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Is Investment Leakage for the Swedish FDI-flows Caused by the EU ETS?

A study examining the connection between the EU Emission Trading System and Swedish foreign direct investment flows in the iron and steel sector

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Abstract:

In the recent decades, the subject of a shift of emission from regions with stringent regulation to developing countries has arisen. At the same time, regulated countries such as Sweden has experienced less industrial growth. In light of this, we will explore if the implementation of the European Union Emission Trading System in 2005 has led to investment leakage in the iron and steel sector from Sweden. As the steel and iron industry is highly emission-intensive and relatively open to trade, the *Pollution Haven Effect* claims that environmental regulations will lead to relocation from a regulated economy to an unregulated. We perform a difference-in-differences strategy examining panel data on Swedish outward FDI flows between 1998 and 2016. Although earlier research find no evidence for a *Pollution Haven Effect*, this analysis points to the opposite by concluding that the EU ETS has led to investment leakage. Due to internal validity threat combined with a limited time frame, our results are drawn with caution opening for future investigations.

Keywords: EU ETS, carbon leakage, difference-in-differences, emission-intensive industries, Foreign Direct Investments (FDI), investment leakage, operational leakage, permits, Pollution Haven Effect, Porter Hypothesis, relocation, Samhällsvetenskapligt miljövetarprogram

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Table of contents

1. Introduction	4
1.1 Background	4
1.2 Purpose	5
1.3 Disposition	6
2. The EU ETS	6
3. Literature Review	7
3.1 Carbon Leakage Literature.....	8
3.2 Relocation Concerns.....	9
4. Theoretical Framework	10
4.1 The Pollution Haven Effect	10
4.2 Porter Hypothesis.....	11
5. Data	12
5.1 FDI-data	12
5.2 Limitations	14
6. Econometric Approach	14
6.1 Difference-in-differences.....	15
6.2 Internal and External Validity.....	18
7. Results for Difference-in-Differences for each Region	20
7.1 Results for North America	21
7.2 Results for Rest of the World	21
7.3 Results for EU28+EFTA	22
8. Discussion	23
9. Conclusions	25
List of sources	26
Data.....	29
Appendix	30

1. Introduction

1.1 Background

Conventional wisdom in energy-intensive industries is that stricter climate policy weakens the capability of performing in a competitive way because of large emission abatement costs and asymmetric climate policies around the world (Zechter et al., 2017). Although different climate policies are emerging globally, the first and largest regional carbon pricing system currently implemented is the European Union Emissions Trading System (EU ETS). It is targeting energy intensive industries with the aim of decreasing greenhouse gases (GHG) caused by the biggest emitters among the EU28 plus Liechtenstein, Norway and Iceland (i.e. EFTA). The key component to accomplish this is allocating a fixed number of tradable GHG allowances to the polluters, and leaving the firms to buy and sell these allowances between one another.

Putting a price on carbon increases the threat of carbon leakage. Reinaud (2008) defines carbon leakage “as the ratio of emissions increase from a specific sector outside the country (as a result of a policy affecting that sector in the country) over the emission reductions in the sector (again, as a result of the environmental policy)” (p.3). This leakage in emissions mainly takes place through two channels: *operational* and *investment leakage*.

One concern of implementing environmental policy is that within a particular sector, the constrained region faces certain costs whereas others, non-constrained regions, do not. This creates a *comparative disadvantage* for the regulated economy to the benefit of non-constrained regions. The additional costs may lead to *operational leakage* in the short-term, which means a shift of market shares from the constrained region to foreign competitors that are not covered by the regulations (Reinaud, 2008). In the long-run, the threat of industries relocating to countries with laxer environmental regulations (*investment leakage*) is emerging. The overall consequence would be an augmentation in GHG emissions globally, which is at the same time affecting the international environment as well as the efficiency of climate policy.

Particularly sensitive sectors to these emission abatement costs are the ones that are highly CO₂-intensive and internationally open to trade, such as the iron and steel sector. The Alliance of Energy Intensive Industries amongst others debates that the implementation of the

EU ETS is a contributing factor to European industries loss in competitiveness (European Commission, n.d.a).

The purpose of this paper is to study investment leakage for the Swedish iron and steel industry. The reason behind this is that this sector stands alone for 36 percent of total emissions in Sweden, making it the largest emitting industry and undeniably a target for the EU ETS. Since Sweden in the recent decades has experienced a diminishing industrial growth and at the same time has increased outward *foreign direct investment* (FDI) flows, the worry of these flows causing emissions in developing countries has arisen (SCB, n.d.; SCB, 2017). The total amount of emissions on a Swedish national level has also decreased after 1990 (Naturvårdsverket, 2017), which could advocate in favour for that emissions have moved outside the country.

Due to trade openness together with uneven climate policies, regulated nations may migrate their production of energy-intensive goods to countries with more favorable climate policies. This is known as the *Pollution Haven Effect* (Copeland & Taylor, 2004). To our knowledge, only a few rigorous *ex post* studies has been made tackling investment leakage as a result of the EU ETS (Koch & Houdou, 2016). Therefore this paper, as is the first of its kind using Swedish data, will be exploring if the concern of relocation is valid with regards to the EU ETS. To further analyse this issue, we will use FDI data provided by Statistiska Centralbyrån (SCB) on outward FDI flows of Swedish firms.

1.2 Purpose

This paper studies the potential consequences of the EU ETS in the iron and steel sector. More precisely, we observe outbound FDI flows from Sweden possibly resulting from the regulation (i.e. the long-run perspective, *investment leakage*). We focus on *horizontal FDI*, when a firm invests in the same sector as the one they operate in their so-called home country (Feenstra & Taylor, 2017, p. 23).

The reason to disregard *operational leakage*, the short-run perspective, is that Swedish steel industry is highly niched and therefore in general not threatened to the same degree by

operational leakage as other countries producing conventional steel (Atallah, 2018, March 1st).
With this in mind, and the largest emission trading scheme being persistent and Sweden

being a target of it, we aim to examine whether the implementation of the EU ETS may have induced *investment leakage* or not.

This potential outcome has its foundations in the *Pollution Haven Effect* as mentioned above. To examine this belief, we apply a difference-in-difference (DID) strategy. Through a DID, we will be able to compare the outcomes before and after the implementation of the EU ETS for a sector affected by the policy change (in this case, the iron and steel sector) to an unaffected. Our theoretical prediction is that outward FDI flows have increased in countries with less stringent regulation since the implementation of the EU ETS. We have for that reason divided our statistics into different regions and will then compare our findings for each region.

1.3 Disposition

This paper is organized as follows. In section 2, we give a deeper background about the EU ETS. Section 3 illustrates an overview of earlier research. After this, the relevant theoretical frameworks are discussed in section 4. Then section 5 will describing the data and the limitations concerning this. From there, in section 6, the econometric model will be both presented and debated. Subsequently, our formed DID-model is tested in section 7 and results are portrayed. Section 8 elaborates on our findings together with illustrating the current circumstances in the iron and steel sector as well as what future research should focus on. Succeeding this, section 9 concludes this paper with emphasize on our discoveries. At last follows the references and appendix.

2. The EU ETS

The EU ETS was launched in 2005 as a policy instrument aiming to reduce GHG emissions by at least 40 percent in 2030 in comparison to historical output in 1990 (European Commission, n.d.b). Operating in 31 countries in total, the mandatory emission trading scheme targets approximately 11,000 energy-intensive installations as it covers about 45 percent of total GHG emissions in the EU. The policy is based on the *cap and trade principle* where a cap is set including a total amount of GHG emissions allowed (permits) by the companies covered by the scheme. It is then up to the companies within the cap to trade permits between one another (if

they wish to do so), which makes this a market based instrument. The cap is then reduced each year by a certain amount to continuously decrease

the environmental impact. Each permit gives the right to emit one ton of carbon dioxide, and the total amount of permits is reduced throughout the years.

The system is divided into four phases. The first phase started with the implementation as a “*learning by doing*” process between 2005 to 2007, where a generous cap of free allowances was set based on estimated needs for targeted installations. The following trading period, phase II, spanned the period from 2008 to 2012 corresponding with the Kyoto Protocol commitment. Although a reduction of emission allowances by 6.5 percent was set in phase II, the economic downturn in 2009 led to a surplus of allowances and the cap on permits remained large. Phase III is the current phase covering the period from 2013 to 2020. Since 2013, the cap is reduced every year, entailing a 21 percent reduction of GHG emissions compared to output in 2005. To achieve the final goal of a 40 percent reduction by 2030, the phase IV (2021 to 2030) needs to be further revised. With respect to emissions in 2005, the installations covered by the system need to reduce their GHG emissions by a total of 43 percent by the end of phase IV. This will be undertaken by yearly reducing the cap by 2.2 percent from 2021 onwards.

By being the first to put a price on carbon, the EU ETS is facing a challenge of lower emissions in regulated areas while the opposite in the so called third countries (i.e. carbon leakage). In order to address this concern, the EC has developed the *free allocation of permits*. This has since the implementation been the dominant principle of allocation, since it is advocated to help preventing the risk of carbon leakage. The alternative way of allocation is auctioning of permits, which is progressively taking place in the majority of the sectors covered by the scheme. As free allocation is the main argument to prevent carbon leakage, the EC has acted very precautionary in carbon-intensive industries concerning auctioning. However, since the share of auctioning is expected to rise significantly in manufacturing industry in the future, associations such as Energy Intensive Industries (n.d.) has been lobbying against the opening up of auctions.

3. Literature Review

The existing evidence about the amount of spillover effects that can be expected due to environmental regulations is not conclusive. Common knowledge advocates that environmental regulations weaken the capability of firms to act in a competitive way, whereas

many empirical studies do not find support for this. This section will discuss earlier research assessing carbon leakage together with different aspects and consequences of relocation.

3.1 Carbon Leakage Literature

Branger et al. (2016) study the carbon leakage effect from the EU ETS, and show that it is non-existent. The authors tested this belief for the cement and steel industry, as these sectors are energy-intensive and likely to be vulnerable for climate policy. Even though these sectors are vulnerable, no evidence for operational leakage could be proven. By using European emission allowances (EUA) prices as their main regression variable, Branger et al. conclude that prices on EUA has little to no impact on the competitiveness of a firm. However, the authors could not conclude that free allocation of allowances should be scrapped, as they disregard the production capacity perspective (i.e. leakage through the investment channel). They referred to the question of *investment leakage* as an open question, as this particular research area is relatively undiscovered.

Koch and Houdou (2016) focus on the issue of production capacity, by studying FDI data on German manufacturing firms. This was applied on a DID analysis with one country being an EU ETS member while the other country is not. The authors conclude that only a small share of the studied firms experienced industrial relocation to a non-EU ETS member since the implementation of the scheme. However, their results cannot be solely attributed to the EU ETS implementation, as the concerned firms did not operate in an emission intensive nor an energy-intensive industry. They further claim that the reason to this could be that many EU ETS firms that are emission-intensive often also are capital-intensive with high fixed plant costs, which creates relatively high relocation costs.

In contrast to studies mentioned above, Aichele and Felbermayr (2012) assessed carbon leakage as a result of the Kyoto protocol and found empirical evidence for this. By using a DID approach, they investigated the impact of the Kyoto protocol comparing CO₂ emissions with CO₂ net imports and carbon footprint in countries committed to the agreement. The authors conclude that the Kyoto protocol has led to domestic emission savings by about 7 percent but without changing the carbon footprint. This *ex post* study showed a 14 percent increase in net

import of carbon dioxide, and thereby indicating (although not explicitly formulated) a carbon leakage estimation of about 100% since the implementation of the protocol. In similarity with the EU ETS, the Kyoto protocol exempts emerging and

developing countries, which raises the question of the *pollution haven effect* as a consequence of the EU ETS.

Wu (2013) concludes that that *Pollution Haven Effect* is a valid concern for the European Union as the stringency of the EU ETS is believed to be the cause behind emissions shift to regions with laxer regulation. To study this connection, Wu employs a difference-in-differences strategy by analyzing panel bilateral trade flows data. This data is then divided into two groups, the trade flows outside and inside the European Union. Her findings for the steel and iron industry, in contrast to her identified Pollution Haven Effect, demonstrates that the EU ETS has led to higher export flows while the opposite holds for imports. Lastly, Wu opens up for future research to investigate this relocation matter by looking at regarding domestic production and foreign direct investment.

3.2 Relocation Concerns

Martin et al. (2014) study the vulnerability to carbon pricing in firms regulated by the EU ETS. They identify two main relocation concerns from climate policy: relocation creates costs in terms of job losses to unregulated countries and weakens the effectiveness of the policy (since GHG is a global public bad). The authors provide a qualitative study interviewing 761 manufacturing firms in 6 European countries to examine firms' propensity to downsize or relocate in response to climate change policy. They conclude that an average firm would neither relocate outside the ETS-borders nor fully shut down the company as a result of the EU ETS. There exists however a substantial variation in the reported vulnerability between sectors, and the iron and steel industry is according to the study among the most vulnerable ones.

Oikonomou et al. (2006) also claim that environmental regulations are unlikely to have a substantial impact on relocation. They point out that when considering relocation, pollution abatement costs are generally lower than other costs such as tariffs, exchange rate volatility, transport costs and availability of qualified labour. Thus, pollution abatement costs are declared to be unlikely to impact relocation. However, Ederington et al. (2005) argue that there in fact are industries where those costs are relatively notable. In those cases, the concerned industries turned

out to be very capital intensive and this diminished their incentives to relocate. Yet again, other costs exceeded the actual pollution abatement costs

and hence the study by Ederlington et al. (2005) corresponds to the conclusions reached by Oikonomou et al. (2006).

Concerning the warnings about the relocation of industries outside the EU, Koch and Houdou (2016) convey that they are rather used as motives by firms to lobby for higher levels of permits than an actual threat. BusinessEurope (2016) sympathizes with this idea as they describe it as an overstatement, by pointing out that location is the last determining factor in carrying out an investment decision. They thereby express that the concern about more stringent environmental regulation is not likely to be the deciding factor for relocation in such a scheme as the EU ETS. However, relocation is still a highly debated subject in the research surrounding leakage for environmental policies as the diverse results founded by Koch and Houdou (2016), Branger et al. (2016) and Wu (2013) shows. This diverge conclusions from studies motivates why this belief should be explored in greater detail which we examine in connection to investment leakage.

4. Theoretical Framework

4.1 The Pollution Haven Effect

The *Pollution Haven Hypothesis* emerged with the purpose of highlighting the potential environmental impacts caused by the liberalization of international trade (Brunnermeier and Levinson, 2004). The hypothesis states that a reduction of trade barriers will result in emission-intensive industries shifting their production from the regulated part to the unregulated part of the world. Regions that experience these changes in FDI inflows are known as *pollution havens*. An example of this could be that more stringent regulation inside the EU cause higher FDI outflows to developing regions such as Asia.

The Pollution Haven Hypothesis has its theoretical foundations in the Heckscher-Ohlin Model (Hille, 2015). In this context, the comparative disadvantage for carbon-constrained industries is the additional pollution abatement costs they face in relation to their foreign competitors. This could either result in losses of market share (operational leakage) or, at longer term, lead to relocation to *pollution havens*. However, the actual magnitude of pollution abatement costs is, as mentioned in the previous section, widely discussed.

According to Copeland and Taylor (2004), a distinction between the *Pollution Haven Hypothesis* and the *Pollution Haven Effect* should be made. They refer to the ‘Hypothesis’ as the effects of trade openness, whereas the ‘Effect’ refers to the consequences of a stringency in pollution regulation. In this context, the latter would be the central concept of this paper.

Although the Pollution Haven Hypothesis often appear as an argument against environmental regulations, the existence and strength of it have yet been difficult to prove empirically. A common argument of its existence is the absence of ambitious climate policies in regions other than the EU, and that the only solution for effective climate policy would be a globally coordinated climate agreement (European Commission, n.d.a). Until such a binding international agreement has taken place, the concern of pollution havens should still be considered as environmental regulations are emerging.

The theoretical prediction for pollution haven is that we will find positive amounts in billion SEK for North America and Rest of the World (ROW). We would expect the opposite to hold for EU28+EFTA as the outward FDI flows to this region is expected to decrease due to the EU ETS. This would then be in line with the ‘Effect’, which advocates higher FDI flows to North America as well as ROW while the contrary would hold for EU28+EFTA.

4.2 Porter Hypothesis

Historically, the view of stricter environmental regulation has been rather negative. The traditional outlook is that decreasing an externality such as air pollution, which a strict environmental regulation does, limits the regulated firms’ options and thereby reduce their profit (Ambec et al., 2011). Porter (1991) contributed to this with a new angle by stating that “Strict environmental regulations do not inevitably hinder competitive advantage against rivals; indeed, they often enhance it” (p. 168). This is commonly referred to as the *Porter hypothesis (PH)* (Brännlund, 2007), which says that environmental regulation will lead to firms investing in research and development (R&D). Firms then either increase their productivity which in turn leads to lower costs or commit to product development that gives of a higher product value. Both of these options according to Porter results in improvement in competitive advantage. By

declaring this idea, Porter also brings new light to the earlier less adverse perspective of negative externalities and gives insights on the positive effects a stricter regulation may result in.

Together with his co-author van der Linde, Porter claims that stricter regulation also results in more innovation (Porter & van der Linde, 1995). These new clean innovations may decrease the carbon footprint, thus improving the environment. This would imply that the innovation effects, that would be created by this connection between innovation and regulation, would lead to the regulated parties experiencing less additional costs (Ambec et al., 2011). The reason behind this is that regulation generates pressure, which in turn lays the foundations for motivations to innovation and progress. Although the theory of Porters and van der Linde has been thoroughly discussed, it is today viewed as a theory to explain the connections behind stricter regulation and more innovation. This provides support for more stringent environmental regulation, which is very needed with the rising trend of environmental policies emerging (Ambec et al. 2011). Research such as Martin and al. (2016) suggest the aspect of clean technology should be further explored by looking into if clean innovation creates repercussions for macroeconomic growth by crowding out of dirty innovations. According to our research, we are yet to find a strong link between EU ETS and the Porter Hypothesis and thereby these ideas will be further debated in the context of this paper.

With regards to the Porter Hypothesis, the previous prediction about investment leakage might not hold. If Swedish firms find a way to become more productive by investing in innovation as a result of the policy, then they might not relocate and would hence diminish FDI outflows.

5. Data

The purpose of this paper is to study the impact of EU ETS on investment leakage, by using foreign direct investment (FDI) as a measure of leakages. A FDI is taking place when an investment is made cross-border by an investor in one country with purpose to establish a durable interest in another country. The ‘durable interest’ is attained when the investor owns at least 10 percent of the enterprise invested in (OECD, 2008). As earlier mentioned, outward FDI flows (referring to energy-intensive investments) could amount to negative environmental impacts in other countries which is the objective to examine in this paper.

5.1 FDI-data

To put this in an econometric perspective, we use *foreign direct investment (FDI) outflows* (assets per sector) as the dependent variable in our regression. We rely on yearly measured data from Statistiska Centralbyråns (SCB) statistical database, measured in billion SEK, that

spans the period from 1998 to 2016. As the EU ETS was implemented in 2005, the *ex ante* period is from 1998 to 2004 and *ex post* is 2005 to 2016.

The data is divided into three different country groups: EU28+EFTA, North America and the rest of the world (ROW). This leads to three different DID analyses. Considering there are already a few ETS implemented in the world (although not in the same magnitude as the EU ETS), five countries are excluded from ROW (Switzerland, Kazakhstan, South Korea, Australia and New Zealand) (Carbon Market Data, n.d.). Even though there are cap-and-trade schemes implemented in both the United States (US) and Canada, we consider that testing for North America is still of high relevance. This is partly because the steel export market to the US is very vital for Sweden, and partly because the magnitude of the cap-and-trade systems compared to the EU ETS is relatively small (Atallah, 2018, March 1st; European Commission, n.d.a). The one closest to the size of the EU ETS, California's cap-and-trade program, was first launched eight years after the EU ETS and is mainly targeting the transportation sector (ICAP, 2018).

Based on our raw data, we observe 10 potential comparison groups (i.e. control groups) to the iron and steel sector. A more thorough explanation of what a control group is and a motivation of which ones that are chosen to be in the analysis will be explained in section 6. As for now, we list the different groups that becomes the foundation of our analysis. *

- Wholesale and retail trade; repair of motor vehicles and motorcycles (*G*)**
- Accommodation and food service activities (*I*)
- Information and communication (*J*)
- Financial and insurance activities (*K*)
- Real estate activities (*L*)
- Professional, scientific and technical activities (*M*)
- Administrative and support service activities (*N*)
- Public administration and defense; Activities of households as employers; Activities of extraterritorial organizations and bodies (*O_T_U*)
- Education (*P85*)
- Human health and social work activities (*Q*)

What separates these sectors from the iron and steel industry is that they are not emission nor energy intensive and unregulated by the EU ETS, which makes them valid comparison groups for the analysis. As the FDI data is measured in billion SEK, the analysis will be run in levels.

**For full data material, see Appendix. ** The letter in the parenthesis is the one corresponding to a specific sector according to the Swedish classification system SNI (SCB, 2007)*

5.2 Limitations

To conduct a richer analysis, it would be preferable that our data were disaggregated into finer regions. The threat of possessing aggregated data is that it might lead to overestimation of the Pollution Haven Effect. This because if in the ROW there are countries which are not pollution havens, the expected result would be no effect. Unfortunately, a more country-specific data requested from SCB led to a large number of data points being unavailable because of secrecy. Choosing the more country-specific data would lead to ignoring numbers in countries that are large steel producers, such as China, India, Turkey and Russia and would thereby weaken the reliability. With a more aggregated data, which we will run our analysis on, we were able to include these important countries in ROW. Nevertheless, data on Swedish FDI outflow to North America was unavailable in 2014 which we solved through interpolation.

Another important aspect is that the assets abroad are presented in the Swedish companies sector affiliations, as the sector of the foreign asset is not specified. This means that if for example a Swedish steel company owns foreign companies within other sectors, these assets will be shown as steel industry. The assumption is further supported by the presence of horizontal FDI flows for the steel sector, in form of the Swedish SSAB investment in the American steel firm IPSCO after the implementation of EU ETS (Sunnesson, 2008, May 20th; SSAB, 2007, May 3rd). However, an overall trend of horizontal FDI flows into the same sector can not be assumed. In light of this, if there are spillovers in other sectors, that is something we will be forced to ignore in this analysis.

6. Econometric Approach

Two common methods for quasi-experimentally testing the impact of a policy changes are simple before-after difference and difference-in-differences strategy (Mitrut, 2018a). The

before-after strategy is generally practiced by comparing the relevant outcome variables before and after the policy is implemented, to discover any possible connections that can be derived as a result of the policy itself (Mitrut, 2018b). However, a drawback of this strategy is that it disregards of other factors that are trending between the studied years that may account for the change in the outcome of interest.

For the purpose of this paper, this neglect is truly problematic as the influence of other macroeconomic factors that change over time most likely will be high. In order to overcome this issue, we adopt a difference-in-differences (DID) strategy since the method allows to control for different factors apart from the policy change that might otherwise lead to biased estimates (Mitrut, 2018a).

6.1 Difference-in-differences

Figure 1 shows annual Swedish outward FDI flows to North America in ‘Manufacture of iron and steel products’ (blue line) and ‘Professional, scientific and technical activities’ (orange line). In the second graph (*Figure 2*), Swedish FDI outflows to ROW are plotted. The blue line as well as the orange line portrays the same sectors for ROW as for North America, but for this region ‘Real estate activities’ (grey line) is added. Lastly, *Figure 3* illustrates the outward FDI flows from Sweden to the EU28+EFTA. This graph includes ‘Manufacturing of iron and steel products’ (blue line), ‘Professional, scientific and technical activities’ (orange line). ‘Information and communication’ (grey line). The data is denoted in billion SEK during the years 1998 to 2016.

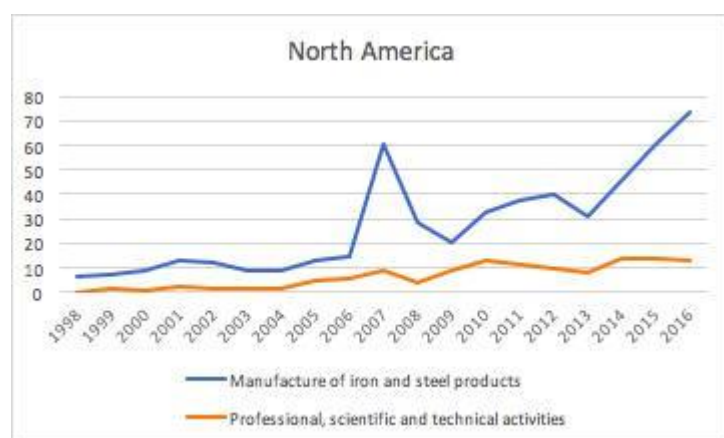


Figure 1. Swedish FDI outflows to North America for the chosen sectors

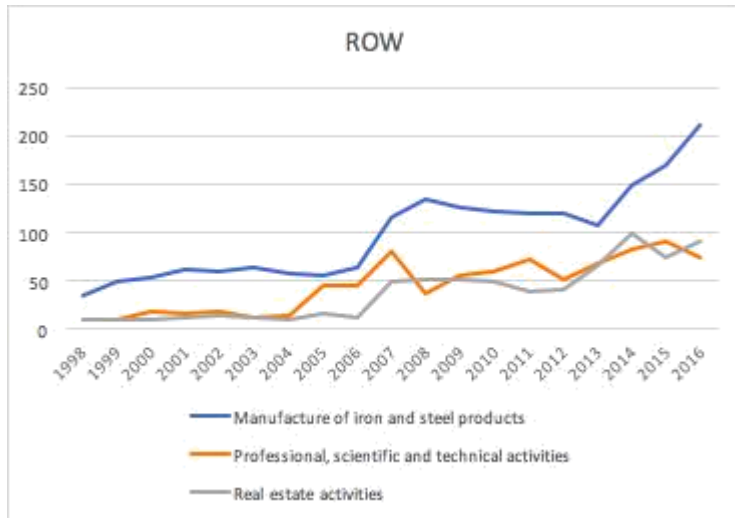


Figure 2. Swedish FDI outflows to ROW for the chosen groups

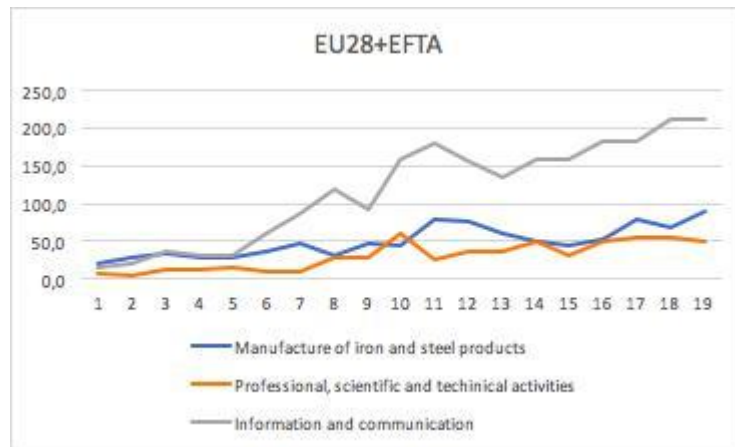


Figure 3. Swedish FDI outflows to EU28+EFTA for the chosen groups

Through a DID, a *treated* (i.e. affected by the EU ETS) and a *control group* (i.e. unaffected by the EU ETS) is compared with each other before and after the policy. The key identification assumption to run the analysis is that in the absence of EU ETS, Swedish FDI in both sectors are assumed to follow the same trend. A necessary condition for this is that they are in parallel trends before the implementation. Another determining factor is that the control group should not be influenced by the policy change, which in this case means that it should not be regulated by the EU ETS. It is also assumed, that there is no policy other than the EU ETS in the post period (2005 onwards) that somehow affects the treatment and control group differently.

As shown in *Figure 1*, both treatment and control group follow a similar trend for FDI outflows to North America. The same holds for the three groups in ROW (*Figure 2*). This

makes the chosen groups valid alternatives as control groups for a DID analysis. In contrast to this, the EU28+EFTA (*Figure 3*) is lacking similar trends before the EU ETS was enforced in 2005 and thus the causal interpretation for this region diminishes. However, we consider it useful to include this region in the analysis as it provides enriching information for the discussion and future research.

The reason why the control groups differ between the regions is because different sectors were in parallel trends with the iron and steel sector in each region group. In North America, there was only one group comparable to the iron and steel sector in the pre-period based on key assumption and hence this region provides only one control group. In total, there are three control groups chosen from the 10 potential comparison groups earlier listed. To illustrate that these sectors are not regulated by the EU ETS, a more detailed explanation of each control group is described below.

- ‘Professional, scientific and technical activities’ (*M*) (SCB, 2007). This consists of legal affairs in form of activities in lawyer firms, legal agencies and agencies focusing on patent issues. Besides that, this control group partly includes affairs concerning accounting and tax advice as well as other economic consulting affairs. Additionally, it contains consultancy services and what is labelled as architecture and technical consultancy. The statistics for FDI flows for the scientific research and development together with advertising and market surveys is also derived from this group.
- ‘Real estate activities’ (*L*) Incorporates trade with owned real estate, rent as well as management of owned and leased these types of properties. Except these, are also real estate agencies and management of real estate by assignment part of this category.
- ‘Information and communication’ (*J*) Contains publisher affairs such as the publications of books and newspapers. Another part of this is releases of films, video- and TV-programs that concerns the whole production process. Furthermore, it involves telecommunications, computer programming together with data consultancy and information services as news

services and data processing.

For each region group, we run the following difference-in-differences regression for 1998 to 2016:

$$FDI_{i,t} = \beta_0 + \beta_1 Steel_i + \beta_2 Post_t + \beta_3 Steel_i * Post_t + \delta_t + U_{i,t}$$

$FDI_{i,t}$ = monetary amount in outward FDI in year t in sector i (*outcome variable*)

$Steel = 1$ if the industry is steel, and 0 if not (*treatment variable*)

$Post = 1$ in the period in which the EU ETS is in place (from 2005 onwards)

δ_t = year fixed effects (capture year-specific shocks affecting FDI flows in both sectors)

$U_{i,t}$ = the *error term*, which captures unobservable determinants of FDI flows in a year t in industry i .

Our main interest in this regression is the interaction term, i.e. the *causal effect of interest* (Dzemeski, 2018). It estimates the difference between the average change, in billion SEK, in FDI in the control group and the average change in the treatment group from 1998 to 2016. This results in an interpretation whether the EU ETS had an impact on Swedish FDI outflows or not.

6.2 Internal and External Validity

As in any quasi-experimental study, validity is divided into two separate segments: internal and external validity (Meyer, 1995). Both of these will be discussed and reviewed with regards to the paper's purpose of analyzing investment leakage for Swedish FDI flows.

To analyze our panel data, we have opted to apply *fixed effects (FE)* (Gujarati and Porter, 2009, p. 599-602). This is an advantage for the analysis that leads to less biased estimates, as it covers for yearly global shocks that may affect both groups simultaneously.

In this case, the main threat to internal validity concerns factors in the *ex post* period that may affect the two groups differently. For example, the financial crisis in 2008 affected the real estate pricing which may have affected the FDI in 'Real estate activities' to ROW. However, *Figure 2* does not show any larger downward fluctuation around this year. Another example of internal validity threat could be changes in relative prices in the steel sector compared to the control group, or lower raw material prices within the steel sector outside the EU that

attracts investments in this particular sector. These concerns are not taken into consideration in this analysis, as our model would conclude all increase in FDI flows as a result of the EU ETS. If there are other factors determining the choice of relocation in this period (which most likely is the case), our estimates could be biased. We acknowledge these limitations, and thus interpret our results with caution.

From a validity standpoint, it is important to also cover the external validity. Meyer (1995) discuss how the effect of the treatment may fluctuate over time periods. For our model, this can be problematic as we are looking at three different phases and time periods for the EU ETS. We are aware of the looser cap in the beginning of the scheme (phase I) as well as the excessive cap in connection with the financial crisis (phase II).

7. Results for Difference-in-Differences for each Region

Table 1. An overview of every performed regression for each region

	North America		Rest of World			
	Prof., Sc. & Tech.		Real est.		Prof., Sc. & Tech.	
Type of reg.	(1)	(2)	(1)	(2)	(1)	(2)
Steel x Post	20.489*** (5.733)	20.489*** (5.003)	27.924* (14.821)	27.924** (7.615)	20.854 (13.716)	20.854* (10.573)
Steel	7.786*** (0.955)	7.786*** (0.718)	43.543*** (3.756)	43.543*** (3.477)	40.571*** (3.977)	40.571*** (3.021)
Post	8.120*** (1.060)	-	42.191*** (7.682)	-	49.261*** (5.240)	-
Obs.	38	38	38	38	38	38
R ²	0.6585	0.8693	0.7062	0.9651	0.7235	0.9177
Year FE		x		x		x

Notes: These regressions were performed by using panel data from year 1998 to 2016. The table present the regressions for each region.

Every variable, except R², is round off to three decimals. The specification in regression (2) includes year fixed effects. Robust standard errors is found inside the parentheses. Post is omitted for regression (2) because of collinearity and thereby these coefficients are not included in the table. Significance level are noted as follow 1(***), 5(**) and 10(*) .

7.1 Results for North America

For North America, our coefficient of interest in regression (1) is taking a value of 20.489 and is significant at the 1 percent level. This means that after 2005, average annual FDI in the iron and steel sector was 20.489 billion SEK higher than “Professional, scientific and technical activities”. The Steel coefficient shows that before the regulation, Swedish annual FDI outflow was higher in the iron and steel sector than in the control group. By analyzing the post coefficient, we observe that both sectors have experienced increasing FDI flows from Sweden in the post period.

Regression in column (2) includes year fixed effects to control for year specific shocks affecting both industries. In regression (2), we find that the coefficient of interest is the same as regression (1) at 20.489, thereby the same interpretation applies here. The Steel coefficient is unchanged, only more precisely estimated just as the coefficient of interest. These findings support that our conclusions for regression (1) is correct. The R^2 in regression (2) has also increased from 0.6585 to 0.8693 when controlling for fixed effects, which indicates that a big part of the explanation is due to yearly variations. Therefore, we can conclude that investment leakage is present for North America due to the EU ETS, as Steel x Post is positive and significant in both regressions.

7.2 Results for Rest of the World

By performing regressions for ROW two control groups are applied: ‘Real estate activities’ and ‘Professional, scientific and technical activities’.

7.2.1 Real estate activities

In regression (1), the coefficient of Steel x Post is 27.924 and is significant at the 10 percent level. This stands for the growth in outward FDI flows from Sweden in the iron and steel industry after 2005 in billion SEK in contrast to ‘Real estate activities’, which is deemed as a result of the policy. The coefficient for Steel at 43.543 reveals that the iron and steel sector had higher FDI flows than in the control group. It is evident when regarding the Post coefficient that, for both sectors, Swedish FDI outflows are trending upwards from 2005 onwards.

For regression (2), when fixed effect for years are included, the Steel x Post is significant at the 5 percent level. The standard errors have decreased from 14.822 to 7.615, and explanatory

power (R^2) has increased by about 32 percentage points. This again strengthens the controlling for fixed effects as we through this discover that a lot of explanation of the model is due to yearly variations. We also observe an unchanged, more precise estimation of the Steel coefficient.

We observe more significant and more precisely estimated coefficients, which indicates that investment leakage in the iron and steel sector has taken place in ROW due to the EU ETS.

7.2.2 Professional, scientific and technical activities

As we can see in the first regression when comparing the iron and steel sector with ‘Professional, scientific and technical activities’, the coefficient of interest is insignificant. The Steel and Post coefficients are however showing significant values at the 1 percent level, and explanatory power is high. We conclude that Swedish annual FDI outflow was 40.571 billion SEK higher in the iron and steel sector in relation to the control one, and an upgoing trend is present from 2005 onwards.

From regression (2), an indication of investment leakage is spotted. The coefficient of interest, showing a value of 20.854, is significant at the 10 percent level and Steel coefficient remains unchanged and significant. Controlling for fixed effects yet again increases the explanatory power and provides more precise estimates. Thereby the same conclusion as with ‘Real estate activities’ is drawn here, which further strengthens the conclusion of investment leakage to North America being present.

7.3 Results for EU28+EFTA

In this case, we expect an inverse result in comparison with the other two. This is because we now use data on Swedish FDI outflows inside the regulated area of the EU ETS (Sweden excluded). After 2005, average annual FDI in treatment group is expected to be lower than in the control one. Econometrically speaking, this implies that our *coefficient of interest*, Steel x Post, should be negative. One important aspect is that the *key assumption* for this region cannot be stated (see *Figure 3*) and hence the causal interpretation diminishes. Despite this, we include these regressions as it provides information about the development of FDI flows within EU28+EFTA.

As expected, Steel x Post is negative regardless of which is the control group. This coefficient for 'Professional, scientific and technical activities' is however far from significant, contrasting with the one for 'Information and communication' with high significance in both regressions. One striking observation in 'Information and communication' is that the Steel coefficient shows that the average FDI for the two sectors is not statistically different from zero in the pre-period, whereas the interaction variable show a large statistically significant difference in the two sectors.

As mentioned above, a conclusive conclusion about the impact of the EU ETS on FDI outflows in the iron in steel sector is not possible for this region. If parallel trends assumption would hold, the conclusion would vary depending on which is the control group. This indicates that any conclusion about investment leakage should be drawn with caution, as the results are contrasting each other and thereby we leave this open for future investigations.

8. Discussion

The majority of our findings points to investment leakage in each region. This contradicts most of what has been determined by earlier literature, where the prevailing conclusion is that environmental regulations have a small to negligible impact on relocations (Oikonomou et al., 2006). However, as investment leakage due to the EU ETS in particular is a relatively undiscovered area it would be irrational to directly connect earlier research with this paper.

One can however elaborate on aspects that somehow could enrichen the analysis. Future research could investigate investment leakage in other emission-intensive sectors than the iron and steel sector. This would strengthen (or question) the conclusions drawn from this analysis. Inclusion of more variables to the analysis is also to consider for future research, not least concerning the cost aspect. As stated by Ederington et al. (2005), emission-intensive industries such as the iron and steel sector face large relocation costs which should be taken into consideration when examining investment leakage. A deeper analysis of the impact of other parameters such as for example trade barriers and political as well as economic risk on relocation to developing countries could also add significant value in this question (Oikonomou et al., 2006).

Approaching the Porter Hypothesis, the Swedish steel market has lately shown commitment in environmentally friendly technology by investing in *green steel* (Löfvenberg, 2018,

February 5th). This is when steel is produced with less GHG emissions as the use of coal is extracted from the production process. Three Swedish firms (LKAB, SSAB and Vattenfall) has committed to the so called HYBRIT project, which is a production facility with the goal of making green steel. The project strives to emit no GHG emissions in the steel production. Should the pursuance become successful, the project may reduce CO₂-emissions on a Swedish national level by 10 percent (TT, 2018, January 21th). It might also in the long run prove to be a profitable strategic investment decision for the firms, especially since the restrictions from the EU ETS has become stricter for each phase and that this trend seems to continue. Besides this, SSAB (2018, February 1st) argues that the HYBRIT project may be the crucial tool that is needed for Sweden to fulfill its commitments according to the Paris Agreement. The existence of this project may strengthen the claims made by Porter and van der Linde in the context of the EU ETS. However, by our research we cannot spot any impacts of stricter environmental goal resulting in innovation effects nor enhanced competitiveness level between firms. Besides, according to the analysis conducted here, the dominating theory seems to be the Pollution Haven Effect.

With further regards to the clean innovation aspect, Vestre (2018) mentions that SSAB offer the most environmentally friendly steel on a global level. Their steel emits 26 percent less than its Chinese counterparts. We will avoid discussing the market implications that this might have for investment leakage as it lies outside the context of this paper. But, once again, that might point at an innovation effect within the Swedish borders. This could be due to the stricter environmental regulation in form of the EU ETS, which Porter and van der Linde argues for. As the innovation effects or any connections to the Porter Hypothesis is at the present unclear, future research could further explore this.

To summarize, future research should keep examining the connection between investment leakage and Pollution Haven Effect with regards to the EU ETS. Except that, an interesting approach would be the potential innovation effects resulting from the climate policy. In such case we suggest a qualitative study focusing on questions around contributing factors to innovation investments. We look forward to see how this research area will develop throughout the years.

9. Conclusions

Our findings through the DID analysis indicates a significant investment leakage within the iron and steel sector to North America and ROW. We also find suggestive evidence of negative spillovers in the steel sector in the case of EU28+EFTA, although the parallel trends assumption does not hold in this case. As shown in Figure 3, and strengthened by the regression, we observe a larger difference in average annual FDI flows in the post period for this region (outward FDI within the iron and steel sector is significantly lower in the post period compared to ‘Information and Communication’). However, due to the violation of the *key identification assumption*, we cannot attribute all of this to the EU ETS.

In those cases when significant investment leakage was found, data at country-specific level would be preferable. Especially in the case of ROW, as we have experienced hardships when identifying the potential *pollution havens* arising from the policy. This means that we cannot distinguish if the FDI has gone mainly to developing countries as for example Pakistan or to a more developed country such as Taiwan.

However, we consider that these conclusions about a significant investment leakage should be drawn with caution. One reason for this is that the results are not corresponding to the majority of earlier empirical studies on carbon leakage and pollution haven literature. This inevitably raises the question of the validity in our model. Referring to our *main internal validity threat*, the reasons could be many. For example, price dumping of steel prices in China and Russia happening simultaneously as the EU is recovering from the financial crisis in 2008 can be considered as one of these concerns. This may not have affected the highly niched Swedish steel, but could be a contributing factor to why FDI outflows in the iron and steel industry are not trending in the same way as our chosen control group. It could also indicate that the relative prices of producing steel outside the EU is decreasing and hence is attracting investments in ROW and North America. One can speculate if these actions have affected the Swedish investment decisions, but due to the lack of data and the limited time frame we leave this as an open question for future research.

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Appendix

For all tables from 2 to 4, the abbreviation of ‘Steel’ includes data from the iron and steel sector.

Table 2. Summary Statistics of FDI flows for North America

Type of FDI	Obs.	Mean	Std. Dev	Min	Max
Steel	19	27.390	20.626	6.2	73.4
Prof.	19	6.663	4.917	0.2	14
Steel + Prof.	38	17.026	18.139	0.2	73.4

Table 3. Summary Statistics of FDI flows for Rest of the World

Type of FDI	Obs.	Mean	Std. Dev	Min	Max
Steel	19	99.068	47.879	34.8	211.4
Real est.	19	37.890	29.292	9.7	98.8
Prof.	19	45.326	27.980	9.3	91.5
Steel + Real est.	38	68.479	49.937	9.7	211.4
Steel + Prof.	38	72.197	47.304	9.3	211.4

Table 4. Summary Statistics of FDI flows for EU28+EFTA

Type of FDI	Obs.	Mean	Std. Dev	Min	Max
Steel	19	49.426	20.306	19.9	89.1
Info. + Com.	19	117.016	68.119	15.9	213
Prof.	19	30.168	18.494	4.8	59.2
Steel + Inf.	38	83.221	60.257	15.9	213
Steel + Inf.	38	39.797	21.499	4.8	89.1

Table 5. Data for North America – measured in billion SEK

Year	Steel & Iron	Prof., Sc. & Tech.
1998	6.2	0.2
1999	6.9	1.6
2000	8.9	0.9
2001	13.1	2.6
2002	11.8	1.7
2003	9.2	1.9
2004	8.8	1.5
2005	12.7	5.2
2006	14.3	5.9
2007	60.2	8.9
2008	28.3	3.7
2009	20.5	9.3
2010	32.6	13.0
2011	37.6	11.7
2012	39.7	9.7
2013	30.6	8.1
2014	45.4	14.0
2015	60.2	13.9
2016	73.4	12.8

Note that for year 2014 interpolation is used for ‘Steel’, which then is the value of 45.4.

Table 6. Data for Rest of the World – measured in billion SEK

Year	Steel & Iron	Real est.	Prof., Sc. & Tech.
1998	34.8	10.6	9.3
1999	50.5	10.1	9.6
2000	54.1	9.7	18.2
2001	61.5	12.4	17.3
2002	60.4	14.1	18.4
2003	64.9	11.7	13.1
2004	57.3	10.1	13.6

2005	56.8	16.5	45.1
2006	64.6	11.5	44.9
2007	116.7	50.5	81.6

Year	Steel & Iron	Real est.	Prof., Sc. & Tech.
2008	134.6	51.4	36.5
2009	126.1	51.1	55.0
2010	122.5	49.1	59.2
2011	120.3	39.7	72.3
2012	119.4	41.4	52.4
2013	107.2	65.2	67.8
2014	148.9	98.8	81.9
2015	170.3	75.2	91.5
2016	211.4	90.8	73.5

Table 7. Data for EU28+EFTA – measured in billion SEK

Year	Steel & Iron	Info. & Com.	Prof., Sc. & Tech.
1998	19.9	15.9	6.7
1999	28.0	19.7	4.8
2000	32.6	36.0	13.1
2001	28.1	29.7	11.6
2002	28.7	31.7	15.2
2003	37.5	59.5	10.4
2004	46.0	87.1	9.4
2005	31.1	118.8	28.2
2006	45.9	91.5	28.0
2007	45.2	157.4	59.2
2008	78.3	178.8	25.4
2009	75.3	156.8	36.4
2010	60.2	134.0	35.8
2011	49.2	159.6	49.3
2012	44.7	157.5	31.1
2013	52.8	182.7	48.7
2014	77.8	181.4	56.2
2015	68.7	213.0	53.7
2016	89.1	212.2	50.0

All data is retrieved from Statistiska Centralbyrån (SCB) through personal communication (e-mail) via Rickard Rens.

