Carbon emissions and firm financial performance:

A comparison between European family and non-family firms

Halit Gonenc* and Atiqa Rehman

University of Groningen

Abstract

This study investigates the differences in the effect of carbon emission levels on firm financial performance between family and non-family firms. Our sample consists of a total 3,633 firm-year observations including 963 observations of family and 2,670 observations of non-family firms from 13 Western European countries for the period 2010-2020. We emphasize the nonlinear effect of family ownership on the relationship between carbon emissions and the firm performance because of two aspects of socioemotional wealth (SEW) approach of family owners' interest depending on the short-term and long-term horizons. We find an inverse U-shaped relationship between carbon emissions and Tobin's Q with family ownership especially after the Paris agreement in 2015 when we observed a dramatic decrease, on average, in sample firms' carbon emissions. Specifically, for family firms with low levels of carbon emissions stock market-related performance decreases at low levels of family ownership and increases at high levels of family ownership. This evidence indicates increasing environmental concerns by controlling family owners with high ownership stakes to create long-term SEW value. The results are robust to alternative estimations based on the matched samples.

Keywords: carbon emissions, financial performance, family control, family ownership

*Halit Gonenc (h.gonenc@rug.nl), corresponding author. Department of Economics, Econometrics and Finance, Faculty of Economics and Business University of Groningen, Nettelbosje 2, 9747 AE Groningen, the Netherlands

1. Introduction

Efforts to reduce greenhouse gas (GHG), mostly in the form of CO2 (carbon) emissions, emitted into the atmosphere to prevent climate change have emerged after significant global corporate challenges especially with the Paris agreement in 2015. If corporations investing in reducing carbon emissions can improve their financial performance, they will be more motivated to focus on long-term goals. However, we do not know much about firm-level motivating factors that would lead to significant cross-sectional relationships between financial performance and carbon emission levels to achieve a sustainable environment in the near future. One important factor is to have a long-term vision for addressing environmental concerns. Family ownership provides an important framework in identification the role of short-term vision versus long-term vision in explaining the relationship between carbon emissions and financial performance.

In the literature, the socioemotional wealth (SEW) describes the nonfinancial aspects (also referred to as affective endowments) that shape controlling owners' strategic preferences in firms controlled by families. According to the review of Swab et al. (2020), SEW approach, which has been applied to varieties of topics to identify the non-financial benefits and costs of the control of families, is multi-dimensional. Gu et al. (2019) emphasize that time horizon dimensions of SEW differentiates family interests that are expected to last in either short-term or long-term (Table 1, page 650). One of the main differences between short and long-term interests by family owners is about adopting a conservative investment approach. Controlling owners with short-term interest try to avoid uncertain and long-term investments while long-term interests of controlling owners support environmental and social oriented projects that will not be liquidated for long terms (Gu et al., 2019).

Harming the natural environment should have negative consequences for firms' long-term financial performance, which indicates a negative image of a firm's contribution to climate change challenges. In their study with a meta-analysis for the period 1997-2019, Galama and

Scholtens (2022) show a negative relationship between corporate carbon emissions and financial performance. The authors conclude that if firms do not utilize their resources sustainably in carbon mitigation strategies, such as green technology innovation (Aboelmaged and Hashem, 2019), green process adoption, and green product development (Wang et al., 2021), they will hurt their financial performance.

The natural resource-based view by Hart (1995) suggests that businesses can gain a competitive advantage by utilizing resources and capabilities for environmental sustainability including preventing pollution, which can serve as a source of competitive advantage through improved stakeholder relations. Emission reduction can only be possible with enhancing efficiency in production processes created by innovative technologies. During the implementation of strategies for pollution prevention to reduce carbon emissions, firms could increase production costs to decrease environmental damage in the short-term, but increase the value in the long-term by strengthening a firm's competitive advantage.

In line with the arguments of the natural resource-based, firms that are not willing to implement pollution prevention strategies can avoid high costs in the short-term, but they could also miss opportunities to benefit in the long-term. We propose significant differences between non-family and family firms depending on the level of family ownership. Family businesses differ from non-family businesses not only in terms of ownership structure but also in terms of strategic behaviour (De Massis et al., 2021; Yu et al., 2020; Jiang et al., 2018) and decisions (Cennamo et al., 2012), such as those related to the environment (Doluca et al., 2018). Even though family firms give considerable importance to the non-financial aspects, the relationship between family ownership and financial performance plays a critical role in the impact of non-financial policies on financial performance across family firms. In our analysis, we take into account low and high levels of family control as an identification strategy for short- and long-term interests of family owners, and investigate how differences in family firms' preferences

for SEW can structure the relationship between carbon emission levels and their financial performances.

We argue that at lower levels of family ownership, family owners follow short-term incentives of SEW value instead of considering long-term SEW benefits to deal with carbon mitigation practices. As a result, family owners may hesitate to invest in carbon emission practices (Miroshnychenko et al., 2022; Fan et al., 2021), such as the acquisition or development of less carbon-intensive technologies and processes and R&D to produce goods and services with low carbon emissions. Consequently, at lower levels of family ownership we expect that the relationship between carbon emissions and financial performance would be positive, which indicates a weak link between efforts to reduce carbon emissions and financial performance.

In contrast, we expect that family owners' desire to pursue long-term SEW as family ownership increases (Swab et al., 2020). Thus, family firms' long-term orientation, desire to pass the business on to their descendants and to preserve their family image and reputation persuade them to participate in carbon emission reduction strategies. Consequently, a family firm participation in carbon emissions mitigation demonstrates a positive image of the firm's contribution to addressing climate change challenges. In this way, investment in the natural environment helps the firm gain a competitive advantage and has positive consequences for its financial performance (Miroshnychenko et al., 2017), thus strengthening the negative relationship between carbon emissions and financial performance.

In 2015, at the 21st Conference of Parties (COP21) by the United Nations Framework Convention on Climate Change (UNFCCC), 197 nations around the globe adopted the Paris Agreement, which laid out a global action plan to protect the world from dangerous climate change effects by limiting global temperatures from rising beyond 1.5°/2°C before the end of the century. Countries and organizations from all over the world seek to reduce global carbon

emissions by 45% and 55%, respectively, by 2030 to reach this goal. Europe, in particular, has increased its efforts and announced its recent EU action plan "Financing Sustainable Growth" in the context of climate change, in addition to the established policies such as the EU Emissions Trading System (EU ETS) (European Commission, 2021). Therefore, we expect to observe our findings to be strong in the post Paris agreement period after 2015. Evidence for a negative and significant effect of the level of carbon emissions on firm financial performance suggests that companies with high emissions have poor performance, but it also implies that firms with low emission levels manage to increase financial performance.

We conduct our study on a sample of 3,633 firm-year observations including 963 observations of family and 2,670 are from non-family firms, representing 703 firms in total from 13 Western European countries for the sample period 2010-2019. Concentrated family ownership is a dominant (Faccio and Lang, 2002) and stable (Croci et al., 2011) ownership structure in Europe, which provides an ideal setting for our analysis. We find that family ownership creates an inverse U-shaped relationship between carbon emission and financial performance, but this relationship holds in the sample period after 2015. More specifically, our analysis shows that at a lower level of family control, family ownership is associated a positive relationship between carbon emissions and firm performance, supporting the argument that at a low level of ownership, family firms are short-term interest of SEW preservation. Thus, they enjoy their high-level financial performance with high carbon emissions or have a low financial performance with less carbon mitigation activities. However, a higher level of family ownership strengthens the negative relationship between carbon emissions and firm performance. Our findings suggest that, as the level of family control increases, the family firm’s preferences for long-term orientation, image, and identification increase. These family firm characteristics motivate them to invest more in pollution prevention strategies and to maintain sustainable development (Craig and Dibrell, 2006). As a result, these natural resource investments increase

family firms' competitive advantage and result in higher financial performance than that of non-family firms.

Our research contributes to the related literature in a number of ways. First, our study adds to the existing discussion on the moderating role of family ownership in the link between company environmental sustainability and financial performance. Our focus is on climate change with one specific operational performance component. We measure corporate carbon performance, which is the relationship between a company's level of CO2 emissions and financial performance in an international context for the period 2010-2020. Our study differs from that of Garcés-Ayerbe et al. (2022), who focus on the moderating role of the overall construct of environmental and financial performance in a single country for the period from 2008 to 2016. Thus, we extend the recent literature on when it pays to be green (Orsato, 2006; Ambec and Lanoie, 2008; Dixon-Fowler et al., 2013; Ghisetti and Rennings, 2014; Garcés-Ayerbe et al., 2022) by highlighting the need to consider moderating variables that could affect the relationship between carbon emissions and financial performance (Grewatsch and Kleindienst, 2017). Second, our research contends that the moderating effect of family ownership is non-linear rather than linear because of differences in short-term and long-term visions. On the one hand, low family ownership is related to the shirt-term vision, which creates a weak link between financial performance and carbon emissions, on the other and, high family ownership is related to the long-term vision, which strengthens the relationship between carbon emissions and firm performance.

The remainder of this paper is organized as follows: In Section 2, we review the related literature and develop our hypotheses. We discuss our data and methodology in Section 3. Section 4 contains the results of the empirical analysis, and Section 5 concludes the paper.

2. Literature review and hypothesis development

2.1. Carbon emissions and financial performance

Previous studies have examined the relationship between carbon emissions and corporate financial performance and show the negative relationship between them (e.g., Galama and Scholtens, 2022; Brouwers et al., 2018; Manrique and Martí-Ballester, 2017; Delmas et al., 2015; Fujii et al., 2013). Some schools of thought argue that carbon emission mitigation is positively related to financial performance (Bush et al., 2022; Garzón-Jiménez and Zorio-Grima, 2021; Nichita et al., 2021; Ganda and Milondzo, 2018; Busch & Lewandowski, 2018; Baboukardos, 2017; Lewandowski, 2015; Busch and Hoffmann, 2011; Kuo et al., 2010).

Lewandowski (2017) and Delmas et al. (2015) argue that carbon emission reduction requires investment, which raises the firm's operating costs and reduces the generation of cash flows, thereby weakening its financial performance (Brouwers et al., 2018). Furthermore, Busch and Lewandowski (2018) conducted a meta-analysis with an explicit focus on the relationship between firms' GHG emissions and financial performance and found an inverse relationship between carbon emissions and financial performance. More recently, Galama and Scholtens (2022) conducted a meta-analysis of international studies from 1997 to 2019 and found a negative relationship between corporate carbon emissions and financial performance. They argue that firms do not utilize their resources sustainably in carbon mitigation strategies, such as green technology innovation (Aboelmaged and Hashem, 2019), green process adoption, and green product development (Wang et al., 2021), and demonstrate a negative image of a firm’s contribution to climate change challenges. Thus, the degradation of the natural environment has negative consequences for firms’ long-term financial performance.

The natural resource-based view (NRBV) by Hart (1995) proposes that businesses can gain a competitive advantage by utilizing resources and capabilities for environmental sustainability. Hart (1995) focuses on three interconnected capabilities: pollution prevention,

product management, and sustainable development, which can serve as a source of competitive advantage through cost savings, competitor anticipation, and improved stakeholder relations. Several authors argue that through the implementation of environmental strategies, such as GHG emissions reduction, pollution prevention, water purification, waste management, recycling, integration of environmental management, and efficient production processes, firms decrease environmental damage, reduce production costs, and increase firm value (Duque-Grisales et al., 2020; Gatimbu et al., 2018; Clarkson et al., 2011).

In particular, Kuo et al. (2010) report a positive link between GHG emission reduction and firms' financial performance and associate it with eco-efficiency to support the NRBV. The authors argue that firms achieve productivity gains through reduction in material consumption, enhanced production techniques, and waste utilization, which in turn enhance business operational efficiency (Kuo et al., 2010), which in turn can strengthen a firm's competitive advantage and financial benefits.

The above literature states that most studies support the negative relationship between carbon emissions and firms' financial performance. According to the natural resource-based perspective, we contend that enterprises that employ sustainable resources in carbon mitigation strategies are able to gain a competitive edge, which implies an increase in financial performance as carbon emissions decreases. Thus, our first hypothesis as follows.

H1: Carbon emissions have a negative effect on financial performance.

2.2 Family firms, carbon emissions and financial performance: SEW and NRBV

One of these conditions that can motivate firms to perform according to the view of the natural resource-based could be time horizon to understand the importance of addressing to environmental concerns. According to the socioemotional wealth (SEW) perspective, family firms have distinguishing characteristics, such as accumulation of intangible values and reputation, or generation of trust with stakeholders (Neubaum et al. 2012). These characteristics

explain why family businesses, in particular, may be concerned with preserving the natural environment for future generations if they view investment in the natural environment as a long-term vision with longer payback periods.

2.2.1. Low family ownership and SEW perspective

At a lower level of family ownership, family firms have short-term vision and less preference for long-term SEW preservation. Thus, family owners might not see the long-term benefits of pollution prevention strategies, and instead prefer to shift firm resources to activities with short-term benefits, which results in underinvestment in pollution prevention activities (Cordeiro and Sarkis, 1997). They are less likely to invest significant amounts of resources in green innovation, because the payoffs associated with these investments are comparatively uncertain (Huang et al., 2016; Samara et al., 2018). As a result, at a low level of ownership, family firms place less emphasis on environmental sustainability practices (Miroshnychenko et al., 2022) to gain short-term financial benefits (Kang et al., 2016; Cordeiro and Sarkis, 1997).

Fan et al. (2018) report that family firms invest less in pollution prevention strategies, which refers to "the use of materials, processes, or practices that reduce or eliminate the creation of pollutants or wastes at the source" (Freeman et al., 1992, p.619) than non-family firms, because they view investment in environmental sustainability as a net cost (Kim et al., 2017). The main reason is that investment in waste reduction and disposal may impose cost burdens on firms' operating costs; and therefore, such investments reduce firm short-term profits. Thus, at lower level of family ownership, we speculate that family owner's association with the family will be less, and as a result, family owners may be hesitant to invest in sustainable practices (Miroshnychenko et al., 2022). As a result, at low level of control family firms low investments in carbon emissions have negative consequences on their financial performance. Thus, we hypothesize.

H2a: The negative effect of carbon emissions on financial performance is weaker at lower levels of family ownership.

2.2.2. High family ownership and SEW perspective

The importance of preserving family control and influence increases as the family ownership percentage increases. At a high level of family ownership, family firms have a long-term orientation, because their goal is to transfer firm ownership to future generations. This long-term orientation may manifest itself in strategic goals such as achieving personal identification, positive family image, reputation and prestige, the pursuit of legitimacy (Broccardo et al., 2019) when making investment decisions, and focusing on accumulating affective endowments and social capital (Dyer & Whetten, 2006; Berrone et al., 2010; Campopiano et al., 2019). Thus, family firms' long-term orientation have strong preferences for SEW preservation, and desire to perpetuate ownership to their descendants persuade family owners. Family owners become more responsive to environmental demands and adopt environmentally friendly policies (Binz et al., 2017; Kim et al., 2017; Craig & Dibrell, 2006), invest in more environmental innovation projects (Huang et al., 2009; Classen et al., 2014; De Massis et al., 2016 ; Duran et al., 2016; Doluca et al., 2018), and implement green investment initiatives (Dangelico et al., 2019). In this way, family businesses fully utilize their organizational resources and capabilities, resulting in improved market share, product quality, customer satisfaction, operational performance, and long-term economic and financial success (Bauweraerts et al., 2022; Miroshnychenko et al., 2017; Craig and Dibrell, 2006; Huang and Li, 2017; Zhang et al., 2020;).

Berrone, et al. (2010) report that family firms pollute less than non-family firms, and implement pollution prevention practices, such as waste and emissions reduction in their operations (Nishitani et al., 2011), which increases production efficiency by lowering the cost of raw materials and waste disposal, decreasing production waste, and increasing productivity

(Huang and Li, 2017; Zhang et al., 2020). Thus, family businesses that want to pass on their businesses to future generations are more likely to engage in pollution prevention activities, thereby lowering the risk of increasing litigation costs associated with environmental damage. Because of these pollution prevention practices, family businesses outperform non-family businesses in terms of financial returns (Gomez-Mejia et al., 2019).

Moreover, in family firms, family names are interlinked with firm activities, products, and processes, which makes them more sensitive to their image in society. Thus, family firms, which care about their image, recognition, and reputation (Broccardo et al., 2018; Sageder et al., 2018), are less likely to greenwash and more likely to adopt green innovative behaviour. They are willing to perform environmental management practices (Berrone et al., 2010; Campopiano et al., 2014; Kim et al., 2017 ; Gomez-Mejia et al., 2019; Yu et al., 2020; Ardito et al., 2019; Huang et al., 2009). Thus, investment in the natural environment generates long-term efficiency and reputational gains in family firms, resulting in greater comparative advantages and improved financial results.

We argue that family participation in sustainable activities depends on the percentage of family ownership. The preservation of SEW is prevalent at high levels of family ownership. Thus, family firms' long-term orientation, desire to transfer the business to their descendants, and preservation of family image and reputation persuade them to participate in carbon emission reduction strategies. Consequently, firms' participation in carbon emission mitigation demonstrates a positive image of their contribution to climate change challenges and has positive consequences on firms' financial performance. Thus, we hypothesize

H2b: The negative effect of carbon emission level on financial performance is stronger at higher levels of family ownership

3. Data and Methodology

3.1 Data

We collected ownership data to classify firms as family control and non-family firms from the Bureau van Dijk ORBIS database, which provides historical information about shareholders of private and publicly listed firms worldwide. Information about shareholders is detailed with the direct and total percentage of shareholdings based on shareholder type. We define family control as the direct percentage of shares held by families or total (direct and indirect) shareholdings of at least 20%. We follow two steps to identify family owned firms and the percentage of shares held by family owners. First, we use direct or total percentage shares held by the type "one or more named individuals or families". We started to define family firms and holding shares with direct holding, and if this is not available or less than 20%, we checked total shareholdings if it exceeded the 20% cut-off. When both the direct and total percentages of shares do not meet our criterion, as the second step, we check the information about controlling ultimate owners with the type "one or more named individuals or families, if it exists, to define the firm as a family firm. If a firm is not identified as a family owner in the first step, and an individual or a family name is given as the ultimate owner, then we identify the percentage of shareholdings through shareholdings of the percentage of shares held by the ultimate owner. In addition, if this is not available, we take the direct percentage of shares held by the corporation. And then, if the direct shareholdings do not meet the criterion, we use the total ownership.

The other ownership type we used from Orbis is for institutions, which we define as the percentage of shares held by one or more the following ownership types: bank; financial company; foundation, research Institute; insurance company; mutual and pension fund, nominee, trust, trustee; private equity firm, venture capital.

We gathered the data on financial performance and carbon emissions from Thomson Reuters DataStream and ESG (Lewandowski, 2017). We exclude utilities and financial firms because of the regulatory differences across industries and countries. After merging with financial accounting data from Thomson Reuters DataStream, our final sample consists of 3,633 firm-year observations representing 703 firms from 13 countries for the period 2010-2020.

We use Tobin's Q (Huang et al., 2014) as a measure of financial performance and construct our independent variable as firm-level carbon emissions based on Scope 1 and Scope 2 CO2 emission levels in a year. We measured carbon emissions as an absolute indicator (Slawinski et al., 2017), which reflects a firm's physical emissions over a given time period and provides direct information about a firm's contribution to climate change (Ekwurzel et al., 2017). Furthermore, to account for the skewed distribution of carbon emissions, we use the natural logarithm conversion (Ben-David et al., 2021).

3.2 Methodology

We perform OLS regressions to investigate the relationship between carbon emissions and financial performance by incorporating the difference between family and non-family firms. In particular, we interact the family dummy with the carbon emissions as well as the impact of family ownership on this relationship. We use the following regression equations:

In model (1), we include the family dummy as a moderating variable.

$$Tobin's\ Q_{it} = \alpha + \beta_1 CO2emissions_{it-1} + \beta_2 Family\_Dummy_{it} + \beta_3\ Family\_Dummy_{it} * CO2emissions_{it-1} + \beta_4 R\&D\ Intensity_{it-1} + \beta_5 Leverage_{t-1} + \beta_6 Size_{it-1} + \beta_7 Tangibility_{it-1} + \beta_8 Dividend_{it-1} + \beta_9 Cash\ Holding_{it-1} + \beta_{10} Institutional\_Own_{it} + \Sigma_t + \Sigma_c + \Sigma_i + \varepsilon_{it} \quad (1)$$

In Model (2), we stress the non-linear impact of family ownership on the relationship between carbon emissions and financial performance.

$$Tobin's\ Q_{it} = \alpha + \beta_1 CO2emissions_{it-1} + \beta_2 Family\_Ownership_{it} + \beta_3 Family\_Ownership\_Square_{it-1} + \beta_4 Family\_Ownership_{it} * CO2emissions_{it-1} + \beta_5\ Family\_Ownership\_Square_{it-1} * CO2emissions_{it-1} + \beta_6 R\&D\ Intensity_{it-1} + \beta_7 Leverage_{it-1} + \beta_8 Size_{it-1} + \beta_9 Tangibility_{it-1} + \beta_{10} Dividend_{it-1} + \beta_{11} Cash\ Holding_{it-1} + \beta_{12} Institutional\_Own_{it} + \Sigma_t + \Sigma_c + \Sigma_i + \varepsilon_{it} \quad (2)$$

where *i*, *c*, and *t* represent the firm, country, and year, respectively. Tobin's Q is the measure of financial performance of firms. We also add the square term of family ownership to measure the marginal effect of increase in ownership concentration of family firms on the relation between carbon emissions and financial performance. Furthermore, we add two interactions between to identify non-linear role of family ownership in explaining then relationship between carbon emissions and financial performance. Family_Ownership and Family_Ownership_Square measure the effect of low and high level of family ownership on the relation between carbon emissions and financial performance. Σ_t refers to the year dummies, Σ_c represents the country dummies and Σ_i represents the industry dummies. We include these dummies to control for the effects of the omitted variable bias.

In all our regression models, we include the control variables that are frequently used in financial performance regressions to reduce omitted variable bias. In particular, we add the financial leverage, firm size, tangibility, dividend payout, and cash holding as firm-level controls. In addition, we also control the percentage of shares held by institutional owners. There a large literature discussion the monitoring role of institutional investors on corporate activities (Ferreira and Matos, 2008) and the scope and quality of carbon emissions reporting (Döring et al., 2023).

To control for the issue that the choice of family is not random because of the potential differences in firm-level characteristics between family and non-family firms, we employ Propensity Score Matching (PSM). This estimation uses similar pairs of family and non-family firms in the same 2-digit industry based on firm characteristics using firm/year observations in the entire sample period. We include firm-level control variables, except R&D intensity, as covariates in the probit regressions to determine propensity scores. In addition, we include leverage square along with leverage because without leverage square there was still difference in leverage between family and non-family matched pairs. To deal with that it was required to add higher term of leverage in matching covariates. We used nearest neighbor one-to-one matching with caliper (0.02) and no replacement. We obtain a matched sample of 377 firm-year observations.

We winsorize all firm-level financial variables at the 1st and 99th percentiles to re.duce the impact of outliers. We take the lag of all independent variables, except family ownership to control for the possibility of reverse causality between carbon emissions and financial performance as higher financial performance provides more funds to reduce carbon emissions. The definitions of all the variables are presented in Appendix 1.

4. Results

4.1. Descriptive statistics

Table 1 presents the descriptive statistics for the full sample for all the variables included in the regressions. The mean of Tobin's Q is 2.00, indicating that the market values of the sample companies, on average, are doubled their book value of assets. This implies that the sample firms have excellent yearly average growth prospects during the sample period. The companies, on average, emit 2.95 million metric tons of CO2. The percentage of family firms in the sample based on 20% ownership cutoff is 27%, indicating that family firms account for 27% of all

sample firms and own 55% of the total shares on average. Furthermore, the average R&D to asset (R&D) value is 2%, and the average cash to asset value is 12%. The average logarithm value of total assets is 15.31, which equals €14 billion, indicating that our sample's average firm size is relatively large. In addition, the average proportion of property, plants, and equipment to total assets is 23%. The leverage ratio is 22%, indicating that outstanding loans account for slightly more than 20% of a firm's average assets. The sample firms, on average, pay 42% of net income as the dividends.

Panel A of Table 2 shows that for all variables, there are significant mean and median differences between family and non-family firms. The mean (median) for Tobin's Q are 2.26 (1.60), compared to 1.91 (1.43) for non-family businesses. This demonstrates that family businesses have higher market value than non-family businesses. These findings suggest that family firms have more growth opportunities than non-family firms do. Furthermore, family firms have less carbon emissions scaled by total assets than non-family firms, which are also larger and have higher leverage and tangibility ratios. On the other hand, family firms have higher dividend to earnings and cash-to-asset ratios than non-family firms do.

Panel B of Table 2 presents comparisons of the mean and median values of all variables between family and non-family matched firms. The results provide the validity of the matching strategy. The statistical tests that compare the mean and median values of the variables used in PSM reveal that there are no significant differences in those values of the variables, rejecting biases in the mean and medians between raw and matched samples.

Table 3 displays the averages for the full sample by country for financial performance (Tobin's Q), carbon emissions, and percentage of family firms and average shares held by family owners. Spain and Italy have the higher proportion of family firms in our sample, 53% and 43%, respectively, bur France shares the ranking of having highest mean of family ownership with Italy at 59%. Table 4 shows the average financial and carbon performance by

industry for the full sample, as well as for family and non-family firms. The results show that the Manufacturing industry has the highest representation in the full sample also for both samples of family firms and non-family firms. The industries manufacturing and retail trade have the highest Tobin's Q relative to other industries for sample of family firms. Furthermore, the manufacturing and transportation industries are the most polluted, according to the full sample and family firms.

4.2. Time trend in carbon emissions; family vs non-family firms

Figure-1 show the time trend of carbon emissions between family and non-family firms for full sample. In 2010, the carbon emissions in family and non-family firms are at the same level and then fluctuates over time. Overall, from 2011 to 2019, family firms emitted less carbon dioxide per year than non-family firms did. Specifically, after 2017, there is a decrease in carbon emissions for both family and non-family firms, which validates the implementation of the Paris Agreement, which requires all member countries around the world to invest in environmentally friendly projects (UNFCCC, 2016); however, this decrease is greater for family firms than for non-family firms. Figure-2 show the time trend of carbon emissions between family and non-family firms for matched sample. The matched sample shows that there are no differences in carbon emissions of family and non-family firms.

4.3. OLS regressions

In this section, we present the results from the regression analysis testing the relationship between carbon emissions and stock-market based related financial performance measured by Tobin's Q. Table 5 presents the results for the entire sample and the period 2010-2020. In all models, we observe that the estimated coefficients corresponding to our variable for carbon emission are negative and statistically significant at the 1 percent level, indicating that Tobin's

Q decreases (increases) when the level of carbon emissions relative to total assets increases (decreases). This finding support our hypothesis 1 and is consistent with findings in the previous litearture (Delmas et al., 2015; Bush et al., 2022).

In Model 2, we include Family_Dummy in the regression model. The coefficient is - positive and significant at the 10 percent level, indicating that the financial performance of family firms is significantly higher than that of non-family firms. The third and fort models includes family ownership and family ownership squared, respectively. The last model including both variables tests whether the relationship between family ownership and Tobin's Q is non-linear. This is important because later in our analysis we try to identify how our relationship differs across family firms based on their percentage of controlling ownership. The results in this table shows that financial performance of family firms do not differ at low and high level of family control.

The estimated coefficients of all control variables are consistent across all models. For instance, last year R&D intensity, tangibility, the proportion of dividends in net income and the proportion of cash holding in total assets increase financial performance of European firms during the sample period. However, Tobin's Q decreases by firm size and the percentage of shares held by institutional investors. We did not find any significant effect of total debt ratio on stock-based performance.

4.3.1 Family control and carbon emission performance

Table 6 presents the results we include interactions of Family_Dummy as well as family ownership variables with the carbon emission variable. Focusing on Model, the negative and significant estimated coefficient of carbon emission together with insignificant interaction indicate that the negative effect of carbon emission on Tobin's Q is similar between family and non-family firms. In Model 2, we find similar outcome when we use family ownership and the

interaction between this and carbon emission. Both variables of do not have significant coefficients, so that we are not able to detect any differences between family firms and non-family firms by using the level of family ownership.

To test this nonlinear effect and examine how the relationship between family ownership and firm performance changes as family control increases, we include the family ownership percentage and family ownership squared in Model 3. Our results show that, at low level of family ownership, the estimated coefficient of the CO2emissions*Family_Ownership interaction is positive and significant at 10% level. This finding shows that the negative effect of carbon emission on Tobin's Q is weak with low level of family ownership. The sum of the two-estimated coefficient turns out to be even positive for family firms controlled by families at low percentage of shareholdings. This evidence supports our hypothesis 2. However, the coefficient of the interaction term CO2*Family_Ownership_Square is negative and significant at the 5% level of significance. This finding suggests that, as family ownership concentration increases, family control strengthens the negative relationship between carbon emissions and firm performance, which supports our hypothesis 3. Combination of these results confirms the differences in the role of short- and long-term views in explaining the carbon performance.

Table A2.1 and A2.2 in the appendix, we also use PSM estimations for our main models with matched sample. The results corroborate the main results. Thus, our findings corroborate those of Agostino and Ruberto (2021), Binz et al. (2017), and Kim et al. (2017), who suggest that family firms' long-term orientation and desire to pass ownership on to their descendants persuade them to become more responsive to environmental demands and adopt environmentally friendly policies, which consequently increase firm value.

4.3.2 Sub-period analysis

We conduct our sub-sample analysis. We divide the sample into two time periods: 2010-2015 and 2016-2020: before and after the Paris Agreement. Table 7 shows that significant differences in the relationship between carbon emissions and financial performance between family and non-family firms during the post-Paris Agreement period are stronger than those we observe in the 2010-2015 period. This is consistent with our time-trend analysis, which shows that the carbon performance of family and non-family firms increases after the Paris Agreement, however, this increase is greater for family firms than for non-family firms, implying that there are differences in the moderating role of family ownership on the relationship between carbon emissions and firm performance in the post-Paris Agreement periods.

These findings indicate that at lower level of family ownership, family firms releasing CO2 have higher financial performance, suggesting that even though in post-Paris agreement period, at lower family ownership family firm preferences for financial benefits over non-financial benefits prevail. However, at high level of family ownership, family firms emitting CO2 have less financial performance than non-family firms, implying that family firms having more carbon emissions are punished more in Post-Paris agreement period than non-family firms. The matched sample results of sub-period analysis are consistent with main results.

In the appendix, the results with PSM in Table A2.1 confirms the evidence we presented above and supports our hypotheses 2 and 3. We also provide two graphs, one with the full sample and the other with matched sample, to visualize these effects before and after Paris agreement.

4.4 Additional Analysis

We plan to use alternative proxies to measure financial performance, especially with accounting-based measure. We will do the same by using alternative proxies of carbon emisssions.

5. Conclusion

Companies in most countries are under increasing pressure to reduce their greenhouse gas emissions. Consequently, those with high carbon emissions are stigmatized as irresponsible corporate citizens, which has an impact on their financial performance. Therefore, it is important to analyse the consequences of firms' carbon emissions on their financial performance. Given the differences in sustainability practices between family and non-family ownership (Miroshnychenko et al., 2022), this study focuses on the moderating role of family ownership on the relationship between carbon emissions and firm financial performance.

Our findings show that at lower levels of control, the joint impact of family ownership and carbon emissions is positive, implying that family firms at lower levels of control are less concerned about their family image and reputation in society and are more concerned about financial objectives; thus, they are less likely to invest in carbon mitigation strategies that reduce their net profits. As a result, more polluted family firms with a low level of ownership outperform financially than non-family firms. However, as family control grows, so do family preferences for image and identity; thus, negative climate change activities have a greater negative impact on their financial performance. As a result, more polluted family firms with a high level of control perform worse financially than non-family firms.

The results of this analysis have important implications for managers, businesses, and strategies. Carbon emissions, a major contributor to climate change, have a significant negative impact on corporate financial performance. Thus, managers must devise appropriate 'corporate

carbon strategies' to maintain or improve their competitiveness. In particular, our findings confirm the importance of ownership in green investment. These findings suggest that family businesses, in particular, should focus more on coordinating research activities to develop new low-carbon technologies that lead to innovation efficiency, thereby improving firms' carbon performance and, as a result, their financial performance. From a policy standpoint, it is critical to recognize the impact of carbon emissions on family and non-family firms' financial performance. Our findings suggest that policymakers should establish long-term incentives to encourage family firms to adopt efficient green technologies and acquire environmentally compatible processes and systems to mitigate the effects of climate change and improve their financial performance.

References

Aboelmaged, M., & Hashem, G. (2019). Absorptive capacity and green innovation adoption in SMEs: The mediating effects of sustainable organisational capabilities. *Journal of cleaner production*, 220, 853-863.

Agostino, M., & Ruberto, S. (2021). Environment-friendly practices: Family versus non-family firms. *Journal of Cleaner Production*, 329, 129689.

Ambec, S., & Lanoie, P. (2008). Does it pay to be green? A systematic overview. *Academy of Management Perspectives,* 22(4), 45–62.

Ardito, L., Messeni Petruzzelli, A., Pascucci, F., & Peruffo, E. (2019). Inter-firm R&D collaborations and green innovation value: The role of family firms' involvement and the moderating effects of proximity dimensions. *Business Strategy and the Environment*, 28(1), 185-197.

Baboukardos, D. (2017). Market valuation of greenhouse gas emissions under a mandatory reporting regime: Evidence from the UK. *In Accounting Forum*, 41(3), 221-233.

Bauweraerts, J., Arzubiaga, U., & Diaz-Moriana, V. (2022). Going greener, performing better? The case of private family firms. *Research in International Business and Finance*, 63, 101784.

Ben-David, I., Jang, Y., Kleimeier, S., & Viehs, M. (2021). Exporting pollution: where do multinational firms emit CO2?. *Economic Policy*, *36*(107), 377-437.

Berrone, P., Cruz, C., Gomez-Mejia, L. R., & Larraza-Kintana, M. (2010). Socioemotional wealth and corporate responses to institutional pressures: Do family-controlled firms pollute less?. *Administrative science quarterly*, 55(1), 82-113.

Binz, C. A., Ferguson, K. E., Pieper, T. M., & Astrachan, J. H. (2017). Family business goals, corporate citizenship behaviour and firm performance: Disentangling the connections. *International Journal of Management and Enterprise Development*, 16(1-2), 34-56.

Broccardo, L., Truant, E., & Zicari, A. (2019). Internal corporate sustainability drivers: What evidence from family firms? A literature review and research agenda. *Corporate Social Responsibility and Environmental Management,* 26(1), 1-18.

Brouwers, R., Schoubben, F., & Van Hulle, C. (2018). The influence of carbon cost pass through on the link between carbon emission and corporate financial performance in the context of the European Union Emission Trading Scheme. *Business Strategy and the Environment*, 27(8), 1422-1436.

Busch, T., & Hoffmann, V. H. (2011). How hot is your bottom line? Linking carbon and financial performance. *Business & Society*, 50(2), 233-265.

Busch, T., & Lewandowski, S. (2018). Corporate carbon and financial performance: A meta-analysis. *Journal of Industrial Ecology*, 22(4), 745-759.

Campopiano, G., Massis, A. D., & Cassia, L. (2014). Corporate social responsibility in family versus non-family enterprises: An exploratory study. *In Social Entrepreneurship* 113-154). Springer, Cham.

Campopiano, G., Rinaldi, F. R., Sciascia, S., & De Massis, A. (2019). Family and non-family women on the board of directors: Effects on corporate citizenship behavior in family-controlled fashion firms. *Journal of cleaner production*, 214, 41-51.

Clarkson, P. M., Li, Y., Richardson, G. D., & Vasvari, F. P. (2011). Does it really pay to be green? Determinants and consequences of proactive environmental strategies. *Journal of accounting and public policy*, 30(2), 122-144.

Classen, N., Carree, M., Van Gils, A., & Peters, B. (2014). Innovation in family and non-family SMEs: An exploratory analysis. *Small Business Economics*, 42(3), 595-609.

Cennamo, C., Berrone, P., Cruz, C., & Gomez–Mejia, L. R. (2012). Socioemotional wealth and proactive stakeholder engagement: Why family–controlled firms care more about their stakeholders. *Entrepreneurship theory and practice*, 36(6), 1153-1173.

Cordeiro, J. J., & Sarkis, J. (1997). Environmental proactivism and firm performance: evidence from security analyst earnings forecasts. *Business strategy and the environment*, 6(2), 104-114.

Craig, J., & Dibrell, C. (2006). The natural environment, innovation, and firm performance: A comparative study. *Family Business Review*, 19(4), 275-288.

Dangelico, R. M., Nastasi, A., & Pisa, S. (2019). A comparison of family and nonfamily small firms in their approach to green innovation: A study of Italian companies in the agri-food industry. *Business Strategy and the Environment*, 28(7), 1434-1448.

Delmas, M. A., Nairn-Birch, N., & Lim, J. (2015). Dynamics of environmental and financial performance: The case of greenhouse gas emissions. *Organization & Environment*, 28(4), 374-393.

De Massis, A., Frattini, F., Kotlar, J., & Messeni-Petruzzelli A, Wright M. (2016). Innovation through tradition: Lessons from innovative family businesses and directions for future research. *Academy of Management Perspectives*, 30(1), 93–116.

De Massis, A., Kotlar, J., & Manelli, L. (2021). Family firms, family boundary organizations, and the family-related organizational ecosystem. *Family Business Review*, 34(4), 350-

Dixon-Fowler, H. R., Slater, D. J., Johnson, J. L., Ellstrand, A. E., & Romi, A. M. (2013). Beyond "does it pay to be green?" A meta-analysis of moderators of the CEP–CFP relationship. *Journal of Business Ethics*, 112(2), 353-366.

Doluca, H., Wagner, M., & Block, J. (2018). Sustainability and environmental behaviour in family firms: A longitudinal analysis of environment-related activities, innovation and performance. *Business Strategy and the Environment*, 27(1), 152-172.

Döring, S., Drobetz, W., El Ghoul, S., Guedhami, O., & Schröder, H. (2023). Foreign institutional investors, legal origin, and corporate greenhouse gas emissions disclosure. *Journal of Business Ethics*, 182, 903–932.

Duque-Grisales, E., Aguilera-Caracuel, J., Guerrero-Villegas, J., & García-Sánchez, E. (2020). Does green innovation affect the financial performance of Multilatinas? The moderating role of ISO 14001 and R&D investment. *Business Strategy and the Environment*, 29(8), 3286-3302.

Duran, P., Kammerlander, N., Van Essen, M., & Zellweger, T. (2016). Doing more with less: Innovation input and output in family firms. *Academy of Management Journal*, 59(4), 1224-1264.

Dyer Jr, W. G., & Whetten, D. A. (2006). Family firms and social responsibility: Preliminary evidence from the S&P 500. *Entrepreneurship Theory and Practice*, 30(6), 785-802.

European Commission. (2021). Eco-innovation Action Plan, Brussels. Retrieved from https://ec.europa.eu/environment/ecoap/frontpage_en

Freeman, H., Harten, T., Springer, J., Randall, P., Curran, M. A., & Stone, K. (1992). Industrial pollution prevention! A critical review. *Journal of the Air & Waste Management Association*, 42(5), 618-656.

Ekwurzel, B., Boneham, J., Dalton, M. W., Heede, R., Mera, R. J., Allen, M. R., & Frumhoff, P. C. (2017). The rise in global atmospheric CO2, surface temperature, and sea level from emissions traced to major carbon producers. *Climatic Change*, *144*(4), 579-590.

Fan, Y., Zhang, F., Zhu, L., (2021). Do family firms invest more in pollution prevention strategy than non-family firms? An integration of agency and institutional theories. *Journal of Cleaner production,* 286, 124988.

Ferreira, M.A., Matos, P. (2008). The colors of investors' money: the role of institutional investors around the world. *Journal of Financial Economics*, 88, 499–533.

Fujii, H., Iwata, K., Kaneko, S., & Managi, S. (2013). Corporate environmental and economic performance of Japanese manufacturing firms: Empirical study for sustainable development. *Business Strategy and the Environment*, 22(3), 187-201

Galama, J. T., & Scholtens, B. (2021). A meta-analysis of the relationship between companies' greenhouse gas emissions and financial performance. *Environmental Research Letters*, 16(4), 043006.

Ganda, F., & Milondzo, K. S. (2018). The impact of carbon emissions on corporate financial performance: Evidence from the South African firms. *Sustainability*, 10(7), 2398.

Garcés-Ayerbe, C., Rivera-Torres, P., Murillo-Luna, J. L., & Suarez-Galvez, C. (2022). Does it pay more to be green in family firms than in non-family firms? *Review of Managerial Science*, 16(5), 1365-1386.

Garzón-Jiménez, R., & Zorio-Grima, A. (2021). Effects of carbon emissions, environmental disclosures and CSR assurance on cost of equity in emerging markets. *Sustainability*, 13(2), 696.

Ghisetti, C., & Rennings, K. (2014). Environmental innovations and profitability: How does it pay to be green? An empirical analysis on the German innovation survey. *Journal of Cleaner production,* 75, 106-117.

Gomez-Mejia, L. R., Lannelongue, G., Muñoz-Bullón, F., Requejo, I., & Sanchez-Bueno, M. J. (2019). Family firms' concern for the environment: Does it pay off to pollute less?. *In Academy of Management Proceedings* (1), 14454.

Grewatsch, S., & Kleindienst, I. (2017). When does it pay to be good? Moderators and mediators in the corporate sustainability–corporate financial performance relationship: A critical review. Journal of Business Ethics, 145(2), 383-416.

Hart, S. L. (1995). A natural-resource-based view of the firm. *Academy of Management Review, 20(4), 986-1014.*

Huang, Y. C., Ding, H. B., & Kao, M. R. (2009). Salient stakeholder voices: Family business and green innovation adoption. *Journal of Management & Organization*, 15(3), 309-326.

Huang, Y. C., Wong, Y. J., & Yang, M. L. (2014). Proactive environmental management and performance by a controlling family. *Management Research Review*, 37(3), 210-240.

Huang, X. X., Hu, Z. P., Liu, C. S., Yu, D. J., & Yu, L. F. (2016). The relationships between regulatory and customer pressure, green organizational responses, and green innovation performance. *Journal of Cleaner Production,* 112, 3423-3433.

Huang, J. W., & Li, Y. H. (2017). Green innovation and performance: The view of organizational capability and social reciprocity. *Journal of Business Ethics*, 145(2), 309-324.

Jiang, D. S., Kellermanns, F. W., Munyon, T. P., & Morris, M. L. (2018). More than meets the eye: A review and future directions for the social psychology of socioemotional wealth. *Family Business Review*, 31(1), 125-157.

Kang, C., Germann, F., & Grewal, R. (2016). Washing away your sins? Corporate social responsibility, corporate social irresponsibility, and firm performance. *Journal of Marketing,* 80(2), 59-79.

Kim, J., Fairclough, S., & Dibrell, C. (2017). Attention, action, and greenwash in family-influenced firms? Evidence from polluting industries. *Organization & Environment*, 30(4), 304-323.

Kuo, L., Huang, S. K., & Wu, Y. C. J. (2010). Operational efficiency integrating the evaluation of environmental investment: the case of Japan. *Management Decision.*

Lee, K. H., Min, B., & Yook, K. H. (2015). The impacts of carbon (CO2) emissions and environmental research and development (R&D) investment on firm performance. *International Journal of Production Economics,* 167, 1-11.

Lee, J. H., & Cho, J. H. (2021). Firm-Value Effects of Carbon Emissions and Carbon Disclosures—Evidence from Korea. *International Journal of Environmental Research and Public Health*, 18(22), 12166.

Lewandowski, S. (2015). Carbon emissions and corporate financial performance: a systematic literature review and options for methodological enhancements. *Corporate Carbon and Climate Accounting,* 193-215.

Lewandowski, S. (2017). Corporate carbon and financial performance: The role of emission reductions. *Business Strategy and the Environment*, *26*(8), 1196-1211.

Manrique, S., & Martí-Ballester, C. P. (2017). Analyzing the effect of corporate environmental performance on corporate financial performance in developed and developing countries. *Sustainability*, 9(11), 1957.

Miroshnychenko, I., Barontini, R., & Testa, F. (2017). Green practices and financial performance: A global outlook. *Journal of Cleaner Production*, *147*, 340-351.

Miroshnychenko, I., De Massis, A., Barontini, R., & Testa, F. (2022). Family firms and environmental performance: A meta-analytic review. *Family Business Review*, 35(1), 68-90.

Neubaum, D. O., Dibrell, C., & Craig, J. B. (2012). Balancing natural environmental concerns of internal and external stakeholders in family and non-family businesses. *Journal of Family Business Strategy*, 3(1), 28-37.

Nichita, E. M., Nechita, E., Manea, C. L., Irimescu, A. M., & Manea, D. (2021). Are reported greenhouse gas emissions influencing corporate financial performance?. *Accounting and Management Information Systems*, 20(4), 585-606.

Nishitani, K., Kaneko, S., Fujii, H., & Komatsu, S. (2011). Effects of the reduction of pollution emissions on the economic performance of firms: an empirical analysis focusing on demand and productivity. *Journal of Cleaner Production*, 19(17-18), 1956-1964.

Orsato, R. J. (2006). Competitive environmental strategies: when does it pay to be green?. *California management review*, 48(2), 127-143.

Sageder, M., Mitter, C., & Feldbauer-Durstmüller, B. (2018). Image and reputation of family firms: a systematic literature review of the state of research. *Review of Managerial Science,* 12(1), 335-377.

Samara, G., Jamali, D., Sierra, V., & Parada, M. J. (2018). Who are the best performers? The environmental social performance of family firms. *Journal of Family Business Strategy*, 9(1), 33-43.

Slawinski, N., Pinkse, J., Busch, T., & Banerjee, S. B. (2017). The role of short-termism and uncertainty avoidance in organizational inaction on climate change: A multi-level framework. *Business & Society*, *56*(2), 253-282.

Swab, R. G., Sherlock, C., Markin, E., & Dibrell, C. (2020). "SEW" what do we know and where do we go? A review of socioemotional wealth and a way forward. *Family Business Review*, *33*(4), 424-445.

Wang, M., Li, Y., Li, J., & Wang, Z. (2021). Green process innovation, green product innovation and its economic performance improvement paths: A survey and structural model. *Journal of Environmental Management*, 297, 113282.

Yu, X., Stanley, L., Li, Y., Eddleston, K. A., & Kellermanns, F. W. (2020). The invisible hand of evolutionary psychology: The importance of kinship in first-generation family firms. *Entrepreneurship Theory and Practice*, 44(1), 134-157.

Zhang, Y., Sun, J., Yang, Z., & Wang, Y. (2020). Critical success factors of green innovation: Technology, organization and environment readiness. *Journal of Cleaner Production,* 264, 121701.

Table 1: Descriptive statistics, full sample

Variable	N	Mean	Median	Min	Max	SD
Tobin's Q	3633	2.001	1.469	0.749	13.323	1.718
CO2emissions	3633	1.446	0.169	0	26.572	3.850
Family_Ownership	963	0.552	0.545	0.2	1	0.207
Family_Dummy	3633	0.265	0.000	0	1	0.441
Institutional_Own	3633	0.253	0.201	0	1	0.222
R&D Intensity	3633	0.021	0.005	0	0.092	0.029
Size	3633	15.317	15.241	10.997	18.625	1.486
Leverage	3633	0.224	0.221	0	0.623	0.140
Tangibility	3633	0.220	0.185	0.006	0.778	0.170
Dividend	3633	0.420	0.386	0	1	0.323
Cash Holding	3633	0.124	0.093	0.006	0.755	0.115

This table reports the descriptive statistics of the regression variables, Tobin's Q, CO2emissions, Family_Dummy, Family_Ownership, Institutional ownership, R&D intensity, Size, Leverage, tangibility, dividend and cash holdings. Appendix 1 provides the definitions of all the variables.

Table 2: Descriptive statistics, family vs non-family firms

	Family			Non-Family			Family - Non-Family	
Variable	N	Mean	Median	N	Mean	Median	Mean	Median
Panel A: Full Sample								
Tobin's Q	963	2.260	1.595	2670	1.907	1.433	0.352***	0.163***
CO2emissions	963	1.285	0.097	2670	1.505	0.198	-0.219	-0.100***
Family_Ownership	963	0.552	0.545	2670	0.011	0.000	0.541***	0.545***
Institutional_Own	963	0.193	0.114	2670	0.275	0.230	-0.082***	-0.116***
R&D Intensity	963	0.019	0.002	2670	0.022	0.007	-0.003***	-0.005***
Size	963	15.180	15.071	2670	15.366	15.302	-0.185***	-0.231***
Leverage	963	0.211	0.196	2670	0.229	0.225	-0.018***	-0.030***
Tangibility	963	0.207	0.178	2670	0.225	0.190	-0.018***	-0.011***
Dividend	963	0.433	0.398	2670	0.415	0.382	0.018	0.016
Cash Holding	963	0.136	0.105	2670	0.120	0.089	0.016***	0.016***
Panel B: Matched Sample								
Tobin's Q	377	2.221	1.664	377	2.113	1.600	0.108	0.064
CO2emissions	377	0.953	0.097	377	1.021	0.166	-0.069	-0.069***
Family_Ownership	377	0.552	0.543	377	0.013	0.000	0.539***	0.543***
Institutional_Own	377	0.215	0.150	377	0.216	0.168	-0.002	-0.018
R&D Intensity	377	0.030	0.021	377	0.031	0.021	0.000	-0.001
Size	377	15.193	15.107	377	15.268	15.352	-0.076	-0.246
Leverage	377	0.212	0.211	377	0.215	0.205	-0.003	0.006
Tangibility	377	0.184	0.168	377	0.181	0.138	0.003	0.030
Dividend	377	0.375	0.347	377	0.406	0.379	-0.031	-0.032
Cash Holding	377	0.139	0.103	377	0.136	0.093	0.002	0.010

This table shows the mean and median values of all regression variables using the full sample (Panel A) and the matched sample (Panel B). Definitions of all variables are given in Appendix 1. *,**, and *** indicate statistical significance at the 10, 5, and 1 percent levels, respectively. The standard errors for the t-test are based on the cross-sectional distribution of means or (medians).

Table 3: Descriptive statistics by country, full sample

Country	N	Tobin's Q	CO2 emissions	Family_Dummy	Family_Ownership
Austria	96	1.314	1.983	0.198	0.545
Belgium	181	1.486	2.007	0.215	0.495
Denmark	234	4.343	1.725	0.102	0.387
Finland	229	1.743	1.439	0.114	0.440
France	623	1.572	0.916	0.225	0.593
Germany	629	1.768	1.299	0.289	0.609
Italy	181	1.593	2.506	0.425	0.583
Luxembourg	41	1.305	6.363	0.244	0.500
Netherlands	226	1.68	1.32	0.195	0.458
Norway	104	2.765	3.318	0.038	0.659
Spain	226	1.839	1.157	0.527	0.540
Sweden	391	2.106	1.293	0.225	0.512
Switzerland	472	2.369	0.965	0.364	0.549
Total	3633	2	1.446	0.265	0.552

This table reports the descriptive statistics of the Tobin's Q, CO2emissions, Family dummy and Family ownership by country. Appendix 1 provides the definitions of all the variables.

Table 4: Descriptive statistics by industry for family vs non-family firms

	Full sample			Family firms			Non-family firms		
Industry	N	Tobin's Q	CO2emissions	N	Tobin's Q	CO2emissions	N	Tobin's Q	CO2emissions
Construction	193	1.209	0.514	47	1.151	0.387	146	1.227	0.555
Manufacturing	2229	2.154	1.802	596	2.428	1.854	1633	2.061	1.783
Retail Trade	203	1.973	0.992	89	2.441	0.29	114	1.607	1.331
Services	371	2.151	0.175	128	2.177	0.154	243	2.138	0.185
Transportation	506	1.628	1.572	91	1.704	0.752	415	1.61	1.752
Wholesale Trade	131	1.527	0.594	12	2.006	0.044	119	1.478	0.65
Total	3633	2	1.446	963	2.259	1.285	2670	1.907	1.504

This table reports the descriptive statistics of the Tobin's Q, CO2emissions, by Industry for full sample, also for family and non-family firms. Appendix 1 provides the definitions of all the variables.

Table 5: The effect of CO2 emissions on financial performance

	DV=Tobin's Q			
CO2emissions	-0.030***	-0.031***	-0.030***	-0.031***
	[0.011]	[0.011]	[0.011]	[0.011]
Family_Dummy		0.196*		
		[0.114]		
Family_Ownership			0.275	0.831
			[0.173]	[0.566]
Family_Ownership_Square				-0.749
				[0.686]
Institutional_Own	-0.492**	-0.427**	-0.434**	-0.426*
	[0.214]	[0.217]	[0.218]	[0.218]
R&D Intensity	6.077*	6.338**	6.261**	6.378**
	[3.130]	[3.135]	[3.130]	[3.134]
Size	-0.160***	-0.157***	-0.158***	-0.154***
	[0.045]	[0.045]	[0.045]	[0.045]
Leverage	-0.744	-0.733	-0.732	-0.729
	[0.494]	[0.489]	[0.490]	[0.487]
Tangibility	0.748**	0.728**	0.728**	0.735**
	[0.335]	[0.326]	[0.328]	[0.327]
Dividend	0.575***	0.572***	0.573***	0.568***
	[0.165]	[0.164]	[0.164]	[0.164]
Cash Holding	2.327***	2.320***	2.328***	2.321***
	[0.507]	[0.504]	[0.505]	[0.506]
Constant	2.012***	1.975***	1.974***	1.916***
	[0.692]	[0.697]	[0.695]	[0.706]
Adjusted-R_square	0.356	0.357	0.357	0.357
N	3633	3633	3633	3633
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes

This table reports the results from multivariate OLS linear and non-linear regressions for the effect of CO2emissions and family ownership on firm performance (Tobin's Q). Institutional ownership, R&D intensity, Size, Leverage, Tangibility, Dividend and Cash holdings are controls. The variable definitions are provided in Appendix 1. The regressions include year, industry and country-fixed effects. Explanatory variables are lagged by one period to minimize the possibility of reverse causality. Robust standard errors clustered at the firm-level are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 6: The role of family ownership in explaining the effect of CO2 emissions on financial performance

	DV=Tobin's Q		
CO2emissions	-0.034**	-0.031**	-0.037**
	[0.015]	[0.014]	[0.014]
Family_Dummy	0.183		
	[0.115]		
CO2emissions*Family_Dummy	0.009		
	[0.015]		
Family_Ownership		0.266	0.669
		[0.179]	[0.583]
CO2emissions*Family_Ownership		0.01	0.190*
		[0.027]	[0.106]
Family_Ownership_Square			-0.522
			[0.702]
CO2emissions*Family_Ownership_Square			-0.326**
			[0.159]
Institutional_Own	-0.430**	-0.435**	-0.425*
	[0.217]	[0.218]	[0.218]
R&D intensity	6.312**	6.255**	6.285**
	[3.137]	[3.131]	[3.140]
Size	-0.157***	-0.157***	-0.157***
	[0.045]	[0.045]	[0.046]
Leverage	-0.739	-0.735	-0.728
	[0.490]	[0.490]	[0.486]
Tangibility	0.732**	0.729**	0.735**
	[0.327]	[0.328]	[0.327]
Dividend	0.572***	0.573***	0.571***
	[0.164]	[0.164]	[0.164]
Cash Holding	2.316***	2.326***	2.319***
	[0.504]	[0.505]	[0.506]
Constant	1.984***	1.974***	1.985***
	[0.695]	[0.695]	[0.705]
Adjusted-R_square	0.357	0.357	0.358
N	3633	3633	3633
Year FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes

This table reports the results from multivariate OLS linear and non-linear regressions for the effect of CO2emissions and the interaction of CO2emissions with 1) Family_Dummy, 2) Family_Ownership and 3) Family_ownership square term on firm performance (Tobin's Q) based on Equation 1 &2. Institutional ownership, R&D intensity, Size, Leverage, Tangibility, Dividend, Cash Holdings are controls. The variable definitions are provided in Appendix 1. The regressions include year, industry and country-fixed effects. Explanatory variables are lagged by one period to minimize the possibility of reverse causality. Robust standard errors clustered at the firm-level are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 7: The role of family ownership in explaining the effect of CO2 emissions on financial performance: Sub period analysis

	Tobin's Q					
	Before 2015			After 2015		
CO2emissions	-0.031**	-0.028**	-0.030**	-0.040**	-0.035**	-0.045**
	[0.014]	[0.012]	[0.013]	[0.019]	[0.017]	[0.018]
Family_Dummy	0.288**			0.107		
	[0.119]			[0.151]		
CO2emissions*Family_Dummy	0.005			0.01		
	[0.017]			[0.019]		
Family_Ownership		0.409*	0.781		0.187	0.479
		[0.212]	[0.542]		[0.222]	[0.796]
CO2emissions*Family_Ownership		0.004	0.144		0.001	0.317*
		[0.038]	[0.101]		[0.033]	[0.164]
Family_Ownership_Square			-0.467			-0.381
			[0.656]			[0.967]
CO2emissions*Family_Ownership_Square			-0.311*			-0.517**
			[0.181]			[0.254]
Institutional_Own	-0.245	-0.263	-0.237	-0.545**	-0.539**	-0.546**
	[0.298]	[0.299]	[0.301]	[0.245]	[0.243]	[0.244]
R&D intensity	1.266	1.196	1.116	9.664***	9.653***	9.742***
	[3.978]	[3.978]	[4.014]	[3.541]	[3.543]	[3.535]
Size	-0.135**	-0.134**	-0.135**	-0.165***	-0.165***	-0.166***
	[0.057]	[0.057]	[0.058]	[0.047]	[0.046]	[0.048]
Leverage	-0.654	-0.642	-0.631	-1.014*	-1.007*	-1.003*
	[0.570]	[0.571]	[0.569]	[0.555]	[0.556]	[0.549]
Tangibility	0.522	0.537	0.528	1.001**	0.990**	1.009**
	[0.378]	[0.382]	[0.379]	[0.432]	[0.429]	[0.430]
Dividend	0.362**	0.365**	0.362**	0.707***	0.708***	0.711***
	[0.148]	[0.147]	[0.147]	[0.220]	[0.220]	[0.221]

Cash Holding	1.773***	1.794***	1.797***	2.466***	2.473***	2.466***
	[0.502]	[0.504]	[0.504]	[0.633]	[0.637]	[0.637]
Constant	2.428***	2.408***	2.420***	2.482***	2.481***	2.498***
	[0.845]	[0.843]	[0.856]	[0.770]	[0.764]	[0.782]
Adjusted-R_square	0.388	0.386	0.386	0.364	0.364	0.366
N	1662	1662	1662	1971	1971	1971
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes

This table reports the results from multivariate OLS linear and non-linear regressions for the effect of CO2emissions and the interaction of CO2emissions with 1) Family_Dummy, 2) Family_Ownership and 3) Family_Ownership square term on firm performance (Tobin's Q) based on Equation 1 &2 in pre-and-post Paris agreement period. Institutional ownership, R&D intensity, Size, Leverage, Tangibility, Dividend, Cash Holdings are controls. The variable definitions are provided in Appendix 1. The regressions include year, industry and country-fixed effects. Explanatory variables are lagged by one period to minimize the possibility of reverse causality. Robust standard errors clustered at the firm-level are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Figure-1: The carbon emissions in family and non-family firms

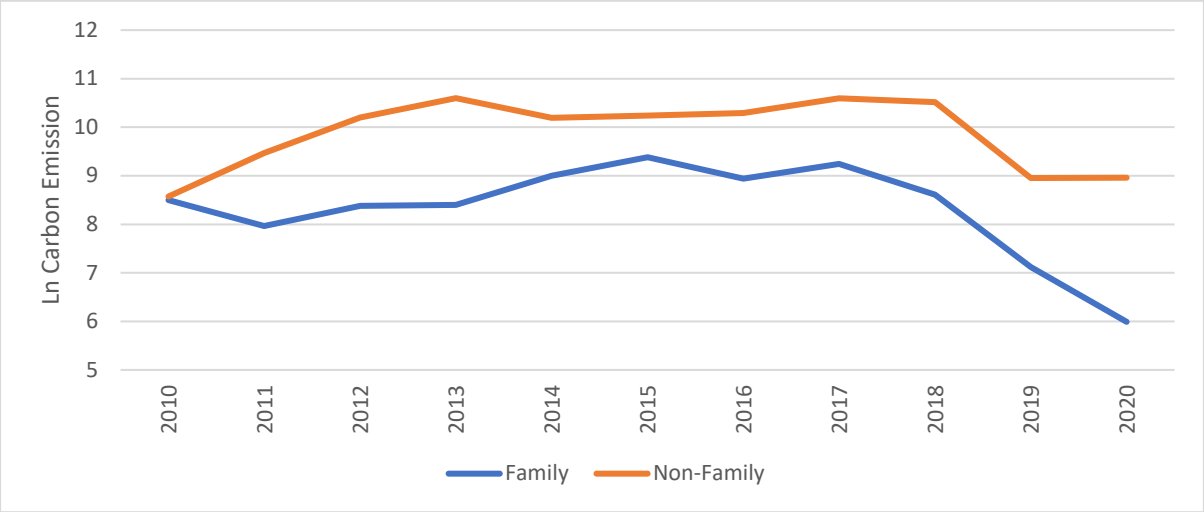
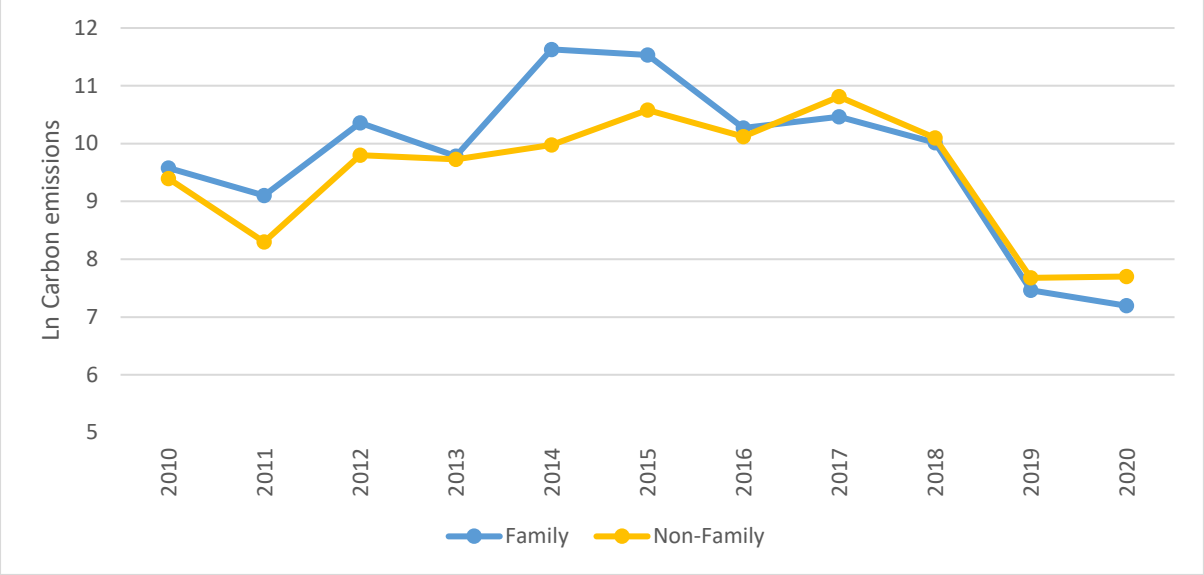


Figure-2: The carbon emissions in family and non-family firms (Matched sample)



.

Appendices
Table A1

Panel A: Definitions of variables

Variables names	**Variable definition and measurement**	**Sources**
Tobin's Q	Ratio of (total assets – book value of equity + market value of equity) to total assets.	Thomson Reuters' DataStream
CO2emissions	Ratio of Carbon dioxide (CO2) and its equivalents in tons [such as methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCS), perfluorinated compound (PFCs), sulfur hexafluoride (SF6), and nitrogen trifluoride (NF3) emissions] to (total assets in Euro x 100).	Thomson Reuters' ESG
Ln_CO2emissions	Natural logarithm of (1+ Carbon dioxide (CO2) and its equivalents in tons)	Thomson Reuters' DataStream
Family_Ownership	Percentage of shares held by one or more named individuals or families.	Bureau van Dijk ORBIS
Family_Dummy	A dummy variable that takes the value 1 if family ownership percentage is 20% or higher, 0 otherwise	Bureau van Dijk ORBIS
Institutional_Own	Percentage of shares held by one or more the following ownership types: bank; financial company; Foundation, research Institute; insurance company; mutual and pension fund, nominee, trust, trustee; private equity firm, venture capital.	Bureau van Dijk ORBIS
R&D Intensity	Ratio of research and development expenditures (R&D) to total assets.	Thomson Reuters' DataStream
Size	Natural logarithm of total assets in Euro.	Thomson Reuters' DataStream
Leverage	Ratio of total debt to total assets.	Thomson Reuters' DataStream
Tangibility	Ratio of property, plant and equipment to total assets.	Thomson Reuters' DataStream
Dividend	Ratio of cash dividend to net income.	Thomson Reuters' DataStream
Cash Holding	Ratio of cash and short-term investments to total assets.	Thomson Reuters' DataStream

Panel B: Correlation

Variables	Tobin's Q	CO2 emissions	Family Ownership	Family Dummy	Institutional_ Own	R&D Intensity	Size	Leverage	Tangibility	Dividend	Cash Holding
Tobin's Q	1										
CO2emissions	-0.103***	1									
Family_Ownership	0.088***	-0.066***	1								
Family_Dummy	0.091***	-0.025	0.908***	1							
Institutional_Own	0.023	-0.005	-0.175***	-0.163***	1						
R&D Intensity	0.259***	-0.165***	-0.030*	-0.045***	0.040**	1					
Size	-0.292***	0.140***	-0.053***	-0.055***	-0.014	-0.228***	1				

Leverage	-0.223***	0.049***	-0.063***	-0.058***	0.043***	-0.244***	0.263***	1			
Tangibility	-0.075***	0.367***	-0.046***	-0.047***	-0.022	-0.254***	0.139***	0.238***	1		
Dividend	0.056***	-0.081***	0.026	0.025	0.011	-0.150***	0.113***	0.006	0.022	1	
Cash Holding	0.262***	-0.104***	0.067***	0.061***	-0.023	0.366***	-0.302***	-0.372***	-0.220***	-0.129***	1

Table A2.1: The effect of CO2 emissions on financial performance

Matched Sample				
	DV=Tobin's Q			
CO2emissions	-0.045	-0.045	-0.044	-0.044
	[0.040]	[0.040]	[0.040]	[0.040]
Family_Dummy		0.125		
		[0.149]		
Family_Ownership			0.269	0.127
			[0.243]	[0.818]
Family_Ownership_Square				0.183
				[1.088]
Institutional_Own	-1.189***	-1.186***	-1.170***	-1.173***
	[0.371]	[0.369]	[0.367]	[0.373]
R&D Intensity	6.661*	6.718*	6.640*	6.592*
	[3.468]	[3.476]	[3.440]	[3.422]
Size	-0.228***	-0.227***	-0.228***	-0.229***
	[0.064]	[0.064]	[0.064]	[0.065]
Leverage	-0.735	-0.729	-0.723	-0.724
	[0.618]	[0.609]	[0.613]	[0.613]
Tangibility	1.375*	1.369*	1.359*	1.361*
	[0.710]	[0.697]	[0.692]	[0.695]
Dividend	0.925***	0.938***	0.940***	0.939***
	[0.275]	[0.276]	[0.276]	[0.273]
Cash Holding	1.808**	1.815**	1.847**	1.851**
	[0.886]	[0.884]	[0.891]	[0.898]
Constant	2.985***	2.901**	2.894**	2.925**
	[1.130]	[1.176]	[1.154]	[1.148]
Adjusted-R_square	0.308	0.308	0.309	0.308
N	754	754	754	754
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes

This table reports the results from multivariate OLS linear and non-linear regressions of matched sample for the effect of CO2emissions and family ownership on firm performance (Tobin's Q). Institutional ownership, R&D intensity, Size, Leverage, Tangibility, Dividend and Cash holdings are controls. The variable definitions are provided in Appendix 1. The regressions include year, industry and country-fixed effects. Explanatory variables are lagged by one period to minimize the possibility of reverse causality. Robust standard errors clustered at the firm-level are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table A2.2: The role of family ownership in explaining the effect of CO2 emissions on financial performance

Matched sample			
DV=Tobin's Q			
CO2emissions	-0.069	-0.047	-0.078
	[0.056]	[0.048]	[0.048]
Family_Dummy	0.081		
	[0.153]		
CO2emissions*Family_Dummy	0.046		
	[0.055]		
Family_Ownership		0.26	-0.507
		[0.254]	[0.856]
CO2emissions*Family_Ownership		0.012	0.980*
		[0.072]	[0.509]
Family_Ownership_Square			0.981
			[1.130]
CO2emissions*Family_Ownership_Square			-1.477**
			[0.750]
Institutional_Own	-1.176***	-1.169***	-1.172***
	[0.370]	[0.367]	[0.372]
R&D intensity	6.751*	6.645*	6.803**
	[3.476]	[3.442]	[3.389]
Size	-0.229***	-0.228***	-0.249***
	[0.064]	[0.064]	[0.065]
Leverage	-0.713	-0.722	-0.684
	[0.600]	[0.613]	[0.594]
Tangibility	1.415**	1.366*	1.337**
	[0.712]	[0.701]	[0.669]
Dividend	0.946***	0.940***	0.976***
	[0.277]	[0.276]	[0.272]
Cash Holding	1.818**	1.847**	1.823**
	[0.885]	[0.892]	[0.891]
Constant	2.934**	2.891**	3.252***
	[1.168]	[1.156]	[1.109]
Adjusted-R_square	0.309	0.308	0.325
N	754	754	754
Year FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes

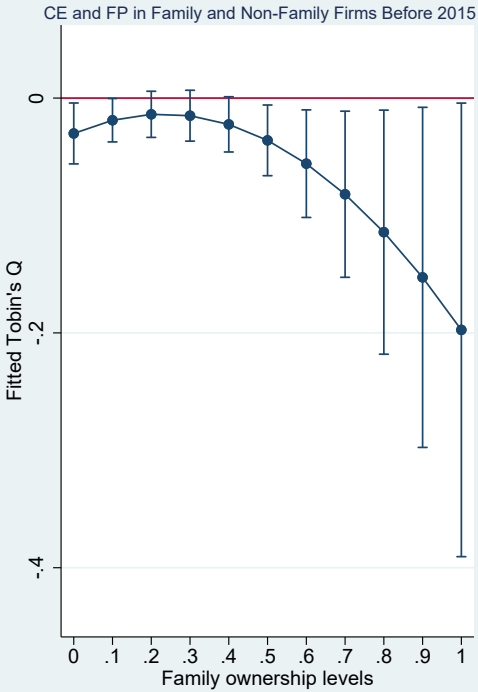
This table reports the results from multivariate OLS linear and non-linear regressions for the effect of carbon emissions intensity and the interaction of CO2emissions with 1) Family_dummy, 2) Family_Ownership and 3) Family_Ownership square term on firm performance (Tobin's Q) based on Equation 1 &2. Institutional ownership, R&D intensity, Size, Leverage, Tangibility, Dividend and Cash holdings are controls. The variable definitions are provided in Appendix 1. The regressions include year, industry and country-fixed effects. Explanatory variables are lagged by one period to minimize the possibility of reverse causality. Robust standard errors clustered at the firm-level are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

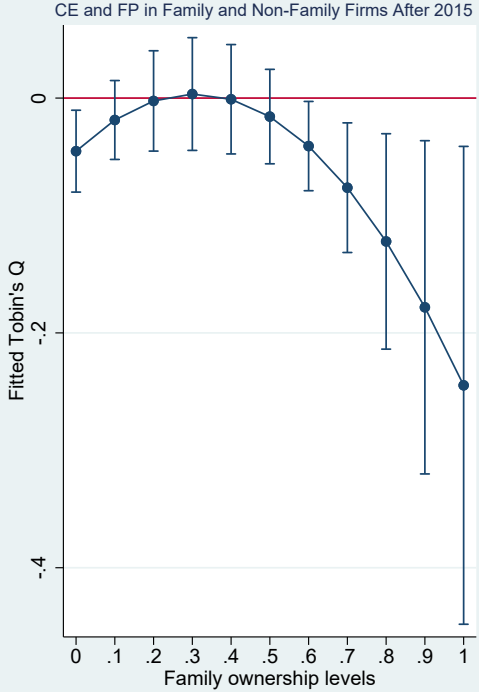
Table A2.3: The role of family ownership in explaining the effect of carbon emissions on market performance: Sub period analysis

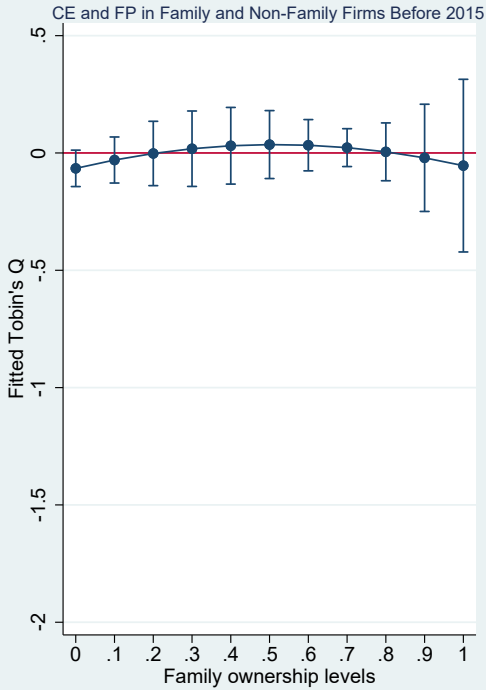
Matched sample						
	Tobin's Q					
	Before 2015			After 2015		
CO2emissions	-0.063	-0.065	-0.066*	-0.069	-0.017	-0.102*
	[0.038]	[0.040]	[0.039]	[0.085]	[0.068]	[0.061]
Family_Dummy	0.174			0.03		
	[0.147]			[0.219]		
CO2emissions*Family_Dummy	0.068			0.034		
	[0.070]			[0.078]		
Family_Ownership		0.237	0.435		0.261	-1.075
		[0.219]	[0.721]		[0.348]	[1.181]
CO2emissions*Family_Ownership		0.183*	0.394		-0.083	1.755***
		[0.110]	[0.456]		[0.110]	[0.602]
Family_Ownership_Square			-0.218			1.625
			[0.901]			[1.545]
CO2emissions*Family_Ownership_Square			-0.382			-2.740***
			[0.623]			[0.930]
Institutional_Own	-0.264	-0.345	-0.231	-1.604***	-1.604***	-1.909***
	[0.327]	[0.337]	[0.346]	[0.545]	[0.546]	[0.546]
R&D intensity	7.227**	7.402**	7.416**	6.015	6.031	6.529
	[3.500]	[3.461]	[3.442]	[4.377]	[4.352]	[4.267]
Size	-0.056	-0.05	-0.055	-0.281***	-0.279***	-0.317***
	[0.067]	[0.065]	[0.064]	[0.078]	[0.077]	[0.079]
Leverage	-1.100**	-1.082**	-1.096**	-0.882	-0.835	-0.736
	[0.550]	[0.545]	[0.549]	[0.755]	[0.764]	[0.731]
Tangibility	0.594	0.581	0.574	1.891**	1.705**	1.593**
	[0.591]	[0.595]	[0.593]	[0.906]	[0.846]	[0.738]

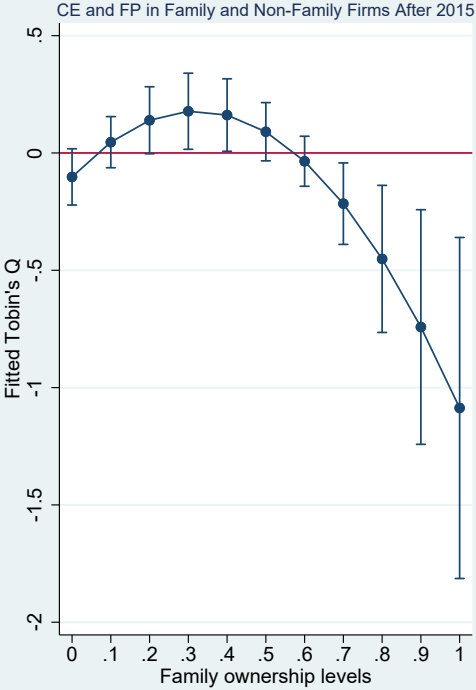
Dividend	0.313	0.313	0.320*	1.158***	1.161***	1.221***
	[0.191]	[0.191]	[0.193]	[0.383]	[0.383]	[0.377]
Cash Holding	0.441	0.526	0.469	2.432**	2.507**	2.411**
	[0.676]	[0.659]	[0.679]	[1.171]	[1.183]	[1.161]
Constant	2.337*	2.330*	2.348**	3.298**	3.216**	3.855***
	[1.276]	[1.228]	[1.150]	[1.357]	[1.332]	[1.287]
Adjusted-R_square	0.427	0.428	0.427	0.292	0.293	0.329
N	276	276	276	478	478	478
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Industy FE	Yes	Yes	Yes	Yes	Yes	Yes

This table reports the results from multivariate OLS linear and non-linear regressions for the effect of CO2emissions and the interaction of CO2 emissions with 1) Family_Dummy, 2) Family_Ownership and 3) Family_Ownership square term on firm performance (Tobin's Q) based on Equation 1 &2 in pre-and-post Paris agreement period. Institutional ownership, R&D intensity, Size, Leverage, Tangibility, Dividend and Cash holdings are controls. The variable definitions are provided in Appendix 1. The regressions include year, industry and country-fixed effects. Explanatory variables are lagged by one period to minimize the possibility of reverse causality. Robust standard errors clustered at the firm-level are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.


CE and FP in Family and Non-Family Firms Before 2015
Fitted Tobin's Q
0
-.2
-.4
0 .1 .2 .3 .4 .5 .6 .7 .8 .9 1
Family ownership levels


CE and FP in Family and Non-Family Firms After 2015
Fitted Tobin's Q
0
-.2
-.4
0 .1 .2 .3 .4 .5 .6 .7 .8 .9 1
Family ownership levels


CE and FP in Family and Non-Family Firms Before 2015
Fitted Tobin's Q
.5
0
-.5
-1
-1.5
-2
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1
Family ownership levels


CE and FP in Family and Non-Family Firms After 2015
Fitted Tobin's Q
.5
0
-.5
-1
-1.5
-2
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1
Family ownership levels