Do M&As impact firm carbon intensity? *,+

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Abstract

We examine the impact of domestic and cross-border M&As on firm carbon intensity in a sample of firms from 84 countries over the period 2002-2020. We find that M&As only impact the firm-level carbon footprint in the short-term, where the impact is to raise it, but that there is no impact on the carbon footprint over the medium term. As such, the supposedly greater efficiency of acquirer firms does not appear to translate into innovations that reduce carbon intensity in either the acquirer or target firm. This result is robust to several tests, including controlling for the type of M&A (vertical or horizontal), the relative strengths of environmental regulation (as measured by environmental taxes) in acquirer and target firm country, and to alternative measures of firms' carbon footprint. The results suggest that M&A activity does little to help achieve countries' climate goals, which would be better achieved if regulators and other firm stakeholders require acquirer firms to make public the likely contribution to those goals of the M&A activity that they are proposing.

Keywords: Carbon emissions, Carbon intensity, Mergers and acquisitions
JEL classification: F21, G15, O32, P28

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1 Introduction

Although the momentum for tackling CO_2 emissions has accelerated since the 2015 Paris Climate Accords, most countries are behind schedule on their commitments to achieve the goal of net-zero emissions in the second half of the twenty-first century (IEA 2021; Jeudy-Hugo et al., 2021). As policymakers have sought to step up their endeavors in this regard, firms have come under greater pressure from governments and stakeholders to find ways to minimize their environmental impact (see, e.g., Coppola and Blohmke, 2019; Mooney, 2021). Firm-level studies of CO_2 emissions are relatively scarce but include examinations of the relationship between carbon emissions on the one hand and firm value and performance (Lewandowski, 2017; Matsumura et al. 2014), gender diversity in the workplace (Altunbaş et al., 2022), mandatory climate reporting (Downar et al., 2021; Tomar, 2019), R&D (Alam et al., 2019), and the allocation of bank credit (Reghazza et al., 2021) on the other hand. In this paper, we study developments in firm-level emissions within the framework of mergers and acquisitions (M&As). The few studies of this type (e.g., Berchicci et al., 2012; Monastyrenko, 2017; Eng and Fikru, 2020; Bose et al., 2021) establish that acquirer firms' pay attention to the environmental performance of potential targets but establish no clear picture as to the actual impact of M&A activity on emissions.

In this paper we extend the empirical work on the relationship between M&As and firm-level carbon emissions employing a cross-country panel comprising firms from the USA, Europe and Asia over the period 2002-2020. We focus on three issues in particular. The first issue is whether M&A activity is associated with a reduction in firm-level carbon emissions. Theory and empirical evidence suggest acquirer firms are among the most efficient firms (Brakman et al. 2005; Neary, 2007), which in turn suggests they are best placed to introduce innovative ways to reduce costs and create higher quality and cleaner outputs and processes, including in response to tighter environmental regulation (Porter and van der Linde, 1995). At the same time, there is ample evidence that the ultimate impact of M&As on firm performance is very mixed and that they often fail to meet their objectives (e.g., Das and Kapil, 2012).

The second issue is whether there is any distinction between domestic and cross border M&As in their impact on firm-level carbon emissions. Theory and empirical evidence suggest that multinational firms pursue more innovation activities as compared to national firms (e.g., Dunning and Lundan, 1998) such that cross-border mergers are especially likely to be associated with innovation, presumably including to reduce carbon emissions. Accordingly, both domestic cross-border M&As should be associated with a reduction in firm carbon emissions. On the other hand, tighter environmental regulations in their home country might push acquirer firms to seek targets in less regulated jurisdictions—the so-called 'pollution haven hypothesis' (e.g., Levinson and Taylor, 2008)—in which case, cross-border M&As might reduce carbon emissions in the acquirer firm country but increase them in the target firm country.

The third issue relates to possible motivations for M&As in the context of carbon emissions, and in particular the extent to which acquirer firms deliberately seek targets that have either a better or a worse environmental performance. In the first instance, this might be because the acquirer firm sees the M&A as means of adding environment-related value to the business post-acquisition; in the second instance, it might reflect a so-called "turnaround" strategy (e.g., Castrogiovanni and Bruton, 2000) where the acquirer views such targets as being cheaper and that a better environmental performance can be achieved.

We report four key results. First, the carbon footprint of firms that have engaged in M&As differs from that of firms that have not done so in the short term, but there is no discernible difference between them in the medium term. The results are clear that, initially, the carbon emissions of the combined firm are greater than those of the two firms prior to the M&A but over the medium term (i.e., after five years), the impact of M&As on firm carbon emissions is largely insignificant. Second, the failure of M&As to impact carbon emissions over the medium term applies to domestic and cross-border M&As. Thus, we find no evidence to support the view that the greater efficiency of national and multinational firms involved in M&As has stimulated innovative processes that reduce carbon emissions in the acquirer or target country. We also find no evidence that acquirer firms shift dirty production to target firms in countries with more lax environmental regulations. Overall, the picture that emerges is that M&As have been largely irrelevant for firm-level carbon emissions other than in the very short term. Third, the short-run

impact of M&As on carbon emissions differs markedly according to the industrial sector classification of the firms involved. In particular, they are most harmful in the construction, manufacturing, mining, and transport and public utility sectors, which are traditionally associated with higher firm-level carbon emissions. In contrast, we find evidence that M&As in the financial sector have been associated with an improved carbon emission performance of the firms involved. Finally, an examination of M&As between targets and acquirer firms whose activities have the same or different UNEPFI-designated climate metrics (i.e., "brown" or "green") provided no evidence of acquirer firms seeking to benefit from target firms' better environment performance.

Our paper makes a number of contributions to the literature. First, M&As have been shown to be associated with (acquirer) firm that are more efficient and innovative. While this might be the case, we show that this has not been translated into lower carbon emissions at the firm level for domestic or cross-border M&As. Second, our results are consistent with the literature casting doubt on the validity of the pollution-haven hypothesis (e.g., Smarzynska et al., 2003). This is consistent with environmental costs representing only a small part of the costs that firms consider when deciding where to locate their operations. Third, whereas the key studies in this field are mainly single industry and single country focused (e.g., Berchicci et al., 2012; Eng and Fikru, 2019), we present our conclusions from a study of firm performance across industries and countries. Fourth, other studies focus mainly on domestic mergers (Berchicci et al., 2012; Eng and Fikru, 2020) or make no distinction between the impact on carbon emissions of domestic and cross-border mergers (Bose et al., 2021; Monastyrenko, 2017), whereas we show that the impact of domestic M&As is significantly different and more harmful with respect to carbon emissions in the short-run but that both domestic and cross-border M&A have little impact on firm-level carbon emissions over the medium run. Finally, we provide additional evidence on role of M&As involving firms with different environmental performance metrics, by showing that that firm-level carbon emissions are only improved when both acquirer and target firms are already undertaking activities classified as "green".

2. Related literature

Our paper draws on three strands of M&A theory as they relate to firm pollution. One strand emphasizes that acquirer firms are the most efficient firms among its competitors (e.g., Brakman et al., 2005; Neary, 2007). Thus, these firms have a capacity to improve, which makes them more likely to undergo innovative ways to reduce costs and to create higher quality and cleaner outputs and process (Cantwell and Janne, 1999; Dunning and Lundan, 1998). A second strand argues that firms exposed to stricter environmental regulation will have an incentive to search for ways to reduce their pollution emissions (Porter, 1995; Porter and van der Linde, 1995) with the actual introduction of cleaner technologies depending on firms' resource capacity, which could be expected to be greater in acquirer firms. In both of these strands, the premise is that high emissions are often the result of the inefficient use of the resources, which leads to extra handling, storage and disposal activities. By eliminating costly materials, reducing disposal costs for the user, making better use of materials in the production process, and recycling, for example, the acquirer firm will reduce emissions. The third strand posits that jurisdictions with weak environmental regulations will attract polluting industries relocating from more stringent countries. This is the so-called pollution haven hypothesis (Candau and Dienesch, 2017; Levinson and Taylor, 2008) the premise of which is that environmental regulations raise the cost of key inputs to goods with pollution-intensive production and reduce jurisdictions' comparative advantage in those goods. In this case the objective of the acquirer firm is simply to relocate a portion of carbon emissions to less regulated jurisdictions rather than to expend resources on creating cleaner outputs.

Empirical research on the role of M&As in firms' environment performance is still in its infancy. One area of this research focuses specifically on post-M&A environmental performance. These studies emphasize that differences in performance between firms provide scope for the transfer and sharing of technologies, resources, and capabilities specific to environmental performance and sustainability (e.g., Eng and Fikru, 2020). In this setting, acquirer firms might pursue a "cream skimming" strategy (Pfeffer and Salancik 1978; Scherer and Ross 1990) and target firms with better environmental performance to bring value to the business post-acquisition, or with a view to replicating the target's environmental commitments rather than building own "greener" capabilities, or because the good environmental performance of the target firm could

improve the financial performance of the acquirer.[1] Alternatively, an acquirer firm might opt for a "turnaround" strategy (Castrogiovanni and Bruton, 2000) and target firms that have a poorer environmental performance because such firms are likely to be cheaper and because the acquirer believes that a better environmental performance can be achieved.

These studies tend to stress the importance of carbon footprints in the decision of a firm to engage in M&A activity and they report evidence of both cream skimming and turnaround strategies. For example, Berchicci et al. (2012) find that relative waste generation by US manufacturing firms was a determinant of M&A deals and that M&As are motivated by cream skimming and turnaround strategies, though both results are conditional on the target being geographically proximate. In addition, in the three years following the M&A, both the targeted "clean" and "dirty" firms reduced waste generation. Eng and Fikru (2020) report that the relative toxic chemical management rate of firms in the US food and beverage industry was a factor in M&A deals; they report a mix of cream skimming and turnaround deals and evidence of post-acquisition improvements in toxic chemical management rates for both targets and acquirers. Cross-country M&A studies of this type include Bose et al. (2021), who report that firm carbon emissions were a factor in the decision to engage in M&A activity and that there was an increased likelihood that firms with higher emissions would acquire foreign targets in countries that had weak environmental, regulatory, or governance standards. Finally, a study by Monastyrenko (2017) reports that M&As in the newly liberalized European electricity industry had a detrimental impact on carbon emissions in the case of vertical M&As.

A second area of the related M&A research examines the role of firms' environmental, social, and governance (ESG) scores in facilitating M&A deals. For example, Gomes (2019) reports that firms' ESG performance is positively associated with the likelihood of becoming an M&A target in a cross-country sample of 608 deals over 2003-2014, with the results holding for all ESG dimensions (environment, social and governance). Similarly, Barros et al. (2022) find that M&A deals have a positive impact on ESG scores in a cross-country sample of 1,722 acquirer

[1] For example, Demas et al. (2015), Dowell et al. (2000), King and Lenox (2002) and Russo and Fouts (1997) report evidence of a positive link between firm environmental and financial performance.

firms involving 3941 M&A deals over the period 2005-2018. Boone and Uysal (2020) report that acquirers are more likely to pair with similar reputation firms and are less likely to acquire firms with lower reputations in a sample of 289 M&As between US firms over 1997-2001, and that firms with an environmentally toxic reputation had a lower probability of being both acquirers and targets. Studies have also shown that the ESG performance of firms engaged in M&A activity can impact stock prices. For example, Aktas et al. (2011) report that the stock market rewards the acquirer firm for making socially and environmentally responsible investments in a cross-country sample of 1,108 firms over the period 2000-2007. Similarly, Gomes and Marsat (2018) find a positive link between target firms overall ESG performance and acquisition premiums and between their environmental performance and acquisition premiums in an international sample of 588 deals announced during 2003–2014. In contrast, Chen and Gavious (2015) find no relationship between ESG involvement and firm sale price for a sample of 134 Israeli M&A.

On the basis of the literature discussed above, we test the following three hypotheses in this paper:

H1: M&As are associated with a reduction in firm-level carbon emissions.

This hypothesis assumes that firms involved in M&As are more efficient and more innovative than other firms and that innovations will include ways to reduce costs and create higher quality and cleaner outputs and processes.

H2: There is no distinction between domestic and cross border M&As as regards their impact on firm-level carbon emissions.

This hypothesis also relies on firms (especially multinational firms) involved in M&As being more efficient and more innovative than others but, importantly, runs counter to the so-called pollution haven hypothesis.

H3: Acquirer firms will target firms that have a better environmental performance.

This hypothesis is consistent with acquirer firms seeing M&As as means of adding environment-related value to the business post-acquisition, for example, because the acquirer firm believes that it can replicate the target's environmental performance.

3. Methodology and data

3.1 Methodology

To investigate the relationship between M&A activity and firm carbon emissions we begin with a panel fixed effects baseline specification that focuses on the "intensity" of firm carbon emissions as follows:

$$CO2\ intensity_{it} = \alpha_i + \beta_1 M\&A_{it} + \theta X_{it} + \delta Z_{it-1} + \gamma_{jt} + \varepsilon_{it} \quad (1)$$

where the dependent variable measures a firm's carbon intensity as the ratio of its CO_2 emissions to total assets, $CO2\_intensity$. The subscripts i, j and t represent firm, country and time, respectively. α indicates firm-fixed effects, which are employed to gauge time-invariant unobservable firm traits. $M\&A_{it}$ is a dummy variable equal to 1 if a firm in the panel completed an M&A transaction and 0 otherwise. A negative and statistically significant coefficient on this variable would indicate that carbon intensity of the newly merged firm is smaller relative to the carbon intensity of the involved firms prior to the M&A and smaller than that of firms not engaged in M&A activity.

X_{it} is a vector of corporate governance characteristics that may affect the level of CO_2 emissions and includes: the size of the firm's executive board (the number of directors), BSIZE, the percentage of independent board members, BINDEP, the experience of the executive board calculated as the percentage of board members who have either an industry specific background or a strong financial background, BEXP, and whether the same person holds the CEO and Chairman positions simultaneously, DUAL. Following De Villiers et al. (2011), we expect larger and more experienced boards to be associated with a better environmental performance because they are likely to include directors who possess better expertise to manage environmental issues.

We expect independent directors to be associated with better firm environmental performance because they are more likely to be conscious of how corporate social performance improves a firm's standing with stakeholders and to have more incentive to pursue environmental innovations (Khoo et al., 2022). Finally, agency theory suggests that CEO duality increases the CEO's entrenchment and power over the board, which leads to higher agency costs, particularly for larger and more complex firms that are more difficult to monitor and have more resources to waste (Jensen and Meckling, 1976; Jensen, 1993). As such, firms with a dual CEO-chair may be less likely to consider the interests of external stakeholders, resulting in a reluctance to engage in sustainability-related activities (e.g., Uyar et al., 2021).

Z is a vector of firm-specific financial characteristics that includes: the logarithm of total assets, FSIZE; firm liquidity, measured as the ratio of cash flow to sales, LIQUID; firm leverage measured as the ratio of debt to total assets, LEVERAGE; the return on equity defined as net income divided by average of previous and current year's common equity, ROE; capital expenditure, measured as the ratio to total assets of expenditure to acquire, maintain and upgrade assets such as property, plant, building and technology, CAPE; and the cost of funds measured as the average cost of existing external funding, CFUND. We include these variables because: larger firms are more likely to recognize environmental issues and deploy dedicated resources to limit CO_2 emissions (Al-Tuwaijri et al. 2004; Clarkson et al. 2008); firms' R&D investment is associated with a reduction in CO_2 emissions (Alam et al. 2019); more profitable firms have a better environmental performance as they are more likely to bear the cost associated with transitioning toward a greener production process (De Villiers et al. 2011); and a positive relationship appears to exist between a high level of firm indebtedness and environmental disclosure (Clarkson et al. 2008), because lower free cash flow may hamper climate-related activism (Haque 2017), and because negative associations between firm environmental performance and the cost of debt and equity capital have been reported (Chiesa et al. 2021; Dhaliwal et al. 2014). γ identifies country and time fixed effects to control for time-varying unobservable country characteristics that may affect the level of CO_2 emissions over time.

Second, we extend our analysis to examine whether domestic and cross border M&As impact differently on firm environment performance for which we estimate the following models:

$$CO2\ intensity_{it} = \alpha_i + \beta_1 DM\&A_{it} + \theta X_{it} + \delta Z_{it-1} + \gamma_{jt} + \varepsilon_{it} \quad (2)$$

$$CO2\ intensity_{it} = \alpha_i + \beta_1 CM\&A_{it} + \theta X_{it} + \delta Z_{it-1} + \gamma_{jt} + \varepsilon_{it} \quad (3)$$

In equation (2) $DM\&A_{it}$ is a dummy variable equal to 1 if the acquirer firm participated in a domestic merger and 0 otherwise and the remaining variables are defined as for equation (1). A negative and statistically significant coefficient on $DM\&A_{it}$ would indicate that carbon intensity of the newly merged firm was smaller relative to the carbon intensity of the firms involved in cross-border M&As, and greater than that of firms not engaged in M&A activity (consistent with our H1). Similarly, in equation (3) $CM\&A_{it}$ is a dummy variable equal to 1 if the acquirer firm participated in a cross-border M&A and 0 otherwise and the remaining variables are defined as for equation (1). A negative and statistically significant coefficient on $CM\&A_{it}$ would indicate that carbon intensity of the newly merged cross-border firm was smaller relative to the carbon intensity of the firms involved in domestic M&A, and smaller than that of firms not engaged in M&A activity.

Third, as some industrial activities impact firm environmental performance more adversely than others the impact of M&As on carbon emission is likely to differ across industrial sectors. Although some of this effect is likely to be captured by the inclusion of firm and industry fixed effects in the estimates, we check further by estimating the baseline regression of equation (1) for samples of firms according to the Standard Industrial Classification (SIC) of their activities.

Fourth, we try to shed additional light on whether the carbon emission performance of target firms located overseas is a factor in driving M&A deals. For this we look for evidence that acquirer firms pursue “cream skimming” strategies (Mueller 1980; Pfeffer and Salancik 1978; Scherer and Ross 1990) by targeting foreign firms with a better environmental performance. We

do this by examining the impact of M&As between firms whose activities are designated as having different climate metrics as designated by the UNEPFI — that is, the so-called "green" (climate solution) or "brown" (climate problem) metrics. For example, an M&A between an acquirer exhibiting mainly brown metrics and a target exhibiting mainly green metrics would be consistent with a cream skimming strategy in which the acquirer hoped to bring value to the business post-acquisition by replicating the target's environmental performance. Alternatively, an M&A between an acquirer exhibiting mainly green metrics and a target exhibiting mainly brown metrics would be consistent with a turnaround strategy in which a firm with a poorer environmental performance is targeted because it is cheaper, and the acquirer believes that a lower carbon intensity can be achieved.

3.2 Data

Data for this study are from Refinitiv Eikon (hereafter, Eikon), which provides information on firm carbon emissions, key balance sheet variables, and information on firm categorization according to the Standard Industrial Classification (SIC).[2] In the case of the latter, we group firms into nine categories: (1) Agriculture, Forestry and Fishing; (2) Construction; (3) Finance, Insurance and Real Estate; (4) Manufacturing; (5) Mining; (6) Retail Trade; (7) Services; (8) Transport and Public Utilities; and (9) Wholesale Trade. Variable definitions and descriptive statistics for carbon emissions and firm-specific variables are shown in Table 1. The average carbon emission intensity per million dollars of firm assets is 0.24 tons. In addition, executive boards exhibit relatively low levels of independence and industry-specific skills. Summary data on the number of firms and M&A deals by year, SIC sector and geographic region are shown in Table 2. The largest number of firms in the sample are in the manufacturing, finance insurance and services and transport and public utility sectors, which are also the sectors that experienced the greatest number of M&As. Firms headquartered in the US and the EU represent, respectively, 38.8% and 36.8% of the total number of firm-year observations in the sample and accounted for 36.7% and 30.9% of all M&A deals respectively. Firm-level descriptive statistics for carbon emission intensity by SIC code and geographic region are shown in Table 3. Average firm level

[2] Eikon follows the Greenhouse Gas Protocol (GGP), which sets the standard for measuring carbon emissions. More information on the GGP can be found at: https://ghgprotocol.org.

carbon emission intensity is greatest by firms in the transport and public utilities and mining sectors and least by firms in the finance, insurance and real estate and the services sectors. Finally, Table 4 presents the Pearson correlation matrix to test for multicollinearity among independent variables. The correlation among the variables is extremely low in all cases (i.e., never above 0.13) suggesting that multicollinearity is not likely to a problem in our model.

4. Empirical results

In this section, we report the empirical results from estimating Equations (1) to (3). In all the estimates robust standard errors are clustered at the firm level, and the firm-specific characteristics are lagged by one period to avoid endogeneity issues related to the simultaneity of balance sheet variables.

4.1 M&A activity and firm level carbon emissions

The results of the baseline estimates of Equation (1) are reported in Table 5. The coefficients on the M&A dummy are positive and statistically significant for the pooled sample of firms and for firms in the US and the EU, suggesting that M&As worsen firm environmental performance in these cases; for Asian firms, M&As appear to have no impact on carbon intensity. Accordingly, there is no general evidence of M&As giving rise to synergies leading to better environmental management practices and knowledge transfer specific to environmental performance, at least in the short run. Nor is there prima facie evidence that M&As are motivated by cream skimming, with acquirer firms looking for targets with a better overall environmental performance to add value to the business post-acquisition, or that acquirers are looking to turnaround the environmental performance of targets to achieve a better environment performance. To the contrary, our results suggest that M&As produce negative synergy from the perspective of firms' environmental performance. One explanation could be that firms' management is focused on short-term profit maximization and more profitable high carbon intensity projects (Herbohn et al., 2019) and undertake the costly redistribution of scarce resources needed to fund more eco-friendly practices (Kim et al., 2012) or accept the uncertainty associated with the investment (Weitzman, 2013).

The coefficients on the control variables are mostly statistically significant. The signs on the coefficients of the governance-related variables broadly support the findings of De Villiers et al. (2011) with larger, more independent and more skilled boards being associated with better firm environmental performance; however, in contrast to the finding of these authors our results suggest that firms with a dual CEO-Chair are less carbon intense, which would be consistent with such firms being more likely to approve longer-run investments in environmental opportunities. The results also suggest that firms' capital expenditures are not geared primarily to reducing carbon intensity since more carbon intensive firms tend to have higher level of capital expenditure. Finally, carbon intensity is associated positively and significantly with corporate profitability. On the other hand, financial markets do appear to penalize carbon intensive firms in that they pay a higher cost of funds than do firms with a better environmental performance. This is consistent with the finding of Reghezza et al. (2021) that since the 2015 Paris Accords banks have reallocated credit away from polluting firms.

4.2 M&A activity, industry classification, and firm level carbon emissions

The results from estimating Equation (1) for the pooled sample of firms in each of the nine SIC level 1 categories are presented in Table 6. They reveal a number of differences between the categories in how M&As and other firm-level variables impact firm-level carbon intensity. First, M&As appear to have no impact on the carbon intensity of the combined firm's performance in the agriculture, forestry and fishing, retail trade, services, and wholesale sectors. Second, the carbon intensity of the combined firm deteriorates in the construction, manufacturing, mining, and transport and public utility sectors. Finally, M&As in the finance and real estate sectors appear to reduce carbon intensity by the combined firm. This suggests that the impact of M&As on carbon intensity depends very much on a firm's industrial classification—irrelevant in some cases (especially in sectors where carbon intensity tends to be relatively low), very important and harmful in others (especially in sectors that are traditionally the most carbon intense), and important and beneficial in the financial sector where M&As appear to have been associated with synergies and knowledge transfers that improved environmental performance. In these estimates,

when the coefficients on firm-specific control variables are statistically significant they are broadly in line with the baseline results reported in Table 5.

In Table 7 we report on the impact on carbon intensity of cross-border M&As from the pooled sample of firms between firms with different climate metrics as designated by the UNEPFI — that is, the so-called green (climate solution)—brown (climate problem) metrics. In these results the M&A dummy indicates alternately M&As in which: the acquirer and target were both in the brown category (denoted BBM&A in column (1) of the table); the acquirer was in the brown category and the target in the green category; (denoted BGM&A in column (2)); the acquirer and target were both in the green category (denoted GGM&A in column (3)); and the acquirer was in the green category and the when firms are target was in the brown category (denoted GBM&A in column (4)). The results show that M&As between firms in which both the acquirer and target firm are brown, and when the target is green and the acquirer is brown, carbon intensity worsens, at least in the initial period of the M&A. Thus, there is no support for either cream skimming or turnaround motives from an environmental performance perspective. Carbon intensity improves only when the M&A involves a target and acquirer that are both green, which might reflect the sharing of technologies and management practices that are already oriented to good environmental performance.

4.3 Domestic v cross-border M&A activity and firm level carbon emissions

The results from estimating equations (2) and (3) are reported in Table 8. The results in columns (1) and (2) include, respectively, dummy variables for domestic and foreign M&As for all firms. The coefficients on both dummy variables are positive and statistically significant suggesting that M&As worsen the environmental performance of the combined firm whether the acquired firm was domestic or foreign. When the results are broken down across regions (columns (3) to (8)), however, the coefficient on the domestic M&As dummy variable is only statistically significant in the case of US firms and the coefficient on cross-border mergers is only statistically significant for EU firms, suggesting that these results appear to be driving the results from the pooled sample. Thus, it appears that in the short run only domestic M&As impact carbon intensity in the case of US firms and only cross-border M&As impact carbon emissions for EU firms. In

both of these results it is mainly US acquirer firms that are involved (i.e., the EU cross-border M&As mainly reflect acquisitions by US firms). As we show later, national regulatory regimes for firm carbon emissions appear to have little impact as drivers of cross-border M&A, which would appear to rule out regulatory differences as an explanation for this finding–the more so as we also show that the impact of M&As loses any significance as a determinant of carbon emissions over the medium term. As such, we are inclined to suggest that these results probably reflect general patterns of M&A behavior where firms seek to maximize goals other than those relating to carbon emissions, and which tend to be dominated by US firms.[3] The signs and statistical significance of the firm-specific controls are broadly in line with the results reported in Table 5.

4. Further estimates

In this section we subject our baseline results to a series of robustness tests.[4]

a. Short- v medium-term impact of M&As on carbon emissions

[3] See, for example, Ernst & Young Tax News Update, July 26, 2021. Available at: https://taxnews.ey.com/news/2021-1421-global-mergers-and-acquisitions-decrease-in-2020-but-2021-is-looking-favorable-for-m-and-ampa#:~:text=Similarly%2C%20the%20top%20five%20acquirer,%25%20of%20cross%2Dborder%20M%26A.

[4] As an additional test, a referee suggested that in light of recent research suggesting that executive board gender was a factor associated with a reduction in firm carbon emissions (e.g., Altunbas et al., 2022; Kyaw et el., 2022), the role of board gender diversity should be explored in the context of post-M&A firm environmental performance. As such, we re-estimated the five-year post M&A estimates reported in Table 9 but incorporating board gender (the share of women on the executive board, BGENDER) and the interaction of board gender with the M&A dummy variable (M&A*BGENDER). In the estimates for the full sample and the sub-samples the coefficient on board gender was indeed negative and statistically significant (i.e., firms with executive boards with a larger share of female directors had lower carbon emission intensity) but the coefficient on the interaction term was never statistically significant. As such, our conclusion that over the medium-term the carbon footprint of firms that engaged in M&As was no different from that of firms that did not engage in M&As holds true after controlling for board gender. The summary result for the full sample is as follows:

$$CO2\ intensity_{it} = \underset{(0.0797)}{0.3889} - \underset{(0.2647)}{0.0136}M\&A - \underset{(0.0016)}{0.0039}BGENDER - \underset{(0.0017)}{0.0001}M\&A * BGENDER$$

where the estimate includes the firm-specific characteristics and macroeconomic controls as in the estimates reported in Tables 5 and 6, as well as and firm-, industry-, and year fixed effects, and robust standard errors are reported in parenthesis. Results for the region/country sub-samples are available from the authors on request.

There is a substantial literature suggesting that many M&As fail to realize a host of acquirer objectives (for a survey see Das et al., 2012). Accordingly, our first test is whether the medium-term impact of M&As on firm-level carbon intensity is different from the short-run impact. Our baseline estimates reported in Table 5 showed that M&As were associated with a deterioration in the carbon footprint of the merged firms in the short run. However, it seems likely that any reductions in costs and steps to bring about better quality and cleaner outputs would take some time to implement. Accordingly, in Table 9 we report results from estimating Equation (1) for the pooled sample of firms and separately for firms located in the US, EU and Asia when the M&A dummy variable indicates an M&A that took place five years previously. The coefficient on the M&A dummy is statistically significant only for US firms (albeit only at the 10% level) where the negative sign suggests the US M&As were associated with a reduction in firm-level carbon intensity over the medium run. Beyond the US, M&As appear to have had no statistically significant impact on carbon intensity over the medium term. The general irrelevance of M&As for carbon intensity is reinforced by the results reported in Table 10 where we distinguish between the effects of domestic and cross-border M&As on carbon intensity after five years. In these results, the coefficients on the M&A dummy variables, including for US firms, are never statistically significant.

b. *Do vertical or horizontal M&As make a difference?*

There is some evidence that post-M&A firm performance differs according to whether the M&A was vertical or horizontal in nature—in particular, that vertical mergers are more likely to be associated with efficiency gains and procompetitive activity (e.g., Blonigen and Pierce, 2016). This suggests that a reduction in carbon intensity is more likely following a vertical M&A than a horizontal M&A. In Table 11 we report summary results separately for the short- and medium term for US firms (panel a) and EU firms (panel b) controlling for the type of M&A.[5] For US firms, the coefficients on the domestic M&A dummy variable remain positive and statistically significant in the short term and not statistically significant over the medium term when controlling for the type of M&A; the coefficients on the cross-border M&A dummy variables are not statistically in either case, and the coefficients on the vertical and horizontal M&A controls are not

[5] The data sample provided insufficient observations to carry out this exercise for Asian firms.

statistically significant over either time period. For EU firms, vertical and horizonal domestic M&As increase firm carbon intensity, and vertical M&As increase carbon intensity for cross border M&As in the short term, but neither type of merger impacts carbon intensity over the medium term. These results are consistent with the results reported in tables 5 and 8.

c. Is there a pollution haven effect?

The pollution hypothesis suggests that post-M&A, firms may relocate dirty production processes to less regulated jurisdictions. Our results cast doubt on this hypothesis as we find no impact of cross border M&As on carbon intensity. However, we test additionally for a pollution haven effect by controlling for the relative strengths of countries' regulatory frameworks in the case of cross-border mergers. To do this, we re-estimate Equation (3) but include a dummy variable to indicate lower environment regulation in the target firm country than in the acquirer firm country. To construct this variable, which we denote as LTXREG, we rely on information provided by the OECD database on cross country environmental taxation.[6] The results for the short- and medium-term are reported in Table 12 (where for reasons of parsimony we do not report the coefficients on the control variables). The coefficients on CM&A remain statistically insignificant over both time periods, consistent with our earlier results. The coefficient on LTXREG is not statistically significant in the case of US and Asian firms and only significant in the short-term for EU firms where it suggests that cross-border mergers with targets in less regulated countries are actually associated with lower carbon intensity. In sum, we find no support for there being a pollution have effect of environmental taxation.

d. Alternative dependent variable

Our analysis has focused on the effects of M&As on firm-level CO2 intensity because of the relevance of this measure for firm efficiency in the use of resources and whether changes in emissions are due to positive or negative firm growth. An alternative measure of firms' overall environmental impact is their total emissions (i.e., CO2 equivalent tons), which also tends to be the focus of regulatory bodies. Accordingly, our final test is to examine the robustness of the

[6] The database is available at www.oecd.org/environment/tools-evaluation/environmentaltaxation.htm

baseline results to employing total carbon emissions as the dependent variable. For this test, we simply re-estimate Equation (1) with firm-level total carbon emissions as the dependent variable. These results are reported in Table 13 separately for US, EU and Asian firms for the first year of the M&A and for five years after. They show that M&As are associated with an increase in carbon emissions for firms in the US, EU and Asia, but that over the medium-term they only impact emissions by Asian firms, where the impact is to raise them. On the whole, the results are broadly similar to using carbon intensity as the dependent variable.

5. Conclusions

Firms in many countries have come under pressure from governments and stakeholders to find ways to minimize their carbon emissions. In this connection, M&As could play a supporting role by facilitating the transfer and sharing of technologies and capabilities specific to firm environmental performance. For example, acquirer firms might pursue cream skimming strategies and target firms with a view to replicating the target's environmental commitments, or turnaround strategies and target firms that have a poorer environmental performance because such may be cheaper, and the acquirer believes that a better environment performance can be achieved. Firm level studies of carbon emissions within the framework of M&As are relatively scarce, though there is some evidence that target firms are motivated by the environment performance of potential targets. In this paper, we extended this area of research by examining the relationship between M&As and firm-level carbon intensity in a large sample of firms from 84 countries over the period 2002-2020.

We find a number of important results. Most importantly, the carbon footprint of firms that have engaged in M&As only differs from that of firms that have not done so in the short term, with no discernible difference between them in the medium term. This result holds for both domestic and cross-border M&As. Accordingly, we find no evidence to support the view that the supposedly greater efficiency of acquirer firms stimulated innovative processes that reduced carbon intensity in either the acquirer or target firm country. We do find that the short-run impact of M&As on carbon intensity differs according to the industrial sector classification of the firms involved, where they are most harmful in the construction, manufacturing, mining, and transport and public utility

sectors, which are traditionally associated with higher firm-level carbon intensity, and that they reduced carbon intensity in the financial and real estate sectors. These effects do not seem to persevere over the medium term, however. Finally, an examination of M&As between targets and acquirer firms whose activities have the same or different UNEPFI-designated climate metrics (i.e., "brown" or "green") provided no evidence of acquirer firms seeking to benefit from target firms' better environment performance. Overall, our conclusion is that over the medium-term M&As are largely irrelevant for firm-level carbon intensity. This conclusion is robust to several tests, including controlling for the type of M&A (vertical or horizontal), the relative strengths of environmental regulation (as measured by environmental taxes) in acquirer firm and target firm countries, and to alternative measures of firms' carbon footprint.

Overall, therefore, our results paint a rather gloomy picture of the role of M&As in meeting countries' climate goals. They have the clear potential to assist in meeting these goals by bringing about a reduction in carbon intensity at the firm level through the transfer of appropriate technology between the firms involved. However, our results suggest that M&A activity in practice does little to aid in the achievement of those goals. Climate goals are more likely to be achieved if regulators and other firm stakeholders require acquirer firms at a minimum to make public the likely contribution to those goals of the M&A activity that they are proposing.

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Table 1
Variable definitions and descriptive statistics

		Descriptive statistics				
Variable	Definition	Obs.	Mean	STD	Minimum	Maximum
CO2_intensity	Ratio of carbon emission (tons) to total assets	40775	0.242	0.558	0.009	4.983
CO2 emissions	Logarithm of Total CO2 equivalent emission (tons)	40775	12.155	2.589	0.693	19.298
M&A	Dummy variable equal to 1 if a firm participated in an M&A and 0 otherwise	40775	0.641	0.480	0.000	1.000
DM&A	Dummy variable equal to 1 (0 otherwise) if the acquirer firm participated in a domestic M&A	40775	0.4383	0.4962	0.000	1.000
CBM&A	Dummy variable equal to 1 (0 otherwise) if the acquirer firm participated in a cross-border M&A	40775	0.2032	0.4024	0.000	1.000
BBM&A	A dummy variable equal to 1 (0 otherwise) both the acquirer and target firms are in the Brown industrial category classified by UNEPFI	40775	0.1865	0.3895	0.000	1.000
BGM&A	A dummy variable equal to 1 (0 otherwise) if the acquirer firm belongs to the Brown industrial category and the target firm belongs to the Green industrial category as classified by UNEPFI	40775	0.0525	0.223	0.000	1.000
GGM&A	A dummy variable equal to 1 (0 otherwise) both the acquirer and target firms are in the Green industrial category classified by UNEPFI	40775	0.3058	0.4607	0.000	1.000
GBM&A	A dummy variable equal to 1 (0 otherwise) if the acquirer firm belongs to the Green industrial category and the target firm belongs to the Brown industrial category as classified by UNEPFI	40775	0.0964	0.2952	0.000	1.000
LTXREG	A dummy variable equal to 1 (0 otherwise) if the host country of the target firm has a lower environmental taxes than the acquirer country. industrial category and the target firm belongs to the Brown industrial category as classified by UNEPFI	40775	0.5503	0.4975	0.000	1.000
BSIZE	The total number of board members at the end of the accounting year	40775	12.3239	3.2317	3.000	41.000
BINDEP	Ratio of independent board members as reported by the firm	40775	0.6542	0.2529	0.000	1.000
BSKILL	Ratio of board members who have either an industry specific background or a strong financial background	40775	0.0767	0.0389	0.000	0.3225
DUAL	A dummy variable equal to 1 (0 otherwise) if the firm CEO is also the Chairperson	40775	0.9066	0.2911	0.000	1.000
LEVERAGE	Ratio debt to total assets	40775	0.331	0.211	0.000	2.968
LIQUIDITY	Ratio of cash flow to total sales: funds from operations is divided by total Sales	40775	0.1996	0.1545	0.0101	0.8959
CAPEXP	Ratio of total funds used by a company to acquire, upgrade, and maintain physical assets such as property, plants, buildings, technology, or equipment to total assets	40775	0.0585	0.0769	0.000	0.7499
ROE	Ratio of Return on equity: net Income divided by average of previous and current year's common equity	40775	0.1270	0.1706	-0.5651	0.8175
CFUNDS	Average cost of existing external funding defined as: interest expense on Debt divided by the sum of short-term debt, the current portion of long-term debt, and long-term debt	40775	0.060	0.067	0.000	0.997
INFLATION	Annual percent change in the acquirer country consumer price index		2.190	1.972	-2.983	44.964
GDP GROWTH	Annual percent change in real GDP growth of the acquirer country.		2.246	2.376	-11.325	24.370

Data are annual for the period 2002-2022 and are from Thompson Reuters Eikon.

Table 2
Firm and M&A sample by year, SIC code and geographic region

	Panel A: Firm and M&A year distribution		Panel B: SIC 1 digit code			Panel C: Regional composition		
Year	No. of firms	No. of M&As	SIC sector	No. of firms	No. of M&As	Region	No. of firms	No. of M&As
2002	2298	1945	1	118	38	USA	10642	5752
2003	2303	1963	2	1537	787	EU	10133	4851
2004	1756	1423	3	8772	2833	Asia	3982	3395
2005	1544	1086	4	14043	5019	Other	2755	1677
2006	1986	1426	5	2430	1109			
2007	2019	1389	6	2180	967			
2008	2056	1571	7	6300	1694			
2009	1220	1140	8	6351	2918			
2010	1904	1540	9	1456	310			
2011	2940	1921						
2012	2501	1691						
2013	2648	2145						
2014	3248	2224						
2015	2922	1807						
2016	2471	1770						
2017	2632	1772						
2018	2703	1795						
2019	2300	1724						
2020	1736	1507						

SIC sectors are (1) Agriculture, Forestry and Fishing; (2) Construction; (3) Finance, Insurance and Real Estate; (4) Manufacturing; (5) Mining; (6) Retail Trade; (7) Services; (8) Transport and Public Utilities; and (9) Wholesale Trade.

Table 3
Descriptive statistics for firm-level carbon emission intensity

Panel A. By sector	Obs.	Mean	STD	Minimum	Maximum
Agriculture, forestry and fishing	440	0.227	0.323	0.026	2.391
Construction	1485	0.122	0.277	0.009	3.072
Finance, insurance and real estate	7342	0.030	0.105	0.009	2.679
Manufacturing	13532	0.279	0.580	0.009	4.797
Mining	2397	0.493	0.723	0.009	4.983
Retail trade	2274	0.108	0.222	0.009	3.264
Services	5818	0.057	0.170	0.009	4.494
Transport and public utilities	6062	0.589	0.852	0.009	4.899
Wholesale trade	1425	0.246	0.580	0.009	4.837
Total	40775	0.242	0.558	0.009	4.983
Panel B. By geographic region					
All countries	40775	0.242	0.558	0.009	4.983
USA	15314	0.174	0.477	0.009	4.983
EU	14021	0.259	0.580	0.009	4.899
Asia	6667	0.324	0.650	0.009	4.837
Other	4773	0.254	0.565	0.009	4.829

Carbon emission intensity is measured as the ratio of carbon emissions to total assets. Data are annual and are from Thompson Reuters Eikon.

Table 4
Correlation matrix

		1	2	3	4	5	6	7	8	9	10	11
1	CO2_intensity	1.000										
2	M&A	-0.068***	1.000									
3	BSIZE	0.044***	0.088***	1.000								
4	BINDEP	-0.027***	0.043***	0.205***	1.000							
5	BSKILL	-0.034***	0.002	-0.033***	0.168***	1.000						
6	DUAL	-0.029***	-0.014**	-0.067***	0.209***	0.126***	1.000					
7	LEVERAGE	0.022***	-0.112***	-0.048***	-0.054***	-0.064***	0.012	1.000				
8	LIQUIDITY	-0.058***	0.001	-0.029***	0.001	-0.019***	-0.014**	0.081***	1.000			
9	CAPEXP	0.134***	-0.068***	-0.109***	-0.009	-0.064***	-0.009	0.069***	0.205***	1.000		
10	ROE	-0.028***	0.118***	0.061***	0.009	0.063***	0.012	-0.045***	0.129***	-0.027***	1.000	
11	CFUNDS	0.034***	-0.013	-0.071***	0.074***	-0.028***	-0.001	-0.147***	-0.099***	-0.023***	-0.003	1.000

The table shows the correlation between independent and dependent variables. *** and ** denote significant correlation at the 1% and 5% levels. Variable definitions are in Table 1

Table 5
M&A activity and carbon emission intensity

	All firms	US firms	EU firms	Asian firms
M&A	0.015**	0.014***	0.027*	0.035
	(0.006)	(0.007)	(0.015)	(0.021)
BSIZE	-0.052***	-0.052*	-0.092**	-0.086
	(0.017)	(0.027)	(0.035)	(0.060)
BINDEP	-0.214***	-0.107***	-0.275***	-0.324***
	(0.021)	(0.030)	(0.041)	(0.074)
BSKILL	-0.815***	-0.687*	-0.635	0.152
	(0.286)	(0.393)	(0.632)	(1.009)
DUAL	-0.039**	-0.054***	0.011	-0.041
	(0.016)	(0.026)	(0.030)	(0.043)
LEVERAGE	0.029	0.038	-0.072	-0.106
	(0.020)	(0.024)	(0.050)	(0.051)
LIQUIDITY	-0.243***	-0.309***	-0.030	-0.388***
	(0.023)	(0.031)	(0.056)	(0.083)
CAPEXP	0.428***	0.179***	0.958***	1.271***
	(0.043)	(0.050)	(0.120)	(0.147)
ROE	0.029*	0.041**	0.048	-0.018
	(0.014)	(0.018)	(0.040)	(0.059)
CFUNDS	0.309***	0.279***	0.416***	0.211
	(0.047)	(0.048)	(0.141)	(0.271)
INFLATION	0.016***	0.016***	0.012***	0.017***
	(0.001)	(0.002)	(0.003)	(0.003)
GDP GROWTH	0.019***	0.011***	0.017***	0.029***
	(0.001)	(0.001)	(0.003)	(0.002)
INTERCEPT	0.4737***	0.467***	0.531***	0.228***
	(0.031)	(0.048)	(0.061)	(0.099)
FIRM FE	YES	YES	YES	YES
INDUSTRY FE	YES	YES	YES	YES
YEAR FE	YES	YES	YES	YES
OBS	40147	15314	14021	6667
R^2	0.020	0.008	0.029	0.030

The table presents panel regression results of M&As on firm-level carbon emission intensity. The dependent variable is the ratio of carbon emissions to total assets. Variables are as defined in Table 1. Robust standard errors are in parenthesis. ***, **, and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 6

M&A activity and carbon emission intensity by SIC sector

SIC category:	1	2	3	4	5	6	7	8	9
M&A	0.000	0.047**	-0.006***	0.021**	0.082*	-0.001	0.002	0.071**	0.056
	(0.024)	(0.019)	(0.002)	(0.010)	(0.045)	(0.004)	(0.005)	(0.032)	(0.042)
BSIZE	0.093	-0.049	0.015**	-0.061**	-0.339***	-0.010	-0.039**	-0.168	0.087
	(0.092)	(0.064)	(0.006)	(0.030)	(0.112)	(0.017)	(0.018	(0.107)	(0.082)
BINDEP	0.280	-0.190***	-0.030***	-0.147***	-0.663***	-0.109***	-0.049***	-0.513***	-0.031
	(0.219)	(0.059)	(0.010)	(0.034)	(0.131)	(0.015)	(0.018)	(0.108)	(0.069)
BSKILL	-1.254	1.475	-0.334***	-1.108**	1.994	-0.384	0.327	-2.942	1.752
	(1.053)	(0.900)	(0.103)	(0.489)	(2.090)	(0.252)	(0.266)	(1.922)	(1.435)
DUAL	0.001	-0.190***	-0.006	-0.138***	0.320***	-0.006	-0.115***	0.216***	-0.153***
	(0.075)	(0.059)	(0.007)	(0.030)	(0.100)	(0.013)	(0.014)	(0.074)	(0.058)
LEVERAGE	-0.035	-0.157*	-0.000	0.047	-0.095	-0.010	-0.015	-0.200	-0.120
	(0.133)	(0.090)	(0.008)	(0.035)	(0.111)	(0.013)	(0.014)	(0.128)	(0.112)
LIQUIDITY	1.446***	0.047	-0.006	0.127	-0.869***	-0.229***	-0.083***	-0.699***	0.412
	(0.485)	(0.104)	(0.005)	(0.085)	(0.127)	(0.041)	(0.026)	(0.155)	(0.352)
CAPEXP	-0.941**	-0.054	0.062***	1.285***	0.513***	0.343***	0.026	0.902***	1.601***
	(0.452)	(0.162)	(0.012)	(0.110)	(0.165)	(0.052)	(0.048)	(0.247)	(0.428)
ROE	-0.235*	-0.016	0.012**	0.039	0.005	0.022**	0.051***	0.224***	-0.190*
	(0.644)	(0.073)	(0.006)	(0.025)	(0.095)	(0.010)	(0.010)	(0.082)	(0.098)
CFUNDS	1.284**	0.476**	0.096***	0.724***	0.910**	0.070***	0.052**	0.794**	2.124***
	(0.644)	(0.206)	(0.025)	(0.086)	(0.377)	(0.026)	(0.023)	(0.334)	(0.503)
INTERCEPT	-0.217	0.356***	0.049***	0.597***	1.257***	0.223***	0.250***	1.350***	-0.051
	(0.175)	(0.085)	(0.012)	(0.050)	(0.167)	(0.022)	(0.027)	(0.145)	(0.112)
FIRM FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
COUNTRY FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
OBS	440	1481	7341	13407	2297	2073	5808	5972	1328
R^2	0.012	0.023	0.012	0.027	0.013	0.034	0.026	0.028	0.024

The table presents panel regression results of M&As on carbon emission intensity for firms in the SIC 1digit categories. The dependent variable is the ratio of carbon emissions to total assets The SIC categories are: (1) Agriculture, Forestry and Fishing; (2) Construction; (3) Finance, Insurance and Real Estate; (4) Manufacturing; (5) Mining; (6) Retail Trade; (7) Services; (8) Transport and Public Utilities; and (9) Wholesale Trade. Variables are as defined in Table 3. Robust standard errors are in parenthesis. ***, **, and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 7
Firm M&A activity and carbon emission intensity by firm UNEPFI category

	BBM&A	BGM&A	GGM&A	GBM&A
CRM&A	0.0518**	0.0360*	-0.0143*	-0.0130
	(0.0233)	(0.0185)	(0.0076)	(0.0140)
BSIZE	-0.0815	0.0978	-0.1468	-0.2723
	(0.1443)	(0.1046)	(0.2017)	(0.3243)
BINDEP	-0.3547***	-0.2205***	-0.1512***	-0.2120*
	(0.0939)	(0.0725)	(0.0514)	(0.1261)
BSKILL	-2.7078***	-1.6112***	-1.0825***	-1.9105**
	(0.6823)	(0.5097)	(0.4086)	(0.9488)
DUAL	0.0174	-0.2646*	-0.0929*	-0.0722
	(0.0949)	(0.1413)	(0.0495)	(0.0867)
LEVERAGE	-0.0050	0.1151	-0.1218**	0.3356**
	(0.1667)	(0.1148)	(0.0593)	(0.1596)
LIQUIDITY	0.0450	0.2386	-0.2330**	-0.0920
	(0.1637)	(0.1494)	(0.1070)	(0.0591)
CAPEXP	0.9053**	0.3528	0.4985	0.6473
	(0.4224)	(0.2161)	(0.3432)	(0.6169)
ROE	-0.0378	0.1158	0.0971	0.0472
	(0.1359)	(0.1192)	(0.0627)	(0.0875)
CFUNDS	0.5649*	0.7313***	0.1974	0.5835**
	(0.3082)	(0.2752)	(0.3936)	(0.2870)
INTERCEPT	0.8659**	0.3676	0.9102*	1.1810
	(0.3712)	(0.3005)	(0.5046)	(0.8549)
FIRM FE	YES	YES	YES	YES
INDUSTRY FE	YES	YES	YES	YES
OBS	7466	2098	12388	3860
R^2	0.033	0.029	0.019	0.018

The table presents panel regression results of the impact of M&As on firm-level carbon emission intensity according to combinations of firms by UNEPFI industrial category. The dependent variable is the ratio of carbon emissions to total assets. BBM&A denotes acquirer and target were both in the brown category; BGM&A denotes acquirer was in the brown category and the target in the green category; GGM&A denotes acquirer and target were both in the green category; GBM&A denotes acquirer was in the green category and the target in the brown category Variables are as defined in Table 1. Robust standard errors are in parenthesis. ***, **, and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 8
Domestic and cross-border M&A activity and carbon emission intensity

	All firms		US firms		EU firms		Asian firms	
DM&A	0.011***		0.014***		0.002		0.025	
	(0.005)		(0.006)		(0.011)		(0.017)	
CM&A		0.014*		-0.009		0.188***		0.031
		(0.008)		(0.008)		(0.013)		(0.026)
BSIZE	-0.052***	-0.089***	-0.051*	-0.060**	-0.094***	-0.081**	-0.086	-0.101
	(0.017)	(0.023)	(0.027)	(0.029)	(0.035)	(0.036)	(0.060)	(0.084)
BINDEP	-0.214***	-0.229***	-0.106***	-0.101***	-0.278***	-0.278***	-0.324***	-0.355***
	(0.021)	(0.027)	(0.030)	(0.033)	(0.042)	(0.043)	(0.074)	(0.098)
BSKILL	-0.821***	-0.548***	-0.692*	-0.990***	-0.565	-0.572	0.106	0.647
	(0.287)	(0.374)	(0.393)	(0.502)	(0.646)	(0.680)	(1.009)	(1.505)
DUAL	-0.039**	-0.031	-0.055***	-0.062**	-0.013	-0.043	-0.042	-0.014
	(0.017)	(0.021)	(0.026)	(0.029)	(0.030)	(0.026)	(0.043)	(0.068)
LEVERAGE	-0.027	-0.010	-0.036	-0.003	-0.086*	0.013	-0.111	-0.355***
	(0.020)	(0.026)	(0.024)	(0.027)	(0.051)	(0.050)	(0.089)	(0.115)
LIQUIDITY	-0.242***	-0.200***	-0.308***	-0.313***	0.039	-0.061	-0.386***	-0.263**
	(0.024)	(0.032)	(0.031)	(0.033)	(0.056)	(0.057)	(0.083)	(0.108)
CAPEXP	0.427***	0.603***	0.179***	0.954***	0.179***	1.024***	1.263***	2.064***
	(0.043)	(0.056)	(0.051)	(0.121)	(0.051)	(0.123)	(0.147)	(0.016)
ROE	0.031***	0.072***	0.042***	-0.039*	-0.055	0.050	-0.016	0.228***
	(0.015)	(0.019)	(0.019)	(0.023)	(0.040)	(0.038)	(0.060)	(0.075)
CFUNDS	0.308***	0.456***	0.278***	0.297**	0.410***	0.439***	0.197	-0.076
	(0.047)	(0.062)	(0.049)	(0.017)	(0.141)	(0.145)	(0.271)	(0.349)
INFLATION	0.016***	0.016***	0.016***	0.017***	0.120***	0.023***	0.009*	0.009*
	(0.002)	(0.002)	(0.003)	(0.003)	(0.0035)	(0.004)	(0.004)	(0.004)
GDP GROWTH	0.008***	0.023***	0.011***	0.013***	0.017***	0.020***	0.030***	0.033***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.001)
INTERCEPT	0.478***	0.506***	0.469***	0.626***	0.545***	0.423***	0.040**	0.099
	(0.031)	(0.040)	(0.049)	(0.051)	(0.061)	(0.062)	(0.098)	(0.129)
FIRM FE	YES	YES	YES	YES	YES	YES	YES	YES
INDUSTRY FE	YES	YES	YES	YES	YES	YES	YES	YES
YEAR FE	YES	YES	YES	YES	YES	YES	YES	YES
OBS	40147	40147	15314	15314	14021	14021	6667	6667
R^2	0.021	0.019	0.009	0.009	0.030	0.033	0.030	0.031

The table presents panel regression results of domestic and cross-border M&As on firm-level carbon emission intensity. The dependent variable is the ratio of carbon emissions to total assets. Variables are as defined in Table 1. Robust standard errors are in parenthesis. ***, **, and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 9
M&A activity and carbon emission intensity—five years post-M&A

	All firms	US firms	EU firms	Asian firms
M&A	-0.012	-0.059*	0.002	0.005
	(0.018)	(0.031)	(0.019)	(0.026)
BSIZE	0.012	0.088	-0.007	0.045
	(0.047)	(0.112)	(0.036)	(0.087)
BINDEP	-0.112**	-0.021	-0.048	-0.015
	(0.057)	(0.107)	(0.054)	(0.102)
BSKILL	-0.566	-2.062	-0.032	-0.746
	(0.751)	(1.540)	(0.659)	(1.244)
DUAL	-0.026	-0.208**	-0.020	-0.019
	(0.051)	(0.102)	(0.043)	(0.073)
LEVERAGE	0.278***	0.391***	0.018	0.116
	(0.051)	(0.090)	(0.062)	(0.126)
LIQUIDITY	-0.157*	-0.380***	-0.066	0.060
	(0.922)	(0.142)	(0.073)	(0.105)
CAPEXP	-0.089	-0.083	0.164	0.194
	(0.111)	(0.175)	(0.158)	(0.171)
ROE	-0.067	-0.101	-0.092	-0.120
	(0.050)	(0.078)	(0.049)	(0.086)
CFUNDS	0.014	-0.050	0.261	0.616*
	(0.152)	(0.242)	(0.265)	(0.370)
INFLATION	0.014***	0.019**	0.021***	0.003
	(0.005)	(0.010)	(0.006)	(0.003)
GDP GROWTH	-0.005	0.003	-0.004	-0.003
	(0.004)	(0.009)	(0.004)	(0.003)
INTERCEPT	0.407***	0.499***	0.269***	0.084
	(0.087)	(0.179)	(0.077)	(0.148)
FIRM FE	YES	YES	YES	YES
INDUSTRY FE	YES	YES	YES	YES
YEAR FE	YES	YES	YES	YES
OBS	17,922	7,304	5,725	2,961
R^2	0.021	0.043	0.022	0.009

The table presents panel regression results of M&As on firm-level carbon emission intensity five years after the M&A took place. The dependent variable is the ratio of carbon emissions to total assets. Variables are as defined in Table 1. Robust standard errors are in parenthesis. ***, **, and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 10
Domestic and cross-border M&A activity and carbon emission intensity—five years post-M&A

	All firms		US firms		EU firms		Asian firms	
DM&A	-0.028		-0.043		-0.019		-0.030	
	(0.018)		(0.030)		(0.017)		(0.026)	
CM&A		0.033		-0.024		0.030		0.050
		(0.023)		(0.032)		(0.021)		(0.032)
BSIZE	0.013	0.011	0.084	0.092	-0.006	-0.006	0.049	0.045
	(0.047)	(0.047)	(0.112)	(0.081)	(0.036)	(0.036)	(0.087)	(0.087)
BINDEP	-0.111*	-0.114**	-0.020	-0.053	-0.047	-0.049	-0.013	-0.009
	(0.056)	(0.056)	(0.107)	(0.081)	(0.054)	(0.054)	().102)	(0.102)
BSKILL	-0.580	-0.543	-2.008	-2.064*	-0.030	-0.034	-0.795	-0.736
	(0.750)	(0.751)	(1.543)	(1.113)	(0.659)	(0.658)	(1.243)	(1.240)
DUAL	-0.026	-0.024	-0.202**	-0.185**	-0.022	-0.018	-0.018	-0.013
	(0.051)	(0.051)	(0.102)	(0.084)	(0.043)	(0.043)	((0.072)	(0.072)
LEVERAGE	0.275***	0.287***	0.404***	0.307***	0.012	0.022	0.116	0.116
	(0.061)	(0.061)	(0.090)	(0.066)	(0.062)	(0.061)	(0.126)	(0.126)
LIQUIDITY	-0.152*	-0.154*	-0.379***	-0.373***	-0.063	-0.063	0.080	0.066
	(0.092)	(0.092)	(0.142)	(0.108)	(0.073)	(0.073)	(0.105)	(0.104)
CAPEXP	-0.088	-0.080	-0.081	0.014	0.166	0.171	0.204	0.202
	(0.111)	(0.111)	(0.175)	(0.130)	(0.158)	(0.158)	(0.171)	(0.171)
ROE	-0.065	-0.074	-0.107	-0.065	-0.088*	-0.095*	-0.117	-0.122
	(0.050)	(0.049)	(0.078)	(0.059)	(0.049)	(0.049)	(0.086)	(0.086)
CFUNDS	0.147	0.147	-0.049	0.074	0.261	0.283	0.620*	0.639*
	(0.152)	(0.152)	(0.242)	(0.175)	(0.265)	(0.265)	(0.370)	(0.370)
INFLATION	0.014***	0.014**	0.018	0.013	0.020***	0.020***	0.003	0.003
	(0.005)	(0.005)	(0.011)	(0.008)	(0.006)	(0.006)	(0.003)	(0.003)
GDP GROWTH	-0.004	-0.005	0.003	0.001	-0.003	-0.003	-0.002	-0.003
	(0.004)	(0.004)	(0.009)	(0.007)	(0.004)	(0.004)	(0.003)	(0.003)
INTERCEPT	0.408***	0.392***	0.470***	0.410***	0.277***	0.259***	0.084	0.067
	(0.087)	(0.087)	(0.179)	(0.135)	(0.076)	(0.076)	(0.148)	(0.148)
FIRM FE	YES	YES	YES	YES	YES	YES	YES	YES
INDUSTRY FE	YES	YES	YES	YES	YES	YES	YES	YES
YEAR FE	YES	YES	YES	YES	YES	YES	YES	YES
OBS	17,922	17,922	7,304	7,304	5,725	5,725	2,961	2,961
R^2	0.023	0.020	0.039	0.032	0.023	0.022	0.007	0.009

The table presents panel regression results of domestic and cross-border M&As on firm-level carbon emission intensity five years after the M&A took place. The dependent variable is the ratio of carbon emissions to total assets. Variables are as defined in Table 1. Robust standard errors are in parenthesis. ***, **, and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 11
Domestic and cross-border M&A activity and carbon emission intensity one and five years after the M&A—the roles of vertical and horizontal M&As

	One year				Five years			
a. US firms								
DM&A	0.017***	0.016***			-0.043	-0.029		
	(0.006)	(0.006)			(0.027)	(0.018)		
CM&A			-0.003	-0.005			0.043	0.036
			(0.008)	(0.008)			(0.027)	(0.024)
VM&A	-0.002		0.005		-0.018		-0.018	
	(0.007)		(0.006)		(0.020)		(0.022)	
HM&A		-0.004		-0.008		-0.002		0.012
		(0.006)		(0.006)		(0.020)		(0.020)
INTERCEPT	0.531***	0.534***	0.538***	0.546***	0.480***	0.405***	0.437***	0.384***
	(0.054)	(0.054)	(0.054)	(0.054)	(0.127)	(0.087)	(0.127)	(0.089)
OBS	15012	15012	15012	15012				
R^2	0.006	0.006	0.006	0.006	0.024	0.023	0.024	0.020
b. EU firms								
DM&A	-0.008	0.005			-0.030	-0.020		
	(0.012)	(0.009)			(0.024)	(0.018)		
CM&A			0.016	0.021			0.029	0.030
			(0.013)	(0.013)			(0.024)	(0.021)
VM&A	0.024**		0.023*		-0.001		-0.001	
	(0.012)		(0.012)		(0.023)		(0.023)	
HM&A		0.017*		0.017		-0.008		0.002
		(0.010)		(0.012)		(0.020)		(0.019)
INTERCEPT	0.486***	0.522***	0.480***	0.472***	0.240**	0.274***	0.210*	0.258***
	(0.063)	(0.052)	(0.063)	(0.063)	(0.120)	(0.078)	(0.111)	(0.077)
OBS	13298	13271	13220	13193				
R^2	0.031	0.031	0.031	0.038	0.025	0.021	0.025	0.022

Notes: The table presents panel regression results of domestic and cross-border M&As on firm-level carbon emission intensity after one and five years according to whether the M&A was vertical (VM&A) or horizontal HM&A) in nature. The dependent variable is the ratio of carbon emissions to total assets. Variables are as defined in Table 1. All estimates include the firm-specific characteristics macroeconomic controls as in the estimates in Tables 5 and 6. As well as firm-, industry-, and year fixed effects.

Table 12
M&A activity and carbon emission intensity: the role of lower environmental taxes in the target firm's country five years post-M&A

	US firms		EU firms		Asian firms	
	1-year M&A	5-year M&A	1-year M&A	5-year M&A	1-year M&A	5-year M&A
CBM&A	-0.003	0.023	0.007	0.027	0.026	0.053
	(0.008)	(0.043)	(0.010)	(0.021)	(0.026)	(0.033)
LTXREG	0.012	-0.030	-0.021**	0.019	0.026	-0.009
	(0.007)	(0.028)	(0.010)	(0.017)	(0.023)	(0.030)
INTERCEPT	0.534***	0.396**	0.559***	0.258***	0.106	0.066
	(0.054)	(0.175)	(0.053)	(0.076)	(0.127)	(0.148)
OBS	15012	7,304	13198	5,725	6667	2,961
R^2	0.006	0.030	0.036	0.012	0.031	0.009

Notes: The table presents panel regression results of cross-border M&As on firm-level carbon emission intensity according to whether the host country of the target firm had lower environmental taxes for 1-year and 5 years after the M&A took place. The dependent variable is the ratio of carbon emissions to total assets. Variables are as defined in Table 1. All estimates include the firm-specific characteristics macroeconomic controls as in the estimates in Tables 5 and 6. As well as firm-, industry-, and year fixed effects.

Table 13
M&A activity and total carbon emissions in one and five years—alternative dependent variable

	First year of M&A			Five years after M&A		
	US firms	EU firms	Asian firms	US firms	EU firms	Asian firms
M&A	0.055*	0.101*	0.708***	0.087	0.203	0.834***
	(0.030))	(0.046)	(0.056)	(0.089)	(0.128)	(0.188)
BSIZE	-0.034	0.106	0.195**	0.002	0.287	0.316
	(0.054)	(0.091)	(0.086)	(0.225)	(0.217)	(0.296)
BINDEP	0.200**	0.378***	-1.267***	0.240	0.676**	-0.326
	(0.087)	(0.087)	(0.127)	(0.287)	(0.266)	(0.409)
BSKILL	1.743**	-1.836	-1.801	1.216	-7.604**	-1.159
	(0.771)	(1.497)	(1.213)	(2.729)	(3.476)	(3.226)
DUAL	-0.564***	-0.599***	-0.134	-0.541*	-1.115***	-0.971***
	(0.068)	(0.063)	(0.118)	(0.277)	(0.224)	(0.364)
LEVERAGE	0.622***	-0.368***	-0.823***	0.668***	-0.344	-2.148***
	(0.068)	(0.105)	(0.204)	(0.190)	(0.314)	(0.570)
LIQUIDITY	-1.952***	-2.099***	-1.831***	-2.017***	-2.177***	
	(0.107)	(0.182)	(0.219)	(0.308)	(0.614)	15314
CAPEXP	2.614***	6.728***	5.239	2.653***	6.872***	6.627***
	(0.196)	(0.443)	(0.542)	(0.563)	(1.119)	(1.575)
ROE	0.726***	0.149	0.108	0.392**	0.412	-0.010
	(0.073)	(0.098)	(0.180)	(0.193)	(0.275)	(0.569)
CFUNDS	0.208	-1.415*	1.622**	-0.422	-1.324	2.174
	(0.152)	(0.027)	(0.635)	(0.587)	(1.389)	(2.396)
INFLATION	0.023**	0.104***	-0.420***	0.011	0.057*	-0.039*
	(0.010)	(0.010)	(0.007)	(0.017)	(0.033)	(0.019)
GDP GROWTH	-0.016**	-0.002	-0.005	0.013	-0.048*	-0.080***
	(0.007)	(0.009)	(0.008)	(0.029)	(0.024)	(0.027)
INTERCEPT	10.915***	12.027***	13.084***	11.068***	13.138***	13.937***
	(0.121)	(0.038)	(0.198)	(0.453)	(0.367)	(0.635)
FIRM FE	YES	YES	YES	YES	YES	YES
INDUSTRY FE	YES	YES	YES	YES	YES	YES
YEAR FE	YES	YES	YES	YES	YES	YES
OBS	15314	14021	6667	7,304	5,725	2,961
R^2	0.064	0.078	0.122	0.062	0.099	0.214

The table presents panel regression results of M&As on total firm-level carbon emissions. The dependent variable is tons of carbon emissions. Variables are as defined in Table 1. Robust standard errors are in parenthesis. ***, **, and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.