OECD Economics Department Working Papers No. 1379

Foreign Direct Investment and The Pollution Haven Hypothesis: Evidence from Listed Firms

Grégoire Garsous,

Tomasz Kozluk

https://dx.doi.org/10.1787/1e8c0031-en

Unclassified **ECO/WKP(2017)11**

Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development

20-Mar-2017

English - Or. English

ECONOMICS DEPARTMENT

ECO/WKP(2017)11
Unclassified

FOREIGN DIRECT INVESTMENT AND THE POLLUTION HAVEN HYPOTHESIS – EVIDENCE FROM LISTED FIRMS

ECONOMICS DEPARTMENT WORKING PAPERS No. 1379

Grégoire Garsous and Tomasz Koźluk

Economics Department Working Papers are available at www.oecd.org/eco/workingpapers.

JT03411064

Complete document available on OLIS in its original format

English - Or. English

Abstract/Résumé

Foreign Direct Investment and The Pollution Haven Hypothesis – Evidence from Listed Firms

Business has often been arguing against the introduction of a carbon tax because it would induce a pollution haven effect – reducing the competitiveness of domestic production and shifting both production and emissions to countries where fossil fuels are cheaper. In this paper, we shed light on such claims by estimating the effect of energy prices on one of the possible channels of the pollution haven effect - foreign direct investment (FDI). Using data for listed firms in 23 OECD countries, we find that the effect of higher domestic energy prices on firms' outward stock of FDI has been significant and positive, but small in magnitude. This effect seems driven by more permanent shocks to energy prices, in particular by those coming from more stringent upstream environmental policies.

JEL classification codes: F21, Q41, Q58

Keywords: energy prices, FDI, pollution haven, environmental policies.

****

Investissement direct étranger et hypothèse de havre de pollution – Preuve par les entreprises cotées

Les entreprises se positionnent généralement contre l'introduction d'une taxe carbone parce que celle-ci générerait un effet de havre de pollution – réduisant la compétitivité de la production domestique et déplaçant la production et les émissions vers les pays où les énergies fossiles sont moins chères. Dans cet article, nous nous penchons sur ces propos en estimant l'effet des prix de l'énergie sur un des possibles canaux de transmission de l'effet de havre de pollution – l'investissement direct étranger (IDE). En utilisant des données d'entreprises cotées dans 23 pays de l'OCDE, nous trouvons que l'effet des prix plus élevés de l'énergie domestique sur le stock de IDE extérieur est significatif et positif, mais petit en magnitude. Cet effet semble être expliqué par des chocs permanents sur les prix de l'énergie, en particulier par ceux provenant des politiques environnementales plus sévères en amont.

Codes JEL : F21, Q41, Q58

Mots-clés : prix de l'énergie, IED, havre de pollution, politiques environnementales.

TABLE OF CONTENTS

Tables

Figures

Boxes

FOREIGN DIRECT INVESTMENT AND THE POLLUTION HAVEN HYPOTHESIS – EVIDENCE FROM LISTED FIRMS

By Grégoire Garsous and Tomasz Koźluk[1]

Main messages

Business has often been arguing against the introduction of a carbon tax because it would induce a pollution haven effect – reducing the competitiveness of domestic production and shifting both production and emissions to countries where fossil fuels are cheaper.

In this paper, we shed light on such claims by estimating the effect of energy prices on one of the possible channels of the pollution haven effect - foreign direct investment (FDI). Using data for listed firms in 23 OECD countries, we derive three main results from our empirical analysis:

1. The effect of higher domestic energy prices on firms outward stock of FDI has been significant and positive, but small in magnitude.
2. We find that this effect is driven by more permanent shocks to energy prices, in particular by those coming from more stringent upstream environmental policies.
3. The effect is found to be insignificant for manufacturing sectors that are less energy dependent. This finding confirms that firms or sectors that are less exposed are also less responsive to energy prices fluctuations.

We also perform a simple simulation of the potential effects of the introduction of a carbon tax. Because countries have different carbon intensity of energy production, we observe heterogeneous effects. Countries relying more on fossil-fuels (e.g. the United States) will be more affected than countries relying more on nuclear energy (e.g. Japan). However, we conclude that, on average, the introduction of a substantial carbon tax of 55 USD/tCO_2 would have a limited impact on delocalisation and offshoring via FDI. While the interpretation requires caution, it signals that concerns that environmental policies may erode domestic production and be globally self-defeating via the pollution haven effect seem to be overstated.

1. This paper is part of the joint work of the Economics Department and Environment Directorate under the Green Growth Workstream. The authors are members of the Economics Department of the OECD. The authors would like to thank Dennis Dlugosch (Economics Department), Giuseppe Nicolett (Economics Department), Shardul Agrawala (Environment Directorate), Naomitsu Yashiro (Economics Department), Mark Baker (Economics Department), Nils-Axel Braathen (Environment Directorate), Paul O'Brien (Economics Department), Silvia Albrizio (Bank of Spain), Jehan Sauvage (Trade and Agriculture Directorate), Kurt Van Dender (Centre for Tax Policy and Administration), Luisa Dressler (Centre for Tax Policy and Administration) and Florens Flues (Centre for Tax Policy and Administration) as well as all participants of the WiP seminar at the OECD and the 2016 FSR Climate Annual Conference in Florence for their useful comments and suggestions. Special thanks go to Catherine Chapuis (who worked in the Economics Department when this paper was written) for statistical assistance and to Sarah Michelson (Economics Department) for excellent editorial support.

1. Introduction

1. Foreign direct investment (FDI) has increased dramatically over the last four decades, both in developed and developing countries. In particular, developing countries have become a primary destination of FDI: in 2012, for the first time they have received more than 50% of worldwide FDI.[2] A significant part of these investments has been made in the manufacturing sector. For example, in China, between 1997 and 2008, manufacturing represented 70% of total FDI inflows for an amount of USD 388 679 million (Liu and Daly, 2011), making China the largest single FDI recipient already by 2002. Similarly in India, between 2000 and 2015, manufacturing FDI accounted for roughly 50% of total FDI inflows, or USD 123 069 million (DIIP, 2015).

2. FDI has potentially large benefits, for both host and investor countries. Such benefits can range from more efficient production patterns, technology and know-how transfer and economic development (see for example De Mello, 1998; Saggi, 2002; OECD, 2002 for surveys on this issue). However, reasons for deciding to invest abroad may also be controversial. For example, outward FDI can be motivated by the difference between more stringent domestic environmental regulation and comparatively lax regulation in the FDI destination country – in line with a Pollution Haven Hypothesis (PHH) type of argument.

3. The PHH postulates that firms will seek to avoid the cost of stringent environmental regulations by locating production in countries where environmental norms are laxer. Consequently, this leads to concerns about the deterioration of competitiveness of environmentally stringent countries, in particular in pollution intensive manufacturing, and about pollution leakage. Business associations, primarily in developed countries, often point out low energy costs and weak environmental regulation in developing countries as being partly responsible for these global FDI trends (Alliance for American Manufacturing, 2008, 2009). More generally, business leaders consider cheap energy as vital for manufacturing industries to compete on global markets.[3] High energy prices would arguably reduce industrial output and significantly reduce employment (Business for Britain, 2014). Consequently such groups argue that the introduction of a (unilateral) carbon tax would have adverse effects on manufacturing industry activity (Morgan, 2012; Green, 2011; American Council for Capital Formation and National Association of Manufacturers, 2009; National Black Chamber of Commerce, 2015).

4. In this paper, we shed light on these claims by estimating the effect of energy prices on firm-level outward FDI. In principle, the pollution haven effect can affect both international trade and international investment patterns. Countries with lax environmental regulations can gain an absolute competitiveness advantage because of lower costs of production, increasing total exports, growth and investment or a comparative advantage in pollution intensive industries (Pethig, 1976; Siebert, 1977; Yohe, 1979; Sato and Dechezleprêtre, 2015; Koźluk and Timiliotis, 2016). In both cases, pollution haven effects should be primarily observed in trade patterns, but firms in the more stringent country also have an incentive to invest in the "pollution haven" (McGuire, 1982).

5. We take two different approaches to isolate more permanent (or structural) changes in energy prices from temporary fluctuations, as we expect they may have different effects on FDI. First, we decompose energy price changes into an environmental policy component and a residual. Second, we focus on over-the-sample changes in energy prices across countries and sectors in order to better capture long-run reactions

2. Historical series of FDI for developed and developing countries can be found on UNCTAD website: http://unctadstat.unctad.org/.

3. See for instance Chazan (2012), Clark (2014a, 2014b) in The Financial Times and Barton et al. (2014) in The Wall Street Journal.

6. Using a sample of listed firms from 9 manufacturing sectors located in OECD countries, we find a statistically significant but small effect. On average, a 10% increase in energy prices is associated with an increase of 0.4 to 0.7 percentage points in firms' international-to-total-assets ratio, whose average is 14%. Listed firms represent only a fraction of total firms that are potentially involved in FDI. They are likely to be larger and more "internationalised" than other firms not included in our data set, but their aggregated FDI follows the same trend as macro-level FDI. Moreover, this approach is appealing in light of increasing evidence that movements in large firms help to explain major parts of aggregate fluctuations (see Gabaix, 2013, for evidence using US data). Our results are robust across various specifications. They also indicate that effects on FDI can be attributed to increasing stringency of environmental policies. Finally, we document that the effect is insignificant for manufacturing sectors that are relatively less energy-dependent.

7. Our findings support the pollution haven hypothesis even though the effect appears to be quantitatively small. In a simple simulation exercise, we illustrate that only a very high carbon tax would have a sizeable effect on FDI. Nonetheless, given that these effects are stronger in energy-dependent sectors and presumably geographically localised, we anticipate the political economy of carbon taxation to be complicated.

8. The paper directly complements the analysis of a companion paper by Dlugosch and Koźluk (2016), which focuses on the impact of environmental policies on total investment using the same dataset. Results are broadly consistent with those in ECO/CPE/WP1(2016)28, who find that while total firm investment responds negatively on average to higher energy prices this decline occurs solely in domestic capital formation of the less energy-intensive firms. Differences in the response of domestic and foreign capital formation across firms with different degrees of energy intensity could well be explained with the pollution-haven type effects on FDI found in this paper.

9. Local energy prices are a result of an interplay of global and domestic forces. Prices for coal and oil are generally set on the global markets, while gas and in particular electricity prices tend to be more country specific. Nevertheless, local energy prices vary across countries because of different domestic composition of the energy basket (the relative shares of the four energy inputs); transportation and production costs (such as refining in the case of oil); country characteristics (natural endowments, market structures); and policies such as taxes and regulations (e.g. excise taxes, a ban on nuclear). Sato et al. (2015) find that differences in taxes explain most of the cross-country variation in energy prices. Precisely, tax differences explain 50% to 90% of the variation of coal, electricity and oil prices across countries. This explanatory power is lower for gas (around 20%) as prices are strongly correlated with geography and transport infrastructure characteristics.

10. In the context of the pollution haven hypothesis, industrial energy prices can be expected to have similar impacts as general environmental policies. One simple way to look at environmental policies is that they increase the (implicit or explicit) price of environmental externalities. In practice, most upstream policy instruments addressing climate or air pollution – carbon taxes, cap-and-trade mechanisms and even command and control instruments – ultimately increase energy prices. Thus, the effect of changes in energy prices on FDI can be viewed as an approximation of the impact of an increase in the stringency of, at least some key types of, environmental policies. We test explicitly whether the energy price effect on FDI can be attributed to environmental policies, but acknowledge the limitations of this approximation however. Firstly, due to data limitations we only explicitly test the policy instruments that have an impact on energy prices. These include climate policies, air pollution and transport regulations. Moreover,

deliberate policy action, such as a carbon tax introduction could have a more salient effect than equivalent market price changes, more likely perceived as temporary.[4]

11. The rest of the paper is organised as follows. Section 2 summarises the literature on the PHH debate. Section 3 explains our empirical strategy. Sections 4 and 5 report the main estimation results and robustness checks respectively. Section 6 concludes with a simulation of the effect of a carbon tax on FDI.

2. Empirical literature on pollution havens and foreign direct investment

12. The debate on the pollution haven hypothesis through FDI is based primarily on the empirical evidence from single-country effects, mostly due to the dearth of relevant bilateral FDI data (the table in Appendix A1 summarises the relevant literature).[5] A large number of existing studies use US inward or outward FDI data (List and Co, 2000; List, 2001; Keller and Levinson, 2002; Xing and Kolstad, 2002; Eskeland and Harrison, 2003; Fredriksson et al., 2003; List et al., 2004; Cole and Elliott, 2005; Kellenberg, 2009; Hanna, 2010). Other studies use outward FDI from U.K. (Manderson and Kneller, 2012), Japan (Kirkpatrick and Shimamoto, 2008; Elliot and Shimamoto, 2008), France (Ben Kheder and Zugravu, 2012), Germany (Wagner and Timmins, 2009) and Korea (Chung, 2014). Others have used inward FDI into China (Di, 2007; Dean et al., 2009), or Mexico (Waldkirch and Gopinath, 2008).

13. Overall, results are mixed with some papers finding strong evidence that FDI decisions are significantly influenced by weaker environmental regulations (Hanna, 2010; Chung, 2014) or not affected at all (Eskeland and Harrison, 2003; Kirkpatrick and Shimamoto, 2008; Manderson and Kneller, 2012). Others find that the effect depends on industries' ability to relocate, proxied by capital intensity - (Cole and Elliot, 2005; Kellenberg, 2009). The effects are also found to depend on the characteristics of the parent countries (Dean et al., 2009) or characteristics of the host countries (Ben Kheder and Zugravu, 2012).[6] The main strength of these studies is that they take advantage of quasi-experiments, and are hence able to establish a causal relationship between environmental stringency and FDI decisions. On the other hand, given the single-country focus of this research, one can hardly generalise these results.

3. Empirical strategy

3.1 Methodology

14. Given inconclusive results obtained from an analysis based on macro data (see Box 1), in this paper we use micro data to estimate the energy price effect on firms' reliance on FDI to do business. A

4 . Assessing the causal effect of a carbon tax per se would require a natural experiment. Comparisons between jurisdictions that experienced the introduction of a carbon tax and a valid control group would allow the estimation of a treatment effect on variables such as trade or FDI. However, existing quasi-experiments are far from ideal (see Sato and Dechezleprêtre, 2015, for discussion). Also, country-sector data are of a very poor quality and allow only very tentative conclusions (See Box 1). Therefore, relying on cross-country firm-level data seems the best available option.

5. Although less directly related to this paper, some papers have also addressed the PHH trough patterns of international trade. Examples are Ederington et al. (2004), Ederington et al. (2005), Levinson and Taylor (2008) or Koźluk and Timiliotis (2016). Closer to our paper, Aldy and Pizer (2011), Gerlagh and Mathy (2011) and Sato and Decheleprêtre (2015) investigate the link between energy prices and trade patterns.

6. Conducting a meta-analysis over this literature, Rezza (2015) suggests that differences among results can be explained by different choices in the definition of FDI as a dependent variable or the use of different proxies for environmental stringency.

natural measure of this is the international-to-total-assets ratio (FDI ratio, hereafter), which captures the relative importance of international assets with respect to the firm's total assets.[7]

15. We therefore relate firm FDI stocks to the level of energy price they face and consider the following equation:

$$FDI\ Ratio_{ijct} = \alpha + \beta EP_{jct} + \gamma X_{ijct} + \mu_i + \theta_{ct} + \rho_{jt} + \varepsilon_{ijct} \qquad (1)$$

16. where $FDI\ Ratio_{ijct}$ is the international-to-total-assets ratio for firm i in sector j in country c at time t, EP_{jct} is the domestic energy price of sector j in country c at time t, X_{ijct} is a set of control variables at the firm level, μ_i is a firm fixed-effect, θ_{ct} and ρ_{jt} are interaction fixed-effects to account for country-year and sector-year unobservable shocks and, ε_{ijct} is the idiosyncratic error term.

17. Under the pollution haven hypothesis, if domestic energy prices rise relative to their level in other countries firms would have more incentives to increase their holdings abroad, raising their FDI ratio. We cannot estimate the effect of relative prices on firm-level bilateral FDI because we do not observe it. An alternative is therefore to regress the FDI ratio on absolute domestic energy prices, with a sector- year fixed effect ρ_{jt} capturing changes in energy price levels abroad.[8] In the robustness tests, we also look into the effects on absolute FDI and more explicitly at the effects of relative energy prices.

18. Country-year fixed-effects θ_{ct} control for potential counfounding factors such as movements in exchange rates, changes in trade patterns or institutional settings at the country level. Note that it also allows for each country to react differently to global shocks such as China's accession to WTO or the great recession.

19. Next, firms in a given sector might not pay the industry-wide energy prices. For example, large firms may be able to negotiate special agreements. Prices in such special contracts are likely to be lower and less prone to frequent modifications. We capture the potential firm-level differences in price levels through firm-fixed effects μ_i.[9]

20. Finally, we control for firm size (number of employees) and international sales in all regressions as both variables are potential confounding factors at the firm level. Bigger companies might have an easier access to international markets and therefore enjoy lower transactions costs when engaging in FDI. Furthermore, some firms might just be more internationally oriented by the nature of their business and therefore find it easier to adjust to energy price changes through FDI.

---

7. This measure of FDI also allows us to work with the large number of firms that have an observed value of zero international assets. Alternatively, using the logarithm of this variable would drop a significant part of the sample important to our analysis. An ad-hoc solution to this problem consists in replacing zero values by a very small number in order to calculate the logarithm. We use this procedure as a robustness check.

8. In principle, we could directly control for relative prices with the sectoral cross-country mean of prices. However, sector-year fixed effect is collinear to this variable and therefore directly controls for it along with any other time-sector unobservable characteristics.

9. The focus on persistent, longer-term changes in the energy prices eventually adopted in this paper has an additional advantage: over the longer term, firm-specific energy prices can be expected to follow the industry level prices.

Box 1. Estimation results with a gravity model

While the micro-data approach is appealing for its precision, we also run regressions at a macro-level for manufacturing in EU countries and the US over 1990-2012. A gravity model was estimated using the Poisson pseudo-maximum-likelihood (PPML) estimator as proposed in Santos Silva and Teneyro (2006):[1]

$$FDI_{ijt} = \exp\left(\alpha + \gamma X_{ijt} + \delta EP\ gap_{ijt} + u_i + v_j + \lambda_t\right) + \varepsilon_{ijt} \quad (1)$$

where FDI_{ijt} denotes the nominal outward manufacturing FDI stock from country i in country j in year t,[2] X_{ijt} is a vector of control variables, $EP\ gap_{ijt}$ is a variable that captures the difference in the average energy price between countries i and j at time t. We also run regressions that use the difference in the environmental policy stringency (EPS) index (see Box 2 for a description of the EPS indicator). Terms u_i, v_j and λ_t represent respectively country i, country j and time fixed-effects and, ε_{ijt} is the idiosyncratic error term.

As in a standard gravity equation, variables in X_{ijt} include GDP of countries i and j, geographical distance between country i and country j, dummy variables for contiguity, common official languages and common legal system. In addition, a set of control variables regarded as being potentially important drivers of FDI are included: a dummy variable to capture the effect of country pairs belonging to the EU, the average tariff for countries and partners and FDI restriction index for the partner country. Following Carr et al. (2001), we include proxies for (dis)similarities in market size (GDP difference) and differences in relative factor endowments (school enrolment difference to control for human capital).

While control variables have the expected signs and plausible magnitudes, the results are insignificant both for and $EP\ gap$ and $EPS\ gap$ coefficients (Table A5.1). The lack of disaggregation by industry is likely the largest hindrance on more meaningful conclusions at this level.

1. Other papers on FDI determinants have followed this procedure (see for example Head and Ries, 2008 or Fournier, 2016). We use the PPML estimator as opposed to a standard log-linearised gravity equation for two reasons. First, OLS estimates from a log-linearised specification are inconsistent unless error terms are statistically independent of the covariates, a very restrictive assumption. Second, if we take the logarithm of the dependent variable, zeros are dropped out of the sample. In our setting, pairs of countries may plausibly have zero bilateral FDI and therefore should not be discarded from the analysis

2. Data on manufacturing FDI are only available for EU countries and the US: http://ec.europa.eu/eurostat/web/balance-of-payments/data/database

21. Our estimations are unlikely to be affected by reverse causality issues as industry-level energy prices are largely exogenous. They are driven by global energy commodity prices, and in terms of cross-country differences, mainly determined by transportation costs and the actions of government regulators, including environmental policy actions (Linn, 2008). We therefore assume that firms are price takers irrespective of their size. Even though it is theoretically possible (although very unlikely) that large FDI outflows may translate into lower domestic activity and energy demand, exerting downward pressure on domestic energy prices, this type of endogeneity would obviously work against the pollution haven hypothesis that we aim to test in this paper. [10]

10. Firms can also respond to relative prices increases in these fuels by changing their input mix. Hence, unobservable firm-level factors (e.g. quality of managerial practices) could explain both the magnitude of this response – and therefore observed energy prices – and FDI. To circumvent this potential issue, we also use an alternative estimation approach - an instrumental variable (IV) strategy following Linn (2008). For the instrument, we keep the relative consumption weights constant across time while allowing national fuel prices to vary.

22. In order to avoid estimating a large number of firm fixed-effect parameters, we first-difference equation (1) to estimate our coefficient of interest β.[11] Therefore, our main regression specification becomes:

$$\Delta FDI\ Ratio_{ijct} = \alpha + \beta\ \Delta EP_{jct} + \gamma\ \Delta X_{ijct} + \ \theta_{ct} + \rho_{jt} + \eta_{ijct} \qquad (2)$$

where Δ is the first-difference operator and η_{ijct} is the idiosyncratic error term of this first-differentiated equation. As explained, we estimate equation (2) by two-stage least squares (2SLS) with a fixed-weight energy price index as an instrumental variable. We use clustered standard errors at the firm level to avoid bias from possible autocorrelation in the error term.

3.2 Data

23. The data on international assets and total assets come from the Worldscope database that provides information on listed companies worldwide. We define foreign direct investment using the Thomson Reuters Worldscope definition of international assets: identifiable assets of foreign operations before adjustments and eliminations, which are effectively for-profit assets held abroad by the company that can be identified and priced. Firm-level control variables (number of employees and international sales) also come from the Worldscope database.

24. Although listed firms represent only a fraction of total firms that potentially do FDI, they are likely to be larger and more “internationalised” than other firms not included in the Worldscope data. Aggregate FDI from firms observed in the Worldscope database follows the same trend as aggregate FDI from the OECD database for the same set of country-sectors (FigureA2.1). As in Dlugosch and Koźluk (2016), the choice to focus on listed firms is data-driven, but is appealing in light of increasing evidence that movements in large firms help to explain major parts of aggregate fluctuations (see Gabaix, 2013, for evidence using US data).

25. We focus our analysis on developed countries because developing countries are likely to be an FDI destination rather than an origin. Developed countries are also more advanced in terms of environmental policies and their policymakers tend to be more concerned about industry flight. A downside of the Worldscope dataset is that the information on the FDI destination is not available in a usable fashion, not allowing an analysis of bilateral FDI. Hence, the analysis focuses on the effects of domestic energy price increases on international assets held.[12] Robustness tests provided below attempt to control for the fact that domestic energy prices could also increase due to change in global commodity prices, which would not be expected to have strong pollution haven type effects.

26. Energy prices come from the database in Sato et al. (2015), and are described in more detail in Box 2.

11. Or equivalently, we use deviations from means instead of first-differences. This is a commonly used technique to estimate panel data regressions that is discussed in Woolridge (2003) or Angrist and Pischke (2008).

12. Consequently, we are assuming that, as firms respond to energy prices increases, outward FDI goes to countries with lower energy prices.

Box 2. Energy price indexes

In this paper, we use energy price indexes constructed by Sato et al. (2015). These energy price indexes are constructed for 12 sectors in 48 countries over 1995-2011, by weighting country-level fuel prices for four different types of fuel – oil, gas, coal and electricity – by the consumption of these fuels in each country-sector:

$$EP_{ist} = \sum_j \frac{F_{ist}^j}{\sum_j F_{ist}^j} . P_{it}^j = \sum_j w_{ist}^j . P_{it}^j$$

where F_{ist}^j is input consumption of fuel j for industrial sector s, in country i at time t, and P_{it}^j is the (log) price of fuel j in country i at time t.

Fuel prices of oil, gas, coal and electricity, and their respective sectoral consumption shares come from the IEA Energy End-Use Prices database, which provides details on the domestic end-use energy prices paid by industrial users in manufacturing sectors (IEA, 2012). Energy prices are 12-month averages and include taxes paid by industry (in particular excise and environmental taxes) but exclude VAT and recoverable taxes and levies. The prices are deflated and converted to constant 2010 USD for tonnes of oil equivalent.

Sato et al. (2015) provide two versions of the index, with different weighting. The Variable-weight Energy Price Level (VEPL) uses the actual industry fuel consumption shares that vary over time, making it more representative of the actual energy prices paid by industry and more suitable for level comparisons across countries and industries at different points in time. The Fixed-weight Energy Price Level (FEPL) uses fixed weights from the baseline year 2010. Hence, the variation in the FEPL comes solely from the changes in domestic energy prices and not from the changes in consumption shares. As changes in relative prices can be driven by changes in industry energy consumption baskets, the FEPL is free of such fuel substitution effects. In practice both indexes are highly correlated.

Sato et al. (2015) find that taxes can explain a substantial part of the variation in energy prices. The tax component is able to explain 80% to 90% of the cross-country variation of coal prices, 60% of the variation in electricity prices, 50% to 80% for oil. For natural gas this relationship is much weaker, with only about 20% being explained by differences in taxes, likely due to gas prices being strongly conditioned on the geography of transport infrastructure and long-term contracts.

The energy price indexes are significantly (positively) correlated with the OECD's Environmental Policy Stringency indicators and World Economic Forum's survey-based environmental stringency score. They also correlate significantly with measures of environmental – such as country energy intensities, CO_2 energy intensities, Yale's Environmental Performance Index and Industry Adjusted Emission Intensities (IAEI) from combustion and processes (Sato et al. 2015; OECD, 2016).

Source: Based on Sato et al. (2015).

27. Our sample covers the following manufacturing sectors: chemicals and petrochemicals, food and tobacco, iron and steel, machinery, non-ferrous metals, non-metallic minerals, paper and print, textile and transport. We drop construction, mining and quarrying and, wood products as these sectors are unlikely to respond to energy prices through FDI. Construction is a genuinely local business with a very low or even null rate of FDI.[13] Mining and wood industries investments in foreign countries mainly respond to natural resources availability.

13 . In our database, over the period of analysis, the firm average FDI ratio in construction is 5% as opposed to 14% for the other industries.

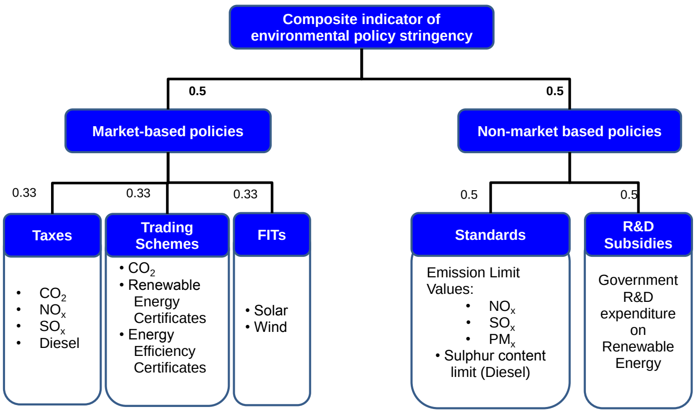
Box 3. Environmental policy stringency and the energy price index

The energy price indices constructed by Sato et al. (2015) provide a wide coverage at the country-sector-year level and are hence used in our main specifications. In line with previous work at the OECD and a large amount of empirical literature (see Koźluk and Zipperer, 2015 for a review), we also use the country-level Environmental Policy Stringency (EPS) indicator to test the robustness of our results.[1]

The OECD EPS indicator covers 29 OECD countries plus the BRIICS – Brazil, Russia, India, Indonesia, China and South Africa (Botta and Koźluk, 2014). It combines information on 14 market-based and non-market policy instruments. Regulations are equally weighted within each category and aggregated into a single indicator. The regulations included focus primarily on energy and transport activities and address mainly climate and air pollutants. Hence, it is based on the assumption that the stringency in key upstream sectors can be representative of that of the entire economy. The indicator ranges from 0 to 6, where 0 is associated with lax and 6 is associated with the most stringent policies (see figure below).

All policy instruments considered in the EPS indicator have ultimately an impact on energy prices. At the country-level, we find that EPS indicator and energy price indices are significantly correlated (Garsous and Koźluk, 2016). One potential important difference is that changes in energy prices due to environmental policies may have a more permanent nature as shocks on energy prices might be only temporary. Moreover, global energy price shocks are less likely to have pollution haven effects than purely domestic increases (as the change in comparative advantage in this case could only result from the differences in the fuel mix). Therefore, estimating the energy price effect on FDI might underestimate the true effect of environmental stringency increases. However, our robustness checks still report that relative differences in EPS values have a significant but small impact on FDI.

Structure of the EPS indicator



Source: Botta and Koźluk (2014)

1. For OECD works using the EPS, see Albrizio et al. (2016) and Koźluk and Timiliotis (2016).

28. The final sample is an (unbalanced) panel of 6 806 companies from 23 OECD countries[14] and 9 industries over the period 1995-2011.[15] Table A2.1 and Table A2.2 provide the ISIC codes that define the manufacturing sectors and countries sample weight respectively. Table A2.3 reports summary statistics of our sample. On average, firms have 14% of international assets (median is 3%), 6 106 employees (with a median of 946), and make USD 4.39 million of yearly international sales (median is USD 60 000), which roughly corresponds to 23% of total sales. Roughly half of the sample is composed by domestically-oriented firms that never engage in FDI. These are smaller firms (1 156 employees in average). The rest of the sample is composed of larger multinational firms. US firms account for half of the sample and we run robustness checks in order to verify that results are not entirely driven by these firms.

14. Countries are Australia, Austria, Belgium, Canada, Switzerland, Czech Republic, Germany, Finland, France, the United Kingdom, Greece, Hungary, Italy, Japan, Korea, the Netherlands, New Zealand, Poland, Portugal, Slovakia, Sweden, Turkey, and the United States.

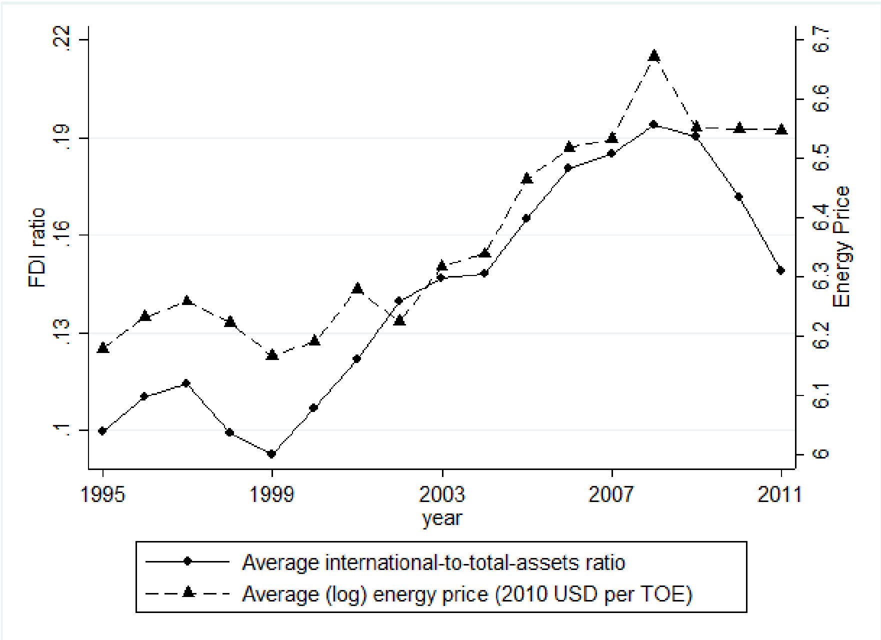
15. We drop observations that have an FDI ratio larger than 1 as they result from measurement error.

3.3 Rising trends in FDI and energy prices

29. Figure 1 displays the yearly firm-average international-to-total-assets ratio (FDI ratio) and (log) real energy prices. The average FDI ratio has been increasing in line with energy prices faced by firms included in the sample. This suggests that the latter is potentially a driver of FDI and motivates the more detailed analysis provided in this paper.

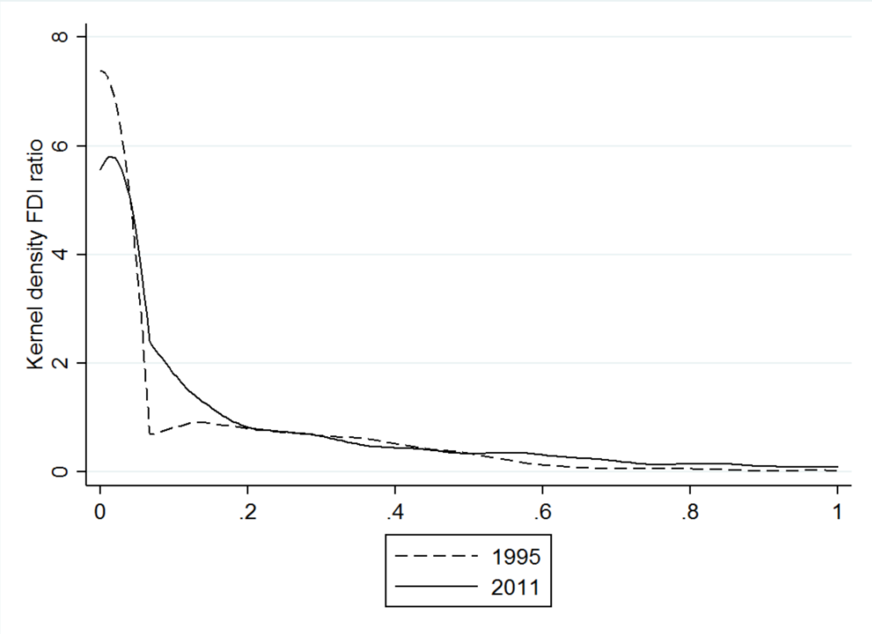
30. Figure 2 plots the kernel densities of the FDI ratio distributions in 1995 and 2011. Notably, the share of firms in our sample with no foreign assets has diminished sharply between the two data points – going down from two thirds to only one third. The distribution of firms with a foreign asset share above 0.2 does not appear to have changed, though this could mask different developments across firms. This could indicate that there are particular effects of energy prices on the extensive FDI margin, i.e. the decision to engage in FDI.

Figure 1. FDI and energy price trends



Source: Authors calculations. Average FDI ratio is an average of international-to-total assets ratio across firms.

Figure 2. Kernel densities of FDI ratio distribution in 1995 and 2011



Source: Authors calculations.

4. Empirical results

4.1 Main estimation results

31. Columns (1) – (3) of Table A3.1 provide estimation results of equation (2) using contemporaneous, one-period lagged and two-period lagged values of energy price inflation respectively. Point estimates are insignificant while the magnitude of coefficients varies widely across specifications.In sum, we are not able to capture a clear effect neither on a particular subsample nor on a particular lag structure.

32. One possible explanation for this is the presence of noise in energy prices, which has little effect on FDI decisions. For example, firms may be less likely to change their FDI strategies in response to commodity price shocks which are perceived as temporary. To the extent these changes are global, they may also have less effect on the attractiveness of investing abroad. However, firms will respond to persistent changes and structural differences in energy prices across countries, such as those due to policy (e.g. a carbon tax) and effects of changes in market structure.

33. In addition, timing matters. We can expect that it is the accumulation of small energy price increases that may at some point influence firms' decisions on investing in foreign countries – and that this timing differs across firms. Some firms may react rapidly or even anticipate changes while others may choose to wait strategically. Effects of policy changes that affect energy prices may come at a different time during the year and may have different effects in terms of timing of a firm's decision (e.g. a carbon tax can be perceived as more permanent hence sparking a more immediate reaction). Therefore, a longer-term average might be able to better identify any true effects. Figure A2.2 provides an illustration of this issue. In panel A, it plots the first-differences in FDI ratio (y-axis) and in energy price (x-axis) for each firm (averaged over time). On average, first-differences in energy price are clustered around zero (and therefore, generally small in magnitude). The relationship seems stronger, however, with longer-term averages (Figure A2.2 Panel B).

34. We therefore take two different approaches to isolate "permanent" factors in energy prices:

- First, we decompose energy prices into an environmental policy component and the remaining variation. This is done by regressing the energy price index on OECD's EPS index (Box 2), and using the predicted energy prices (the "policy component") and residuals instead of energy prices themselves in equation (2).[16] The results for the policy component – predicted-by-EPS energy price – are now strongly significant, indicating that the tightening environmental policies have had effects on the FDI ratio via energy prices (columns (1) – (3) in Table 1).

- Second, we use the time variation between the first and the last years of observation (for each firm) consequently exploiting the accumulation of (net) energy prices increase over time and its effect on FDI.[17] We therefore limit the influence of temporary energy prices shock that fade away over the period of analysis. Hence, we estimate how country-sectors with larger, more "permanent", energy prices *increases* have also experienced larger FDI *increases*.

35. In other words, we transform our panel-data into a cross-sectional dataset in order to estimate the following equation:

$$\tilde{\Delta} FDI\ Ratio_{ijc} = \alpha + \delta\, \tilde{\Delta} EP_{jc} + \gamma\, \tilde{\Delta} X_{ijc} + \theta_c + \rho_j + \tilde{\varepsilon}_{ijc} \qquad (2')$$

where $\tilde{\Delta} Z$ is the difference between the first and the last year in variable Z. Panel B of Figure A2.2 plots $\tilde{\Delta} FDI\ Ratio$ (y-axis) and $\tilde{\Delta} EP$ (x-axis). It is easy to see that compared to panel A, variation in panel B is much larger as observations are much more scattered around the plot. The fitting line also suggests that the correlation between $\tilde{\Delta} FDI\ Ratio$ and $\tilde{\Delta} EP$ is higher.

36. Columns (4) and (5) of Table 1 report results from OLS regressions and two stage least squares (2SLS) regressions respectively. Point estimates are significantly different from zero. Over all, results reported in Table 1 suggest that a 10% increase in energy price is associated with an increase between 0.4 and 0.7 percentage points in the FDI ratio (compared with the average ratio of 14% in our sample).

16. We estimate sector-specific coefficients that are used to predict country-sector-year energy prices with country-year EPS. Estimation results can be found in Table A3.9.

17 . The first and last years of observation for each firm do not necessarily correspond to 1995 and 2011 as we have an unbalanced panel data of observations.

Table 1. Main estimation results

	(1)	(2)	(3)	(4)	(5)
Dependent variable: Foreign over total assets ratio		**Panel data**		**Cross section**	
Predicted-with-EPS energy price	0.0470**				
	(0.0218)				
Residuals	0.0267				
	(0.0203)				
Predicted-with-EPS energy price (t-1)		0.0715***			
		(0.0223)			
Residuals (t-1)		0.0376*			
		(0.0214)			
Predicted-with-EPS energy price (t-2)			0.0747***		
			(0.0232)		
Residuals (t-2)			0.0275		
			(0.0224)		
Log(Energy price)				0.0572***	0.0447***
				(0.0111)	(0.0132)
International sales (in USD million)	9.49E-05	9.96E-05	0.000134	-7.06E-05	-6.06E-05
	(0.000152)	(0.000146)	(0.000142)	(0.000175)	(0.000175)
Employees (in thousands)	0.0106***	0.0106***	0.00880**	0.000854*	0.000869*
	(0.00347)	(0.00386)	(0.00413)	(0.000467)	(0.000467)
Country x Year fixed effect	YES	YES	YES	YES	YES
Industry x Year fixed effect	YES	YES	YES	YES	YES
Observations	49,688	40,769	34,223	6,806	6,806
R-squared	0.074	0.078	0.077	0.028	0.028
Number of firms	6,678	6,520	5,761	6,806	6,806

Note: Columns (1), (2) and (3) provide panel data estimations results for the contemporaneous, first lag and second lag effect of predicted-with-EPS energy price index on the FDI ratio, respectively. Regressions are estimated by the within estimator on an unbalanced panel. All regressions include country-time and industry-time fixed-effects. Column (4) provides the OLS estimation of the energy price index on the FDI ratio using the N-difference in the observed energy prices. Column (5) provides the Two Stage Least Squares (2SLS) estimation result using the N-difference in fixed-weight price index as an instrument for the N-difference in the observed energy prices. Control variables are firms' international sales and number of employees. Robust standard errors clustered at the firm level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

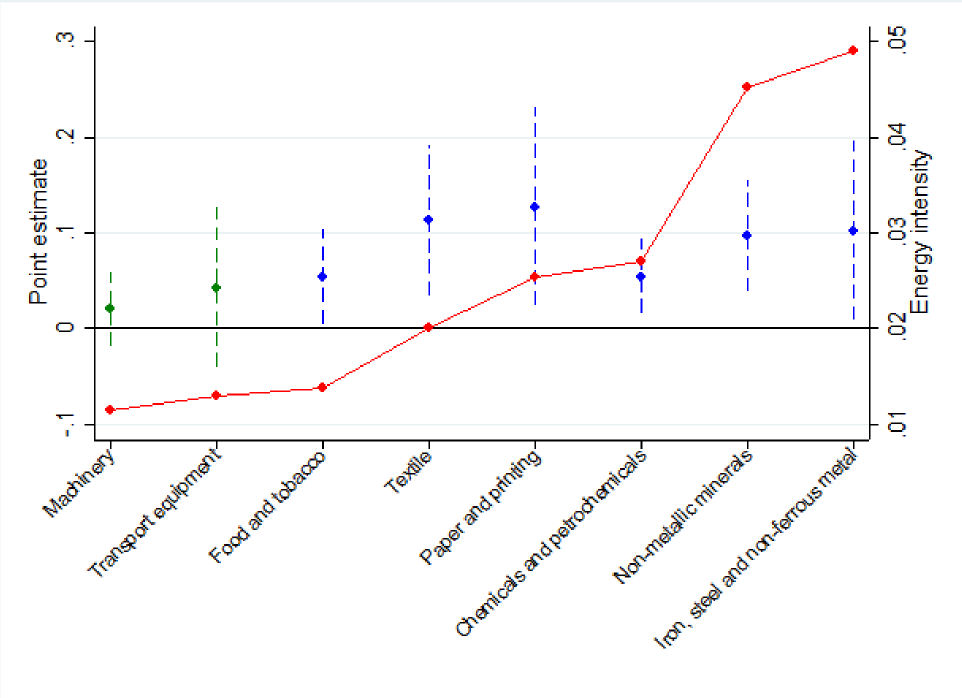
37. Additionally, to address the question of exposure and responsiveness to energy price changes, we assess whether sectors that rely more on energy inputs are more prone to invest in foreign assets as a response to higher energy prices (i.e. whether sectoral effects are differentiated by energy intensity).[18] We do so by estimating equation (2') for 8 sectors separately.[19] Estimation results are summarised in Figure 3.

18. We construct an energy intensity measure as the ratio of sectoral amount of energy (used as an input) to sectoral value-added (considered as the output) for the pre-sample period 1990-1995. Our measure is the cross-country average of our sample. Data come from STAN OECD database.

19. Data for our energy intensity indicator are provided for Iron and Steel and Non-ferrous metal as an aggregate sector. We therefore run regressions on firms from these two sectors and obtain a unique coefficient.

The coefficients that are insignificant (machinery, transport equipment) have also the lowest energy intensity. For sectors with higher energy intensity, the effects are significant.

Figure 3. Effects of energy prices on FDI appear stronger for more energy intensive sectors



Note: All regressions are estimated by Two Stage Least Squares (2SLS), using the N-difference in fixed-weight price index as an instrument for the N-difference in the observed energy prices. Control variables are firms' international sales and number of employees. All regressions include country fixed-effects. Robust standard errors to calculate confidence intervals are clustered at the firm level. Point estimates (dots) are reported with 90% confidence intervals (dashed lines). The energy intensity indicator is calculated as the cross-country average of the energy/value added ratio. Iron and steel and non-ferrous metals are merged into one sector as data for the energy intensity indicator are provided at an aggregate level.

4.2 Robustness checks and additional tests

38. We performed the following additional tests:

39. *The energy price gap.* In a pure pollution haven type setting, what should drive the firm's decision to invest abroad rather than domestically is the difference between home and host countries environmental policies (or in our case energy prices). At the same time, the energy prices reflect, among others, global energy price movements – which should not be relevant from the PHH point of view. The Worldscope dataset does not allow a direct test of bilateral difference of energy prices on bilateral assets, as the information on the actual location of international assets is scarce and non-standardised. However, some notion of whether this is the effect we capture can be drawn by estimating equation (2') with the difference between domestic price and an average of Chinese and Russian energy prices.[20] Point estimates are positive significant confirming the role of domestic price changes for FDI (Table A3.2).

20. We use China and Russia because they represent the lowest energy prices on the world market. China is particularly relevant since, as illustrated before, it is a very important FDI destination country. Therefore, any price difference with this country in particular should matter for firms FDI decisions in more advanced economies.

40. *Extensive and intensive margin firms.* As mentioned above, firms that have no initial FDI can acquire foreign assets during our sample period. Such firms may need to be modelled differently than firms that have been investing abroad for a long time and face a decision whether to upscale existing FDI.[21] Therefore, we replicate estimations of columns (1) – (3) for two different subsamples of observations:

- Intensive-margin firms - firms that have a positive value in FDI ratio every year (that is, firms that always have a stock of foreign assets over the sample period). Regressions on this subsample estimate the intensive margin of international asset holdings.

- Extensive-margin firms - firms that have no international assets for at least one year of the period of analysis and that potentially engage in FDI at some point. Estimations with this subsample capture the effects on the extensive margin.

41. We perform the robustness tests both in the panel setting and in the cross-sections. Columns (4) – (6) of Table A3.1 display the estimation results of equation (2) using intensive-margin firms only. Columns (7) – (9) report the same estimations results for extensive-margin firms only. Point estimates are statistically insignificant. Next, Table A3.3 reports these results for the cross-section regressions. We find no evidence of differentiated effects for intensive versus extensive margin firms.

42. *The effects of the global financial crisis.* Since the global financial crisis both FDI and energy prices have fallen (Figure 1), potentially undermining many of the transition channels through which pollution haven type effects might work (e.g. financing). Consequently, restricting our sample to the pre-crisis period yields similar estimates (Table A3.4).

43. *Robustness to the exclusion of the United States.* US firms are very active in FDI, while at the same time the shale-gas revolution has contributed to a downward evolution of global energy prices. These effects may potentially reduce the generality of our results, as half of the firm sample is composed of US firms. Estimation results excluding US firms point to an even larger effect of the energy prices on FDI (Table A3.5).

44. These last two results suggest that the main relationship is not as evident for US multinationals during the late 2000s. While meriting a further investigation that goes beyond the scope of this paper, the results point to the possible role of particular events such as the financial crisis and the US shale gas revolution in dampening the effects of energy prices on FDI.

45. *Effects on FDI stocks rather than the FDI ratio.* With international-to-total-assets ratio as the dependent variable, fluctuations of domestic investment affecting the denominator could be another possible driver of our results (see Dlugosch and Koźluk, 2016; for a discussion). We therefore verify whether an energy price increase leads to a net increase in FDI (real international asset stocks in 2010 USD) by estimating equation (2') with the (log) values of foreign assets as a dependent variable.[22] Results are reported in Table A3.6. Point estimates are all significantly positive which supports the claim that energy price increases lead to absolute FDI increases.

46. *More direct proxies for environmental policies.* As argued in the introduction, upstream environmental policy instruments in the energy sector ultimately have an impact on energy prices. We also test the robustness of the effects found by using a more comprehensive measure of environmental policy stringency - OECD EPS indicators (Botta and Koźluk, 2014). As the EPS is only available at the national

21. For instance, Buch et al. (2010) provide a theoretical model for how financial constraints have differentiated effects on extensive and intensive margins of FDI.

22. The zero values found in our database are set to 0.001 in order to be able to calculate the natural logarithm.

level (energy prices are industry-level) we did not choose these for the main specification. Columns (1) and (3) in Table A3.7 report the estimation results of equation (2') with the EPS index instead of our energy price index. As before, point estimates are positive significant and coefficient magnitudes are in line with our previous results. A one unit increase in EPS is associated with at most an increase of 4 percentage point in the FDI ratio.[23] In sum, the effect of EPS on FDI is significant but small.

47. *The environmental policy gap.* Similarly, we repeat the exercise using the gap between domestic environmental policies and policies in the potential pollution haven destinations (China and Russia). The results are very similar (Table A3.8), providing some confidence that we do capture small pollution haven type effects.

5. Concluding remarks: the effect of a carbon tax introduction on FDI

48. The estimated results can be extended to assess the impact of a uniform carbon tax on all upstream carbon emissions of a country. This is a simple back of the envelope simulation exercise, subject to many caveats. In particular, our simulations are based on average effect estimates and do not provide lower or upper bounds of this effect.

49. The exercise is based on the following assumptions:

- Countries have different carbon intensity for energy production and hence carbon tax effects will be heterogeneous. By combining our estimation results with a country-year carbon intensity measure, we simulate the average effect of a carbon tax introduction on firms FDI ratio across countries.[24]

- We assume that (domestic) energy prices increase in the countries of our sample only (and not everywhere else, especially in developing countries where FDI could take place).

- Given no consensus about the optimal carbon price, we consider two scenarios: (i) a carbon tax of USD 15 per tonne of CO_2 (tCO_2), which is calculated by Rezai and van der Ploeg (2015) to be the global optimal price of carbon; (ii) a carbon tax of 55 USD/tCO_2, which is an estimate of the necessary increase in the EU carbon price for European countries to achieve their GHG reduction objectives by 2030 (Sato and Dechezleprêtre, 2015).

50. Figure 4 reports the simulated firm-level average 1995-2011 FDI ratio for the full sample and the countries most represented in the latter (the United States, Germany, Japan and the United Kingdom). Heavily relying on nuclear energy within our sample, Japan has a low CO_2 intensity (tCO_2 generated by TOE). Therefore, the introduction of a uniform carbon tax on all carbon emissions does not affect energy prices as much as in countries that rely on fossil fuels (e.g. the United States).

51. In the 15-USD scenario (panel A), energy price increases by 7% on average, with the highest impact in the United States (around 9%) and the lowest in Japan (around 4%). This translates into an increase of 0.3 percentage points in the FDI ratio (0.4 for the US and 0.16 for Japan). The USD 55 scenario (panel B) implies a 25% increase in energy price on average (32% for the United States and 14% for

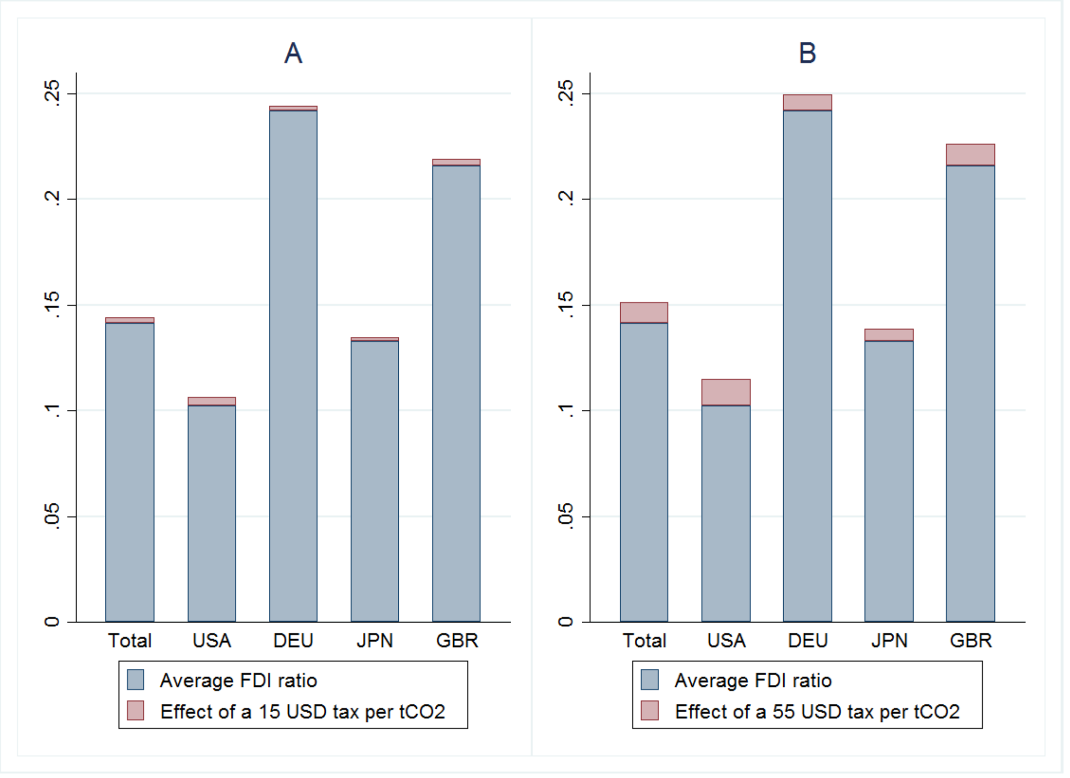
---

23. A 1-unit increase in EPS is a very large increase. In our sample, the EPS indicator increases by 1.71 units over 17 years of observations. Therefore, a 1-unit increase corresponds to almost 10 years of reforms in environmental policies.

24. For a detailed explanation of the simulation procedure see Appendix A4. A cross-country dataset on carbon intensity is available from the World Bank: http://data.worldbank.org/indicator/EN.ATM.CO2E.EG.ZS?end=2011&start=1995

Japan). This translates into an increase of 1 percentage point in the FDI ratio (1.2 pp for the United States and 0.6 pp for Japan).

Figure 4. Carbon tax effect on FDI



Note: These figures report the simulated effect of the introduction of a carbon tax on the FDI ratio using the estimation result of column (5) in Table 1. We consider two scenarios: a USD 15 carbon tax (panel A) and a USD 55 carbon tax (panel B). Details on the simulation procedure are provided in Appendix A4.

52. To sum up, our results indicate that even the unilateral introduction of a substantial carbon tax of 55 USD/tCO2 would have a limited impact on firm-level FDI (i.e. the relative importance of FDI with respect to their size). This scenario seems particularly relevant as OECD (2015a, 2015b) consider that a carbon price of 34 USD/tCO2 (EUR 30) is a lower-end estimate of the social climate cost of carbon emissions. The same studies also recall the urgent need for action in implementing carbon prices as roughly 90% of CO2 emissions in OECD countries, BRIICS and Argentina are priced below this level. In line with other recent results on the PHH (Timiliotis and Koźluk, 2016; Sato and Dechezleprêtre, 2015), we conclude that concerns regarding the effect of stricter environmental rules on economic activity and carbon leakages via the pollution haven effect are likely overstated.

REFERENCES

Albrizio, S., T. Koźluk and V. Zipperer (2016), “Environmental policies and productivity growth: Evidence across industries and firms”, Journal of Environmental Economics and Management, forthcoming 2016, http://dx.doi.org/10.1016/j.jeem.2016.06.002.

Aldy, J. and Pizer, W. (2011), "The competitiveness impacts of climate change mitigation policies", *NBER Working Papers 17705*.

Alliance for American Manufacturing (2009), *An Assessment of Environmental Regulation of the Steel Industry in China,* http://goo.gl/8uyNWZ.

Alliance for American Manufacturing (2008), *Shedding Light on Energy Subsidies in China: An Analysis of China’s Steel Industry from 2000-2007,* http://goo.gl/dv5Tg3.

American Council for Capital Formation and National Association of Manufacturers (2009), *An Analysis of the Waxman–Markey Bill ‘The American Clean Energy and Security Act of 2009’ (H.R. 2454) Using the National Energy Modeling System (NEMS/ACCF-NAM 2),* http://goo.gl/s7KNsA.

Angrist, J. and Pischke, J.-S. (2008), *Mostly harmless econometrics: An empiricist's companion,* Princeton university press.

Barton, D., Gunther McGrath, R., Ikenson, D., Mainardi, C., Muro, M. and Plant, R., (2014), "Will the U.S. See a Major Manufacturing Revival?", *The Wall Street Journal*, July 3.

Beccherle, J. and Tirole, J. (2011), "Regional initiatives and the cost of delaying binding climate change agreements", *Journal of Public Economics, 95*(11), pp. 1339-1348.

Ben Kheder, S. and Zugravu, N. (2012), "Environmental regulation and French firms location abroad: An economic geography model in an international comparative study", *Ecological Economics, 77*, pp. 48-61.

Botta, E., and Koźluk, T. (2014), "Measuring environmental policy stringency in OECD countries: A composite index approach", *OECD Economics Department Working Papers, No. 1177*.

Buch, C., Kesternich, I., Lipponer, A. and Schnitzer, M. (2010), "Exports versus FDI revisited: Does finance matter?", *Deutsche Bundesbank discussion paper No 03/2010*.

Business for Britain (2014), *Energy policy and the EU. How a better deal could bring down the cost of energy and save job,* http://goo.gl/ZROqnW.

Carr, D., Markusen, J. and Maskus, K. (2001), "Estimating the Knowledge-Capital Model of the Multinational Enterprise", *American Economic Review, 91*, pp. 693-708.

Chazan, G.(2012), "Energy cost is top worry for chemical groups", *The Financial Times*, April 30.

Chung, S. (2014), "Environmental regulation and foreign direct investment: Evidence from South Korea", *Journal of Development Economics, 108*, pp. 222-236.

Clark, P., (2014a), "Energy price gap with the US to hurt Europe for 'at least 20 years'", *The Financial Times*, January 19.

Clark, P., (2014b), "EU energy costs widen over trade partners", *The Financial Times*, January 20.

Cole, M. and Elliott, R. (2005), "FDI and the Capital Intensity of "Dirty" Sectors: A Missing Piece of the Pollution Haven Puzzle", *Review of Development Economics, 9,* pp. 530–548.

De Mello Jr, L. (1997), "Foreign direct investment in developing countries and growth: A selective survey", *The Journal of Development Studies, 34,* pp. 1-34.

Dean, J., Lovely, M. and Wang, H. (2009), "Are foreign investors attracted to weak environmental regulations? Evaluating the evidence from China", *Journal of Development Economics, 90*, pp. 1-13.

Di, W. (2007), "Pollution abatement cost savings and FDI inflows to polluting sectors in China", *Environment and Development Economics, 12*, pp. 775-798.

DIIP (2015), *Fact sheet on FDI from April 2000 to April 2015,* Ministry of Commerce and Industry, Department of Industrial Policy and Promotion, Government of India.

Dlugosch D. and Koźluk T. (2016), "Investment and environmental policies - Firm level evidence", *OECD mimeo*, to be discussed at Autumn 2016 WP1 and WPIEEP meetings.

Ederington, J., Levinson, A. and Minier, J. (2004), "Trade Liberalization and Pollution Havens", *The B.E. Journal of Economic Analysis and Policy (Advances), 4,* pp. 1-22.

Ederington, J., Levinson, A. and Minier, J. (2005), "Footloose and pollution-free", *The Review of Economics and Statistics, 87,* pp. 92-99.

Elliott, R. and Shimamoto, K. (2008), "Are ASEAN countries havens for Japanese pollution-intensive industry?", *World Economy, 31,* pp. 236-254.

Eskeland, G. and Harrison, A. (2003), "Moving to greener pastures? Multinationals and the pollution haven hypothesis", *Journal of Development Economics, 70,* pp. 1-23.

Fournier, J.-M. (2016), "The negative effect of regulatory divergence on foreign direct investment", *OECD Economics Department Working Papers, No. 1268,* OECD Publishing.

Fredriksson, P., List, J. and Millimet D. (2003), "Bureaucratic corruption, environmental policy and inbound US FDI: theory and evidence", *Journal of Public Economics, 87,* pp. 1407–1430.

Gabaix, X. (2011), "The Granular Origins of Aggregate Fluctuations", *Econometrica*, Vol. 79, No.3, pp. 733-722.

Garsous, G. and Koźluk, T. (2016), "*How stringent are environmental policies? Policy perspectives",* OECD publishing.

Gerlagh, R. and Mathys, N. (2011), "Energy abundance, trade and industry location", *Nota di Lavoro 003.2011 FEEM*.

Gollier, C. and Tirole, J. (2015), "Negotiating effective institutions against climate change", *Economics of Energy and Environmental Policy, 4*(2), pp. 5-27.

Green, K. (2011), *Dissecting the Carbon Tax,* American Enterprise Institute.

Hanna, R. (2010), "US Environmental Regulation and FDI: Evidence from a Panel of US-Based Multinational Firms", *American Economic Journal: Applied Economics, 2*, pp. 158-189.

Head, K. and Ries, J. (2008), "FDI as an outcome of the market for corporate control: Theory and evidence", *Journal of International Economics*, *74*, pp. 2-20.

Kellenberg, D. (2009), "An empirical investigation of the pollution haven effect with strategic environment and trade policy", *Journal of International Economics, 78*, pp. 242-255.

Keller, W. and Levinson, A. (2002), "Pollution abatement costs and foreign direct investment inflows to U.S. States", *The Review of Economics and Statistics, 84*, pp. 691–703.

Kirkpatrick, C. and Shimamoto, K. (2008), "The effect of environmental regulation on the locational choice of Japanese foreign direct investments", *Applied Economics, 30*, pp. 1399-1409.

Koźluk, T. and Timiliotis, C. (2016), "Do environmental policies affect global value chains? A new perspective on the Pollution Haven Hypothesis", *OECD Economics Department Working Papers*, No. 1282, OECD Publishing.

Levinson, A. and Taylor, M. (2008), "Unmasking the pollution haven effect", *International Economic Review*, *49*, pp. 223-254.

List, J. (2001), "US county-level determinants of inbound FDI: evidence from a two-step modified count data mode", *International Journal of Industrial Organization, 19*, pp. 953–973.

List, J., and Co, C. (2000), "The effect of environmental regulation on foreign direct investment", *Journal of Environmental Economics and Management, 40*, pp. 1-40.

List, J., McHone, W., and Millimet, D. (2004), "Effects of environmental regulation on foreign and domestic plant births: is there a home field advantage?", *Journal of Urban Economics, 56*, pp. 303-326.

Liu, K., and Daly, K. (2011), "Foreign Direct Investment in China Manufacturing Industry - Transformation from a Low Tech to High Tech Manufacturing", *International Journal of Business and Management*, *6*(7), pp. 15-27.

Manderson, E. and Kneller, R. (2012), "Environmental Regulations, Outward FDI and Heterogeneous Firms: Are Countries Used as Pollution Havens?", *Environmental and Resource Economics, 51*, pp. 317-352.

McGuire, M. (1982), "Regulation, factor rewrads and international trade", Journal of Public Economics, 17, pp. 335-354.

Morgan, D. (2012), *A carbon tax would harm US competitiveness and low-income americans without helping the environment,* The heritage Foudation Backgrounder #2720 on Energy and Environment and Taxes.

National Black Chamber of Commerce (2015), *Potential impact of proposed EPA regulations on low income groups and minorities*, http://goo.gl/PUkqoN.

OECD (2015a), *Effective Carbon Rates on Energy,* OECD Publishing, Paris.

OECD (2015b), *Taxing Energy Use 2015: OECD and Selected Partner Economies,* OECD Publishing, Paris.

OECD (2002), *"Foreign Direct Investment for Development: Maximising Benefits, Minimizing Costs"*, OECD Publishing, Paris.

Pethig, R. (1976), "Pollution, welfare, and environment policy in the theory of comparative advantage", Journal of Environmental Economics and Management, 2, pp. 160-169.

Rezai, A. and van der Ploeg, R. (2015), *Global carbon taxation: Intuition from a back-of-the-envelope calculation*, Retrieved from VOX CEPR's Policy Portal: http://voxeu.org/article/global-carbon-taxation.

Rezza, A. (2015), "A meta-analysis of FDI and environmental regulations", *Environment and Development Economics, 20*, pp. 185-208.

Saggi, K. (2002), "Trade, foreign direct investment, and international technology transfer: A survey", *The World Bank Research Observer, 17*, pp. 191-235.

Sato, M. and Dechezleprêtre, A. (2015), "Asymmetric industrial energy prices and international trade", *Energy Economics*, *52*, pp. 130-141.

Sato, M., Singer, G., Dussaux, D. and Lovo, S. (2015), "International and sectoral variation in energy prices 1995-2011: how does it relate to emissions policy stringency?", *Centre for Climate Change Economics and Policy Working Paper No. 212*.

Siebert, H. (1977), "Environmental quality and the gains from trade", Kyklos, 30, pp. 657-673.

Stock, J., and Yogo, M., (2005), *Testing for Weak Instruments in Linear IV Regression. In: Andrews DWK, Identification and Inference for Econometric Models*, Cambridge University Press, pp. 80-108.

The World Bank (2010), "*World development report 2010"*, http://goo.gl/RuvMMR.

Wagner, U. and Timmins, C. (2009), "Agglomeration effects in foreign direct investment and the pollution haven hypothesis", *Environmental and Resource Economics*, *43*, pp. 231-256.

Waldkirch, A. and Gopinath, M. (2008), "Pollution control and foreign direct investment in Mexico: an industry-level analysis", *Environmental and Resource Economics, 41*, pp. 289-313.

Wooldridge, J. (2015), *Introductory econometrics: A modern approach,* Nelson Education.

Xing, Y. and Kolstad, C. (2002), "Do lax environmental regulations attract foreign investment?", *Environmental and Resource Economics, 21,* pp. 1–22.

Yohe, G. (1979), "The backward incidence of pollution control – some comparative statics in general equilibrium", Journal of Environmental Economics and Management, 6, pp. 187-198.

APPENDIX A1: SUMMARY OF LITERATURE REVIEW

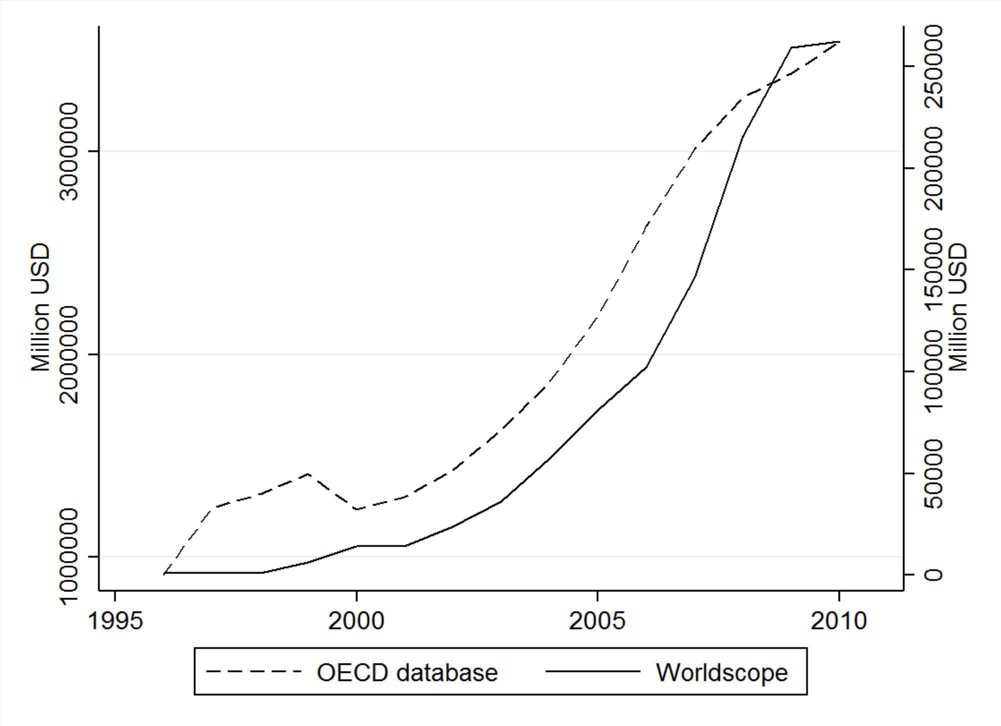
Table A1.1 Summary of literature review

Paper	Parent Country	Host country	Period	Level of analysis	Type of FDI	Type of data	Proxy for EPS	Evidence of PHH
Ben Kheder and Zugravu (2012)	France	74 countries	1996-2002	Firm	Establishment location decision	Cross-section	Index	MIXED
Chung (2014)	South-Korea	Rest of the world	2000-2007	Firm	Flows	Panel data	Survey	YES
Cole et al. (2005)	USA	Brazil and Mexico	1989-1994	Sector	Stock	Panel data	Abatement cost	MIXED
Dean et al. (2009)	Rest of the world	China	1993-1996	Firm	Establishment location decision	Cross-section	Abatement cost	MIXED
Di (2007)	Rest of the world	China	1992-1995	Firm	Establishment location decision	Cross-section	Authorized pollution	YES
Elliot and Shimamoto (2008)	Japan	3 South-East Asian countries	1986-1998	Sector	Flows	Panel data	Abatement cost	NO
Eskeland and Harrison (2003)	USA	4 developing countries	1977-1990	Sector	Outward investment	Panel data	Abatement cost	NO
Fredriksson et al. (2003)	Rest of the world	USA	1977-1987	Sector	Flows	Panel data	Abatement cost	YES
Hanna (2010)	USA	Rest of the world	1966-1999	Firm	Stock (foreign assets)	Panel data	Authorized pollution	YES
Kellenberg (2009)	USA	50 countries	1999-2003	Sector	Value added of US multinational affiliates	Panel data	Survey	YES
Keller and Levinson (2002)	Rest of the world	USA	1967-1994	Aggregate FDI in US states	Stock (foreign assets)	Panel data	Abatement cost	YES
Kirkpatrick and Shimamoto (2008)	Japan	Rest of the world	1992-1997	Firm	Establishment location decision	Cross-section	International treaties	NO
Kukenova and Monteiro (2008)	Rest of the world	Rest of the world	1981-2005	Aggregate FDI	Flows	Panel data	Authorized pollution	YES
List (2001)	Rest of the world	USA	1983-1992	Firm	Establishment location decision	Cross-section	Authorized pollution	NO
List and Co (2000)	Rest of the world	USA	1986-1993	Firm	Establishment location decision	Cross-section	Index	YES
List et al. (2004)	Rest of the world	USA	1980-1990	New plants in US counties	Establishment location decision	Panel data	Authorized pollution	NO
Manderson and Kneller (2012)	UK	Rest of the world	2005	Firm	Establishment location decision	Cross-section	Abatement cost	NO
Wagner and Timmins (2009)	Germany	Rest of the world	1996-2003	Sector	Flows	Panel data	Survey	YES
Waldkirch and Gopinath (2008)	Rest of the world	Mexico	1994-2000	Sector	Flows	Cross-section	Authorized pollution	YES
Xing and Kolstad (2002)	USA	Rest of the world	1985-1990	Aggregate FDI	Flows	Cross-section	Authorized pollution	MIXED

APPENDIX A2: DATASET ADDITIONAL INFORMATION

Figure A2.1 Trends of outward manufacturing FDI

(OECD macro data versus Worldscope)



Source: Authors calculations. This figure reports trends of aggregate outward FDI for the same set of country-sector from two different databases: (i) OECD database on aggregate FDI; (ii) firm-level database Worldscope. Trends are calculated by moving average with one lag and one lead. Industries included in the sample are the 9 manufacturing sectors used in our empirical analysis.

Table A2.1 SIC codes used in manufacturing industries

	SIC codes
Chemicals and petrochemicals	28, 29, 30
Food and tobacco	20, 21
Iron and steel	331, 332
Machinery	35, 36, 38
Non-ferrous metal	333, 334, 335, 336
Non-metallic minerals	32
Paper and printing	26, 27
Textile	22, 23, 31
Transport equipment	37

Table A2.2 List of countries included in the full sample

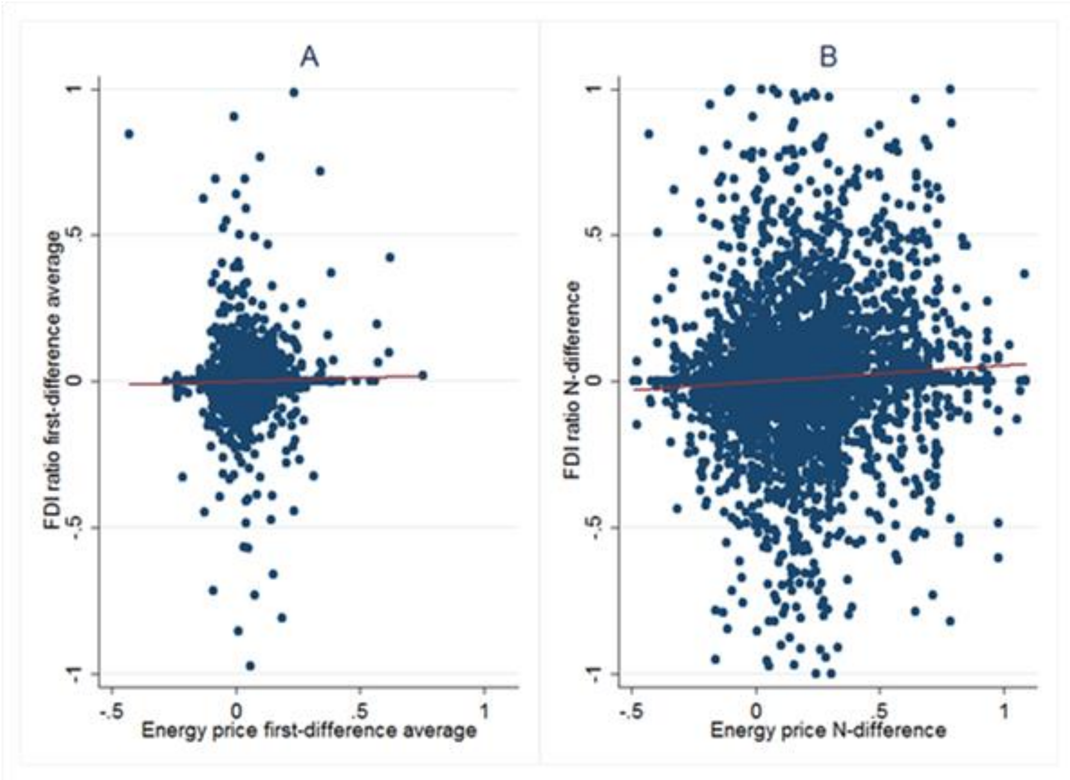
Country	Share of observations
AUS	0.010
AUT	0.005
BEL	0.005
CAN	0.026
CHE	0.016
CZE	0.002
DEU	0.031
FIN	0.006
FRA	0.016
GBR	0.084
GRC	0.004
HUN	0.002
ITA	0.008
JPN	0.218
KOR	0.015
NLD	0.007
NZL	0.000
POL	0.005
PRT	0.001
SVK	0.000
SWE	0.008
TUR	0.025
USA	0.506

Table A2.3 Descriptive statistics

Variable		Obs.	Mean	Std. Dev.	Median
International-to-total-assets ratio		50,652	0.14	0.21	0.03
Log energy price (US$ per TOE)		50,652	6.36	0.44	6.22
International sales (million US$)		50,652	4.39	26.90	0.06
Number of employees		50,652	6,106	14,882	946
Number of firms		6,806			
Observations per group of firms:					
	Min	2			
	Avg	7.4			
	Max	17			

Figure A2.2 FDI ratio and energy price scatter plots

First and N differences



Source: Authors calculations. Panel A: Scatter plot of first-difference averages for FDI ratio and energy price. Panel B: Scatter plot of firm-level difference between last and first year of observation (N-difference) for FDI ratio and energy price.

APPENDIX A3: ESTIMATION RESULTS AND ROBUSTNESS CHECKS

Table A3.1 Panel data estimation results

	Full sample			Intensive margin			Extensive margin		
Dependent variable: International-to-total-assets ratio	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log(Energy price)	-0.0746			0.00121			-0.0272		
	(0.0715)			(0.0909)			(-0.106)		
Log(Energy price)[t-1]		-0.0551			0.0264			-0.00712	
		(0.0876)			(0.107)			(0.142)	
Log(Energy price)[t-2]			-0.0421			-9.83E-05			0.0327
			(0.0938)			(0.115)			(0.169)
Control variables	YES	YES	YES	YES	YES	YES	YES	YES	YES
Country x Year fixed effect	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry x Year fixed effect	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	50,652	40,524	33,729	25,068	20,807	17,774	25,584	19,717	15,955
R-squared	0.073	0.076	0.076	0.112	0.116	0.11	0.113	0.109	0.11
Number of firms	6,806	5,768	4,982	3,018	2,679	2,350	3,788	3,089	2,632
Kleibergen-Paap rk LM statistic	668	598	502	419	395	339	217	175	145
Kleibergen-Paap rk Wald F statistic	2,470	2,299	1,781	2,200	3,317	2,493	1,195	967	738

Note: All regressions are estimated by a Two Stage Least Squares (2SLS) within estimator, using the first-difference in fixed-weight price index as an instrument for the first-difference in observed energy prices. Control variables are firms' international sales and number of employees. All regressions include country-year and industry-year interactions. The Kleinbergen-Paap statistics are results of tests for IV weak identification. Reported results are all above critical values compiled by Stock and Yogo (2005) and therefore reject the hypothesis that the first-stage model is under identified. Robust standard errors clustered at the firm level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table A3.2 Effect of relative energy prices on FDI

Dependent variable: International-to-total-assets ratio	Full sample (1) OLS	(2) 2SLS	Pre-crisis sample (3) OLS	(4) 2SLS
Diff. between local and RUS/CHN energy prices	0.0306***	0.0352**	0.0409***	0.0598***
	(0.00839)	(0.0151)	(0.00812)	(0.0129)
Control variables	YES	YES	YES	YES
Country fixed-effect	YES	YES	YES	YES
Industry fixed-effect	YES	YES	YES	YES
Observations (Number of firms)	6,573	6,573	6,315	6,315
R-squared	0.037	0.037	0.042	0.041
Kleibergen-Paap rk LM statistic	n.a	511	n.a	3,429
Kleibergen-Paap rk Wald F statistic	n.a	1,658	n.a	3,409

Note: Columns (1) and (3) provide OLS estimations results. Regressions in columns (2) and (4) are estimated by Two Stage Least Squares (2SLS). The main regressor is the N-difference of the log ratio of local energy price to the average of Russian and Chinese energy prices. The instrument in 2SLS estimations is the N-difference of the log ratio of local fixed-weight energy price index to the average of Russian and Chinese fixed-weight energy price index. Control variables are firms' international sales and number of employees. All regressions include country and industry fixed-effects. The Kleinbergen-Paap statistics are results of tests for IV weak identification. Reported results are all above critical values compiled by Stock and Yogo (2005) and therefore reject the hypothesis that the first-stage model is under identified. Robust standard errors clustered at the firm level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table A3.3 Estimation results for intensive and extensive margin firms

Dependent variable: International-to-total-assets ratio	Full sample (1) OLS	(2) 2SLS	Intensive margin (3) OLS	(4) 2SLS	Extensive margin (5) OLS	(6) 2SLS
Log(Energy price)	0.0572***	0.0447***	0.0590***	0.00786	0.0576***	0.0738***
	(0.0111)	(0.0132)	(0.0221)	(0.0262)	(0.0125)	(0.0138)
Control variables	YES	YES	YES	YES	YES	YES
Country fixed effect	YES	YES	YES	YES	YES	YES
Industry fixed effect	YES	YES	YES	YES	YES	YES
Observations (Number of firms)	6,806	6,806	3,018	3,018	3,788	3,788
R-squared	0.028	0.028	0.044	0.043	0.066	0.066
Kleibergen-Paap rk LM statistic	n.a	2,196	n.a	943	n.a	1,124
Kleibergen-Paap rk Wald F statistic	n.a	7,055	n.a	5,843	n.a	6,589

Note: Columns (1), (3) and (5) provide OLS estimations results. Regressions in columns (2), (4) and (6) are estimated by Two Stage Least Squares (2SLS), using the N-difference in fixed-weight price index as an instrument for N-difference in the observed energy prices. Control variables are firms' international sales and number of employees. All regressions include country and industry fixed-effects. The Kleinbergen-Paap statistics are results of tests for IV weak identification. Reported results are all above critical values compiled by Stock and Yogo (2005) and therefore reject the hypothesis that the first-stage model is under identified. Robust standard errors clustered at the firm level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table A3.4 Pre-crisis estimation results

Dependent variable: International-to-total-assets ratio	Full sample (1) OLS	(2) 2SLS	Intensive margin (3) OLS	(4) 2SLS	Extensive margin (5) OLS	(6) 2SLS
Log(Energy price)	0.0721***	0.0664***	0.0784***	0.0560**	0.0565***	0.0646***
	(0.0102)	(0.012)	(0.0209)	(0.0238)	(0.00932)	(0.0111)
Control variables	YES	YES	YES	YES	YES	YES
Country fixed effect	YES	YES	YES	YES	YES	YES
Industry fixed effect	YES	YES	YES	YES	YES	YES
Observations (Number of firms)	6,315	6,315	2,850	2,850	3,465	3,465
R-squared	0.045	0.045	0.077	0.076	0.105	0.105
Kleibergen-Paap rk LM statistic	n.a	2,433	n.a	1,040	n.a	1,242
Kleibergen-Paap rk Wald F statistic	n.a	9,087	n.a	7,314	n.a	7,895

Note: Columns (1), (3) and (5) provide OLS estimations results. Regressions in columns (2), (4) and (6) are estimated by Two Stage Least Squares (2SLS), using the N-difference in fixed-weight price index as an instrument for the N-difference in observed energy prices. Control variables are firms' international sales and number of employees. All regressions include country and industry fixed-effects. The Kleinbergen-Paap statistics are results of tests for IV weak identification. Reported results are all above critical values compiled by Stock and Yogo (2005) and therefore reject the hypothesis that the first-stage model is under identified. Robust standard errors clustered at the firm level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table A3.5 Estimation results with non-US firms only

Dependent variable: International-to-total-assets ratio	Full sample (1) OLS	(2) 2SLS	Pre-crisis sample (3) OLS	(4) 2SLS
Log(Energy price)	0.0875***	0.0945***	0.132***	0.165***
	(0.0137)	(0.0165)	(0.0135)	(0.0163)
Control variables	YES	YES	YES	YES
Country fixed effect	YES	YES	YES	YES
Industry fixed effect	YES	YES	YES	YES
Observations (Number of firms)	3 421	3 421	3,152	3,152
R-squared	0,046	0,046	0.071	0.069
Kleibergen-Paap rk LM statistic	n.a	5,826	n.a	2,710
Kleibergen-Paap rk Wald F statistic	n.a	4,028	n.a	1,696

Note: Columns (1) and (3) provide OLS estimations results. Regressions in columns (2) and (4) are estimated by Two Stage Least Squares (2SLS), using the N-difference in fixed-weight price index as an instrument for N-difference in the observed energy prices. Control variables are firms' international sales and number of employees. All regressions include country and industry fixed-effects. The Kleinbergen-Paap statistics are results of tests for IV weak identification. Reported results are all above critical values compiled by Stock and Yogo (2005) and therefore reject the hypothesis that the first-stage model is under identified. Robust standard errors clustered at the firm level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table A3.6 Effect of energy prices on foreign assets

Dependent variable: Log(real international assets)	Full sample (1) OLS	(2) 2SLS	Pre-crisis sample (3) OLS	(4) 2SLS
Log(Energy price)	3.657*** (0.348)	5.382*** (0.472)	3.590*** (0.332)	4.807*** (0.429)
Control variables	YES	YES	YES	YES
Country fixed effect	YES	YES	YES	YES
Industry fixed effect	YES	YES	YES	YES
Observations (Number of firms)	6,806	6,806	6,315	6,315
R-squared	0.033	0.03	0.035	0.033
Kleibergen-Paap rk LM statistic	n.a	2,165	n.a	1.60E+04
Kleibergen-Paap rk Wald F statistic	n.a	6,970	n.a	9,087

Note: Columns (1) and (3) provide OLS estimations results. Regressions in columns (2) and (4) are estimated by Two Stage Least Squares (2SLS), using the N-difference in fixed-weight price index as an instrument for the N-difference in observed energy prices. The dependent variable is the logarithm of firms' foreign assets. Control variables are firms' international sales and number of employees. All regressions include country and industry fixed-effects. The Kleinbergen-Paap statistics are results of tests for IV weak identification. Reported results are all above critical values compiled by Stock and Yogo (2005) and therefore reject the hypothesis that the first-stage model is under identified. Robust standard errors clustered at the firm level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table A3.7 Effect of EPS on FDI

Dependent variable: International-to-total-assets ratio	Full sample (1)	Pre-crisis sample (2)
EPS	0.0218*** (0.00644)	0.0400*** (0.00757)
Control variables	YES	YES
Country fixed effect	YES	YES
Industry fixed effect	YES	YES
Observations (Number of firms)	6,806	6,315
R-squared	0.026	0.043

Note: Columns (1) and (2) provide OLS estimations results for the effect of EPS on the FDI ratio. All regressions use the N-difference in EPS. Control variables are firms' international sales and number of employees. All regressions include country and industry fixed-effects. Robust standard errors clustered at the firm level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table A3.8 Effect of environmental policy gap on FDI

Dependent variable: International-to-total-assets ratio	Full sample (1)	Pre-crisis sample (2)
EPS Gap	0.0264*** (0.00649)	0.0459*** (0.00747)
Control variables	YES	YES
Country fixed effect	YES	YES
Industry fixed effect	YES	YES
Observations (Number of firms)	6,806	6,315
R-squared	0.027	0.044

Note: Columns provide OLS estimations results using the gap between domestic EPS and the average EPS in China and Russia. All regressions use the N-difference in the EPS gap. Control variables are firms' international sales and number of employees. All regressions include country and industry fixed-effects. Robust standard errors clustered at the firm level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table A3.9 EPS as a predictor of energy prices (sectoral coefficients)

Dep. variable: Energy price index	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
EPS	7.572*** (0.0416)	7.438*** (0.0856)	7.323*** (0.18)	8.131*** (0.0287)	7.661*** (0.185)	6.412*** (0.208)	7.302*** (0.112)	7.305*** (0.143)	7.608*** (0.0875)
Observations	11,406	3,885	1,134	22,772	850	1,495	2,786	2,135	3,225
R-squared	0.744	0.661	0.594	0.779	0.669	0.389	0.604	0.549	0.701

Note: Columns provide estimation results from regressing energy prices on the EPS for each sector of the sample. Column (1): Chemicals and petrochemicals; Column (2): Food and tobacco; Column (3): Iron and steel; Column (4): Machinery; Column (5): Non-ferrous metal; Column (6): Non-metallic minerals; Column (7): Paper and print; Column (8): Textile; Column (9): Transport

APPENDIX A4: CARBON TAX EFFECT SIMULATION PROCEDURE

1. We calculate the effect of a carbon tax introduction as follows. First, we match a country-year carbon intensity measure for energy production – which accounts for the amount of CO_2 emitted per ton of oil equivalent (TOE) – with our firms dataset.[25]

2. Next, for each firm, we calculate the hypothetic energy price including the carbon tax by:

- multiplying the carbon intensity measure (tCO_2/TOE) with the hypothetical carbon tax (USD/tCO_2), which provides the carbon price per TOE (USD/TOE);
- adding this carbon price (USD/TOE) to the observed price (USD/TOE) faced by firms.

3. Finally, by multiplying the percentage increase in energy price due to the carbon tax and our estimated coefficients, we obtain the effect of carbon pricing on the FDI ratio in percentage points.[26]

25. The dataset on carbon intensity is available from the World Bank: http://data.worldbank.org/indicator/EN.ATM.CO2E.EG.ZS?end=2011&start=1995.

26. We use the 2SLS estimation result of column (5) in Table 1 as it captures the average effect for all firms.

APPENDIX A5: ESTIMATION RESULTS WITH GRAVITY MODEL

Table A5.1 Macro results

Dependent variable: outward FDI	(1)	(2)	(3)	(4)	(5)	(6)
Ln(gdp country)	0.726	0.785	0.989*	0.646	0.680	0.904*
	(0.561)	(0.559)	(0.530)	(0.552)	(0.543)	(0.545)
Ln(gdp partner)	0.443*	0.432*	0.335	0.347	0.310	0.154
	(0.235)	(0.225)	(0.226)	(0.273)	(0.264)	(0.256)
Ln(dist capital)	-0.442***	-0.437***	-0.478***	-0.441***	-0.436***	-0.525***
	(0.0961)	(0.0946)	(0.154)	(0.100)	(0.0978)	(0.171)
Contiguity	0.0504	0.0408	0.104	-0.0620	-0.0628	0.000269
	(0.215)	(0.219)	(0.222)	(0.233)	(0.234)	(0.236)
Common law	0.409***	0.407***	0.433***	0.289**	0.274*	0.303*
	(0.130)	(0.139)	(0.144)	(0.141)	(0.150)	(0.159)
Common language official	0.330*	0.368*	0.288	0.501**	0.512**	0.429*
	(0.181)	(0.193)	(0.212)	(0.202)	(0.209)	(0.235)
Both countries in EU		-0.0853	-0.0188		-0.0122	0.104
		(0.189)	(0.220)		(0.212)	(0.239)
Ln(tariff country)		-1.495	-2.507		-2.166	-0.374
		(1.531)	(1.864)		(1.745)	(0.630)
Ln(tariff partner)		0.0204	0.0859		-0.0649	-0.0308
		(0.123)	(0.132)		(0.142)	(0.154)
Ln(FDI restriction index partner)		-0.323	-0.263		-0.383	-0.273
		(0.203)	(0.192)		(0.253)	(0.238)
Ln(gdp difference)			-0.0198			-0.0205
			(0.0203)			(0.0246)
Ln(skills difference)			0.0382			0.0281
			(0.0353)			(0.0415)
Tax gap			-0.0313			-0.262
			(0.912)			(0.902)
EPS gap	-0.0681	-0.0746	-0.0510			
	(0.0477)	(0.0490)	(0.0483)			
Energy price gap				0.0371	-0.00249	-0.0694
				(0.365)	(0.369)	(0.326)
Constant	-22.88	-23.88	-24.56*	-18.84	-17.61	-17.90
	(17.28)	(17.13)	(13.76)	(17.52)	(17.53)	(15.96)
Observations	3,095	2,986	2,781	2,040	1,973	1,820
R-squared	0.798	0.798	0.787	0.798	0.798	0.787

Note: All regressions are estimated by Poisson pseudo-maximum likelihood (PPML) based on a gravity model. Robust standard errors clustered at the firm level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.