Protocol, and this effect is more pronounced for firms following the classical tax system. We define dividend payers as those firms that paid dividend in at least one year during the period 2002-2013. We do not report these results to conserve space.

[20] We find consistent results when we use log of market capitalization as a proxy for size instead of log of total assets.

Table 4.
Falsification test on the timing of Australia's ratification of Kyoto protocol.

	Determinants of Decision to Pay Dividend (Dep. Var. = $DIVDUM_t$)		Determinants of Dividend Payout ratio (Dep. Var. = $DIVPAYOUT_t$)	
	1	2	3	4
POLLUTER	−0.460***		−0.190***	
	[−7.09]		[−8.86]	
$BEFORE^{-1y}$	0.016		−0.018	
	[0.16]		[−0.93]	
CURRENT0	−0.034		0.021	
	[−0.34]		[1.01]	
$AFTER^{1y+}$	−0.194***		−0.040***	
	[−3.40]		[−3.07]	
POLLUTER*$BEFORE^{-1y}$	**−0.056**	**−0.021**	**−0.013**	**−0.006**
	[−0.38]	[−0.14]	[−0.36]	[−0.17]
POLLUTER*$CURRENT^{0}$	**−0.292****	**−0.274****	**−0.093****	**−0.088****
	[−2.17]	[−1.98]	[−2.48]	[−2.34]
POLLUTER*$AFTER^{1y+}$	**−0.207****	**−0.203****	**−0.056****	**−0.054****
	[−2.40]	[−2.24]	[−2.08]	[−1.96]
$DIVDUM_{t-1}$	1.584***	1.458***		
	[23.08]	[22.53]		
$DIVPAYOUT_{t-1}$			0.637***	0.566***
			[21.77]	[20.47]
$FRANK_{t-1}$	1.472***	1.508***	0.400***	0.409***
	[19.81]	[20.27]	[12.40]	[13.21]
$SIZE_{t-1}$	0.243***	0.274***	0.066***	0.073***
	[14.45]	[15.97]	[13.07]	[12.97]
ROA_{t-1}	1.357***	1.137***	0.626***	0.584***
	[3.30]	[3.09]	[2.96]	[2.89]
$RETAIN_{t-1}$	0.128	0.121	0.046	0.043
	[1.47]	[1.52]	[1.45]	[1.36]
$TOBINQ_{t-1}$	0.017	0.027***	−0.005	−0.004
	[1.63]	[2.80]	[−0.76]	[−0.50]
$CASH_{t-1}$	0.125	0.225**	0.031	0.071**
	[1.23]	[2.21]	[0.94]	[2.16]
LEV_{t-1}	0.011	−0.062	0.011	−0.026*
	[0.24]	[−1.24]	[0.69]	[−1.75]
$TANG_{t-1}$	0.197*	0.248**	0.125***	0.148***
	[1.91]	[2.34]	[3.63]	[4.11]
Constant	−5.535***	−6.558***	−1.494***	−1.675***
	[−18.83]	[−16.86]	[−14.52]	[−8.63]
Industry FE	No	Yes	No	Yes
Year FE	No	Yes	No	Yes
Firm Cluster	Yes	Yes	Yes	Yes
Observations	16,855	16,688	16,834	16,796
Pseudo R-squared	0.76	0.77	0.61	0.63

This table presents falsification tests on the timing of the Kyoto Protocol ratification. $BEFORE^{-1y}$, $CURRENT^{0}$, and $AFTER^{1y+}$ are year dummy variables indicating year 2007 or not, 2008 or not, and 2009 onwards or not. Models 1 and 2 use probit regressions, while Models 3 and 4 use tobit regressions. Industry and year fixed effects are included in Models 2 and 4. The t-statistics based on robust standard errors clustered by firm are reported in square brackets. Continuous variables are winsorized at 1st and 99th percentiles. We report detailed definitions of all variables in Appendix. *, **, and *** indicate significance at 10%, 5%, and 1%, respectively.

intuition is that the Kyoto Protocol ratification could be a bad news for polluting firms (e.g., through increasing operating and financing costs, or restricting some polluting activities), whereas it could not be a bad news for non-polluting firms (e.g., they may even better off through reduced competition or better access to external funds).

We perform a two-step approach for this test. First, using market reaction to Kyoto protocol ratification in Australia, we show that our industry-based polluters reacted more negatively to the event than industry-based non-polluters. That is, three-day event window from the day before to the day after the ratification announcement date mean (median) abnormal return is −0.53% (−0.22%) for polluters and −0.23% (−0.04%) for non-polluters.[21] The market reaction is significantly negative for polluter subsample, while it is insignificant for non-polluter subsample.

Second, we rerun our baseline DiD model using a propensity score matching (PSM) method where treated (control) firms are defined to experience negative (insignificant or positive) CAR (−1,1) around the event date (December 04, 2007). Panel A of Table 5 presents our post-match diagnostic test of mean differences between treated and control firms for the variables used in the first-stage logit regression. The *t* test results confirm that both groups of firms have similar firm characteristics prior to the official ratification of Kyoto Protocol in Australia. Panel B of Table 5 reports our DiD regression results which are consistent with the main findings drawn on the industry-based measure. In particular, the coefficients on the TREATED*POST double-interaction are significant and negative for both DIVDUM and DIVPAYOUT (except for Model 4 for DIVDUM). Further, the coefficients on the TREATED*POST*FRANK triple-interaction are insignificant in Models 3 and 4, and weakly significant at the 10% level in Models 1 and 2 for DIVDUM, while being highly significant at the 1% level for all Models of DIVPAYOUT. The results in Panel B of Table 5 suggest that while the post-Kyoto reduction in the likelihood of paying dividend of treated firms is not significantly different between im-

[21] We calculate abnormal returns of all firms listed on the Australia Stock Exchange (ASX) on December 4, 2007, by taking the difference between the actual and expected stock returns using the market model parameters estimated over the window (-260, -61) relative to the announcement date. Our selection of three-day event window is to capture leakage of information. In fact, the former Kevin Rudd administration announced the Kyoto Protocol ratification in late night of December 3, 2007, when the market closed.

Table 5.
DiD regressions: Negative vs. Non-negative reactors to announcement of Kyoto protocol ratification in Australia.

Panel A - Post-match Diagnostic Test

	Treated (N = 390)	Control (N = 390)	*t* test
SIZE$_{t-1}$	17.325	17.415	−0.58
ROA$_{t-1}$	−0.162	−0.119	−1.57
RETAIN$_{t-1}$	−0.250	−0.173	−1.25
TOBINQ$_{t-1}$	2.300	2.392	−0.49
CASH$_{t-1}$	0.246	0.261	−0.84
LEV$_{t-1}$	0.209	0.194	0.44
TANG$_{t-1}$	0.171	0.168	0.17

Panel B - DiD Regression using a PSM-matched Sample

	Decision to Pay (Dep. Var. = DIVDUM$_t$)				Determinants of Payout ratio (Dep. Var. = DIVPAYOUT$_t$)			
	1	2	3	4	5	6	7	8
TREATED	0.069	0.034	0.037	0.018	0.023***	0.022***	−0.008	−0.009
	[0.67]	[0.30]	[0.44]	[0.21]	[3.40]	[3.21]	[−1.34]	[−1.35]
POST	−0.072		−0.197**		0.035***		−0.011*	
	[−0.79]		[−2.51]		[5.29]		[−1.78]	
TREATED*POST	**−0.308****	**−0.298****	**−0.204***	**−0.190**	**−0.120*****	**−0.117*****	**−0.069*****	**−0.066*****
	[−2.35]	[−2.15]	[−1.74]	[−1.56]	[−15.17]	[−14.67]	[−8.91]	[−8.43]
TREATED*FRANK$_{t-1}$	−0.216	−0.139			−0.057***	−0.056***		
	[−0.73]	[−0.47]			[−8.10]	[−7.86]		
POST*FRANK$_{t-1}$	−0.634**	−0.707**			−0.087***	−0.090***		
	[−2.32]	[−2.57]			[−13.06]	[−13.34]		
TREATED*POST*FRANK$_{t-1}$	**0.690***	**0.652***	**0.169**	**0.140**	**0.151*****	**0.148*****	**0.056*****	**0.053*****
	[1.82]	[1.72]	[0.78]	[0.66]	[16.97]	[16.61]	[7.67]	[7.14]
DIVDUM$_{t-1}$	1.426***	1.253***	1.414***	1.244***				
	[15.43]	[13.78]	[15.43]	[13.77]				
DIVPAYOUT$_{t-1}$					0.446***	0.453***	0.444***	0.452***
					[58.26]	[58.50]	[58.82]	[59.16]
FRANK$_{t-1}$	1.858***	1.817***	1.536***	1.498***	0.464***	0.463***	0.415***	0.413***
	[7.96]	[7.77]	[13.23]	[12.78]	[72.54]	[71.59]	[68.42]	[67.59]
SIZE$_{t-1}$	0.214***	0.283***	0.214***	0.280***	0.060***	0.060***	0.060***	0.060***
	[8.71]	[10.41]	[8.70]	[10.30]	[159.08]	[156.24]	[159.87]	[157.20]
ROA$_{t-1}$	2.806***	2.706***	2.803***	2.733***	1.298***	1.300***	1.294***	1.296***
	[4.87]	[4.65]	[4.88]	[4.69]	[62.59]	[62.50]	[62.74]	[62.70]
RETAIN$_{t-1}$	0.012	0.016	0.016	0.026	−0.004	−0.003	−0.003	−0.002
	[0.14]	[0.18]	[0.18]	[0.28]	[−1.02]	[−0.73]	[−0.85]	[−0.55]
TOBINQ$_{t-1}$	−0.054*	−0.006	−0.053*	−0.009	−0.032***	−0.033***	−0.031***	−0.033***
	[−1.67]	[−0.17]	[−1.65]	[−0.24]	[−11.02]	[−11.49]	[−10.93]	[−11.40]
CASH$_{t-1}$	−0.460**	0.013	−0.484**	−0.013	0.004	0.008	0.004	0.007
	[−2.45]	[0.07]	[−2.56]	[−0.07]	[0.24]	[0.42]	[0.22]	[0.38]
LEV$_{t-1}$	0.070	−0.035	0.071	−0.033	−0.013***	−0.011**	−0.012**	−0.010**
	[1.05]	[−0.46]	[1.06]	[−0.42]	[−2.70]	[−2.22]	[−2.57]	[−2.09]
TANG$_{t-1}$	−0.099	0.074	−0.105	0.066	0.137***	0.134***	0.136***	0.132***
	[−0.71]	[0.46]	[−0.76]	[0.42]	[10.10]	[9.74]	[10.01]	[9.67]
Constant	−5.043***	−6.289***	−4.983***	−6.139***	−3.677***	−3.583***	−3.657***	−3.568***
	[−12.08]	[−12.18]	[−11.86]	[−12.08]	[−508.71]	[−486.99]	[−505.14]	[−484.92]
Industry FE	No	Yes	No	Yes	No	Yes	No	Yes
Year FE	No	Yes	No	Yes	No	Yes	No	Yes
Firm Cluster	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7,147	7,147	7,147	7,147	7,276	7,276	7,276	7,276
Pseudo R-squared	0.76	0.77	0.77	0.77	0.65	0.65	0.65	0.65

In the first stage, we estimate a logit model of TREATED dummy on all firm characteristics used in the baseline models (except for DIVDUM$_{t-1}$, DIVPAYOUT$_{t-1}$, and FRANK$_{t-1}$) and observed in 2007, and obtain the predicted values of the dependent variable, or propensity scores (PSCORE). TREATED dummy takes the value of one (zero) for firms that negatively (positively and insignificantly) reacted to announcement of Kyoto Protocol ratification in Australia, using CAR(−1,1). We then match negative (treated) and non-negative reacting (control) firms on same GICS industry, same year, nearest neighbor within 1% caliber and no replacement. Panel A presents the post-match diagnostic test results with *t*-test of mean differences between treated and control firms. Panel B documents our DiD regression results with TREATED dummy indicating treated firms, POST dummy indicating the post-Kyoto period, and TREATED*POST is the interaction terms between the two dummies. In Panel B, Models 2, 4, 6 and 8 control for both GICS industry and year fixed effects, but their estimates are suppressed for brevity. The t-statistics based on robust standard errors clustered by firms are provided in square brackets. We report detailed definitions of all variables in Appendix. *, **, and *** indicate significance at 10%, 5%, and 1%, respectively.

putation and classical tax systems, the reduction in payout ratio is significantly smaller in the imputation environment than classical tax system. Overall, the analysis based on firm-specific definition of polluters and non-polluters confirms our prediction that carbon risk reduces the likelihood of paying dividend and the level of payout.

5.4.3. Control for the global financial crisis

In this section, we control for the Global Financial Crisis (GFC) since a large number of firms adjust their dividend policy due to changes in macro-economic as well as financing conditions during this period (Bliss et al., 2015). Australia also ratified the Kyoto Protocol at the onset of this crisis, which poses concerns about the possibility of the contamination effect of the crisis on the association between carbon risk and dividend policy. In particular, we re-estimate Eqs. 2 and 3 with a further inclusion of an indicator variable GFC that indicates the crisis period, and an interaction POLLUTER*GFC. Since there is no consensus on the definition of the GFC period, especially in Australia, we adopt the two most generally accepted timespans including 2008–2009 (as indicated by GFC0809 dummy variable) and 2007–2009 (as indicated by GFC0709 dummy variable) to characterize the crisis time.

We report the results of these tests in Table 6 for DIVDUM (Models 1 and 2) and DIVPAYOUT (Models 3 and 4) using GFC0809 in Panel A and GFC0709 in Panel B. The regression results show that neither GFC nor POLLUTER*GFC has statistically significant explanatory powers over dividend policy in all models. In other words, polluters do not significantly change their dividend policy relative to non-polluters during the Global Financial Crisis. Overall, these results rule out the possibility that potential confounding effects of the crisis that occurred in the post-ratification period influence our findings

5.4.4. Out-of-sample test: U.S. polluters

We further address possible concerns that the main results are simply driven by industry-specific trends or unique Australian institutional settings rather than being a true effect of the Kyoto Protocol ratification on dividend policy. To do so, we need to identify a country that satisfies two conditions: (i) the country has never adopted the Kyoto Protocol, and (ii) the sample is large enough to draw statistically and economically meaningful inferences. The U.S. stands out as the best candidate for this exercise. First, the U.S. is a major economy with the biggest number of public firms available for empirical research; hence it has attracted an enormous number of prior studies on corporate dividend policy (see DeAngelo et al., (2009) for a survey). Second, the U.S. government has never ratified the Kyoto Protocol and, in fact, was one of only two developed economies that refused to adopt the Kyoto Protocol when it was first introduced in 1997, the other being Australia (Subramaniam et al., 2015). If the baseline results in Australia are due to global trends at industry level other than carbon risk, then we should observe the same patterns in other countries such as the U.S.

In this section, we employ U.S. data for our out-of-sample test. Specifically, we apply to the U.S. counterparts similar sample selection and methodology we used for Australian firms. For the U.S. sample, we obtain necessary data on firm financial characteristics and GICS industry classifications from Compustat database. We restrict the sample period to 2002–2013 to be consistent with that of Australia. We also define a U.S. firm-year as a polluter if it belongs to one of nine following GICS industries: (1) Oil, Gas and Consumable Fuels; (2) Electric Utilities; (3) Gas Utilities; (4) Independent Power Producers and Energy Traders; (5) Multi-Utilities; (6) Chemicals; (7) Construction Materials; (8) Metals and Mining; and (9) Paper and Forest Products (CDP 2012). Next, we create a dummy variable, POST07, for our analysis based on U.S. firms, which is exactly the same as the POST dummy used for Australia. In addition, we create another dummy variable, POST05, to indicate the period 2006–2013 over which the Kyoto Protocol was internationally effective.

We then re-estimate Eqs. 2 and 3 for U.S. firms with POST being replaced by either POST05 or POST07. To be consistent with Australia-based analyses, we follow John et al. (2011) to define DIVDUM dummy variable as taking the value of 1 if a firm-year has positive cash dividends on common stock, and zero otherwise. Also, we define DIVPAYOUT variable as the ratio of cash dividends on common stock over net income, and set this ratio to one for payers with negative net incomes as well as dividend payments greater than net incomes, to be comparable with those used for Australian firms. Note that for the U.S. data, we follow Hoberg et al. (2014) to exclude firms with book value of equity below 250,000 dollars or total assets below 500,000 dollars, and only include firms incorporated in the U.S. Moreover, variable $FRANK_{t-1}$ is omitted in these regressions due to the fact that the U.S. does not have the imputation tax system.

Panel A of Table 7 reports results for this out-of-sample test. Similar to the Australia-based analyses, Panel A1 presents probit regression results with DIVDUM being the dependent variable, and Panel A2 documents tobit regression results with DIVPAYOUT being the dependent variable. The variables of interest here are the interaction terms POLLUTER*POST05 and POLLUTER*POST07 that capture the relative change in the probability of paying dividend (DIVDUM) and the change in dividend payout ratio (DIVPAYOUT) of U.S. polluters after year 2005 or 2007 compared to the previous periods, respectively. The statistically insignificant coefficients on these interaction terms across all estimated models suggest that there were no significant changes in the U.S. polluters' dividend policy relative to the U.S. non-polluters after the Kyoto Protocol came into effect both internationally and in Australia. This evidence strengthens our conclusion that the main results observed in Australia are indeed attributed to its ratification of the Kyoto Protocol in December 2007, rather than a pure industry effect or simply an effect of the unique Australian setting.

5.4.5. Out-of-sample test: U.K. polluters

In our second out-of-sample test, we select United Kingdom (U.K.) for several reason. First, U.K. is a major economy in the Europe with the London Stock Exchange being the largest stock exchange in Europe.[22] Second, U.K. has been one of the most carbon intensive countries in Europe.[23] Finally, the U.K. firms' emissions are subject to two major environmental policies in the world, including the Kyoto Protocol and the EU-ETS, both implemented from 2005 in the U.K. In fact, U.K. accepted the Kyoto Protocol ratification in May 2002 but the policy entered into force in February 2005.[24] EU ETS is a cornerstone of the EU's policy to combat climate change and its key tool for reducing greenhouse gas emissions cost-effectively, works on the "cap and trade" principle. The overall volume of greenhouse gases that can be emitted for a multi-year phase by the power plants, factories and other companies covered by the system is subject to a cap set at EU level. Within this cap, companies receive or buy emission allowances which they can trade, if they wish to do so. Over our sample period 2002–2013, we are interested in the first two phases of the EU-ETS, including the first trading period 2005–2007 which constituted a process of "learning by doing" with EU-ETS successfully established as the world's biggest carbon market, and the second trading period 2008–2012 which observed a stricter restriction of emissions with the number of allowances reduced by 6.5%.[25]

Methodologically, we replicate what we have done for U.S. firms in Panel A of Table 7 using U.K. data sourced from Thomson Reuters Worldscope database, and present the results in Panel B of Table 7. We use industry sector data from Datastream database to sort U.K. firms into polluters and non-polluters. In particular, a U.K. firm is defined to be a polluter if its industry sector is one of the followings: (1) Chemicals; (2) Construction and Materials; (3) Electricity; (4) Forestry and Paper; (5) Gas, Water and Multi-utilities; (6) Industrial Metals and Mining; (7) Mining; (8) Oil and Gas Producers, and a non-polluter otherwise. To be consistent with Australia and U.S.-based analyses, we restrict U.K. firms to sample period 2002–2013 and use POST05 as a binary variable indicating year 2006 onwards to examine the impact of the implementation

[22] Source: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?end=2016&locations=DE-IT-FR-GB&name_desc=false&start=2000 (for Gross Domestic Product by country); and https://data.worldbank.org/indicator/CM.MKT.TRAD.CD?end=2017&locations=FR-DE-IT-GB&start=2000 (for Total Value of Stocks Traded by country).

[23] Source: https://data.worldbank.org/indicator/EN.ATM.CO2E.PC?end=2014&locations=GB-DE-IT-FR-1W&start=2000 (for CO2 emissions per capita by country).

[24] Source: https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-a&chapter=27&clang=_en.

[25] Source: https://ec.europa.eu/clima/sites/clima/files/factsheet_ets_en.pdf.

Table 6
Control for the global financial crisis.

Panel A – Global Financial Crisis 2008–2009				
	Decision to Pay (Dep. Var. = $DIVDUM_t$)		Determinants of Payout ratio (Dep. Var. = $DIVPAYOUT_t$)	
	1	2	3	4
POLLUTER	−0.470***		−0.193***	
	[−7.44]		[−9.10]	
POST	−0.165***		−0.033**	
	[−2.93]		[−2.55]	
POLLUTER*POST	**−0.211****	**−0.210****	**−0.061****	**−0.060****
	[−2.45]	[−2.32]	[−2.25]	[−2.15]
POLLUTER*GFC0809	**−0.009**	**−0.003**	**0.004**	**0.004**
	[−0.08]	[−0.02]	[0.15]	[0.13]
GFC0809	−0.008		0.018	
	[−0.10]		[1.25]	
$DIVDUM_{t-1}$	1.586***	1.458***		
	[23.10]	[22.54]		
$DIVPAYOUT_{t-1}$			0.636***	0.566***
			[21.76]	[20.48]
$FRANK_{t-1}$	1.471***	1.508***	0.400***	0.409***
	[19.86]	[20.31]	[12.39]	[13.21]
$SIZE_{t-1}$	0.242***	0.274***	0.066***	0.073***
	[14.52]	[15.99]	[13.06]	[12.98]
ROA_{t-1}	1.357***	1.137***	0.625***	0.584***
	[3.30]	[3.08]	[2.95]	[2.89]
$RETAIN_{t-1}$	0.128	0.121	0.045	0.042
	[1.48]	[1.51]	[1.44]	[1.35]
$TOBINQ_{t-1}$	0.020*	0.027***	−0.005	−0.004
	[1.90]	[2.77]	[−0.68]	[−0.50]
$CASH_{t-1}$	0.126	0.225**	0.030	0.071**
	[1.24]	[2.21]	[0.89]	[2.15]
LEV_{t-1}	0.013	−0.062	0.011	−0.026*
	[0.30]	[−1.24]	[0.68]	[−1.76]
$TANG_{t-1}$	0.198*	0.249**	0.127***	0.148***
	[1.93]	[2.36]	[3.68]	[4.12]
Constant	−5.524***	−6.555***	−1.498***	−1.675***
	[−18.85]	[−16.91]	[−14.54]	[−8.64]
Industry FE	No	Yes	No	Yes
Year FE	No	Yes	No	Yes
Firm Cluster	Yes	Yes	Yes	Yes
Observations	16,855	16,688	16,834	16,796
Pseudo R-squared	0.76	0.77	0.61	0.63
Panel B – Global Financial Crisis 2007–2009				
	Decision to Pay (Dep. Var. = $DIVDUM_t$)		Determinants of Payout ratio (Dep. Var. = $DIVPAYOUT_t$)	
	1	2	3	4
POLLUTER	−0.465***		−0.193***	
	[−7.24]		[−9.04]	
POST	−0.168***		−0.027**	
	[−3.18]		[−2.27]	
POLLUTER*POST	**−0.210*****	**−0.210****	**−0.060****	**−0.058****
	[−2.64]	[−2.54]	[−2.41]	[−2.30]
POLLUTER*GFC0709	**−0.027**	**−0.010**	**−0.002**	**0.000**
	[−0.30]	[−0.11]	[−0.07]	[0.01]
GFC0709	0.001		0.004	
	[0.01]		[0.36]	
$DIVDUM_{t-1}$	1.586***	1.458***		
	[23.15]	[22.55]		
$DIVPAYOUT_{t-1}$			0.636***	0.566***
			[21.77]	[20.48]
$FRANK_{t-1}$	1.471***	1.508***	0.401***	0.409***
	[19.86]	[20.30]	[12.39]	[13.21]
$SIZE_{t-1}$	0.242***	0.274***	0.066***	0.073***
	[14.56]	[15.98]	[13.06]	[12.98]
ROA_{t-1}	1.356***	1.137***	0.625***	0.584***
	[3.30]	[3.08]	[2.95]	[2.89]
$RETAIN_{t-1}$	0.128	0.121	0.045	0.042
	[1.48]	[1.51]	[1.45]	[1.35]
$TOBINQ_{t-1}$	0.020*	0.027***	−0.005	−0.004
	[1.93]	[2.79]	[−0.64]	[−0.50]
$CASH_{t-1}$	0.126	0.225**	0.029	0.071**
	[1.24]	[2.21]	[0.88]	[2.15]
LEV_{t-1}	0.013	−0.062	0.012	−0.026*
	[0.30]	[−1.24]	[0.71]	[−1.76]
$TANG_{t-1}$	0.198*	0.249**	0.126***	0.148***

(*continued on next page*)

Table 6 (*continued*)

Panel A – Global Financial Crisis 2008–2009				
	Decision to Pay (Dep. Var. = $DIVDUM_t$)		Determinants of Payout ratio (Dep. Var. = $DIVPAYOUT_t$)	
	1	2	3	4
	[1.93]	[2.36]	[3.67]	[4.12]
Constant	−5.526***	−6.556***	−1.498***	−1.675***
	[−18.86]	[−16.88]	[−14.50]	[−8.63]
Industry FE	No	Yes	No	Yes
Year FE	No	Yes	No	Yes
Firm Cluster	Yes	Yes	Yes	Yes
Observations	16,855	16,688	16,834	16,796
Pseudo R-squared	0.76	0.77	0.61	0.63

This table reports the results on the impact of carbon risk on dividend policy, after controlling for the Global Financial Crisis (GFC) period. We adopt two definitions for the GFC time period: 2008–2009 (Panel A) and 2007–2009 (Panel B). Models 1 and 2 use probit and Models 3 and 4 use tobit regressions. Industry and year fixed effects are included in Models 2 and 4. The t-statistics based on robust standard errors clustered by firm are reported in square brackets. Continuous variables are winsorized at 1st and 99th percentiles. We report detailed definitions of all variables in Appendix. *, **, and *** indicate significance at 10%, 5%, and 1%, respectively.

of Kyoto Protocol and EU-ETS in 2005 in the U.K.[26] The negative and significant coefficients on POLLUTER*POST05 in all models in Panel B of Table 7 suggest that U.K. polluters significantly decrease both propensity to pay dividend and dividend payout ratio in comparison to U.K. non-polluters after the EU-ETS entered into force in 2005. We also use POST07 dummy to examine the effect of the implementation of the second phase of EU-ETS. The negative and significant coefficients on POLLUTER*POST07 indicate that U.K. polluters relatively further reduce their dividend payments after the EU-ETS started its second phase 2008–2012.

5.5. Channel analysis: earnings uncertainty

In this section, we examine whether the carbon risk increases earnings uncertainty, which in turn affects the dividend policy. We measure earnings uncertainty, ROAVOL, by taking the logarithm transformation of the standard deviation of annual ROAs over a five-year rolling window.[27] First, we examine whether the carbon risk prompts any increase in earnings uncertainty, and whether the increase in earnings uncertainty is stronger for polluters than for non-polluters during the post-ratification period, presenting the results in Panel A of Table 8. We find that earnings uncertainty is higher for polluters than non-polluters. The earnings uncertainty increases subsequent to ratification of the Kyoto Protocol and this effect is stronger for polluters than non-polluters, which is supportive of our H3 (a).

Second, we examine the impact of carbon risk on dividend policy controlling for earnings uncertainty. We present the results in Panels B and C of Table 8 for the decision to pay dividend and dividend payout ratio, respectively. We find that the coefficient of earnings uncertainty is significantly negative in Panels B and C, indicating that firms with higher earnings uncertainty have a lower probability of paying dividend and a lower dividend payout ratio, which is consistent with prior studies (Brav et al., 2005, 2008; Chay and Suh 2009; Lintner 1956). Further, the coefficient of POLLUTER*POST is significantly negative in both Panels A and B indicating that both propensity to pay dividend and dividend payout ratio are lower for polluters than non-polluters during the post-ratification period, even after controlling for earnings uncertainty.

Finally, by classifying our sample into high (low) earnings uncertainty groups, we examine whether the impact of carbon risk on dividend policy is stronger among firms with higher earnings uncertainty. We create two binary variables HROAVOL (high earnings uncertainty group) and LROAVOL (low earnings uncertainty group). HROAVOL is equal to one for those observations where ROAVOL is above the cross-sectional median every year. The binary variable LROAVOL is one minus HROAVOL. We interact POLLUTER*POST separately with each binary variable such that we obtain a coefficient estimate of the impact of carbon risk on dividend policy for both the sub-sample of firms with relatively higher earnings uncertainty and the sub-sample of firms with relatively lower earnings uncertainty. We find that both POLLUTER*POST*HROAVOL and POLLUTER*POST*LROAVOL are significantly negative in Panels B and C. Further, we find that the coefficient of POLLUTER*POST*HROAVOL is significantly more negative than POLLUTER*POST*LROAVOL (p-value: 0.05 in Models 5 and 6) in Panel C. These findings provide support for the notion that ratification of the Kyoto Protocol increases earnings uncertainty, which in turn reduces the level of dividend payout of polluters, and provide support for our hypothesis H3 (c). However, we do not find any significant difference between the coefficients of POLLUTER*POST*HROAVOL and POLLUTER*POST*LROAVOL (p-values: 0.32 and 0.33 in Models 5 and 6) in Panel B, indicating that though both increased earnings uncertainty and ratification of the Kyoto Protocol reduce the likelihood of paying dividend, ratification does not affect the decision to pay via earnings uncertainty.

6. Conclusion

In this paper, we present evidence on the causal effect of carbon risk on firm dividend policy and how this effect differs between imputation and classical tax systems. We do so by utilizing the unique Australia tax setting where both imputation and classical tax systems operate concurrently. Further, Australia ratified the Kyoto Protocol in December 2007, serving as a quasi-natural experiment for our identification strategy. The Protocol mandates Australia to reduce its greenhouse emissions to no greater than eight percent above the 1990 level over the 2008–2012 commitment period, therefore exogenously affecting firms in carbon intensive industries (polluters). By classifying firms as franked dividend payers and otherwise, we are able to examine how the effect of carbon risk on dividend varies across tax systems. Finally, Australia is among the developed economies with the highest level of carbon intensity as measured by greenhouse gas per capita.

Using difference-in-differences specifications, we find a reduction in both propensity to pay dividend and the level of dividend

[26] In an untabulated test, we restrict the U.K. sample period to 2000-2011 to cover six years before and after the EU-ETS implementation and find qualitatively similar results.

[27] We take logarithm transformation to minimize the impact of skewness of standard deviation of annual ROAs. We also conduct analyses using alternative rolling windows of three and four years, and find similar results.

Table 7
Out of sample tests.

Panel A - Out of Sample Test: U.S. Polluters

	Panel A1 - Decision to Pay (Dep. Var. = $DIVDUM_t$)				Panel A2 - Determinants of Payout ratio (Dep. Var. = $DIVPAYOUT_t$)			
	1	2	3	4	5	6	7	8
POLLUTER	0.106**		0.142***		0.062***		0.054***	
	[2.21]		[3.63]		[4.74]		[4.61]	
POST05	−0.108***				0.010**			
	[−6.22]				[2.04]			
POLLUTER*POST05	**0.066**	**0.070**			**−0.004**	**−0.017**		
	[1.16]	[1.23]			[−0.30]	[−1.38]		
POST07			−0.113***				−0.009*	
			[−6.58]				[−1.87]	
POLLUTER*POST07			**0.014**	**0.028**			**0.013**	**0.004**
			[0.29]	[0.57]			[1.17]	[0.37]
$DIVDUM_{t-1}$	3.047***	2.982***	3.046***	2.982***				
	[134.36]	[121.09]	[134.44]	[121.13]				
$DIVPAYOUT_{t-1}$					1.109***	1.015***	1.111***	1.016***
					[105.87]	[92.73]	[105.89]	[92.91]
$SIZE_{t-1}$	0.132***	0.139***	0.133***	0.139***	0.064***	0.062***	0.065***	0.062***
	[25.78]	[23.42]	[25.76]	[23.41]	[28.24]	[25.14]	[28.18]	[25.11]
ROA_{t-1}	0.625***	0.554***	0.622***	0.554***	0.445***	0.451***	0.446***	0.451***
	[3.66]	[3.09]	[3.65]	[3.09]	[3.65]	[3.38]	[3.65]	[3.38]
$RETAIN_{t-1}$	0.006***	0.005***	0.006***	0.005***	0.004***	0.003***	0.004***	0.003***
	[4.21]	[3.21]	[4.20]	[3.22]	[7.79]	[5.37]	[7.74]	[5.37]
$TOBINQ_{t-1}$	0.007**	0.009***	0.007**	0.009***	0.003	0.005***	0.003	0.005***
	[2.31]	[3.37]	[2.11]	[3.37]	[1.55]	[3.66]	[1.53]	[3.64]
$CASH_{t-1}$	−0.232***	0.289***	−0.222***	0.290***	−0.335***	0.081***	−0.330***	0.081***
	[−3.47]	[4.03]	[−3.30]	[4.04]	[−11.63]	[2.89]	[−11.44]	[2.88]
LEV_{t-1}	−0.012**	−0.021***	−0.012**	−0.021***	−0.002	−0.009***	−0.003	−0.009***
	[−2.12]	[−3.61]	[−2.11]	[−3.62]	[−1.52]	[−5.26]	[−1.58]	[−5.25]
$TANG_{t-1}$	−0.234***	−0.033	−0.229***	−0.032	−0.172***	0.010	−0.173***	0.009
	[−5.53]	[−0.57]	[−5.41]	[−0.56]	[−9.64]	[0.45]	[−9.69]	[0.42]
Constant	−2.354***	−2.951***	−2.376***	−2.956***	−0.700***	−0.936***	−0.693***	−0.933***
	[−63.79]	[−33.29]	[−65.31]	[−33.32]	[−39.17]	[−23.54]	[−39.40]	[−23.48]
Industry FE	No	Yes	No	Yes	No	Yes	No	Yes
Year FE	No	Yes	No	Yes	No	Yes	No	Yes
Firm Cluster	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	68,744	68,744	68,744	68,744	68,483	68,483	68,483	68,483
Pseudo R-squared	0.74	0.75	0.74	0.75	0.47	0.51	0.47	0.51

Panel B - Out of Sample Test: U.K. Polluters

	Panel B1 - Decision to Pay (Dep. Var. = $DIVDUM_t$)				Panel B2 - Determinants of Payout ratio (Dep. Var. = $DIVPAYOUT_t$)			
	1	2	3	4	5	6	7	8
POLLUTER	−0.089		−0.197**		−0.081**		−0.099***	
	[−0.88]		[−2.39]		[−2.54]		[−3.48]	
POST05	−0.054				−0.105***			
	[−1.43]				[−10.74]			
POLLUTER*POST05	−0.353***	−0.453***			−0.067**	−0.135***		
	[−3.05]	[−6.33]			[−2.21]	[−5.04]		
POST07			−0.184***				−0.080***	
			[−5.17]				[−8.33]	
POLLUTER*POST07			−0.254**	−0.472***			−0.062**	−0.145***
			[−2.47]	[−5.95]			[−2.20]	[−5.08]
$DIVDUM_{t-1}$	2.413***	2.461***	2.409***	2.464***				
	[58.82]	[59.27]	[59.04]	[59.38]				
$DIVPAYOUT_{t-1}$					0.147***	0.143***	0.150***	0.144***
					[17.31]	[17.24]	[17.48]	[17.28]
$SIZE_{t-1}$	0.141***	0.146***	0.146***	0.145***	0.057***	0.056***	0.057***	0.056***
	[13.64]	[13.21]	[13.87]	[13.22]	[20.65]	[19.70]	[20.54]	[19.68]
ROA_{t-1}	4.624***	4.613***	4.651***	4.618***	1.669***	1.685***	1.660***	1.686***
	[17.32]	[17.03]	[17.22]	[17.05]	[27.30]	[27.76]	[26.75]	[27.76]
$RETAIN_{t-1}$	0.018***	0.018***	0.018***	0.018***	0.012***	0.012***	0.012***	0.012***
	[3.08]	[3.11]	[3.02]	[3.09]	[6.62]	[6.45]	[6.50]	[6.45]
$TOBINQ_{t-1}$	−0.034***	−0.043***	−0.039***	−0.043***	−0.036***	−0.032***	−0.038***	−0.032***
	[−2.61]	[−3.08]	[−2.96]	[−3.11]	[−5.46]	[−5.24]	[−5.41]	[−5.22]
$CASH_{t-1}$	−0.405***	−0.383***	−0.412***	−0.398***	−0.277***	−0.274***	−0.285***	−0.279***
	[−2.93]	[−2.71]	[−2.99]	[−2.84]	[−6.56]	[−6.55]	[−6.69]	[−6.68]
LEV_{t-1}	0.003	0.003	0.002	0.003	0.014***	0.011**	0.013***	0.011**
	[0.19]	[0.15]	[0.11]	[0.17]	[2.81]	[2.16]	[2.61]	[2.20]
$TANG_{t-1}$	−0.071	−0.074	−0.089	−0.081	−0.054**	−0.047**	−0.049**	−0.050**
	[−1.00]	[−0.99]	[−1.23]	[−1.10]	[−2.31]	[−2.01]	[−2.09]	[−2.12]
Constant	−3.744***	−4.048***	−3.769***	−4.032***	−0.902***	−0.911***	−0.933***	−0.909***
	[−19.98]	[−19.70]	[−19.97]	[−19.73]	[−16.82]	[−16.57]	[−17.18]	[−16.54]
Industry FE	No	Yes	No	Yes	No	Yes	No	Yes
Year FE	No	Yes	No	Yes	No	Yes	No	Yes

(*continued on next page*)

Table 7 (*continued*)

Panel A - Out of Sample Test: U.S. Polluters								
	Panel A1 - Decision to Pay (Dep. Var. = $DIVDUM_t$)				Panel A2 - Determinants of Payout ratio (Dep. Var. = $DIVPAYOUT_t$)			
	1	2	3	4	5	6	7	8
Firm Cluster	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	16,290	16,290	16,290	16,290	16,257	16,257	16,257	16,257
Pseudo R-squared	0.72	0.72	0.72	0.72	0.49	0.50	0.49	0.50

This table reports the results on the impact of carbon risk on dividend policy, using U.S. data (Panel A) and UK data (Panel B). POST05 and POST07 are year dummy variables indicating year 2006 onwards or not, and year 2008 onwards or not, respectively. Panels A1 and B1 presents the probit regression results on the impact of carbon risk on decision to pay. Panels A2 and B2 presents the tobit regression results on the impact of carbon risk on the determinants of dividend payout ratio. The t-statistics based on robust standard errors clustered by firm are reported in square brackets. Continuous variables are winsorized at 1st and 99th percentiles. We report detailed definitions of all variables in Appendix. *, **, and *** indicate significance at 10%, 5%, and 1%, respectively.

Table 8
Channel Analysis: Carbon Risk, Earnings Uncertainty and Dividend Policy.

Panel A - The impact of carbon risk on Earnings Uncertainty (Dep. Var. = ROAVOL)						
	1	2	3	4	5	
POLLUTER	0.178***	0.081*	0.095**			
	[4.94]	[1.72]	[2.00]			
POST		0.173***	0.167***			
		[5.25]	[5.06]			
POLLUTER*POST		**0.122****	**0.132****	**0.122****	**0.128****	
		[2.37]	[2.56]	[2.35]	[2.44]	
GFC0709	0.055**	0.017	0.054*			
	[2.54]	[0.82]	[1.92]			
POLLUTER*GFC0709			−0.072*		−0.040	
			[−1.69]		[−0.95]	
$SIZE_{t-1}$	−0.286***	−0.293***	−0.293***	−0.282***	−0.282***	
	[−29.85]	[−30.31]	[−30.30]	[−27.16]	[−27.15]	
ROA_{t-1}	−0.485***	−0.475***	−0.474***	−0.473***	−0.472***	
	[−23.79]	[−23.58]	[−23.59]	[−23.64]	[−23.64]	
$RETAIN_{t-1}$	−0.073***	−0.071***	−0.071***	−0.064***	−0.064***	
	[−8.03]	[−7.95]	[−7.95]	[−7.39]	[−7.39]	
$TOBINQ_{t-1}$	0.033***	0.034***	0.034***	0.031***	0.031***	
	[6.95]	[7.01]	[7.06]	[6.35]	[6.37]	
$CASH_{t-1}$	0.122**	0.096	0.099*	0.013	0.015	
	[2.07]	[1.64]	[1.68]	[0.22]	[0.25]	
LEV_{t-1}	−0.128***	−0.119***	−0.119***	−0.061**	−0.061**	
	[−3.73]	[−3.48]	[−3.49]	[−1.97]	[−1.98]	
$TANG_{t-1}$	0.022	0.069	0.069	0.167**	0.168**	
	[0.28]	[0.85]	[0.86]	[2.03]	[2.03]	
Constant	2.454***	2.506***	2.497***	2.450***	2.445***	
	[13.82]	[14.06]	[14.00]	[8.38]	[8.37]	
Industry FE	No	No	No	Yes	Yes	
Year FE	No	No	No	Yes	Yes	
Firm Cluster	Yes	Yes	Yes	Yes	Yes	
Observations	17,608	17,608	17,608	17,566	17,566	
Adjusted R-squared	0.425	0.431	0.431	0.452	0.452	
Panel B - Decision to Pay Dividend (Dep. Var. = $DIVDUM_t$)						
	1	2	3	4	5	6
POLLUTER	−0.474***	−0.469***				
	[−7.55]	[−7.41]				
POST	−0.172***	−0.174***				
	[−3.31]	[−3.31]				
POLLUTER*POST	**−0.155****	**−0.151***	**−0.186****	**−0.183****		
	[−2.01]	[−1.93]	[−2.27]	[−2.22]		
ROAVOL	−0.094***	−0.094***	−0.093***	−0.093***		
	[−5.07]	[−5.08]	[−4.91]	[−4.91]		
GFC0709	−0.027	−0.017				
	[−0.61]	[−0.28]				
POLLUTER*GFC0709		−0.026		−0.016		−0.010
		[−0.29]		[−0.17]		[−0.10]
POLLUTER*POST*HROAVOL					**−0.219****	**−0.217****
					[−2.31]	[−2.26]
POLLUTER*POST*LROAVOL					**−0.204****	**−0.203****
					[−2.26]	[−2.24]
$DIVDUM_{t-1}$	1.509***	1.509***	1.450***	1.450***	1.458***	1.458***
	[21.30]	[21.30]	[22.20]	[22.20]	[22.56]	[22.56]
$FRANK_{t-1}$	1.364***	1.363***	1.494***	1.494***	1.508***	1.508***
	[19.21]	[19.20]	[19.84]	[19.84]	[20.30]	[20.31]

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Table 8 (*continued*)

Panel A - The impact of carbon risk on Earnings Uncertainty (Dep. Var. = ROAVOL)						
	1	2	3	4	5	
SIZE$_{t-1}$	0.221***	0.221***	0.255***	0.255***	0.274***	0.274***
	[13.44]	[13.44]	[14.78]	[14.77]	[15.98]	[15.96]
ROA$_{t-1}$	1.534***	1.534***	1.089***	1.089***	1.136***	1.136***
	[3.38]	[3.38]	[2.88]	[2.88]	[3.08]	[3.08]
RETAIN$_{t-1}$	0.105	0.106	0.118	0.119	0.121	0.121
	[1.09]	[1.10]	[1.41]	[1.41]	[1.51]	[1.52]
TOBINQ$_{t-1}$	0.021*	0.021*	0.033***	0.033***	0.027***	0.027***
	[1.88]	[1.89]	[3.52]	[3.55]	[2.78]	[2.80]
CASH$_{t-1}$	0.102	0.103	0.240**	0.240**	0.226**	0.226**
	[1.01]	[1.01]	[2.37]	[2.37]	[2.22]	[2.22]
LEV$_{t-1}$	−0.001	−0.001	−0.071	−0.071	−0.062	−0.062
	[−0.03]	[−0.02]	[−1.41]	[−1.41]	[−1.24]	[−1.24]
TANG$_{t-1}$	0.154	0.154	0.254**	0.253**	0.249**	0.249**
	[1.51]	[1.51]	[2.39]	[2.39]	[2.36]	[2.36]
Constant	−5.337***	−5.339***	−6.490***	−6.492***	−6.553***	−6.554***
	[−18.57]	[−18.54]	[−15.79]	[−15.77]	[−16.90]	[−16.87]
Industry FE	No	No	Yes	Yes	Yes	Yes
Year FE	No	No	Yes	Yes	Yes	Yes
Firm Cluster	Yes	Yes	Yes	Yes	Yes	Yes
POLLUTER*POST*(HROAVOL- LROAVOL)					−0.015	−0.014
p-value					0.32	0.33
Observations	16,852	16,852	16,685	16,685	16,685	16,685
Pseudo R-squared	0.76	0.76	0.77	0.77	0.77	0.77
Panel C - Determinants of Dividend Payout (Dep. Var. = DIVPAYOUT$_t$)						
	1	2	3	4	5	6
POLLUTER	−0.189***	−0.189***				
	[−8.94]	[−8.88]				
POST	−0.024**	−0.024**				
	[−2.02]	[−2.03]				
POLLUTER*POST	**−0.058****	**−0.058****	**−0.057****	**−0.057****		
	[−2.35]	[−2.31]	[−2.27]	[−2.23]		
ROAVOL	−0.018***	−0.018***	−0.013**	−0.013**		
	[−3.02]	[−3.02]	[−2.15]	[−2.15]		
GFC0709	0.004	0.005				
	[0.43]	[0.44]				
POLLUTER*GFC0709		−0.003		−0.001		0.001
		[−0.12]		[−0.03]		[0.04]
POLLUTER*POST*HROAVOL					**−0.079****	**−0.079****
					[−2.36]	[−2.33]
POLLUTER*POST*LROAVOL					**−0.045***	**−0.045***
					[−1.72]	[−1.71]
DIVPAYOUT$_{t-1}$	0.632***	0.632***	0.564***	0.564***	0.566***	0.566***
	[21.68]	[21.68]	[20.38]	[20.38]	[20.47]	[20.47]
FRANK$_{t-1}$	0.393***	0.393***	0.404***	0.404***	0.409***	0.409***
	[12.09]	[12.09]	[13.06]	[13.06]	[13.18]	[13.19]
SIZE$_{t-1}$	0.062***	0.062***	0.070***	0.070***	0.072***	0.072***
	[12.04]	[12.04]	[12.34]	[12.34]	[12.94]	[12.94]
ROA$_{t-1}$	0.621***	0.621***	0.579***	0.579***	0.584***	0.584***
	[2.90]	[2.90]	[2.84]	[2.84]	[2.88]	[2.88]
RETAIN$_{t-1}$	0.044	0.044	0.042	0.042	0.042	0.042
	[1.36]	[1.36]	[1.30]	[1.30]	[1.34]	[1.35]
TOBINQ$_{t-1}$	−0.003	−0.003	−0.002	−0.002	−0.003	−0.003
	[−0.39]	[−0.39]	[−0.33]	[−0.33]	[−0.48]	[−0.48]
CASH$_{t-1}$	0.034	0.035	0.073**	0.073**	0.073**	0.073**
	[1.05]	[1.05]	[2.22]	[2.22]	[2.21]	[2.21]
LEV$_{t-1}$	0.008	0.008	−0.028*	−0.028*	−0.026*	−0.026*
	[0.51]	[0.51]	[−1.88]	[−1.88]	[−1.75]	[−1.75]
TANG$_{t-1}$	0.125***	0.125***	0.149***	0.149***	0.148***	0.148***
	[3.63]	[3.63]	[4.13]	[4.13]	[4.10]	[4.11]
Constant	−1.479***	−1.479***	−1.663***	−1.663***	−1.670***	−1.670***
	[−14.45]	[−14.42]	[−8.50]	[−8.50]	[−8.61]	[−8.61]
Industry FE	No	No	Yes	Yes	Yes	Yes
Year FE	No	No	Yes	Yes	Yes	Yes
Firm Cluster	Yes	Yes	Yes	Yes	Yes	Yes
POLLUTER*POST*(HROAVOL- LROAVOL)					−0.034	−0.034
p-value					0.05**	0.05**
Observations	16,834	16,834	16,796	16,796	16,796	16,796
Pseudo R-squared	0.61	0.61	0.63	0.63	0.63	0.63

Panel A of the table displays the results on the impact of carbon risk on earnings uncertainty. Panels B and C of the table display the impact of carbon risk on decision to pay dividend and dividend payout, respectively after controlling for earnings uncertainty. We report detailed definitions of all variables in Appendix. *, **, and *** indicate significance at 10%, 5%, and 1%, respectively.

payouts subsequent to the Kyoto Protocol ratification for polluters compared to non-polluters. We do not find any support for the imputation tax environment affecting the impact of carbon risk on the decision to pay dividend. However, we document that the post-ratification reduction in dividend payouts is weaker for firms operating in the imputation environment than for those operating in the classical tax system, so complementing the findings of Balachandran et al., (2017) on the impact of imputation on dividend payout. We further show that increase in earnings uncertainty is stronger for polluters compared to non-polluters subsequent to Kyoto Protocol ratification, which in turn relatively reduces dividend payouts of polluters. These results provide evidence on the causal negative impact of carbon risk on earnings stability, which eventually leads to a decrease in the level of dividend payouts. Overall, the study adds to the strands of literature on (i) the financial impact of carbon risk; (ii) the determinants of dividend policy, and (iii) the effect of the imputation tax environment on dividend policy.

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Appendix. Variable Definitions

Variable abbreviation	Variable name	Definition
Main dependent variables		
DIVDUM	Current dividend dummy	Dummy variable that takes the value of 1 if the firm pays cash dividend in year t, and zero otherwise.
DIVPAYOUT	Current dividend payout ratio	Ratio of paid cash dividends over after-tax earnings in year t. Consistent with Holmen et al. (2008) and Balachandran et al. (2017), the payout ratio is set to one if (i) dividends are paid but after-tax earnings are negative, or (ii) dividends are larger than after-tax earnings.

(continued on next page)

Variable abbreviation	Variable name	Definition
Main independent variables		
POLLUTER	Current polluter dummy	Dummy variable that takes the value of 1 if the firm is classified into one of these nine GICS industries: (1) Oil, Gas & Consumable Fuels; (2) Electric Utilities; (3) Gas Utilities; (4) Independent Power Producers & Energy Traders; (5) Multi-Utilities; (6) Chemicals; (7) Construction Materials; (8) Metals & Mining; and (9) Paper & Forest Products (CDP 2012) in year t, and zero otherwise.
POST	Post-Kyoto dummy	Dummy variable that takes the value of 1 if the firm is observed in year 2008 onwards, and zero otherwise.
POLLUTER*POST	Interaction term	Interaction term between POLLUTER dummy and POST dummy
Control variables		
$DIVDUM_{t-1}$	Lagged dividend dummy	Dummy variable that takes the value of 1 if the firm pays cash dividend in year t-1, and zero otherwise.
$DIVPAYOUT_{t-1}$	Lagged dividend payout ratio	Payout ratio in year t-1
$FRANK_{t-1}$	Lagged franked dividend dummy	Dummy variable that takes the value of 1 if the firm pays franked dividends in year $t-1$, and zero otherwise.
$SIZE_{t-1}$	Lagged firm size	Logarithm transformation of total assets in year t-1
ROA_{t-1}	Lagged profitability	Ratio of pre-tax earnings over total assets in year t-1
$RETAIN_{t-1}$	Lagged retained/capital mix	Ratio of retained earnings over book value of equity in year t-1
$TOBINQ_{t-1}$	Lagged growth opportunities	Tobin's Q = (Total assets + market value of equity - book value of equity)/total assets in year t-1
$CASH_{t-1}$	Lagged cash holdings	Ratio of cash balance over total assets in year t-1
LEV_{t-1}	Lagged leverage	Ratio of long-term debt over book value of equity in year t-1
$TANG_{t-1}$	Lagged tangibility	Ratio of net value of property, plant, and equipment over total assets in year t-1
$ROAVOL_{t-1}$	Earnings volatility	Logarithm transformation of standard deviation of yearly ROA (pre-tax earnings over total assets) over a five-year rolling window covering year t-4 to t
Other variables		
$BEFORE^{-1y}$	Year 2007 dummy	Dummy variable that takes the value of 1 if the firm is observed in year 2007, and zero otherwise.
$CURRENT^{0}$	Year 2008 dummy	Dummy variable that takes the value of 1 if the firm is observed in year 2008, and zero otherwise.
$AFTER^{1y+}$	Post-2008 dummy	Dummy variable that takes the value of 1 if the firm is observed in year 2009 onwards, and zero otherwise.
POST05	Post-2005 dummy	Dummy variable that takes the value of 1 if the firm is observed in year 2006 onwards, and zero otherwise.
POST07	Post-2007 dummy	Dummy variable that takes the value of 1 if the firm is observed in year 2008 onwards, and zero otherwise.

(continued on next page)

Variable abbreviation	Variable name	Definition
GFC0809	GFC 2008–09 dummy	Dummy variable that takes the value of 1 if the firm is observed in the Global Financial Crisis time 2008–09, and zero otherwise.
GFC0709	GFC 2007–09 dummy	Dummy variable that takes the value of 1 if the firm is observed in the Global Financial Crisis time 2007–09, and zero otherwise.
HROAVOL	High earnings volatility dummy	Dummy variable that takes the value of 1 if ROAVOL is above the sample cross-sectional median value every year.
LROAVOL	Low earnings volatility dummy	Dummy variable that is measured as 1 minus HROAVOL

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