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Environmental policy stringency and the location choices of French FDI: examining the pollution haven hypothesis

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Abstract

In this study, I investigate how environmental policy stringency influences the location choices of French foreign direct investment in industries characterized by high levels of environmental pollution. Using mixed logit regressions, I examine French outward greenfield foreign direct investment projects in 37 countries between 2003 and 2018. The results suggest that French multinational enterprises operating in pollution-intensive industries are more likely to locate their foreign direct investment projects in countries with weaker environmental policy stringency. This finding is robust across different subsamples and model specifications. While results suggest that among French multinational enterprises operating in pollution-intensive industries, the tendency to locate foreign direct investment projects in countries with weaker environmental policy stringency is stronger for those operating in industries with higher mobility compared to those with lower mobility, this finding does not remain statistically significant when controlling for average wage. Despite limitations related to data availability and potential endogeneity issues, this study contributes to the literature by using a new measure of environmental policy stringency and focusing on the French context, where environmental policy is relatively stringent.

Keywords: foreign direct investment, environmental policy, pollution haven hypothesis, MNEs

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1. Introduction

Pollution, the introduction of unwanted, typically hazardous, material into the Earth's environment by human activity, threatens human health and harms ecosystems (Landrigan et al., 2018). 99% of the global population breathes air that contains higher levels of pollutants than World Health Organization guideline limits, with low- and middle-income countries experiencing the greatest levels of exposure (World Health Organization, n.d.). Diseases caused by air pollution are responsible for 6.5 million premature deaths each year (Fuller et al., 2022).

Some air pollutants have climate-warming properties, because they trap heat from the sun in the atmosphere (University Corporation for Atmospheric Research, n.d.). Human activities have significantly increased atmospheric levels of these greenhouse gases. Particularly through the extraction and combustion of fossil fuels, driven by increased global energy consumption since 1970 (National Academy of Sciences, 2020). Research suggests that by 2022, globally averaged surface concentrations of carbon dioxide, methane, and nitrous oxide have increased by 150%, 264%, and 124%, respectively, compared to pre-industrial levels before 1750 (World Meteorological Organization, 2023).

Greenhouse gas emissions have significantly contributed to a rise in global surface temperature. In the years 2011-2020, the temperature was 1.09 [0.95 to 1.20] °C higher compared to the years 1850-1900. The Intergovernmental Panel on Climate Change is highly confident that since 1970, global surface temperature has increased faster than in any other 50-year period in the last 2000 years (IPCC, 2023). The temperature rise has caused widespread climate change, damaging ecosystems and biodiversity. Increasing extreme weather events have led to food shortages, reduced water security, and health risks including malnutrition, diseases, and displacement. Cities, settlements, and infrastructure are increasingly vulnerable to flood damage. Climate-exposed sectors such as agriculture, forestry, fishery, energy, and tourism have suffered economic losses (IPCC, 2023).

Governments worldwide are putting in efforts to address pollution and climate change through policy measures. An example is the Paris Agreement, a legally binding international treaty with the objective of limiting the increase of global surface temperature to 1.5 °C above pre-industrial levels (United Nations Climate Change, n.d.). However, environmental policy efforts vary significantly among nations. In a global context, diverging climate action across countries may affect competitiveness and induce carbon leakage, thereby limiting the impact of increased climate initiatives (Nachtigall et al., 2021). Carbon leakage occurs when emission-intensive activities are relocated from countries with climate policies to countries with no or more lenient climate regulations (Böhringer et al., 2017). The pollution haven hypothesis (PHH) suggests that in countries with stringent environmental regulations, firms in pollution-intensive industries face higher compliance costs. These industries, characterized by high levels of environmental pollution, may relocate to regions with less stringent environmental regulations to maintain competitiveness against foreign firms (Taylor, 2005; Kellenberg, 2009).

Lenient environmental policies and low compliance costs might provide firms with location advantages and motivate them to engage in foreign direct investment, as described by Dunning (2000). Foreign Direct Investment (FDI) refers to cross-border investments in which an investor resident in one economy establishes a lasting interest in and a significant degree of influence over an enterprise resident in another economy (OECD, n.d.). Multiple studies have found a pollution haven effect in the FDI location decisions of (formerly) European Union-based firms (e.g., Wagner & Timmins, 2009; Naughton, 2014; Mulatu, 2017; Bialek & Weichenrieder, 2021). However, the pollution haven hypothesis is debated in the literature, as several studies do not find empirical support for its assertions (e.g., Raspiller & Riedinger, 2008; Manderson & Kneller, 2012; Rivera & Oh, 2013).

Over the last two decades, France had ambitious environmental policies targeting climate change and air pollution. This is reflected in the country's high scores on the OECD Environmental Policy Stringency Index, averaging 3.59 points annually on a scale of 0 to 6 over the period 2003-2018 (Kruse et al., 2022). In comparison, Brazil and Indonesia averaged 0.5 and 0.6 points, respectively. Potentially, French firms operating in pollution-intensive industries face significant costs related to environmental compliance. Additionally, France is a major source of FDI. From 2003 to 2018, France's average net outflow of FDI was 60,147 million dollars annually (UNCTAD, 2023). This raises the question of whether French MNEs in pollution-intensive industries consider variations in environmental policy stringency when choosing FDI locations, and whether this reflects a potential pollution haven effect. In this study, I address this question by examining:

"How does environmental policy stringency influence the location choices of French FDI in pollution-intensive industries?"

Using data on French outward greenfield FDI projects over the period 2003-2018, I first investigate whether French multinational enterprises operating in pollution-intensive industries are more likely to locate their FDI projects in countries with weaker environmental policy stringency (hypothesis 1). Greenfield investments involve setting up new subsidiaries or facilities in target markets to expand internationally. These investments are appropriate for analyzing the location decisions of MNEs, as they do not rely on prior capital investments, in contrast to mergers and acquisitions (Marinescu, 2016; Ascani et al., 2016; Wang et al., 2023).

Moreover, it is argued that pollution-intensive industries with different levels of mobility have varying responses to environmental regulations (Dou & Han, 2019). Potentially, industries characterized by higher mobility are more negatively impacted by stringent environmental policy compared to relatively mobile or "footloose" industries, as suggested by Kellenberg (2009). Therefore, I examine whether, among French multinational enterprises operating in pollution-intensive industries, the tendency to locate foreign direct investment projects in countries with weaker environmental policy stringency is stronger for those operating in industries with higher mobility compared to those with lower mobility (hypothesis 2).

In this study, I integrate two areas of economic research: the first explores determinants of foreign direct investment and the foreign activities of multinational enterprises, while the second focuses on the pollution haven hypothesis. This study contributes to the literature by focusing specifically on French outward FDI projects. It is the first study in this context in which FDI data from years after 2003 is analyzed, and the first in which the role of industry mobility is investigated. Moreover, a potential reason for the inconsistent results in previous studies is the challenge of accurately measuring environmental policy stringency (Bialek & Weichenrieder, 2021). I aim to address this challenge by investigating the pollution haven hypothesis using the OECD Environmental Policy Stringency Index, a recently updated composite indicator of environmental policy stringency (Kruse et al, 2022).

The study is relevant for policymakers, for two key reasons. First, it provides insights into how environmental policy stringency impacts a country's economic competitiveness. Second, understanding whether environmental policy stringency affects a country's attractiveness for FDI in pollution-intensive industries helps to assess the risk of carbon leakage, which limits the impact of climate initiatives.

I summarize the findings of this study as follows. Mixed logit estimations across a sample of 37 countries suggest that French multinational enterprises operating in pollution-intensive industries are more likely to locate their foreign direct investment projects in countries with weaker environmental policy stringency (hypothesis 1). Moreover, results from the main analysis suggest that among French multinational enterprises operating in pollution-intensive industries, the tendency to locate foreign direct investment projects in countries with weaker environmental policy stringency is stronger for those operating in industries with higher mobility compared to those with lower mobility (hypothesis 2). However, while the findings for hypothesis 1 are robust across subsamples of varying business activities and consistent under different model specifications, the findings for hypothesis 2 are not statistically significant when controlling for average wage.

The remainder of this paper is structured as follows. Section two provides a brief overview of literature addressing foreign direct investment location choices, research exploring the pollution haven hypothesis, and available empirical evidence of its effect on the FDI location choices of multinational enterprises. Section three describes the data and methodology, and section four presents the results. In section five the findings of this study are discussed, including its implications, the limitations of the study, and suggestions for future research.

2. Theoretical framework

This section outlines the theoretical framework of this study. First, I present an overview of existing theories concerning the FDI location choices of multinational enterprises and the pollution haven hypothesis. Next, I provide contextual background on environmental policy in France. Finally, I review empirical studies on the impact of environmental policy stringency on the FDI location decisions of multinational enterprises. Based on this literature review, I formulate two hypotheses.

2.1 Theoretical foundations of FDI and environmental policy

2.1.1 Theory on FDI location choice

Foreign Direct Investment (FDI) refers to cross-border investments where an investor resident from one economy establishes a lasting interest and a significant degree of influence over an enterprise in another economy (OECD, n.d.). FDI can take various forms, such as greenfield investments or mergers and acquisitions. Greenfield FDI refers to investments made to establish new subsidiaries or facilities within specific target markets to expand internationally (Marinescu, 2016; Ascani et al., 2016; Wang et al., 2023). In contrast, mergers and acquisitions are investments to gain ownership of an existing firm (Bialek & Weichenrieder, 2021). Multinational enterprises (MNEs) are characterized by their involvement in FDI and ownership or control of value-added activities across multiple countries. This definition of MNE is widely acknowledged within academic and business communities, by data-collecting organizations such as the Organisation for Economic Co-operation and Development (OECD) and recognized by most national governments and supranational entities (Dunning & Lundan, 2008).

An essential aspect of FDI activity concerns understanding why a firm would choose to service a foreign market through affiliate production. Dunning (2000) has formulated an influential theory concerning FDI decisions: the eclectic paradigm, also known as the OLI-framework. This framework is used for accommodating economic theories of the determinants of foreign direct investment and the foreign activities of multinational enterprises. It relies on the theory that a firm's decision to participate in FDI is based on the assessment of ownership advantages, location advantages, and internalization advantages, collectively known as OLI-factors.

Ownership advantages are the competitive advantages a firm has compared to its peers, like unique resources and capabilities. Location advantages are characteristics of the destination country that are attractive to firms, such as its regulations and policies. Internationalization advantages are present when a firm’s ownership advantages are better utilized within the organization, rather than being shared through contractual arrangements like franchising, licensing, or outsourcing with local firms. Based on the OLI-framework, a firm will engage in foreign direct investment when its ownership advantages, the location advantages of the host country, and the internalization advantages outweigh the cost of engaging in commercial activities in a foreign country.

The liability of foreignness theory, as described by Zaheer (1995), highlights the costs that multinational enterprises face in foreign markets that local firms do not incur. Eden & Miller (2004) expanded on this concept and argued that the liability of foreignness encompasses social costs that arise from the unfamiliarity, discriminatory, and relational hazards encountered by foreign firms beyond what local firms typically face in the host country. Unfamiliarity hazards arise from lack of experience, discriminatory hazards result from biased treatment by various stakeholders, and relational hazards encompass increased administrative, governance, negotiation, and trust-building costs incurred by multinational enterprises operating across borders.

Dunning and Lundan (2008) stated that the importance and composition of the three advantages within the OLI-framework vary based on a firm's motivation for investing abroad. Dunning (2000) described four main motives of foreign-based MNE activity. Market-seeking FDI is aimed at meeting the needs of specific foreign markets. Resource-seeking FDI is intended to secure access to resources such as minerals, agricultural products, or unskilled labor. Efficiency-seeking or vertical FDI is aimed at enhancing the efficiency of labor division or specialization within the existing portfolio of foreign and domestic assets by MNEs. The purpose of strategic asset seeking FDI is to protect or enhance an investing firm's ownership-specific advantages, as discussed in the OLI-framework. In the literature, each of these motives is associated with different determinants of FDI (e.g., Villaverde & Maza, 2015).

Environmental policy stringency across countries potentially influences the FDI location choices of MNEs. Complying with stringent environmental policy can increase costs for firms (Wagner & Timmins, 2009) (Wagner & Timmins, 2009). Examples of cost-increasing policies are emissions taxes. In countries with more lenient environmental policies, the compliance costs are lower, which offers a location-specific advantage as described by Dunning (2000). Therefore, MNEs may choose to invest in countries with lax environmental regulations to avoid the higher costs associated with stricter policies. This choice relates to Dunning's (2000) efficiency-seeking motive (Santos & Forte, 2021).

2.1.2 The pollution haven hypothesis

Building upon the understanding of factors influencing FDI location decisions, the potential cost advantages offered by lenient environmental policies relate very closely to the pollution haven hypothesis (PHH). This is a major theory in economic literature that proposes that in countries with relatively strict environmental policies, firms operating in pollution-intensive industries incur high costs associated with compliance. As a result, these firms relocate to areas where environmental policy is less stringent, to avoid losing their competitiveness against foreign firms (Kellenberg, 2009).

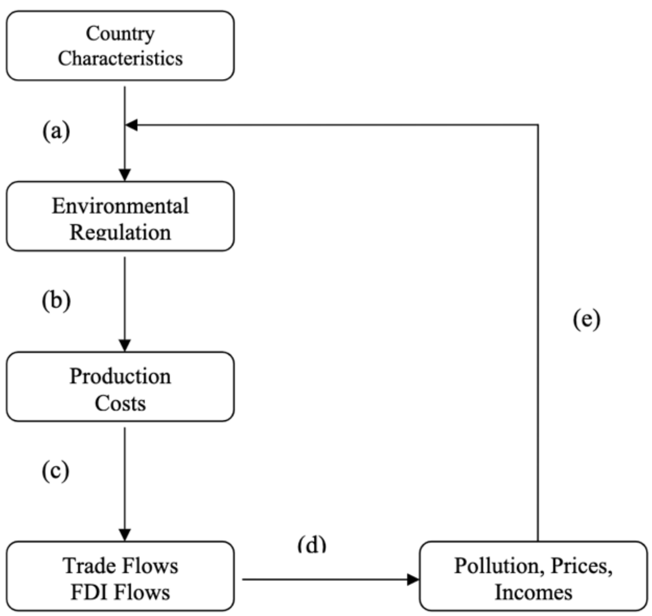
The debate on the relationship between environment and investment flows started in the 1970's and intensified in the 1990's with the expansion of trade openness by various organizations including the

North American Free Trade Agreement and the World Trade Organization. At this time, concerns grew about the potential impact of increased international trade on the environment (Stonehouse, 2000; Ederington, 2007; Gill et al., 2018).

Taylor (2005) provided a schematic representation to illustrate the framework of the pollution haven hypothesis, which is depicted in Figure 1. This framework considers country-specific characteristics, such as unique endowments of productive factors, as given. Different countries adopt varying levels of environmental policies (a), influenced by their country characteristics. High-income countries tend to have stricter environmental policies than low-income countries. These environmental policies, like pollution taxes, influence the costs of goods production in the economy. Given that certain production methods are more polluting than others, the impact of environmental policies will vary across industries. Therefore, environmental policies affect how goods are priced in an economy (b). Changes in prices affect a country's competitiveness and influence trade and FDI flows (c). Pollution-intensive industries might relocate from countries with strict policies to countries with lenient policies. This shift in investment impacts pollution levels, incomes, and global market prices (d). These changes create a feedback loop, where adjustments in trade, pollution, and environmental policies are all determined simultaneously (e).

Figure 1

Schematic representation of the pollution haven hypothesis



Note. Figure obtained from Taylor, M. S. (2005). Unbundling the pollution haven hypothesis. *Advances in Economic Analysis & Policy, 4*(2), p. 6.

When industries that produce high levels of pollution move from countries with stringent environmental policies to countries with no or more lenient climate policies, it leads to carbon leakage (Böhringer et al., 2017). Carbon leakage occurs when carbon dioxide emissions relocate from one region to another (Naegele & Zaklan, 2019; Cameron & Baudry, 2023). Globally, varying approaches to climate action can induce carbon leakage, which undermines the effectiveness of increased climate efforts (Nachtigall et al., 2021).

2.2 Context of the study: environmental policy stringency in France

Levels of environmental policy stringency vary significantly across different countries. In the context of this study, I specifically focus on greenfield FDI that originates from France. France is notable for its relatively stringent environmental policies, having set ambitious environmental goals for addressing pollution and climate change over the past two decades.

For a large part, France's policies within this domain are shaped by international policies. For instance, by commitment to the Kyoto Protocol, the first international treaty to set legally binding targets to reduce greenhouse gas emissions. It entered into force in 2005 and mandated parties to reduce greenhouse gas emissions by 5 percent below 1990 levels (United Nations, n.d.). Through the European Union, France participates in the EU Emissions Trading System. Under this system, a limit is set on the total greenhouse gas emissions that are allowed from installations and aircraft operators. The limit is lowered annually to ensure emissions decline over time. Companies must buy additional allowances if they exceed their emission limits, while those emitting less can sell their allowances (European Commission, n.d.-a). Finally, France is a party to the Paris Agreement and played a key role in the adoption of this agreement by the Conference of the Parties to the United Nations Framework Convention on Climate Change (OECD, 2016).

While international policies play an important role, France has also been proactive on a national level. In 2005, the Environmental Charter was adopted and incorporated into the French Constitution. This initiative established the right to live in a balanced environment and showed France's dedication to environmental protection (Marrani & Turner, 2019). Since then, taxation has played a crucial role in France's pollution and climate change policy. For instance, excise duties on unleaded petrol and diesel in France surpassed EU minimum rates. In 2010, the EU minimum rate was 359 euros per 1,000 liters for unleaded petrol and 330 euros per 1,000 liters for diesel. In comparison, France's rates were much higher, at 607 euros per 1,000 liters for unleaded petrol and 428 euros per 1,000 liters for diesel (European Automobile Manufacturers Association, 2010). In addition, France introduced a carbon dioxide emission tax in 2014. The tax rate started at seven euros per ton of emissions, which increased annually until it reached €44.60 per ton in 2018 (Savolainen, 2020). Including France, only fourteen countries worldwide had both a carbon dioxide tax and an emissions trading system operating in 2014 (World Bank Group, n.d.).

Moreover, under the National Emission Ceilings Directive, France had relatively low emission ceilings for sulfur dioxide (SO_2) and nitrogen oxides (NO_x) compared to other large EU economies. For example, France's emission ceiling for SO_2 in 2010 was set at 375 kilotons, which was lower than Germany's ceiling of 520 kilotons and the United Kingdom's ceiling of 585 kilotons (European Federation of Clean Air and Environmental Protection Associations, n.d.). In addition, France restricts pollution by road transport through various low-emission zones throughout the country. In these areas, vehicle access is limited based on vehicle emissions performance or certification level (LEZ-France.fr, n.d.).

France's environmental policies targeting climate change and air pollution are reflected in the country's high scores on the OECD Environmental Policy Stringency Index (Kruse et al., 2022). Between 2003 and 2018, France achieved an average annual score of 3.59 out of 6. By annual average, France tied with Denmark and outperformed every other country included in the dataset during these years. The index and its composition will be explained in more detail in the data section (4.1.3) of this thesis. As France's environmental policy stringency is relatively high compared to other countries, French firms potentially face significant costs related to environmental compliance. For example, the carbon dioxide emissions tax places financial burdens on firms that produce high levels of pollution. These costs could drive firms to seek investment opportunities abroad, particularly in countries with more lenient environmental policies, as predicted by the pollution haven hypothesis.

2.3 Empirical literature and hypotheses

This study contributes to an extensive body of literature that examines the relationship between environmental policy stringency and the FDI location choices of MNEs. In this section, I provide an overview of prior empirical studies and formulate two hypotheses. First, I discuss research on the pollution haven effect. Second, I discuss studies that investigate the role of industry mobility.

2.3.1 Empirical studies on the pollution haven effect

As stated by Naughton (2014), the presence of a substantial pollution haven effect is a necessary condition for validating the pollution haven hypothesis. This effect is present when FDI moves from countries with stringent environmental regulations to those with more lenient regulations in response to regulatory differences. Although this phenomenon has been widely studied, empirical findings vary.

Several studies focused on FDI originating from specific European countries and suggest the presence of a pollution haven effect. Wagner and Timmins (2009) investigated the outward FDI flows of various industries in the German manufacturing sector and found robust evidence of a pollution haven effect for the chemical industry in Germany. Similarly, Bialek and Weichenrieder (2021) showed that stricter environmental regulations reduce greenfield investments by German firms in polluting industries. Their results suggest that the impact of environmental regulations is much stronger on greenfield investments compared to the number of mergers and acquisitions. Additionally, Mulatu (2017) investigated UK-based multinational activity in 64 countries across 23 industries and found that there is a significant effect of environmental policy on the pattern of UK outbound FDI. The results suggest that when environmental laxity increases by one standard deviation, the FDI in industries that are above-average pollution-intensive increases by 28%.

Further research on outward FDI from groups of European or OECD countries also suggests the presence of a pollution haven effect. For instance, Mulatu et al. (2010) observed a pollution haven effect in the context of the location choice of manufacturing industries in Europe. Garsous and Kozluk (2017) investigated the effect of higher domestic energy prices, driven by environmental policy, on the outward stock of FDI of listed firms in 23 OECD countries. They found a significant, but modest, positive association between energy price increases on the outward FDI stock of firms. The effect is primarily driven by long-term fluctuations in energy prices that are caused by strict upstream environmental regulations. Additionally, Naughton (2014) analyzed a bilateral FDI dataset that includes 28 OECD countries for the period 1990-2000 and found that increased environmental regulations in host countries decrease FDI. Moreover, evidence of a pollution haven effect has also been found for firms from the United States (Hanna, 2010; Millimet & Roy, 2016) and Asia (Zhang & Fu, 2008; Chung, 2014; Yoon and Heshmati, 2021).

However, the debate in the literature regarding the Pollution Haven Hypothesis continues, as several studies have not found empirical support for its assertions. Manderson and Kneller (2012) investigated outward FDI by firms from the United Kingdom and found that environmental regulations do not significantly influence the decision to internationalize. Furthermore, MNEs with high environmental compliance costs do not demonstrate a greater propensity to locate subsidiaries in host countries with lenient environmental policies compared to MNEs with low environmental compliance costs. Findings by Rivera and Oh (2013) contradict the pollution haven hypothesis regarding the investments of 94s MNEs across 77 countries. Their results suggest that FDI tends to flow to countries with clearer and more stable environmental regulations compared to the home countries of MNEs.

Three prior studies have focused on FDI originating from France. These studies show mixed results, reflecting a debate on the impact of environmental policy. Ben Kheder (2010) examined French outward FDI projects from 1999 to 2003 and found that environmental regulation is negatively associated with both polluting and less polluting FDI, with a greater negative effect observed in polluting industries. Ben Kheder and Zugravu (2012) found evidence that environmental policy stringency is correlated with the FDI location choice of firms for a pooled sample of countries receiving French FDIs from 1996 to 2002. However, a sensitivity analysis confirmed this effect for developed countries, most of emerging economies, and Central and Eastern European countries only, and not for most countries of the Commonwealth of Independent States and developing countries. Raspiller and Riedinger (2008) examined the location choices of French firms between the years 1993 and 1999 and concluded that environmental regulations do not significantly determine the FDI location choice of these firms. They argued that this finding is driven by a lack of economic impact, as they found that even under harmonization of environmental regulations, the overall distribution of new firms would change by less than 1.5%.

These prior studies focusing on FDI originating from France provide useful insights. However, they focus on earlier years, ranging from the early 1990s to the early 2000s. This limits their relevance to current conditions, as environmental policy has evolved significantly since then. As such, the impact of environmental policy stringency on outward French FDI in recent years remains underexplored. This study addresses this gap by analyzing French greenfield FDI data from 2003 to 2018, capturing more recent trends and environmental policy changes.

Various arguments have been proposed to explain why empirical evidence of a pollution haven effect is not always found. Some argue that the endogeneity of environmental policy leads to biased estimates (Ederington & Minier, 2004; Levinson & Taylor, 2008; Millimet & Roy, 2016). Reverse causality might also affect results, as some studies suggest that environmental regulation stringency potentially attracts foreign direct investment (Kim & Rhee, 2019; Poelhekke & Van der Ploeg, 2015). Besides, most studies do not distinguish between market-seeking FDIs and efficiency-seeking FDIs. Most evidence suggests that market-seeking motives are the primary driver of most FDI, while the pollution haven hypothesis may only explain the motives for efficiency-seeking FDI (Rezza, 2015). Other arguments include that industries rely on home markets, that low-regulation countries have characteristics such as pollution that deter investment, and that foreign investors do not wish to have a reputation for taking advantage of lenient environmental policy (Cole, 2004).

Finally, finding a measure that accurately represents environmental policy poses a challenge (Bialek & Weichenrieder, 2021). For instance, many studies rely on survey results from the WEF Executive Opinion Survey to measure environmental policy stringency. These survey results reflect how business leaders evaluate environmental policy stringency (e.g. Kellenberg, 2009; Wagner & Timmins, 2009; Manderson & Kneller, 2012; Chung, 2014; Poelhekke & Van der Ploeg, 2015; Bialek & Weichenrieder, 2021; Yoon & Heshmati, 2021). A downside of this measure is that it is based on subjective perceptions, which can introduce bias and may not accurately reflect actual policy stringency. To address this challenge, I use the recently updated OECD Environmental Policy Stringency Index to measure environmental policy stringency (Kruse et al., 2022). This index offers a more objective and comprehensive measure, by comparing specific policies addressing climate change and air pollution, as explained in section 3.2.1.

2.3.2 Hypothesis 1

As described in section 2.1.1, Dunning's (2000) OLI-framework proposes that firms will engage in FDI when its ownership advantages, the location advantages of the host country, and the internalization advantages outweigh the cost of engaging in commercial activities in a foreign country. Stringent environmental policies can lead to significant compliance costs for firms (Wagner & Timmins, 2009). To avoid these costs, MNEs might prefer investing in countries with more lenient policies, to gain a location-specific advantage as described by Dunning (2000). This strategy matches with Dunning's (2000) efficiency-seeking motive, as firms aim to reduce operational expenses (Santos & Forte, 2021). It also aligns with the pollution haven hypothesis, which proposes that firms in pollution-intensive industries are incentivized to relocate to countries with less stringent environmental regulations to minimize compliance costs and remain competitive in the global market (Taylor, 2005; Kellenberg, 2009).

For French MNEs, the consideration of environmental policy stringency is particularly relevant. Section 2.2 outlines that over the last two decades, French policies on pollution and climate change have been stringent, including a carbon dioxide tax, high excise duty rates on Diesel, and greenhouse gas emission limits. These measures have contributed to France's high annual OECD Environmental Policy Stringency Index scores (Kruse et al., 2022). Consequently, this provides firms operating in pollution-intensive industries with an incentive to relocate to countries with more environmental policies to reduce expenses and maintain competitiveness, as stated by the pollution haven hypothesis.

Additionally, France has been a major source of FDI outflow. Between 2003 to 2018, France's average annual net outflow of FDI was 60,147 million dollars, representing quite a substantial portion of the total average of 1,356,859 million dollars for that period (UNCTAD, 2023). If the pollution haven hypothesis is valid, there should be observable evidence of a pollution haven effect, where FDI moves from countries with strict environmental regulations to those with more relaxed policies in response to these policy differences (Naughton, 2014).

As described in section 2.3.1, empirical studies provide mixed results. While some studies observe a pollution haven effect (e.g., Wagner & Timmins, 2009; Ben Kheder, 2010; Mulatu, 2017); others do not find a significant influence of environmental policy on the FDI location decisions of MNEs (e.g. Manderson & Kneller, 2012; Rivera & Oh, 2013). Given these mixed findings, I explore the relationship between environmental policy stringency and the FDI location choices of French MNEs operating in polluting-intensive industries during the period 2003-2018. I propose the following hypothesis:

Hypothesis 1 (**H1**): French multinational enterprises operating in pollution-intensive industries are more likely to locate their foreign direct investment projects in countries with weaker environmental policy stringency.

2.3.3 The role of industry mobility

Industries differ in how easily they can change locations. For example, power plants have to produce locally, which limits their ability to relocate in response to stringent environmental policy (De Beule et al., 2022). In the literature, some studies focus on how industry mobility affects the sensitivity of MNEs to changes in environmental policy.

Letchumanan and Kodama (2000) argued that it is not realistic to assume that industries can move freely across borders in the context of pollution havens. If studies assume that industries are perfectly mobile, the transaction costs of moving industries between locations are underestimated. This is supported by Ederington et al. (2005), who argued that when the average effect of an increase in environmental costs is estimated over all industries, the effect of environmental policies on trade flows in mobile industries is understated. Moreover, the industries with the largest pollution abatement costs are often relatively immobile. If studies no not consider this correlation, this can result in the finding that pollution-intensive industries are less sensitive to changes in environmental policy. They used three indicators to measure industry mobility: the product-market transport costs, fixed plant costs, and the level of agglomeration economies.

Furthermore, Kellenberg (2009), found that pollution havens are driven by relatively mobile industries. Mobile industries, such as electronic and appliance manufacturing, are more negatively impacted by stringent environmental policy compared to less mobile industries like mining, chemicals, or metals. In the study, industries with a high capital-to-labor ratio are considered to be less mobile. Similarly, Cole et al. (2010) analyzed trade flow data between the United States and Japan and found that stringent environmental policies had a minimal impact on imports of less mobile industries. Their findings suggest that the pollution haven effect is most notable in industries that are both mobile and heavily polluting.

Moreover, Dou and Han (2019) found that pollution-intensive industries with varying levels of mobility respond differently to environmental policies. Industries with higher levels of mobility are more likely to relocate to areas with lenient environmental policies, while less mobile industries tend to increase investments in research and development to meet environmental requirements. They used sunk costs, asset specificity, employment size, and ratio of state-owned capital to measure how mobile industries are.

De Beule et al. (2022) investigated the European Union Emissions Trading System and linked trade intensity to industry mobility. They found that pollution-intensive industries that have low trade intensity with countries that do not participate in the trading system are less likely to relocate to these non-participating countries to avoid the costs of the emissions policy. This finding aligns with Tang (2015), who found that local-market-oriented FDI and export-oriented FDI respond to changes in environmental policy in a different way. Local-market-oriented MNEs are less sensitive to environmental policy changes compared to export-oriented MNEs. Local-market-oriented MNEs benefit from being close to the market, which can outweigh the costs of complying with environmental policies. However, export-oriented MNEs are likely to experience a competitive disadvantage compared to their foreign competitors if costs increase.

The studies listed all suggest that industry mobility influences how industries respond to environmental policies. However, research that investigates how industry mobility levels affect FDI decisions within national contexts is still quite limited. While previous studies have focused on the impact of environmental policies on the location choices of French outward FDI (Raspiller & Riedinger, 2008; Ben Kheder, 2010; Ben Kheder & Zugravu, 2012), they have not yet considered whether industry mobility affects this relationship. In this study, I address this gap by investigating how industry mobility affects the relationship between environmental policies and the location choices of French FDI.

2.3.4 Hypothesis 2

As stated in the first hypothesis, I expect that multinational enterprises operating in pollution-intensive industries are more likely to locate their foreign direct investment projects in countries with weaker environmental policy stringency. However, while pollution-intensive industries might have an incentive to relocate to countries with lenient environmental policies, these industries are generally less geographically mobile (Ederington et al., 2005). A potential explanation for this is that pollution-intensive sectors are characterized by having capital-intensive production processes (Cole & Elliott, 2005).

In the context of the pollution haven hypothesis, assuming perfect mobility underestimates the transaction costs of relocating industries (Letchumanan & Kodama, 2000). Disregarding industry mobility potentially leads to the conclusion that polluting industries are less sensitive to increases in environmental costs (Ederington et al., 2005). Previous studies have found empirical support that pollution-intensive industries with different levels of mobility have varying responses to environmental policy (Kellenberg, 2009; Dou & Han, 2019). By proposing the following hypothesis, I examine whether the expected relationship between environmental policy stringency and the location choices of French FDI in pollution-intensive industries is moderated by industry mobility:

Hypothesis 2 (**H2**): Among French multinational enterprises operating in pollution-intensive industries, the tendency to locate foreign direct investment projects in countries with weaker environmental policy stringency is stronger for those operating in industries with higher mobility compared to those with lower mobility.

3. Data and Methodology

3.1 Data

3.1.1 Foreign Direct Investments

I retrieved data on foreign direct investment projects from the fDi Markets Database, a service provided by the Financial Times Group. The dataset includes 2,112 cross-border greenfield investment projects dating between 2003 and 2018 in 37 countries, with France as the source country. It provides details on the investor, destination area, year, relevant sectors, and business functions for each investment project. The data is collected from various sources, including newswires, market research companies, and project data from industry organizations and investment agencies. Investment projects of all sizes are included. Moreover, each investment project is cross-referenced with multiple sources, with a primary focus on direct company sources, to ensure accuracy (FDi Markets, n.d.)

The FDi Markets Database is frequently used in studies investigating the location choices of MNEs (e.g., Crescenzi et al., 2014; Georgallis et al., 2021; Wang et al., 2023). In contrast to mergers and acquisitions, greenfield investments are not reliant on prior capital investments. Therefore, greenfield investments are particularly appropriate to analyze the location decisions of MNEs (Marinescu, 2016; Ascani et al., 2016; Wang et al., 2023). I excluded three investment projects from the sample, as the value of 'estimated investment' was equal to zero, which suggests a lack of actual investment. Finally, I verified that all countries included in the sample have been chosen for at least one investment project.

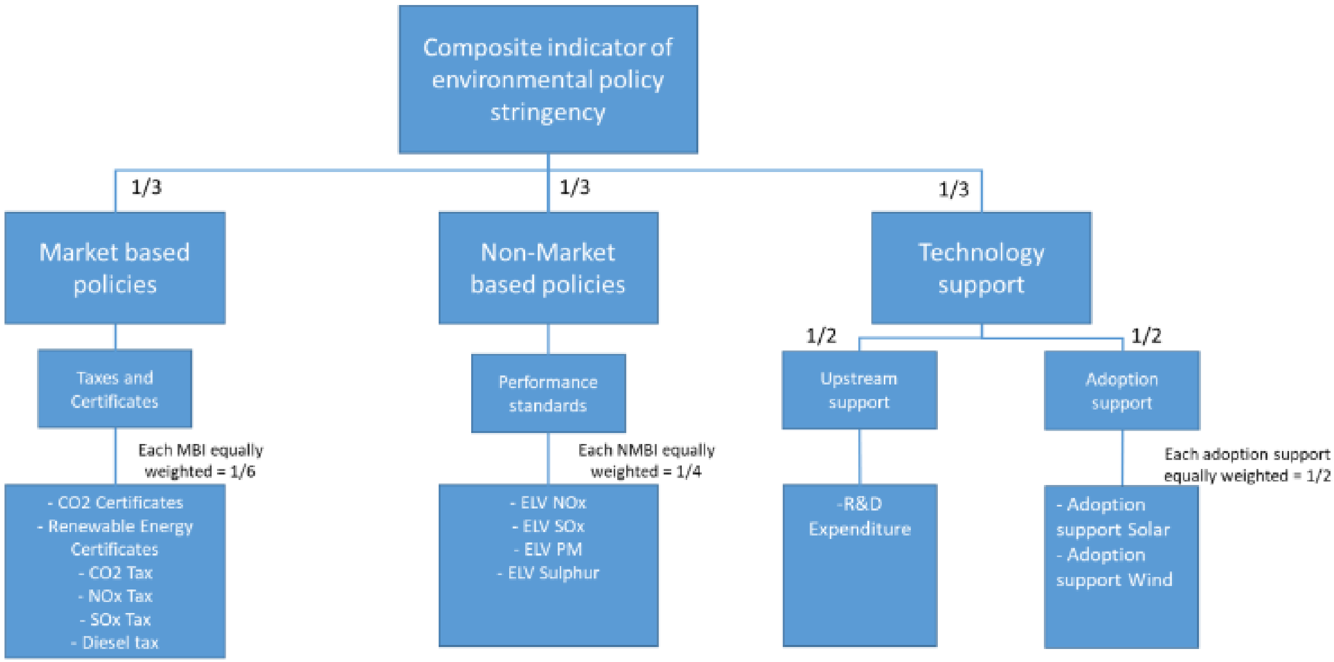
3.1.2 OECD Environmental Policy Stringency Index

I used the OECD Environmental Policy Stringency (EPS) Index to measure environmental policy stringency on a national level (Kruse et al., 2022). The EPS Index incorporates policies that address climate change and air pollution, two policy domains for which extensive data is accessible. The index does not include policies within other environmental domains such as water, biodiversity, or waste management. Data on these policies is not available in a large cross-country panel, as these policies are frequently set at the municipal level and are challenging to turn into a quantitative cross-country indicator. Figure 2 illustrates the composition of the Environmental Policy Stringency Index.

The EPS consists of three sub-indexes: market-based instruments (MBI), non-market-based instruments (NMBI), and technology support (TS) policies. The MBI sub-index entails policies that put a price on pollution: carbon dioxide trading schemes, renewable energy trading schemes, carbon dioxide taxes, sulfur oxide taxes, and Diesel fuel taxes. The NMBI sub-index encompasses policies that mandate emission limits and standards: emission limit values for nitrogen oxides, sulfur oxides and particulate matter, and sulfur content limit for Diesel fuel. The TS sub-index comprises public research and development

Figure 2

Composition of the OECD Environmental Policy Stringency Index



Note. Figure adapted from Kruse et al. (2022). *Measuring environmental policy stringency in OECD countries: An update of the OECD composite EPS indicator* (OECD Economics Department Working Papers No. 1703). OECD Publishing.

expenditure on low-carbon energy technologies and renewable energy support for solar and wind energy technologies. Based on these factors, countries receive a score that ranges from zero (indicating no environmental policy) to six (indicating stringent environmental policy) (Kruse et al., 2022). Table 1 displays all countries in the dataset, the number of French FDI projects they received during 2003-2018, and their mean Environmental Policy Stringency Index score during the same period.

3.1.3 Greenhouse gas air emission intensities by NACE Rev. 2 activity

To identify pollution-intensive industries, I retrieved annual greenhouse gas emission intensities for different economic activities in France, classified under the NACE Rev. 2 system, from Eurostat (n.d.). Greenhouse gas emissions comprise carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3), all expressed in CO_2 equivalents. Emissions intensities are measured in kilograms of greenhouse gases per euro of gross value added. The values are chain-linked to the year 2010 to adjust for inflation and provide a consistent basis for comparison over time.

Table 1

French FDI distribution in pollution-intensive industries and Environmental Policy Stringency Index Scores across countries in the sample

Country	Number of French FDI projects in pollution-intensive industries	Environmental Policy Stringency Index score (mean)
United States	306	2.01
United Kingdom	212	2.81
Spain	190	2.34
China	182	1.52
Germany	118	2.96
Russian Federation	113	0.81
Brazil	110	0.51
India	98	1.71
Poland	93	2.44
Canada	74	2.68
Belgium	73	2.60
Mexico	58	1.04
Italy	47	3.18
Turkey	44	1.92
Australia	44	2.41
Portugal	40	2.47
Netherlands	38	2.88
Indonesia	30	0.58
Chile	29	1.00
Czech Republic	25	2.75
South Africa	24	0.74
Hungary	22	2.92
Japan	21	3.35
South Korea	20	2.90
Ireland	17	2.42
Switzerland	11	3.18
Austria	11	2.70
Slovakia	10	2.29
Finland	8	3.25
Norway	9	3.18
Greece	7	2.31
Denmark	7	3.48
Slovenia	6	2.25
New Zealand	5	0.64
Israel	4	0.76
Sweden	4	3.38
Estonia	2	3.21

As the data is available starting from 2008, I retrieved emission intensities for the years 2008-2018. During this period, the annual average emission intensity for all NACE Rev. 2 classified economic activities in France was 0.20 kilograms of greenhouse gases per euro of gross value added. Industries with an annual average emission intensity above this threshold are classified as pollution-intensive. Using this threshold exactly includes all activities within the top quartile, identifying 16 pollution-intensive economic activities across 24 NACE Rev. 2 divisions.

In the fDi Markets database, each project is classified based on its sector and sub-sector using a proprietary industry classification system (FDi Markets, n.d.-a). This classification does not precisely match the NACE Rev. 2 classification. Stöllinger (2021) provided a correspondence table to convert the classification of subsectors used in the fDi Markets database into NACE Rev. 2 classification. Since Stöllinger's (2021) table is not entirely comprehensive, I expanded it by mapping additional subsectors. Table 1 of the appendix displays the extended conversion table. I identified 73 subsectors in the fDi Markets database as pollution-intensive, with investment projects present across 68 of these subsectors. The greenhouse gas emission intensities of NACE Rev. 2 activities are displayed in Table 2 of the appendix.

3.1.4 Industry mobility

Following Kellenberg (2009), I used the industry capital-to-labor ratio as a proxy to assess industry mobility. Industries with lower fixed costs relative to their number of employees are assumed to be more footloose and mobile. To calculate the industry capital-to-labor ratio, I retrieved annual employment and annual fixed assets by economic activity from OECD (n.d.-b; n.d.-c), with France as the reference area. Annual employment is measured in hundreds of persons and includes employees and self-employed individuals. Employees include both residents and non-residents working for resident producer units, while self-employed individuals include both residents and non-residents who operate their businesses within these units. Annual fixed assets are measured in gross value in millions of euros in current prices, covering items covering items such as buildings, machinery, and equipment.

Both employment and fixed assets are classified according to Revision 4 of the International Standard Industrial Classification of All Economic Activities (ISIC), as described by The Department of Economic and Social Affairs of the United Nations Secretariat (2007). I manually matched these industries to subsectors classified as pollution-intensive in the FDi Markets Dataset. The mapping table of this matching process is included in Table 3 of the appendix. I calculated the capital-to-labor ratio by dividing annual employment by annual fixed assets for each economic activity annually. Table 2 presents the mean capital-to-labor ratios across industries used in the analysis.

Table 2

Mean capital-to-labor ratios by ISIC Classified Economic Activity (in millions of €/hundred employees)

ISIC classified economic activity	Mean capital-to-labor ratio (in millions of €/hundred employees)
Agriculture, forestry and fishing	26.76
Mining and quarrying	236.76
Manufacture of food products; beverages and tobacco products	12.59
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials; manufacture of paper and paper products; printing and reproduction of recorded media	15.34
Manufacture of coke and refined petroleum products	77.63
Manufacture of chemicals and chemical products	41.50
Manufacture of rubber and plastic products and other non-metallic mineral products	14.05
Manufacture of basic metals and fabricated metal products, except machinery and equipment	16.76
Electricity, gas, steam and air conditioning supply	136.43
Water supply; sewerage, waste management and remediation activities	64.41
Transportation and storage	17.51

3.1.5 Control variables

I included several control variables in the analysis to account for factors that might confound the relationship between French FDI location decisions and Environmental Policy Stringency. For the choice of control variables, I referenced literature on the pollution haven hypothesis and determinants of FDI. Table 3 provides descriptions and statistics of the main and control variables used in the analysis.

First, I included multiple economic determinants. I included gross domestic product (GDP) in current US dollars, retrieved from the World Bank (n.d.-a), as a measure of the size of a host country's economy. Economy size reflects market potential and relates to the market-seeking motive as described by Dunning (2000). GDP is frequently included as a control variable in FDI location choice analyses (e.g., Tang, 2015; Karreman et al., 2017; Yoon & Heshmati, 2021). Additionally, I used gross domestic product per capita (World Bank, n.d.-b) as a proxy for market affluence. Numerous studies have used GDP per capita to assess economic conditions for foreign investment (e.g., Houston et al., 2012; Naughton, 2014; De Beule et al. 2022).

I included the unemployment rate of host countries to measure the labor market's functioning. A low unemployment rate might reflect a large labor supply, whereas a low unemployment rate might indicate

Table 3

Descriptions and summary statistics of the main and control variables

Variable	Description	Mean	SD	Min	Max
Environmental policy stringency	Environmental policy stringency index. Ranges from zero (no environmental policy) to six (stringent environmental policy).	2.33	1.06	0.06	4.22
Industry capital-to-labor ratio	Annual fixed assets in gross value in millions of euros in current prices divided by annual employment in hundreds of persons per industry.	50.40	53.18	9.33	249.34
Economic factors					
GDP	Gross Domestic Product in current US dollars.	$1.46*10^{12}$	$2.82*10^{12}$	$7.37*10^{9}$	$1.95*10^{13}$
GDP per capita	Gross Domestic Product per capita in current US dollars.	30358.76	21051.66	468.84	103553.8
Unemployment rate	Unemployment rate. (% of total labor force)	8.00	4.54	2.49	27.69
Trade openness	The ratio of the sum of exports and imports of goods and services to GDP. (%)	82.16	42.17	20.45	228.14
Corporate tax	Statutory corporate tax rate. (%)	26.87	6.38	9	40.87
Governance & institutions					
Political stability	Index measuring perceptions of the likelihood of political instability and/or politically- motivated violence. Ranges from -2.5 (stable) to +2.5 (unstable).	0.46	0.80	-2.1	1.75
Regulatory quality	Index measuring government ability to formulate and implement effective policies and regulations supporting private sector development. Ranges from -2.5 (weak) to 2.5 (strong).	1.05	0.68	-0.87	2.08
EU Membership	Binary variable taking value 1 if the country is a member of the European Union and 0 if not.	0.50	0.50	0	1
Demographics & infrastructure					
Population density	The total number of people per square kilometer of land area.	141.22	138.463	2.54	526.73
Education	Mean years of schooling of population aged 25 and more.	11.03	2.25	4.30	14.13
Telecom infrastructure	Mobile cellular subscriptions (per 100 people).	105.37	29.37	1.18	172.15
Agglomeration externalities					
Ln FDI Inflow 2002	Total foreign direct investment inflow in 2002 in millions of US dollars at current prices.	13429.33	16969.1	39.56	74457

Notes: Total number of observations = 78,144 an unattractive labor market (Basile et al., 2008; Karreman et al., 2017; De Beule et al., 2022). The unemployment rate is measured as a share of the total labor force (World Bank, n.d.-c). In addition, I included a measure of openness to trade, as this may be inversely related to the degree of restrictions and costs associated with international transactions, thereby attracting FDI (Liargovas & Skandalis, 2012; Naughton, 2014; Kim & Rhee, 2019). Openness to trade is measured as the ratio of the sum of exports and imports of goods and services to GDP (World Bank, n.d.-d). I included the corporate tax rate as a measure of the cost of capital. Previous studies suggest that the corporate tax rate is negatively correlated with the probability that a host country receives FDI (Head & Mayer, 2004; Karreman et al., 2017; Lawless et al., 2018). I retrieved corporate tax rates from the Tax Foundation (n.d.).

Subsequently, I included three control variables related to governance and institutions in the analysis, as a host country's governance quality may significantly impact the business environment of firms (Gani, 2007; Lskavyan & Spatareanu, 2008). I included political stability to assess the perceived likelihood of political instability and politically motivated violence, and regulatory quality as a measure of government's ability to formulate and implement effective policies and regulations that support private sector development. The inclusion of these control variables follows the approach of Sabir et al. (2019), whose results suggest that political stability and regulatory quality are determinants of FDI. I retrieved the data from the World Bank's Worldwide Governance Indicators dataset (Kaufmann & Kraay, 2023). Following Rivera and Oh (2013), I included a variable representing institutional closeness between France and the host country. I set this dummy variable to 1 if the host country is an EU member, and 0 if not.

Moreover, Wagner and Timmins (2009) argue that neglecting to include externalities linked to the agglomeration of FDI can lead to biased estimates and complicate the detection of a pollution haven effect. Therefore, I included the FDI inflow in millions of US Dollars at current prices in the year 2002 as a proxy for agglomeration externalities, as 2002 is the last year before the study period. I retrieved this data from the United Nations Trade and Development (UNCTAD, 2023).

Furthermore, I included population density as a proxy for the cost of land, which could make regions less attractive. However, it might also capture the benefits of consumer agglomeration, which would enhance attractiveness (Basile et al., 2008). Population density is defined as the number of people per square kilometer of land area and retrieved from the World Bank (n.d.-e). To assess human capital, I retrieved the mean years of schooling for the population aged 25 and older from the United Nations Development Programme (n.d.). Sadeghi et al. (2020) previously used mean years of schooling as a proxy for human capital and found it to be a significant determinant of inward FDI.

Finally, I used the number of mobile cellular subscriptions per 100 people (World Bank, n.d.-f) to proxy for telecommunications infrastructure availability, as the availability and quality of supportive infrastructure are crucial for the efficient operations of MNEs in host countries. The selection of this proxy aligns with the methodologies used by Zeb et al. (2014), Shah (2014), and Meidayati (2017). While this variable provides an indication of telecommunications infrastructure, it does not capture the full spectrum of infrastructure quality and availability, particularly in terms of transportation. Unfortunately, comprehensive data on transportation infrastructure was not available.

I merged the data for the control variables with the dataset containing all FDI projects, environmental policy stringency index scores, and industry capital-to-labor ratios. Finally, I formatted the dataset into a structure that is appropriate for mixed logit analyses. Each investment project is associated with data from all 37 countries for the given year. The variable *choice* represents the investment decisions and serves as a binary choice variable within a choice set. This set comprises 37 possible options, each representing a different country where an investment decision could potentially be made. The variable takes value one for the country that was chosen for the investment project, and value zero for the countries that were not chosen for this investment project.

Table 4 displays a correlation matrix with pairwise correlations of all main and control variables to examine potential multicollinearity issues. The pairwise correlation between *environmental policy stringency* and the natural logarithm of *GDP per capita* is 0.60, which indicates a moderate level of correlation. A positive correlation between institutions and GDP per capita is known to complicate measuring the impact of institutional factors on FDI (Bénassy-Quéré et al., 2007). However, I did not remove *GDP per capita* from the model, as excluding it would overlook economic context and potential interactions between economic development and environmental policy. Moreover, the table demonstrates no other problematic correlations between control variables and *environmental policy stringency*.

3.2 Methodology

In line with established practice (e.g., Head & Mayer, 2004; Basile et al., 2008), I assume that a firm initially decides whether to enter a foreign market. Afterward, the firm chooses from various entry modes, such as licensing or FDI. Finally, if the firm opts for FDI, it selects the location for its operations. This study is focused on this final step of the decision-making process. To analyze whether environmental policy stringency influences the FDI location decisions of French MNEs, I employed a mixed logit model. This method is appropriate for investigating location decisions and was previously used for this purpose in other studies (e.g., Basile et al., 2008; Karreman et al., 2017; Bialek & Weichenrieder, 2021).

A mixed logit model is a discrete choice model where individual i chooses among a set of J_{it} choices in time t. The probability distribution across these choices is defined as:

Table 4

Pairwise correlation matrix for the main and control variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) Environmental policy stringency	1.00													
(2) Ln Industry capital-to-labor ratio	0.08	1.00												
(3) Ln GDP	0.03	0.04	1.00											
(4) Ln GDP per capita	0.60	0.05	0.06	1.00										
(5) Ln unemployment	-0.11	0.01	-0.26	-0.24	1.00									
(6) Ln trade openness	0.39	0.03	-0.65	0.25	0.05	1.00								
(7) Corporate tax	-0.21	-0.07	0.51	-0.06	-0.03	-0.61	1.00							
(8) Political stability	0.54	-0.00	-0.26	0.68	-0.18	0.43	-0.14	1.00						
(9) Regulatory quality	0.51	0.00	-0.16	0.84	-0.18	0.36	-0.10	0.78	1.00					
(10) EU membership	0.52	0.01	-0.33	0.34	0.28	0.60	-0.28	0.44	0.37	1.00				
(11) Ln Population density	0.17	0.00	0.10	-0.11	-0.05	0.24	0.05	-0.17	-0.15	0.28	1.00			
(12) Education	0.48	0.04	-0.15	0.74	-0.20	0.38	-0.19	0.63	0.73	0.28	-0.17	1.00		
(13) Telecom infrastructure	0.44	0.15	-0.11	0.51	0.02	0.27	-0.34	0.30	0.33	0.40	0.03	0.47	1.00	
(14) Ln FDI inflow 2002	0.14	-0.00	0.58	0.22	-0.15	-0.10	0.24	0.12	0.19	-0.00	0.03	0.08	-0.14	1.00

$$P_{it,j} = \Pr(consumer\ i\ makes\ choice\ j\ at\ time\ t,\ given\ choice\ set), \qquad j = 1, \ldots, J_{it}$$

Indicators that measure individual heterogeneity are compiled into a set of variables denoted as *z*. Unmeasured indicators, which are considered random from the analyst's perspective, are denoted as *u*. Other elements of the choice mechanism are parameters *β*, *γ*, etc.The choice indicators are defined as $d_{it,j}$ = 1 if individual *i* makes choice *j* at time *t*, and 0 otherwise. The discrete probability distribution is expressed as:

$$P_{it,j} = \Pr\left(d_{it,j} = 1 \middle| X_{it}, z_{it}, u_{it}, \beta, \gamma, \ldots\right), \qquad j = 1, \ldots, J_{it}$$

In the distribution function, X_{it} is the set of attributes of all J_{it} choices in the choice set for individual *i* at time *t*. The model assumes individuals make decisions in each choice situation. If an individual can choose between more than two options, the decision constitutes a multinomial choice (Greene, 2009). The mixed logit model is an extension of the Canonical multinomial logit (MNL) model, of which the basic form is as follows:

$$\Pr(y_{it}) = j|X_{it}) = \frac{\exp\left(\alpha_{ji} + {}_i\, x'_{it,j}\beta_i\right)}{\sum_{q=1}^{J_{it}} \exp\left(\alpha_{qi} +_i x'_{it,q}\beta_i\right)}$$

In this model, α_{ji} are alternative specific constants and x_{ji} attributes. In the mixed logit model, individual-specific parameter vector β_i is introduced. The simplest version of the model is specified as follows:

$$\beta_{ki} = \beta_k + \sigma_k v_{ki},$$

$$\alpha_{ji} = \alpha_j + \sigma_j v_{ji},$$

In this model, β_k is the population mean, while v_{ki} represents individual-specific heterogeneity with mean zero and standard deviation one. Moreover, σ_k is the standard deviation of the distribution of the parameters β_{ki} around β_k (Revelt & Train, 1998; McFadden & Train, 2000; Greene, 2009). The choice-specific constants, represented by α_{ji}, and the components of β_i are distributed randomly among individuals while maintaining fixed means. The model allows the means of the parameter distributions to vary based on observed data z_i, which represents a set of choice-invariant characteristics that measure individual heterogeneity in the means of the randomly distributed coefficients. This gives the following function:

$$\beta_{ki} = \beta_k + z'_i\delta_k + \sigma_k v_{ki,}$$

(Greene, 2009). Moreover, a mixed logit model estimates the following utility function:

$$U_{ij} = \alpha' Z_{ij} + \varepsilon_{ij}$$

$$= (a' + \xi'_i) Z_{ij} + \varepsilon_{ij}$$

$$= a'Z_{ij} + \xi i'Z_{ij} + \varepsilon_{ij}$$

Where U_{ij} represents the utility for individual *i* choosing location *j*, Z_{ij} represents explanatory variables and ε_{ij} is an error term assumed to be independently and identically distributed with an extreme value distribution. In a mixed logit model, parameter α varies across individuals. It can be split into a mean component denoted as a, and individual-specific deviation around this mean, represented by ξ. By allowing α to vary across individuals, the mixed logit model can account for variations in preferences among individuals (Cushing & Cushing, 2007).

This is an important factor in this study, as the firms in the dataset have varying characteristics and are likely to have different preferences regarding location characteristics. Another advantage of the mixed logit model is that it does not rely on the independence from irrelevant alternatives (IIA) assumption, in contrast to the conditional logit discrete choice model. The IIA assumption states that the likelihood ratio of individuals selecting between two options remains unaffected by the presence or characteristics of other available alternatives. A violation of this assumption may result in incorrect predictions of the probability of destinations being chosen (Cushing & Cushing, 2007; Greene, 2009). For this study, the IIA assumption would be too restrictive. Firms that have decided to enter a foreign market by engaging in FDI are likely to consider many potential countries, and changes in the characteristics or availability of these destinations can affect their choice decisions. The mixed logit model can handle these complexities, making it a suitable choice for this analysis.

I applied mixed logit models to analyze choice sets that contain all available countries for each investment location decision. I estimated the models using the 'mixlogit' module written by Hole (2007) in Stata. For each investment, binary variable *choice* indicates the location decision by taking value one for the chosen country and zero for the remaining countries. *Environmental policy stringency* is included as the main variable of interest. To test the second hypothesis, I extended the mixed logit model to include an interaction term between *environmental policy stringency* and *industry mobility*. I used this approach to test whether the mobility of pollution-intensive industries influences the responsiveness of MNEs to environmental policy stringency. To obtain incremental effects, I used 'mixlelast', a post-estimation command for Hole's (2007) mixed logit module that was written by Zeigermann (2024).

In both models, I included multiple control variables that might influence investment location decisions, such as political risk and market size. For the control variables that do not follow a normal distribution, I used logarithmic transformations to mitigate heteroskedasticity risks. Moreover, I incorporated a one-year lag for the variable of interest and the control variables to account for the time delay between the location decision-making process and the actual FDI investment.

4. Results

4.1 Main analysis

Table 5 displays the baseline estimates of two mixed logit models with variable *choice* as the dependent variable to examine whether there is a correlation between environmental policy stringency and the probability that a country attracts French greenfield FDI from pollution-intensive industries. In the first model, the coefficient of *environmental policy stringency* is negative and statistically significant at the 0.1% significance level (-0.424***). This suggests that environmental policy stringency has a negative and significant effect on the probability of attracting French greenfield FDI from pollution-intensive industries.

The first column in Table 6 displays the mixed logit sample mean incremental effects derived from model one, calculated for an absolute change of one unit in Environmental Policy Stringency Index score. The mean incremental effects vary across countries, indicating different sensitivities to changes in environmental policy stringency. The United States shows the largest mean incremental effect, suggesting that if the Environmental Policy Stringency Index score of the United States increases by one unit, the probability that the United States attracts French FDI from pollution-intensive industries decreases by 4.17 percentage points on average. In contrast, Estonia shows the smallest mean incremental effect, suggesting that if Estonia's Environmental Policy Stringency Index score increases by one unit, the probability that Estonia attracts French FDI from pollution-intensive industries decreases by 0.06 percentage points on average. On average, a one-unit increase in the Environmental Policy Stringency Index score decreases the probability of attracting French FDI in pollution-intensive industries by 0.89 percentage points[1].

This finding aligns with hypothesis 1, which predicts that French multinational enterprises operating in pollution-intensive industries are more likely to locate their foreign direct investment projects in countries with weaker environmental policy stringency. The random part coefficient of *environmental policy stringency* is not statistically significant, which suggests that there is no heterogeneity between firms in how they value environmental policy stringency in the FDI location decisions.

The second model includes an interaction term of *environmental policy stringency* and *industry capital-to-labor ratio* to investigate whether the relationship between environmental policy stringency and the probability that a country attracts French FDI from pollution-intensive industries varies depending on levels of industry mobility, proxied as industry capital-to-labor ratio. The separate variable *Industry capital-to-labor ratio* cannot be included in the analysis, as the mixed logit model relies on variation within groups and the value of this variable does not vary within the same investment project. In the second model, the

[1] I obtained this figure by calculating the simple mean of all mixed logit sample mean incremental effects derived from the first model presented in Table 5. This approach does not provide standard errors.

Table 5

Results of mixed logit analyses across a sample of pollution-intensive industries with the probability of receiving FDI as the dependent variable

	(1)	(2)
Main variable		
Environmental policy stringency (t-1)	-0.424*** (0.045)	-0.681***(0.108)
Environmental policy stringency (t-1) × Ln Industry capital-to-labor ratio (t-1)		0.073** (0.028)
Control variables		
Ln GDP (t-1)	0.747*** (0.057)	0.750*** (0.058)
Ln GDP per capita (t-1)	-0.495*** (0.069)	-0.495*** (0.069)
Ln Unemployment ratio (t-1)	0.389*** (0.071)	0.388*** (0.071)
Ln Trade openness (t-1)	-0.033 (0.124)	-0.025 (0.124)
Corporate tax rate (t-1)	-0.015* (0.006)	-0.014* (0.006)
Political stability (t-1)	-0.168** (0.064)	-0.170** (0.064)
Regulatory quality (t-1)	0.387*** (0.093)	0.388*** (0.093)
EU membership (t-1)	1.203*** (0.120)	1.204*** (0.120)
Ln Population density (t-1)	-0.090* (0.037)	-0.091* (0.037)
Education (t-1)	0.062*** (0.019)	0.061** (0.019)
Telecom infrastructure (t-1)	-0.004** (0.002)	-0.004* (0.002)
Ln FDI inflow 2002 (t-1)	0.143*** (0.031)	0.142*** (0.031)
Random part coefficients		
Corporate tax rate (t-1)	0.035* (0.015)	0.037** (0.014)
Ln Population density (t-1)	0.285*** (0.064)	0.284*** (0.061)
Number of observations	78,144	78,144
Number of investment decisions	2,112	2,112
Countries in sample	37	37

Notes: Stars indicate the p-values of a two-tailed t-test. *** p-value≤0.001, ** p-value≤0.01, * p-value≤0.05 Standard errors are displayed between parentheses. Only statistically significant random components of the coefficients are reported. Ln stands for natural logarithm.

coefficient of *environmental policy stringency* is negative and statistically significant at the 0.1% significance level (-0.681***). The coefficient for the interaction term *environmental policy stringency* × *industry capital-to-labor ratio* is positive and statistically significant at a 1% significance level (0.073**).

The second column of Table 6 displays the mixed logit sample mean incremental effects derived from model two, calculated for an absolute change of one unit in environmental policy stringency score. Like the mixed logit sample mean incremental effects derived from model one, the mean incremental effects vary across countries. The United States shows the largest mean incremental effect while Estonia shows the smallest. Overall, the magnitudes of the mixed logit sample mean incremental effects derived from model two are larger than those derived from model one. On average, a one-unit increase in Environmental

Table 6

Mixed logit sample mean incremental effects, calculated for an absolute change of one unit in environmental policy stringency score

Country	(1)	(2)
Australia	-0.0069 (0.0014)	-0.0098 (0.0021)
Austria	-0.0020 (0.0003)	-0.0029 (0.0005)
Belgium	-0.0052 (0.0007)	-0.0075 (0.0011)
Brazil	-0.0177 (0.0026)	-0.0256 (0.0047)
Canada	-0.0105 (0.0025)	-0.0150 (0.0038)
Switzerland	-0.0011 (0.0001)	-0.0015 (0.0002)
China	-0.0306 (0.0057)	-0.0446 (0.0086)
Czech Republic	-0.0034 (0.0009)	-0.0049 (0.0014)
Germany	-0.0275 (0.0019)	-0.0398 (0.0035)
Denmark	-0.0025 (0.0002)	-0.0036 (0.0004)
Spain	-0.0232 (0.0047)	-0.0335 (0.0069)
Estonia	-0.0006 (0.0002)	-0.0008 (0.0003)
Finland	-0.0035 (0.0006)	-0.0051 (0.0009)
United Kingdom	-0.0237 (0.0028)	-0.0343 (0.0045)
Greece	-0.0027 (0.0004)	-0.0038 (0.0006)
Hungary	-0.0028 (0.0006)	-0.0041 (0.0009)
Indonesia	-0.0059 (0.0008)	-0.0085 (0.0014)
India	-0.0177 (0.0015)	-0.0253 (0.0024)
Ireland	-0.0066 (0.0013)	-0.0095 (0.0019)
Israel	-0.0025 (0.0005)	-0.0036 (0.0007)
Italy	-0.0103 (0.0020)	-0.0149 (0.0029)
Japan	-0.0052 (0.0008)	-0.0074 (0.0012)
Korea	-0.0026 (0.0007)	-0.0037 (0.0011)
Mexico	-0.0097 (0.0013)	-0.0138 (0.0020)
Netherlands	-0.0077 (0.0014)	-0.0111 (0.0022)
Norway	-0.0007 (0.0001)	-0.0009 (0.0002)
Poland	-0.0099 (0.0030)	-0.0142 (0.0043)
Portugal	-0.0028 (0.0007)	-0.0040 (0.0010)
Russia	-0.0154 (0.0020)	-0.0222 (0.0036)
Slovakia	-0.0031 (0.0008)	-0.0044 (0.0012)
Slovenia	-0.0010 (0.0002)	-0.0014 (0.0003)
Sweden	-0.0055 (0.0011)	-0.0078 (0.0018)
Turkey	-0.0045 (0.0005)	-0.0064 (0.0008)
United States	-0.0417 (0.0055)	-0.0611 (0.0084)
South Africa	-0.0065 (0.0009)	-0.0093 (0.0016)
New Zealand	-0.0020 (0.0004)	-0.0028 (0.0006)

Notes: Standard errors are displayed between parentheses. The sample mean incremental effects in the first column are derived from model one in Table 5, while those in the second column are derived from model two in Table 5.

Policy Stringency Index score decreases the probability of attracting French FDI in pollution-intensive industries by 1.28 percentage points.

These results again suggest a negative association between environmental policy stringency and the probability to attract French FDI from pollution-intensive industries. However, the industry capital-to-labor ratio appears to moderate this association. For industries with lower capital-to-labor ratios, the negative association between environmental policy stringency and the probability that a country receives FDI is more pronounced. This finding supports hypothesis 2, which predicts that among French multinational enterprises operating in pollution-intensive industries, the tendency to locate foreign direct investment projects in countries with weaker environmental policy stringency is stronger for those operating in industries with higher mobility compared to those with lower mobility. The random part coefficient of *environmental policy stringency* is not statistically significant, which suggests that there is no heterogeneity between firms in how they value environmental policy stringency in their FDI location decisions.

The coefficients of most control variables are statistically significant, which suggests that they are relevant in explaining the FDI location choices of French multinational enterprises operating in pollution-intensive industries. The coefficient of *trade openness* is not statistically significant in both models, suggesting that a country's level of trade openness does not play a critical role in attracting French FDI from these high-emission industries. In both models, only the random part coefficients of *corporate tax rate* and *population density* are statistically significant. This suggests that there is heterogeneity between firms in how they value a country's corporate tax rate and population density in FDI location decisions, but no heterogeneity between firms for other factors included in the model.

4.2 Heterogeneity between business activities

The main analyses do not differentiate between different business activities. However, the association between environmental policy stringency and the probability of a country to receive French FDI in industries that are above-average pollution intensive might vary across business activities. Therefore, I repeated the analyses, differentiating between the three business activities with the largest number of investments in the dataset. Table 7 displays how many investments are in the dataset of each business activity.

For the mixed logit model, each country included in the analysis must be chosen at least one time (Greene, 2009). However, not all countries included in the main analysis are represented in each business activity category. To maintain consistency, using the same set of countries in all models would be ideal. However, this significantly restricts the sample size, making it impractical to obtain results for all categories. Therefore, the analyses include varying countries, complicating direct comparisons. The manufacturing

Table 7

The number of French FDI projects in pollution-intensive industries by industry activity

Industry activity	Number of FDI projects
Manufacturing	807
Logistics, distribution and transport	346
Sales, marketing and support	300
Electricity	200
Retail	187
Headquarters	70
Design, development and testing	50
Extraction	39
Research and development	34
Recycling	30
Education and training	25
Customer contact centre	12
Business services	7
Maintenance and servicing	3
Shared services centre	1
Technical support centre	1

sample excludes Denmark, Greece, Estonia, Israel, Norway, and New Zealand. The logistics, distribution, and transportation sample excludes Australia, Finland, Greece, Indonesia, Israel, Japan, Korea, Norway, and New Zealand. Finally, the sales, marketing, and support sample excludes Estonia, Israel, and Sweden. Since the subsets differ in composition, any observed differences in results could be due to the varying countries rather than true differences in the relationship between environmental policy stringency and FDI probability across business activities. Therefore, interpretations require a nuanced approach.

Table 8 presents the results of the mixed logit regressions for subsamples of the three business activities within pollution-intensive industries. In all models, the coefficient of *environmental policy stringency* is negative and statistically significant at the 0.1% significance level. This suggests that environmental policy stringency has a negative and significant effect on the probability of attracting French FDI from pollution-intensive industries across varying business activities.

Specifically, within the subsample of manufacturing FDI, I found that a one-unit increase in Environmental Policy Stringency Index score decreases the probability of attracting French FDI by an average of 1.08 percentage points. For the subsample of logistics, distribution and transportation FDI, the same increase in the index score decreases the probability of attracting French FDI by an average of 1.62 percentage points. Finally, within the subsample of sales, marketing and support FDI, a one-unit increase in Environmental Policy Stringency Index score decreases the probability of attracting French FDI by an average of 0.88 percentage points.[2] The coefficients of the random part coefficients of *environmental policy stringency* are not statistically significant, which suggests that there is no heterogeneity in how firms value environmental policy stringency within each subsample.

Table 8

Results of mixed logit analyses across varying subsamples of business activities within pollution-intensive industries, with the probability of receiving FDI as the dependent variable

Business activity	Manufacturing	Logistics, distribution and transportation	Sales, marketing and support
Main variable			
Environmental policy stringency (t-1)	-0.438***(0.079)	-0.651***(0.126)	-0.484***(0.146)
Control variables			
Ln GDP (t-1)	0.650*** (0.103)	0.655***(0.195)	0.901*** (0.192)
Ln GDP per capita (t-1)	-0.194 (0.124)	-0.285 (0.198)	-0.545* (0.245)
Ln Unemployment ratio (t-1)	0.467***(0.119)	0.538***(0.167)	0.043 (0.243)
Ln Trade openness (t-1)	0.196 (0.204)	-0.360 (0.363)	0.192 (0.388)
Corporate tax rate (t-1)	-0.021* (0.010)	-0.003 (0.014)	-0.004 (0.017)
Political stability (t-1)	-0.230* (0.109)	-0.482** (0.173)	0.016 (0.235)
Regulatory quality (t-1)	-0.008 (0.150)	0.287 (0.253)	0.353 (0.291)
EU membership (t-1)	0.359 (0.230)	2.923***(0.417)	-25.202 (77.7)
Ln Population density (t-1)	-0.032 (0.062)	-0.024 (0.129)	0.003 (0.104)
Education (t-1)	0.060 (0.033)	0.117* (0.054)	0.108 (0.061)
Telecom infrastructure (t-1)	-0.005 (0.003)	-0.008 (0.004)	0.006 (0.006)
Ln FDI inflow 2002 (t-1)	0.202*** (0.059)	0.001 (0.101)	0.099 (0.086)
Random part coefficients			
Ln GDP (t-1)		0.347* (0.142)	-0.482** (0.181)
Ln GDP per capita (t-1)			-0.757** (0.280)
Number of observations	25,017	9,688	10,200
Number of investment decisions	807	346	300
Countries in sample	31	28	34

Notes: Stars indicate the p-values of a two-tailed t-test. *** p-value≤0.001, ** p-value≤0.01, * p-value≤0.05 Standard errors are displayed between parentheses. Only statistically significant random components of the coefficients are reported. Ln stands for natural logarithm.

[2] These figures are based on estimated incremental effects derived from the mixed logit models presented in Table 8.

4.3 Robustness checks

To ensure the robustness of this study's findings on the relationship between environmental policy stringency and the FDI location choices of French MNEs in pollution-intensive industries, I conducted several additional analyses. These robustness checks include using a different measure of environmental policy stringency, controlling for the average wage, exploring varying specifications of industry mobility, and examining different industry samples based on emissions intensities.

4.3.1 Measure of environmental policy stringency

The challenge of measuring environmental policy stringency is considered a potential reason for the inconsistent Pollution Haven Hypothesis results in previous studies (Bialek & Weichenrieder, 2021). To ensure that the findings of this study are not influenced by any specific characteristic of the OECD Environmental Policy Stringency Index, I repeated the main analyses using data retrieved from the *Executive Opinion Survey* published by the World Economic Forum (WEF). This survey offers an annual assessment of crucial socio-economic development aspects that are challenging to measure globally with existing statistical methods. It gathers insights from business leaders, who evaluate their economy to identify key factors driving productivity and socioeconomic progress (World Economic Forum, 2023).

One survey question is: 'How would you assess the stringency of your country's environmental regulations?'. I retrieved the data regarding this survey question from reports issued by the World Economic Forum: the 2004-2005 edition of the *Global Competitiveness Report* (Porter & Schwab, 2004) and the 2007, 2009, 2011, 2013, 2015, and 2017 editions of the *Travel & Tourism Competitiveness Report* (Blanke & Chiesa, 2007, 2009, 2011, 2013; World Economic Forum, 2015, 2017). Each country receives a score ranging from 1 to 7, calculated as a simple average of valid responses. The final country score is a weighted average of scores based on two years of data collection (World Economic Forum, 2023).

The WEF Executive Opinion Survey score is a very common and potentially the most frequently used measure of environmental policy in the pollution haven hypothesis literature (e.g., Kellenberg, 2009; Wagner & Timmins, 2009; Manderson & Kneller, 2012; Chung, 2014; Poelhekke & Van der Ploeg, 2015; Bialek & Weichenrieder, 2021; Yoon & Heshmati, 2021). An argument used in favor of this method is that using the perceptions of managers effectively captures the stringency of environmental regulations that firms consider when making investment decisions (Bialek & Weichenrieder, 2021).

While a widely accepted measure, a disadvantage of using the survey data is that there is a risk of response heterogeneity, resulting from differences in perspectives, experiences, or understanding of the survey questions among the respondents. Another limitation of using this measure of environmental policy is that the data was only accessible biannually for the years 2005 until 2017. As a result, the analysis was done for investment projects in the period 2006-2018 instead of 2003-2018 (considering a lag of one year).

To incorporate all years of this period in the analysis, I used linear interpolation to account for the missing years.

There are noteworthy differences between the OECD Environmental Policy Stringency Index and the WEF environmental regulation stringency score. Despite France receiving high scores on the OECD index, it is surpassed by several countries on the WEF score, such as Germany, Norway, and Japan. Additionally, while OECD index scores generally increase over time for most countries, WEF scores decrease in some cases. For instance, Germany received a score of 6.8 in 2005, which decreased to 6.0 by 2017. Cross-checking both measures provides a pairwise correlation coefficient of r = 0.51.

The results of mixed logit analyses using the World Economic Forum measure of environmental policy stringency as the variable of interest are displayed in Table 9. I must note that *environmental policy stringency* has relatively high pairwise correlations with *GDP per capita*, *political stability*, and *regulatory quality* (respectively 0.74, 0.78, and 0.81). Therefore, the results might be affected by multicollinearity. Despite this risk, I included the variables in the model to maintain consistency with the main analysis.

In the first model, the coefficient of *environmental policy stringency* is negative and statistically significant at the 0.1% significance level (-0.292***). This suggests that environmental policy stringency has a negative and significant effect on the probability of attracting French greenfield FDI from pollution-intensive industries. Specifically, a one-unit increase in the Environmental Policy Stringency Index score decreases the probability of attracting French FDI in pollution-intensive industries by 0.58 percentage points on average.[3] This finding aligns with the main results and supports hypothesis 1.

In the second model, the coefficient of *environmental policy stringency* is negative and statistically significant at the 0.1% significance level (-0.690***). This suggests that environmental policy stringency has a negative and significant effect on the probability of attracting French greenfield FDI from pollution-intensive industries. On average, a one-unit increase in the Environmental Policy Stringency Index score decreases the probability of attracting French FDI in pollution-intensive industries by 1.27 percentage points.[4] In addition, the coefficient for the interaction term *environmental policy stringency* × *Industry capital-to-labor* ratio is positive and statistically significant at the 1% significance level (0.107**). This suggests that the negative association between environmental policy stringency and the probability on attracting FDI is moderated by the industry capital-to-labor ratio. This result is in line with hypothesis 2.

In both models, the random part coefficient of *environmental policy stringency* is not statistically significant, suggesting no heterogeneity between firms in how they value environmental policy stringency in the FDI location decisions. This is consistent with the results of the main analysis.

[3] This figure is based on estimated incremental effects derived from mixed logit model one in Table 9.

[4] This figure is based on estimated incremental effects derived from mixed logit model two in Table 9.

Table 9

Results of mixed logit analyses with the probability of receiving FDI as the dependent variable and the World Economic Forum measure of environmental policy stringency as the variable of interest

	(1)	**(2)**
Main variable		
Environmental policy stringency (t-1)	-0.292*** (0.060)	-0.690*** (0.143)
Environmental policy stringency (t-1) × Ln Industry capital-to-labor ratio (t-1)		0.107** (0.036)
Control variables		
Ln GDP (t-1)	0.655*** (0.073)	0.646*** (0.069)
Ln GDP per capita (t-1)	-0.894*** (0.084)	-0.751***(0.086)
Ln Unemployment ratio (t-1)	0.231* (0.096)	0.297*** (0.083)
Ln Trade openness (t-1)	-0.650*** (0.172)	-0.381*(0.162)
Corporate tax rate (t-1)	0.005 (0.007)	0.003 (0.007)
Political stability (t-1)	-0.384*** (0.073)	-0.388*** (0.071)
Regulatory quality (t-1)	0.772*** (0.115)	0.738*** (0.115)
EU membership (t-1)	-20.627 (22.029)	1.140*** (0.190)
Ln Population density (t-1)	-0.236*** (0.040)	-0.197*** (0.037)
Education (t-1)	0.127*** (0.024)	0.101*** (0.024)
Telecom infrastructure (t-1)	-0.003 (0.002)	-0.002 (0.002)
Ln FDI inflow 2002 (t-1)	0.173*** (0.037)	0.183*** (0.036)
Random part coefficients		
Ln Trade openness (t-1)	1.75*** (0.232)	0.881** (0.300)
Corporate tax rate (t-1)	0.054** (0.018)	0.036 (0.019)
Number of observations	68,302	68,302
Number of investment decisions	1,846	1,846
Countries in sample	37	37

Notes: Stars indicate the p-values of a two-tailed t-test. *** p-value≤0.001, ** p-value≤0.01, * p-value≤0.05 Standard errors are displayed between parentheses. Only statistically significant random components of the coefficients are reported. Ln stands for natural logarithm.

4.3.2 Controlling for labor costs

The main analysis did not include labor costs as a control variable due to limited data availability. However, according to traditional FDI theory, pursuing low labor costs is a motive for firms to expand production abroad (Zhang & Markusen, 1999; Yeaple, 2003; Hou et al., 2021). Therefore, variations in labor costs could influence FDI decisions and confound the relationship between environmental policy stringency and the location decisions of French FDI. To address this, I re-evaluated the main analysis by including *average wage* as a control variable to test the robustness of the results. Average wage is defined as the average annual wage per employee in full-time equivalent units in the total economy, expressed in US dollars in 2022 constant prices converted to purchasing power parity (PPP). The data is retrieved from the OECD (n.d.-d).

The PPP conversion accounts for differences in cost of living and inflation rates between countries. As a result, the wage figures reflect real purchasing power rather than nominal values. This adjustment is essential for comparability. However, nominal wages may be more relevant for firm's FDI decisions, as they reflect the actual expenses incurred by firms. Therefore, using PPP-adjusted wages might not fully capture the financial burden faced by firms when choosing FDI locations. This limitation could lead to an inaccurate representation of the impact of labor costs on FDI decisions.

In addition, this analysis is limited to OECD member countries due to data availability, excluding Brazil, China, India, Indonesia, South Africa, and Russia. These excluded countries received a significant number of French FDI projects in pollution-intensive industries during the study period and generally had lower Environmental Policy Stringency scores compared to other countries in the dataset. Consequently, this exclusion may bias the results. Furthermore, focusing only on OECD member countries could introduce selection bias, as these countries typically share common characteristics, including democratic governance, protection of human rights, the rule of law, and market-based economic principles (OECD, n.d.-e).

The results of the mixed logit analyses that include *average wage* as a control variable are presented in Table 10. In both models, the coefficient for *average wage* is positive and statistically significant at the 0.1% level (0.000***), suggesting higher average wages are associated with a higher probability of attracting French FDI. This suggests that within OECD countries, French firms in pollution-intensive industries are attracted to countries where average wages adjusted to purchasing power parity are higher. This implies that factors other than low labor costs might be driving investment in OECD countries.

In the first model, the coefficient for *environmental policy stringency* is negative and statistically significant at the 0.1% significance level (-0.310***) indicating a significant negative effect on the probability of attracting French FDI in pollution-intensive industries. Specifically, controlling for average wage, I found that a one-unit increase in the Environmental Policy Stringency Index score decreases the probability of attracting French FDI in pollution-intensive industries by 0.80 percentage points on average.[5] This result aligns with hypothesis 1 and is consistent with the findings of the main analysis.

In the second model, the coefficient for *environmental policy stringency* is negative and statistically significant at the 1% significance level (-0.444***). The interaction term of *environmental policy stringency* × *Industry capital-to-labor* ratio is positive, but not statistically significant (0.037). This suggests that, within this sample, industry mobility does not significantly moderate the relationship between environmental policy stringency and French FDI location choices. This result contrasts with hypothesis 2.

[5] This figure is based on estimated incremental effects derived from mixed logit model one in Table 10.

Table 10

Results of mixed logit analyses across a sample of pollution-intensive industries with the probability of receiving FDI as the dependent variable, controlling for average wage

	(1)	(2)
Main variable		
Environmental policy stringency (t-1)	-0.310*** (0.065)	-0.444**(0.167)
Environmental policy stringency (t-1) × Ln Industry capital-to-labor ratio (t-1)		0.037 (0.043)
Control variables		
Average wage (t-1)	0.000*** (0.000)	0.000*** (0.000)
Ln GDP (t-1)	0.830*** (0.089)	0.834*** (0.091)
Ln GDP per capita (t-1)	-1.347*** (0.165)	-1.342*** (0.160)
Ln Unemployment ratio (t-1)	0.400*** (0.091)	0.404*** (0.090)
Ln Trade openness (t-1)	-0.185 (0.188)	-0.177 (0.189)
Corporate tax rate (t-1)	-0.026*** (0.008)	-0.026*** (0.008)
Political stability (t-1)	0.054 (0.087)	0.052 (0.087)
Regulatory quality (t-1)	0.480** (0.160)	0.477** (0.159)
EU membership (t-1)	1.102*** (0.149)	1.100*** (0.147)
Ln Population density (t-1)	-0.010 (0.046)	-0.007 (0.045)
Education (t-1)	-0.047 (0.029)	-0.047 (0.030)
Telecom infrastructure (t-1)	-0.006* (0.002)	-0.006* (0.002)
Ln FDI inflow 2002 (t-1)	0.124** (0.040)	0.124** (0.040)
Random part coefficients		
Ln Population density (t-1)	0.323*** (0.080)	0.329*** (0.077)
Number of observations	48,205	48,205
Number of investment decisions	1,555	1,555
Countries in sample	31	31

Notes: Stars indicate the p-values of a two-tailed t-test. *** p-value≤0.001, ** p-value≤0.01, * p-value≤0.05 Standard errors are displayed between parentheses. Only statistically significant random components of the coefficients are reported. Ln stands for natural logarithm.

This lack of significance can have several potential causes. For instance, the sample might have insufficient variation in capital-to-labor ratios to detect a significant moderating effect. It is possible that most pollution-intensive industries within the OECD countries have similar capital-to-labor ratios, or that the variation is too narrow. Besides, it is possible that within the sample of OECD countries, the industries represented have similar sensitivities to environmental policy stringency, regardless of their capital-to-labor ratios.

Finally, in both models, the random part coefficient of *environmental policy stringency* is not statistically significant, which suggests that there is no heterogeneity between firms in how they value environmental policy stringency in the FDI location decisions. This aligns with the main results.

4.3.3 Proxy for industry mobility

In the main analysis, I proxied industry mobility by the industry capital-to-labor ratio. This ratio is calculated by dividing annual fixed assets by annual employment, with fixed assets measured in gross value in millions of euros at current prices. To ensure the robustness of the analysis, I recalculated the capital-to-labor ratio using fixed assets measured in chain-linked values with 2014 as the base year to adjust for inflation. As a second robustness check, I recalculated the capital-to-labor ratio using net fixed assets instead of gross fixed assets. The net value of an asset is defined as its gross value decreased by the value of consumption of fixed capital, to adjust for depreciation. The results are displayed in Table 11.

Table 11

Results of mixed logit analyses with the probability of receiving FDI as the dependent variable, using varying specifications of industry capital-to-labor ratio

	Capital-to-labor ratio, fixed assets in chain-linked values (2014)	**Capital-to-labor ratio, net fixed assets**
Main variable		
Environmental policy stringency (t-1)	-0.676*** (0.109)	-0.650*** (0.092)
Environmental policy stringency (t-1) × Ln Industry capital-to-labor ratio (t-1)	0.071* (0.028)	0.079** (0.027)
Control variables		
Ln GDP (t-1)	0.749*** (0.058)	0.750*** (0.058)
Ln GDP per capita (t-1)	-0.497*** (0.069)	-0.495***(0.069)
Ln Unemployment ratio (t-1)	0.387*** (0.071)	0.388*** (0.071)
Ln Trade openness (t-1)	-0.026 (0.124)	-0.025 (0.124)
Corporate tax rate (t-1)	-0.014* (0.006)	-0.014* (0.006)
Political stability (t-1)	-0.171** (0.064)	-0.169** (0.064)
Regulatory quality (t-1)	0.389*** (0.093)	0.387*** (0.093)
EU membership (t-1)	1.204*** (0.120)	1.204*** (0.120)
Ln Population density (t-1)	-0.092* (0.037)	-0.091* (0.037)
Education (t-1)	0.061** (0.019)	0.060** (0.019)
Telecom infrastructure (t-1)	-0.004* (0.002)	-0.004* (0.002)
Ln FDI inflow 2002 (t-1)	0.142*** (0.031)	0.142*** (0.031)
Random part coefficients		
Corporate tax rate (t-1)	0.036** (0.014)	0.037** (0.014)
Ln Population density (t-1)	0.282***(0.061)	0.285*** (0.061)
Number of observations	78,144	78,144
Number of investment decisions	2,112	2,112
Countries in sample	37	37

Notes: Stars indicate the p-values of a two-tailed t-test. *** p-value≤0.001, ** p-value≤0.01, * p-value≤0.05 Standard errors are displayed between parentheses. Only statistically significant random components of the coefficients are reported. Ln stands for natural logarithm.

In both models, the coefficient estimates for *environmental policy stringency* remain negative and statistically significant at the 0.1% level. The coefficient for the interaction term *environmental policy stringency* × *industry capital-to-labor ratio* is positive and statistically significant in both models, although the significance levels vary (0.071* and 0.079**). Despite variations in significance levels, the results consistently suggest that industry capital-to-labor ratio moderates the negative association between environmental policy stringency and the probability that a region receives French FDI from pollution-intensive industries.

These findings imply that while the way industry mobility is specified can affect the results, the general trend remains consistent, suggesting that among French multinational enterprises operating in pollution-intensive industries, the tendency to locate foreign direct investment projects in countries with weaker environmental policy stringency is stronger for those operating in industries with higher mobility compared to those with lower mobility.

4.3.4 Selection of industries

This study focuses on pollution-intensive industries, as they are expected to face higher compliance costs costs under stringent environmental policies and may therefore seek to relocate to minimize these costs. For the main analysis, pollution-intensive industries are defined as those with average annual greenhouse gas (GHG) emissions intensities higher than the overall average from 2008 and 2018. Specifically, this includes industries with air emissions intensities greater than 0.20 kilograms of GHG emissions per euro of gross value added. This threshold captures all industries in the 75th percentile of emissions intensities.

To assess whether different thresholds for pollution intensity impact the results, I repeated the analysis with two different samples. First, with industries in the 85th percentile, these have GHG air emissions intensities of 1.009 kilograms or higher per euro of gross value added. Second, those in the 65th percentile, which have GHG air emissions intensities of 0.105 kilograms or higher per euro of gross value added. Additionally, to assess whether the observed effect of environmental policy stringency is specific to industries with relatively high pollution intensities or more broadly applicable, I repeat the analysis using a sample of investment projects within industries with below-average GHG air emissions intensities. These industries have GHG air emissions intensities below 0.20 kilograms of greenhouse gases per euro of gross value added.

For the analysis of industries in the 85th percentile, I excluded Estland, as it was never chosen as the location for an investment project within this sample. This exclusion complicates direct comparisons with the main analyses. However, for the models of industries in the 65th percentile and industries with below-average GHG emissions intensities, I used the same set of countries as in the main analyses.

The results of mixed logit analyses across subsamples of industries with varying emission intensities are displayed in Table 12. In all models, the coefficient of *environmental policy stringency* is negative and statistically significant at the 0.1% significance level. This suggests that environmental policy stringency has a negative and significant effect on the probability of attracting French greenfield FDI from industries with varying GHG emissions intensities.

Table 12

Results of mixed logit analyses with the probability of receiving FDI as dependent variable, across industries with varying emission intensities

	Industries with GHG emissions intensities in 85th percentile	**Industries with GHG emissions intensities in 65th percentile**	**Industries with below- average GHG emissions intensities**
Main variable			
Environmental policy stringency (t-1)	-0.353*** (0.055)	-0.360*** (0.037)	-0.148*** (0.026)
Control variables			
Ln GDP (t-1)	0.685*** (0.073)	0.681*** (0.049)	0.690*** (0.035)
Ln GDP per capita (t-1)	-0.738*** (0.088)	-0.398*** (0.061)	-0.478***(0.051)
Ln Unemployment ratio (t-1)	0.261** (0.092)	0.506*** (0.064)	0.586*** (0.040)
Ln Trade openness (t-1)	-0.263 (0.152)	-0.156 (0.105)	-0.105 (0.072)
Corporate tax rate (t-1)	-0.009 (0.008)	-0.011* (0.005)	0.024*** (0.004)
Political stability (t-1)	-0.032 (0.081)	-0.091 (0.056)	-0.228*** (0.038)
Regulatory quality (t-1)	0.529*** (0.112)	0.222** (0.078)	0.366*** (0.060)
EU membership (t-1)	0.813*** (0.152)	1.101*** (0.102)	0.792*** (0.066)
Ln Population density (t-1)	-0.086* (0.044)	-0.051 (0.03)	-0.009 (0.020)
Education (t-1)	0.080** (0.025)	0.094*** (0.017)	0.113*** (0.012)
Telecom infrastructure (t-1)	-0.000 (0.002)	-0.006*** (0.001)	-0.005*** (0.001)
Ln FDI inflow 2002 (t-1)	0.210*** (0.044)	0.194*** (0.027)	0.242*** (0.020)
Random part coefficients			
Ln Population density (t-1)	0.251** (0.090)	0.254*** (0.060)	
Telecom infrastructure (t-1)		0.008* (0.003)	-0.012*** (0.002)
Number of observations	52,596	115,847	263,588
Number of investment decisions	1,461	3,131	7,124
Countries in sample	36	37	37

Notes: Stars indicate the p-values of a two-tailed t-test. *** p-value≤0.001, ** p-value≤0.01, * p-value≤0.05 Standard errors are displayed between parentheses. Only statistically significant random components of the coefficients are reported. Ln stands for natural logarithm.

Specifically, within the subsample of industries in the 85th percentile of GHG emissions intensity, I found that a one-unit increase in Environmental Policy Stringency Index score decreases the probability of attracting French FDI by 0.83 percentage points on average. For the subsample of industries in the 65th percentile of GHG emissions intensity, I found that the same increase in the index score decreases the probability of attracting French FDI by an average of 0.77 percentage points. Finally, within the subsample of industries that have below-average emissions intensities, I found that a one-unit increase in Environmental Policy Stringency Index score decreases the probability of attracting French FDI by an average of 0.35 percentage points.[6]

These results suggest that environmental policy stringency has a negative and significant effect on the probability of attracting French greenfield FDI across industries with varying emission intensities. Although the magnitude of the effect is smaller for industries with below-average emissions intensities, the persistent negative association suggests that the deterrent effect of strict environmental regulations is widespread. This implies that environmental policy stringency may influence investment decisions across a broad range of industry types.

5. Discussion and conclusion

The pollution haven hypothesis is still debated in the literature, as several studies do not find empirical support for its assertions. In this study, I addressed the pollution haven hypothesis by analyzing how environmental policy stringency influences the location choices of French FDI in pollution-intensive industries. Using mixed logit regressions, I investigated this relationship by examining outward greenfield FDI projects originating from France in the period 2003 to 2018.

The results suggest that environmental policy stringency has a negative and significant effect on the probability of attracting French FDI from pollution-intensive industries. Specifically, I found that on average, a one-unit increase in the Environmental Policy Stringency Index score decreases the probability of attracting French FDI in pollution-intensive industries by 0.89 percentage points. The negative association between environmental policy stringency and the probability of attracting French greenfield FDI from pollution-intensive industries is robust across subsamples of varying business activities and remains consistent under different model specifications. These findings are consistent with the first hypothesis, which posits that French multinational enterprises operating in pollution-intensive industries are more likely to locate their foreign direct investment projects in countries with weaker environmental policy stringency.

[6] These figures are based on estimated incremental effects derived from the mixed logit models presented in Table 12.

Notably, the negative association persists even when using a sample of investments within industries with below-average GHG emission intensities. This suggests that while the observed effect is larger in magnitude across pollution-intensive industries, the impact of environmental policy stringency might be more broadly applicable across industries with varying pollution levels. These findings align with Ben Kheder (2010) who found that environmental regulation negatively impacts both polluting and less polluting French FDI, with a greater negative effect observed in polluting industries. The findings also support Ben Kheder and Zugravu (2012), who found a pollution haven effect for a pooled sample of countries receiving French FDI. The findings counter Raspiller and Riedinger (2008), whose study suggests that environmental regulations are not a significant determinant of the FDI location choice of French firms.

The mixed logit results from the main analysis initially suggested that the negative association between environmental policy stringency and the probability that a country receives French FDI from pollution-intensive industries is significantly moderated by lower levels of industry mobility, as measured by the industry capital-to-labor ratio. This finding aligns with the second hypothesis, which posits that among French multinational enterprises operating in pollution-intensive industries, the tendency to locate foreign direct investment projects in countries with weaker environmental policy stringency is stronger for those operating in industries with higher mobility compared to those with lower mobility. The finding also supports Kellenberg (2009) and Dou and Han (2019), who argue that pollution havens may be driven by relatively mobile industries.

However, while the findings remain consistent across different calculations of capital-to-labor ratio, the coefficient of interest is no longer statistically significant when average wage is incorporated in the model as a control variable. This suggests that while a moderation effect could be found in the main analysis, it may not hold when accounting for wage differences. However, due to limited data availability, the robustness analysis controlling for average wage is conducted for a sample of OECD member countries only. Potentially, pollution-intensive industries that are located within these countries have similar capital-to-labor ratios, or the variation is too narrow. Besides, it is possible that within the sample of OECD countries, the industries represented have similar sensitivities to environmental policy stringency, regardless of their capital-to-labor ratios.

Finally, none of the mixed logit models in this study show a statistically significant random part coefficient for environmental policy stringency. This suggests that French firms in pollution-intensive industries do not vary significantly in how they value environmental policy stringency when selecting locations for FDI. Although the mixed logit model was chosen for its ability to account for individual-specific preferences, as described by Cushing and Cushing (2007), the results suggest there is minimal variation in the valuation of environmental policy stringency across firms in the sample. Despite this, the mixed logit remains suitable for this analysis, because its ability to relax the independence from irrelevant alternatives assumption remains valuable. The mixed logit model acknowledges that the choice between options can be influenced by the presence or characteristics of other available alternatives (Cushing & Cushing, 2007; Greene, 2009).

I interpret the findings with caution, as the study has several limitations. First, multiple limitations issues arise from the issue of limited data availability. The analysis is constrained by a relatively small sample size, with the number of countries ranging from 37 in the main analysis to just 28 for the subsample focusing on logistics, distribution, and transportation subsample. Notably, most of the countries included are members of the OECD or the BRICS. This limited country coverage is a drawback of the OECD Environmental Policy Stringency Index as a measure of environmental policy stringency. As a result, variations in environmental policy stringency index scores across most countries in the sample are relatively small. Moreover, many developing countries which might be pollution havens are not included in the analysis. For example, Bangladesh, a country where the pollution haven hypothesis has been supported by Raihan (2023), is excluded from the study.

The limited country coverage limits the generalizability of the findings and might obscure the full scope of the relationship between environmental policy stringency and FDI in pollution-intensive industries. To address these limitations, future research should expand the scope of the data to include a broader range of countries, especially developing countries. This would likely introduce greater variation in environmental policy stringency and enhance the generalizability of the findings. However, this would require exploring alternative measures of environmental policy stringency, which poses a challenge.

In addition, as the investment data was available until the year 2018, this study does not include the most recent developments in the environmental policy landscape. A recommendation for future research is to investigate the relationship between environmental policy stringency and FDI location choice after 2018.

Moreover, the study includes different sets of countries in various analyses, depending on the availability of data on investment projects. For example, this is the case with subsamples in the heterogeneity analysis. This inconsistency in country subsets complicates comparison of results across the analyses. Besides, it is uncertain whether differences in results are caused by differences in the data or by the fact that different country subsets are included in each analysis.

The granularity of data results in limitations as well. The data used to calculate the industry capital-to-labor ratios was only available in classes according to Revision 4 of the International Standard Industrial Classification of All Economic Activities. This data is aggregated to a high level, which leads to a significant loss of detail and reduces the accuracy of the findings. For future studies, it would be beneficial to use more disaggregated data, such as data specific to sub-sectors or even on a company level. Similarly, the data on emissions intensities is classified in NACE Rev. 2 levels. For future research, more disaggregated emissions data would provide a more accurate picture of firms in pollution-intensive industries.

Furthermore, multiple endogeneity concerns must be acknowledged. First, reverse causality likely affects the study and limits the validity of the results. While this study investigated whether FDI is attracted through lenient environmental policy stringency, environmental policy may be affected by FDI inflow. For instance, Cole et al. (2006) argued that FDI influences environmental policy and that the impact depends on the level of corruption within the local government. To address this, future studies could try to estimate causal effects using an instrumental variable. However, finding a valid instrumental variable is very challenging.

Moreover, there is a chance that omitted variable bias undermines the validity of the results. Even though various control variables were included in the analysis, there are likely factors which affect both FDI inflow and environmental policy stringency that are not included in the model. In addition, besides capital-to-labor ratios, this study does not take firm heterogeneity into account, while it is possible that there are other firm characteristics that influence the effect of environmental policy stringency on the probability that a country is chosen for FDI. The study also does not consider investment sizes. Further research could focus on these factors and investigate how they affect the relationship between environmental policy stringency and FDI location decisions.

Besides, to provide a numerical interpretation of the mixed logit results, I obtained sample mean incremental effects, calculated for an absolute change of one unit in environmental policy stringency score, through a post-estimation module by Zeigermann (2024). To obtain the average incremental effects of a model, I calculated the simple mean of all mixed logit sample mean incremental effects. This method does not provide any standard errors. The absence of standard errors limits the understanding of the reliability, precision and statistical significance of the average incremental effects. Without standard errors, the robustness of the average incremental effects figures I obtain is uncertain. Therefore, these figures must be interpreted carefully.

This study contributes to the current pollution haven hypothesis literature by specifically investigating French outward greenfield FDI projects. The focus on French FDI is relevant because French environmental policy has been relatively stringent over the last two decades, providing pollution-intensive industries in France with an incentive to relocate to avoid costs related to environmental compliance. While this is not the first study in this context to examine FDI originating from France (Raspiller & Riedinger, 2008; Ben Kheder, 2010; Ben Kheder & Zugravu, 2012), to my knowledge, it is the first to use FDI data from years after 2003. As many developments have occurred in the environmental policy landscape since 2003, extending the study period provides a new perspective. Additionally, this is the first study in this context that focuses on how industry mobility affects the impact of environmental policies on the location choices of French outward FDI.

Furthermore, this study contributes to a broader scope of the pollution haven literature by using a relatively new measure of environmental policy stringency. Many previous studies rely on data from the World Economic Forum Executive Opinion Survey, which is used for a robustness analysis in this study (e.g., Kellenberg, 2009; Wagner & Timmins, 2009; Manderson & Kneller, 2012; Chung, 2014; Poelhekke & Van der Ploeg, 2015; Bialek & Weichenrieder, 2021; Yoon & Heshmati, 2021). The OECD Environmental Policy Stringency Index used for the main analyses provides an alternative viewpoint, as it reflects environmental policy initiatives instead of executive opinions about environmental policy. As the revised Environmental Policy Stringency Index was made public quite recently (Kruse et al., 2022), this study contributes to a new strand of literature that uses this measure to investigate the relationship between environmental policies and FDI (e.g., Wen et al. 2022; Ullah et al., 2022; Yıldırım, 2024).

Finally, this study contributes to the mapping of subsectors from the fDi Markets cross-border investment database to NACE Rev. 2 classifications by incorporating additional subsectors into Stöllinger's (2021) conversion table.

The results of this study have two key practical implications. First, they suggest that the stringency of environmental policies can affect a country's ability to attract FDI. This is a relevant consideration for governments designing environmental policy, as stringent policies might discourage foreign investment and have economic impacts. To balance effective environmental policies with an attractive investment climate, governments could consider offering subsidies or other incentives to MNEs to support their transition to greener practices. For instance, the EU Emissions Trading System provides businesses in industries with a high risk of carbon leakage with a higher share of free emission allowances. This approach encourages these businesses to remain within the European Union while gradually working towards emission reduction (European Commission, n.d.-b).

Second, the study highlights that the effectiveness of stringent environmental policy in one country can be undermined by more lenient policies in other countries. Although France has relatively stringent environmental policies, if French investments in pollution-intensive industries are relocated to countries with more lenient policies, overall emissions may simply shift from France to a country with lenient policy instead of decreasing. To prevent carbon leakage, it is important that governments cooperate to reduce disparities in environmental policy stringency across countries. Consistency in environmental standards across countries would reduce the risk of emissions being displaced to countries with lenient policies and increases the effectiveness of environmental policies.

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Appendix

Table 1

Mapping from subsectors in the fDi Markets database to NACE Rev. 2 activities based on Stöllinger (2021)

Subsectors in the FDi Markets Database	**NACE Rev. 2 division**	**NACE Rev. 2 Activities**
Water transportation	50	Water transport
Petroleum refineries	19	Manufacture of coke and refined petroleum products
Other petroleum & coal products		
Air transportation	51	Air transport
Steel products	24	Manufacture of basic metals
Other (Metals)		
Nonferrous metal production & processing		
Iron & steel mills & ferroalloy		
Architectural & structured metals		
Alumina & aluminium production and processing		
Foundries		
Crop production	1	Crop and animal production, hunting and related service activities
Animal production		
Animal slaughtering & processing		
Waste management & remediation services	37, 38, 39	Sewerage, waste management, remediation activities
Water, sewage & other systems		
Asphalt paving, roofing & saturated materials	23	Manufacture of other non-metallic mineral products
Cement & concrete products		
Other (Building & Construction Materials)		
Clay product & refractory		
Other (Building materials)		
Glass & glass products		
Other (Ceramics & Glass)		
Lime & gypsum products		
Other (Minerals)		
Other non-metallic mineral products		
-	3	Fishing and aquaculture
Resin & artificial synthetic fibres & filaments	20	Manufacture of chemicals and chemical products
Pesticide, fertilisers & other agricultural chemicals		
Cosmetics, perfume, personal care & household products		
Soap, cleaning compounds, & toilet preparation		
Paints, coatings, additives & adhesives		
Other chemical products & preparation		
Basic chemicals		

Biomass power	35	Electricity, gas, steam and air conditioning supply
Geothermal electric power		
Hydroelectric power		
Marine electric power		
Other electric power generation (Alternative/Renewable Energy)		
Solar electric power		
Wind electric power		
Fossil fuel electric power		
Natural, liquefied and compressed gas		
Nuclear electric power generation		
Other electric power generation (Coal, Oil and Natural Gas)		
Pulp, paper, & paperboard	17	Manufacture of paper and paper products
Other (Paper, Printing & Packaging)		
Converted paper products		
Truck transportation	49	Land transport and transport via pipelines
Freight/Distribution Services		
Rail transportation		
Transit & ground passenger transportation		
Pipeline transportation of natural gas		
Other pipeline transportation		
Oil & gas extraction	5, 6, 7, 8, 9	Mining and quarrying
Support activities for mining & energy		
Copper, nickel, lead, & zinc mining		
Other metal ore mining		
Nonmetallic mineral mining & quarrying		
-	2	Forestry and logging
Bakeries & tortillas	10, 11, 12	Manufacture of food products; beverages and tobacco products
Sugar & confectionary products		
Snack food		
Seasoning & dressing		
Seafood products		
Fruits & vegetables & specialist foods		
Dairy products		
Other (Beverages)		
Coffee & tea		
Animal food		
All other food		
Tobacco		
Soft drinks & ice		
Breweries & distilleries		

Wineries *Grains & oilseed*		
-	77	Rental and leasing activities
Amusement & theme parks *Other amusement & recreation industries*	93	Sports activities and amusement and recreation activities
Wood products Other (Wood Products)	16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
Apparel accessories & other apparel Apparel knitting Clothing & clothing accessories Cut & sew apparel Footwear Leather & hide tanning and finishing Other (Textiles) Other leather & allied products Textiles & Textile Mills	13, 14, 15	Manufacture of textiles, wearing apparel, leather and related products
-	45	Wholesale and retail trade and repair of motor vehicles and motorcycles
Artificial & synthetic fibres Laminated plastics plates, sheets & shapes Other plastics products Plastic bottles Plastic pipes, pipe fitting & unlaminated profile shapes Plastics packaging materials & unlaminated film & sheets Polystyrene foam products Urethane, foam products & other compounds Other rubber products Rubber hoses & belting Tyres	22	Manufacture of rubber and plastic products

Note. Source: NACE Rev. 2 divisions are retrieved from Eurostat (2008). Subsectors are selected based on air emission intensities from Eurostat (n.d.). The subsector mapping is based on Stöllinger (2021). All subsectors displayed in italics are added by the author.

Table 2

Average greenhouse gas (GHG) emission intensity in kilograms per euro of gross value added by NACE Rev. 2 activities, 2008-2018

NACE Rev. 2 Activities	**Average GHG emission intensity in kilograms per euro in gross value added (2008-2018)**
Water transport	11.30
Manufacture of coke and refined petroleum products	7.08
Air transport	3.28
Manufacture of basic metals	3.18
Crop and animal production, hunting and related service activities	2.87
Sewerage, waste management, remediation activities	2.68
Manufacture of other non-metallic mineral products	2.59
Fishing and aquaculture	1.47
Manufacture of chemicals and chemical products	1.39
Electricity, gas, steam and air conditioning supply	1.31
Manufacture of paper and paper products	0.63
Land transport and transport via pipelines	0.48
Mining and quarrying	0.41
Forestry and logging	0.30
Manufacture of food products; beverages and tobacco products	0.28
Rental and leasing activities	0.21

Note. Source: Air emissions intensities are retrieved from Eurostat (n.d.).

Table 3

Mapping from subsectors in the fDi Markets database to Revision 4 of the International Standard Industrial Classification of All Economic Activities (ISIC) as described by The Department of Economic and Social Affairs of the United Nations Secretariat (2007)

Subsector FDI markets	**ISIC Revision 4**
Animal slaughtering & processing	Agriculture, forestry and fishing
Crop production	
Animal production	
Nonmetallic mineral mining & quarrying	Mining and quarrying
Other metal ore mining	
Support activities for mining & energy	
Copper, nickel, lead, & zinc mining	
Oil & gas extraction	
Animal food	Manufacture of food products; beverages and tobacco products
Bakeries & tortillas	
Breweries & distilleries	
Coffee & tea	
Dairy products	
Wineries	
Sugar & confectionary products	
Fruits & vegetables & specialist foods	
Soft drinks & ice	
Snack food	
Seasoning & dressing	
Grains & oilseed	
Seafood products	
All other food	
Other (Paper, Printing & Packaging)	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials; manufacture of paper and paper products; printing and reproduction of recorded media
Pulp, paper, & paperboard	
Converted paper products	
Petroleum refineries	Manufacture of coke and refined petroleum products
Other petroleum & coal products	
Other chemical products & preparation	Manufacture of chemicals and chemical products
Soap, cleaning compounds, & toilet preparation	
Cosmetics, perfume, personal care & household products	
Pesticide, fertilisers & other agricultural chemicals	
Basic chemicals	

Paints, coatings, additives & adhesives	
Architectural & structured metals	Manufacture of basic metals and fabricated metal products, except machinery and equipment
Nonferrous metal production & processing	
Other (Metals)	
Steel products	
Alumina & aluminum production and processing	
Fossil fuel electric power	Electricity, gas, steam and air conditioning supply
Geothermal electric power	
Hydroelectric power	
Natural, liquefied and compressed gas	
Marine electric power	
Nuclear electric power generation	
Wind electric power	
Other electric power generation (coal, oil and natural gas)	
Other electric power generation (alternative/renewable energy)	
Solar electric power	
Biomass power	
Water, sewage & other systems	Water supply; sewerage, waste management and remediation activities
Waste management & remediation services	
Water transportation	Transportation and storage
Rail transportation	
Pipeline transportation of natural gas	
Transit & ground passenger transportation	
Other pipeline transportation	
Freight/Distribution Services	
Truck transportation	
Air transportation	
Cement & concrete products	Manufacture of rubber and plastic products and other non-metallic mineral products
Asphalt paving, roofing, & saturated materials	
Clay product & refractory	
Glass & glass products	
Lime & gypsum products	
Other (building & construction Materials)	
Other (building materials)	
Other (ceramics & glass)	
Other non-metallic mineral products	