Politecnico di Torino

Master of Science Management and Engineering
A.y. 2021/2022
Sessione di Laurea Mese Anno

Does FDI influence environmental regulations?

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Abstract

In a historical period in which the environmental consciousness is finally becoming a day-to-day topic, it is interesting to understand how countries can measure the effectiveness and the stringency of their decisions in terms of regulations. Observing the enormous flow of capital going into less controlled countries, researchers have interrogated themselves trying to find connections between economic instruments as the Foreign Direct Investments (FDI), the environmental regulatory stringency, and the corruptibility of a certain host country.

Among the numerous contributions brought by the literature, we decided to replicate the approach conducted by Cole et al. in the paper "Endogenous Pollution Havens: Does FDI Influence Environmental Regulations?". In a world in which the majority of the researchers investigate how the environmental stringency may influence the presence and the frequency of FDIs, Cole et al. asked themselves how the FDIs can influence policy makers and, in general, the environmental regulations.

Taking this as a starting point, to emulate the research we decided to update the dataset used by exploiting the FDI Market Database. This database helped us to cluster the investments according to the activity type, and hence it gave us some interesting insight.

This thesis will briefly present the theories behind FDIs, why they are undertaken and what are the consequences both on the investor and on the destination country of using such instruments.

Then, it is reported the main contributions about the Environmental Stringency: what it is, how it can be measured and why it is so difficult to be measured. After having analyzed this peculiar index, we propose some approaches used by researchers and comment their strengths and potential issues.

We opted to utilize a different measure with respect to the original research to describe the environmental stringency degree, i.e. the OECD environmental stringency indicator (EPS) since it offers cross-country and time coverage and it is easy to update. Moreover, the use of a simple proxy makes the measure easier to understand but still it is based on actual policies.
To close the chapter, we will highlight again what are the externalities related to environmental policies and why they are necessary to regulate the market.

Moreover, we will show an interesting theoretical model that can predict the results of the econometric analysis proposed by Cole et al.

Finally, we apply a similar empirical approach as the one in Cole et al, that is based on fixed effects and instrumental variable approaches to measure the causal effect of environmental stringency on FDI. However, our results support partially diverging conclusions.

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Foreign direct investment (FDI)

We can define a foreign direct investment (FDI) as a particular kind of investment after which the investor controls part of the ownership of a foreign firm, which is geographically located in a different country with respect to the investor's one. This peculiar economic phenomenon implies a long-term relationship between the two firms.

Usually, we refer to FDIs for cross-countries investments with the objective to get long-term control of a foreign firm or to build new branches outside one's domestic country in which the investor is part of the board.

Whenever an FDI takes place, it is clear that we would have an outflow and an inflow of capital between countries.

It is possible to distinguish between greenfield FDIs whenever a firm creates new plants or commercial activities abroad, and brownfield FDIs whenever a firm buys the control of an already-existing firm through for example M&A operations.

FDIs have become popular in the last 50 years and have contributed to globalization. They are of course correlated with the birth of multinational firms, i.e. companies which arrange their production activities in at least two different countries.

Now that we have briefly described what FDIs are, we should analyze why firms undertake FDIs.

Motives for FDI [Dunning]

The main contribution regarding FDIs is brought by Dunning[1]. According to him, it is possible to summarize FDIs motives into four groups:

- Resource seeking;
- Market seeking;
- Efficiency seeking;
- Strategic asset seeking.

The resource-seeking firms decide to invest abroad to obtain specific resources at a lower cost than the one they incur in their domestic country, or maybe because they want to exploit a particular resource that is not available at all in their home country.
For this category, Dunning highlighted three types of resource seekers:

a. Those seeking physical resources (raw materials and agricultural products)
b. Those seeking cheap labor
c. Those seeking technological capacity, management or marketing expertise, and organizational skills

Market seekers firms are willing to invest in a certain region or country because they think they can serve a non-satisfied demand. This could happen when:

a. A firm's main supplier or customers have expanded abroad to maintain its business, then the firm needs to follow them
b. A firm should adapt its product to local preferences, so they need to gather information and be present in that market through an FDI
c. Get closer to an already-served market
d. Compete in other countries after a strategic decision

[1] Dunning, J.H. (1993): Multinational Enterprises and the Global Economy. Harlow, Essex: Addison-Wesley Publication Company.
Dunning, J.H./Rojec, M. (1993): Foreign Privatization in Central and Eastern Europe. Ljubljana, Slovenia: Central and Eastern European Privatization Network.
Dunning, J.H. (1998): Location and the Multinational Enterprise: A Neglected Factor? in: Journal of International Business Studies, 29, 1, 45-66.

In case of efficiency-seeking foreign direct investors want to improve their production and distribution operations by for example creating synergies among different countries. This can occur by exploiting cost differences.

Finally, strategic asset seekers undertake FDIs to expand and promote their long-term objectives, enhancing their international competitiveness.

Horizontal and Vertical FDIs

Researchers have furthermore classified these investments in horizontal and vertical FDIs.

We can refer to a horizontal FDI whenever a firm is producing the same good or service in plants based in two different countries, each plant is responsible to serve its local market through its production activities.

This kind of FDI exploits the possibility to avoid transportation costs while having access to more than one country. In this case, indeed, the main trade-off is between the fixed additional costs occurring for building a new plant abroad and the variable transportation costs [Markusen, 1984][2]. According to Markusen, horizontal FDIs are an alternative to trade and grant a mix of both local and foreign firms in each country. The existence of horizontal FDIs reduces the need for exports since the local market is served mainly by local firms and they are more likely to occur whenever transportation costs are higher than the investment costs.

Vertical FDIs represent the case in which a multinational firm decides to split its production process into different phases. This idea reflects the fact that different production phases need different inputs, so it is possible to exploit the costs difference of those inputs and be more profitable by, for example, obtaining a cheaper workforce.

This does not come without drawbacks: splitting production operations in different countries implies additional transportation costs.

[2] Markusen, J. R. (1984) "Multinationals, multi-plant economies", and the gains from trade, Journal of International Economics, 16(3–4), pp. 205–226.

Now that we briefly have gone through the main classifications of FDIs, it is important to give an overview of the most famous economic theories about this phenomenon.

Economic theories of FDIs

The first contribution is brought by the classical market theories of Smith and Ricardo in the 19^{th} century. According to them, a country produces goods and services and first, it uses them in the domestic market, then it may export them. As a consequence, it is crucial for a country to import those goods that are not convenient to be produced in the domestic economy.

Economic conditions emerge from the differences in productive inputs in each country such as raw materials, capital, labor, and technology. So, according to classical theories, importing and exporting goods is the result of the differences between countries in the availability of production inputs.

The second important contribution that goes beyond classical theories is the Product life cycle theory developed by Vernon[3] which basically demonstrates dynamic comparative advantage. The idea is that there are four stages during the product life cycle. A firm starts selling a new product to domestic consumers and, only when a foreign demand emerges, it starts exporting the new product aiming for economies of scale, in order to minimize the risk of expanding prematurely its production capacity. When the product is in the mature phase, there is usually a large number of competitors, and the market starts to saturate. Only then, the firm will import the end-product from the foreign country to the domestic one.

From this model we can say that technological development is able to change those differences in the availability of production inputs, hence it may change comparative advantage over time.

We can now go through more specific economic theories about FDIs.

[3] Vernon R. (1966), "International investment and international trade in the product cycle". Quarterly Journal of Economics 80, pp. 190-207

Internationalization Theory

Internationalization theory tries to explain the increasing number of international firms and foreign investments. It was formulated in the '70s; it distinguished two categories of intermediate goods: knowledge flows connecting research and development (R&D) to production, and components and raw materials flow from an upstream plant to a downstream one.

FDIs according to this theory occur when a firm capitalize its value entering in a new foreign market thanks to intangible assets. For example, a new product is developed in the home country, but when its production is moved to a foreign country, the know-how is transferred and so the firm becomes multinational.

Internationalization theory explains why international economic activities are concentrated in innovative markets characterized by high-intensity knowledge and where the quality of the components and raw materials is difficult to assess and control.

Eclectic Paradigm

The Eclectic Paradigm was formulated by Dunning in 1979, it is an economic method for analyzing the attractiveness of making an FDI. According to the author, multinational firms undertake an FDI when there are three advantages at the same time:

- The Ownership advantage is the competitive advantage that comes with the FDI. Ownership can also be defined as the possession of a unique and valuable resource that cannot be easily imitated (as in the VRIO framework) and thus it grants a competitive advantage against potential foreign competitors.
  We may think about some challenges associated with FDIs, regarding ownership, due to the fact that the investor is usually non-native in the destination country of the investment. This situation includes possible language barriers or a general lack of knowledge about preferences among the local consumers.
- The Location advantage, i.e. all those advantages related to the geographic location of the host country, like for example, the direct access to the ocean. Other location advantages are low-cost labor and raw materials, lower taxes, skilled labor force, etc.

- The Internalization advantage, i.e. the advantage of outsourcing activities with respect to performing them in the domestic country. This can include lower costs and a well-trained workforce or a better knowledge of the local (destination) market.

This approach is known as the OLI approach (Ownership, Location, Internalization). Dunning by the way remarks the fact that the context of the investor country and the destination country also plays an important role in the decision of undertaking an FDI.

After having analyzed the reasons and the theories behind FDIs, it is important to focus on what are their consequences on the countries involved.

Externalities and FDIs

The externalities resulting from FDIs have been studied a lot throughout the literature, researchers have been curious about what are the effects of such investments on both the domestic country and the destination economy. The outputs however depend on several factors, so they are quite complicated to study.

The first comprehensive study is the one of Paus and Gallagher (2008)[4] which states that the occurrence of FDIs depends on potential spillovers of foreign investments, on how well local agents are capable to absorb new technologies, and on the interactions between these two factors. The way these factors interact depends on the institutional context, the characteristics of the host country, and the channels for technology transfers.

The potential spillover of an FDI is the potential advantage obtained by the diffusion of a certain technology, the know-how, and notions brought by the foreign investors to the local firms. The absorptive capacity is instead the capability of a firm to recognize the value of new information and to absorb and exploit with commercial purposes [Cohen and Levinthal, 2000][5].

[4] Paus, E., and K. Gallagher. 2008. "Missing Links: Foreign Investment and Industrial Development in Costa Rica and Mexico." Studies of Comparative International Development 43 (1): 53–80.
[5] Cohen, W. M., & Levinthal, D. A. (2000). "Absorptive capacity: A new perspective on learning and innovation." In Strategic Learning in a Knowledge economy (pp. 39- 67).

The spillovers can be distinguished between horizontal spillovers whenever the investor firm undertakes an FDI in the same industry it is operating, while we can refer to a vertical spillover whenever the effects of the investment propagate throughout the value stream of the investor firm.

Now that we have summarized what the spillovers are, it is important to understand how they influence and propagate when an FDI is undertaken.

The literature pointed out that there are three main channels of propagation of these effects, i.e. the supply chains, the labor force turnover, and the changes in the market forces.

For the ones propagating through the supply chain, it is possible to define as a *"backward spillover"* whenever the local firm becomes the supplier of the investor firm, and, consequently, we can talk about *"forward spillovers"* for those effects resulting from the situation in which the investor company supplies inputs to the local firm.

There could be spillovers whenever a multinational firm requests new or better production inputs, in that case, every other firm competing in the same industry may take advantage of that. Furthermore, multinationals can help local firms by exchanging their know-how, but there could be also spillovers related to workforce training.

Spillovers may be intentional or not, for example, the presence of a multinational in a certain industry may enhance the competition in that particular market, resulting in better products, higher quality, etc. [Blomström et al.,2001][6]. Of course, there are always potential drawbacks in enhancing competition, indeed an aggressive behavior of an investor entering a local market may subtract market share to local firms, unable to meet the new higher standards. [Goldsteind and Piscitello, 2007][7].

Multinationals undertaking FDIs provide workers with new knowledge and capabilities, but the benefits are not immediate since new information needs to be absorbed and it takes time. This kind of spillover depends on the capability of the local firm to attract workers who were employed in multinationals, on

[6] Blomström, M., Kokko, A., & Globerman, S. (2001). "The determinants of host country spillovers from foreign direct investment: a review and synthesis of the literature." In Inward Investment Technological Change and Growth (pp. 34-65). Palgrave Macmillan, London.
[7] Goldstein, A., & Piscitello, L. (2007). "Le multinazionali.", il Mulino.

the effectiveness of the training of the new workers, and on the amount of information actually transferred during the training.

Spillovers can also be caused by changes in the market forces, such as competition, cooperation, and imitation. The entrance of a multinational in a local market may trigger the competition between local firms willing to become the supplier of the new firm, resulting in a higher quality of raw materials and components [Crespo e Fontoura, 2007][8]. Moreover, local firms are able to imitate and reverse-engineer the operations and products brought by the investors.

Foreign firm characteristics

As we said, it is important to understand the context and the characteristics of both the local firm and the investor firm.

Farole and Winkler (2014)[9,10] divide the characteristics of the investor firm into different components, the first one is the percentage of ownership of the local firm. A higher quota means a higher control grants a smoother transfer of knowledge but a lower percentage of shares owned by the investors would result in less involvement and less intention to limit the spillovers, granting a positive effect to the local market. Empirically, it has been shown that a major involvement of the local firm indeed results in better relationships with local suppliers.

Another important metric is the time horizon in which the FDI takes place. It has been observed that longer relationships brought bigger benefits to the local economy, probably because it takes time to understand a new market, to cooperate with new suppliers, and to manage accurately a new labour force.

The occurrence of spillovers is also influenced by the characteristics of the country where the investor firm is based. For example, managerial best practices and routines in training people and in developing new competencies can affect the intensity and the frequency of the spillovers. In addition, the more foreign investors are capable to establish their multinationals in a local economy, the better the local firms become to understand and absorb new competencies and knowledge.

[8] Crespo, N., and M. Fontoura. (2007). “Determinant Factors of FDI Spillovers— What Do We Really Know?” World Development 35 (3): 410–25

[9] Farole, T.,Winkler, D. (Eds.). (2014). “Making foreign direct investment work for SubSaharan Africa: local spillovers and competitiveness in global value chains.” The World Bank, 1-97

[10] Farole, T., Winkler, D. (2014). “Does FDI Work for Africa? Assessing Local Spillovers in a World of Global Value Chains”, World Bank, Economic Premise Number 135

Moreover, greenfield investments are more likely to implement new technologies, while a brownfield investment usually results in adopting and upgrading the technology of the host country [Crespo and Fontoura, 2007][11].

Local firm characteristics

As already mentioned, the local firm characteristics play an important role in the occurrence and intensity of the spillovers related to FDIs. The most relevant characteristics that have been studied in the literature are the absorptive capacity and the technological gap between local and foreign firms.

The technological gap is that situation in which the technological efficiency and competencies differ remarkably between the two firms involved in the FDI. Without it, there could not be any spillover and, if the two firms are quite close from a technological point of view, the potential benefits deriving from the spillovers are low [Kokko, 1994][12].

According to researchers then, the impact of spillovers increases with the technological gap but if this distance is too high the local firms may find it too difficult to absorb new competencies and get benefit from the spillovers.

It has been discovered that absorptive capacity is positively correlated with the dimension of the firm, indeed bigger firms are usually more productive, and better positioned to compete with multinationals and imitate their routines and capabilities. Moreover, bigger firms may pay workers higher wages and attract workers before employed in multinationals.

Another important aspect to be considered is the region in which the local firm is based. For example, firms near research centers usually can absorb easily new information.

One last factor that may influence the absorptive capacity of a firm is the type of ownership. Researchers found out that private firms are usually more capable to exploit the positive effects of spillovers with respect to public ones since they are used to imitating foreign firms and more involved in exporting

[11] Crespo, N., and M. Fontoura. (2007). "Determinant Factors of FDI Spillovers— What Do We Really Know?" World Development 35 (3): 410–25

[12] Kokko, A. (1994), "Technology, Market Characteristics, and Spillovers", Journal of Development Economics, 43, pp. 279-293

products. Public firms are usually bigger firms and more financially stable, but still less inclined to foreign markets, so it is not easy to predict their absorptive capacity and the consequences of spillovers in this case.

The geopolitical context of the destination country

It is easy to understand that all the characteristics related to the local firm are influenced by the geopolitical context of the country in which the firm is based.

The administrative and commercial context, the market characteristics, regulations, and policies influence competition and thus the impact of potential spillovers.

Market regulations may influence the number and the frequency of FDI in a certain country or region and can influence the absorptive capacity of local firms. A more flexible market with respect to the one of the investor firm can yield positive effects on local firms [Javorick and Spatareanu, 2008][13]. But if the labor market is too flexible, the investors have fewer incentives to organize training for the workforce, hence lowering the possibilities for local firms to absorb new capabilities and knowledge.

Moreover, the characteristics of the local market may determine the type of investment and the impact of potential spillovers. Investors are usually attracted from open markets because they can have bypassed the dimension and the efficiency of the local market. Indeed, in open markets, foreign investors are inclined to export, and this can enhance the probability that local firms too will export goods and services.

In the case of a market that is too open, there is the risk that both local and foreign firms would concentrate their efforts on exporting technologies instead of developing locally, with a negative effect on local firms.

On the other hand, foreign investors usually bring more mature technologies into more closed markets to guarantee the success of the adoption of the new technology and the positive impact of spillovers.

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[13] Javorcik, B., and M. Spatareanu. (2008). "To Share or Not to Share: Does Local Participation Matter for Spillovers from Foreign Direct Investment?" Journal of Development Economics 85 (1–2): 194–221.

The quality of regulations and institutions in the destination country can influence the occurrence of FDIs. For example, corruption, strict bureaucracy, and other inefficiencies may discourage multinationals to invest in a certain country and hence reduce the benefit of spillovers in the local economy.

In a nutshell, it is not immediate to predict the effect of FDIs, they are not always a positive event for the local economy since their impact is determined by several factors.

Environmental Stringency

What is Environmental stringency?

Environmental policies are responsible for the wellbeing and the sustainability of long-term growth. They help to reach environmental objectives that markets alone fail to deliver.

They basically tend to make pollution and environmental services more costly to change both producer and consumer behavior.

Stringency can be defined as the strength of the environmental policy signal – the explicit or implicit cost of environmentally harmful behavior, for example, pollution.[14]

Environmental policies can influence economic activities having effects on competitiveness and innovation. However, measuring it is not immediate. Here we can report some approaches used by researchers, but before discussing them it is important to explain why environmental policy stringency is difficult to measure.

What are the obstacles to measuring environmental stringency?

Brunel and Levinson[15] highlighted four main reasons why measuring environmental stringency may not be immediate. We shall analyze them to better understand how to approach such a measure.

1. Multidimensionality

The first problem in measuring environmental stringency is multidimensionality. This case occurs since Governments regulate different environmental media at the same time, namely air, water, and solid and hazardous waste.

Thus, different regulations set thresholds for different pollutants into those media: Sulphur dioxide, sewage, toxic chemicals, etc. Some regulations address households, others target industries. Some

[14] Gozluk, Garsous, HOW STRINGENT ARE ENVIRONMENTAL POLICIES, OECD ®, 2016

[15] Brunel, Levinson, OECD Trade and Environment Working Papers, 2013/05

policies set standards for total emissions, emissions concentrations, ambient environmental quality, or for the technologies employed by producers [Johnstone et al., 2010].

Multidimensionality poses many problems for measuring stringency. Some regulations may limit something that is not relevant to some other policy question. Imagine you want to reduce waste and enhance recycling activities from households, then you are not investigating whether environmental regulation causes industrial flight from strict countries.

Another problem due to multidimensionality is due to the fact that complex regulations are not easily comparable.
Some analysts avoid multidimensionality by focusing on one particular environmental problem using directly comparable stringency measures; some others construct composite indexes or proxies for environmental stringency, while this approach is helpful to rank policies, it cannot determine how distant are two regulations (if country A has a compound index of 6 and country B has a compound index of 3, it is not true that A is twice as stringent as B).

We can conclude that the two main workarounds used by researchers to avoid multidimensionality are using a composite index or studying a very narrow example at a time. These may seem limiting, but still usable, indeed multidimensionality is the easiest obstacle to get rid of while measuring environmental stringency.

The second conceptual barrier in studying environmental stringency is simultaneity.

2. Simultaneity

Researchers look for measures of regulatory stringency to better understand the consequences of those regulations, however, those consequences may also simultaneously help to determine regulatory stringency.

It is difficult to separate the effect of regulations on economic outcomes from the effect of the outcomes on environmental regulations. For example, countries with a high level of pollution can impose stringent standards but if polluting-intensive industries have more power they could contract for less stringent regulations.

In this case, researchers use instrumental variables for stringency, to overcome simultaneity problems.

Researchers contributed with several examples of instrumental variables studies, for example, Xing and Kolstad (2002) used infant mortality and population density; Ederington and Minier (2003) used instruments motivated by political-economy theories; Levinson and Taylor (2008) to investigate the US regulatory stringency faced by industries, created an instrumental variable using the geographic distribution of the industry across US states and the pollution abatement costs incurred by other industries in those states. Kellenberg (2012) instrumented for the WEF index using lagged values of countries' corruption, income, urbanization, and education. Jug and Mirza (2005) used prior years' wages and investment in environmental equipment.

The last two obstacles to measuring regulatory stringency may be considered as special cases of simultaneity, but they are crucial to providing a good measure, thus it is worth discussing them separately.

3. Industrial Composition

This obstacle recalls a fundamental economic principle formulated by Ricardo and Smith: the *"comparative advantage"*. Since countries have the opportunity to trade, they will specialize in producing and exporting goods they can produce relatively inexpensively, and importing the rest. Those differences in the industrial composition arise from natural resources, labor skills, proximity to transportation, agricultural conditions, and regulatory stringency. As a consequence, every country is different in the product mix it produces and exports.

This situation poses problems in measuring environmental stringency based on pollution abatement costs. It is clear that countries with relatively more pollution-intensive industries will spend more on pollution abatement, even if every country has the same regulation.

Industrial composition is a particular example of simultaneity since industrial activities may determine both measured and actual regulatory stringency, while analysts prefer to isolate the effect of the actual stringency on industrial activity (or vice versa).

4. Capital Vintage

The final obstacle in measuring environmental stringency is due to the fact that many regulations are "vintage-differentiated", meaning they are stricter for new sources of pollution than existing sources. It is easy to understand if we think about cars. Governments have imposed standards on allowable vehicle emissions, but the strictest standards apply only to new cars; this may induce car owners to keep their old cars longer than they would have otherwise, resulting in higher emissions [Stavins, 2006][16].

The same concept applies to industrial pollution regulations, providing a disincentive for new development and protection to existing industries against new competition [Buchanan and Tullock, 1975][17]. So, a strict vintage-differentiated regulation may deter new investment in eco-friendlier production and can be seen as a lack of stringency looking at the emission values which would stay high.

The four obstacles do not necessarily mean that measuring regulatory stringency is impossible and they have not stopped researchers from their attempt. This overview is helpful to understand that we need to interpret results carefully.

In the following part, we will discuss the main approaches used by researchers to measure environmental stringency, highlighting the advantages and potential drawbacks of selecting one method instead of another.

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[16] Stavins, R. (2006), "Vintage-differentiated environmental regulation", Stanford Environmental Law Journal, 25(1), pp. 29-63.

[17] Buchanan, J. M. and G. Tullock (1975), "Polluters' profits and political response: Direct controls versus taxes," American Economic Review, 65(1), pp. 139-47.

Approaches used by the literature

1. OECD's environmental policy stringency (EPS) indicator

This indicator aggregates information on selected environmental policies to construct a composite index of relative policy stringency across countries and over time [Botta and Kozluk, 2014][18]. It focuses the attention on upstream sectors like energy and transport among countries.

It has a range of 0 to 6, where 6 means that the policies are more stringent. For each policy instrument (tax, emission limits, deposits, and refund schemes) stringency defines a higher implicit or explicit cost on the relevant environmental damage produced by firms or consumers.

The EPS measure can approximate the aggregate environmental policy stringency based on the presence of some instruments in a certain country, as represented in Figure 1.

Let us now discuss the potential advantages and disadvantages of such an approach.

Like all the composite indexes, the EPS measure is a simple proxy, based on actual policies – mainly climate and air policies in key upstream sectors – which are important and relatively comparable polluters across economies. The indicator has a cross-country and time coverage, and it can be easily updated and expanded depending on data availability. However, the measure also shows some limitations.

For example, it does not consider other important areas concerning environmental sustainability – water, biodiversity, waste – and some policy instruments – such as tax incentives for "green" investments – are not taken into account.

More importantly, the continuous change of policies and the extent of those policies generates issues related to the heterogeneity of the policy instruments, making the comparison across countries and time really problematic.

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

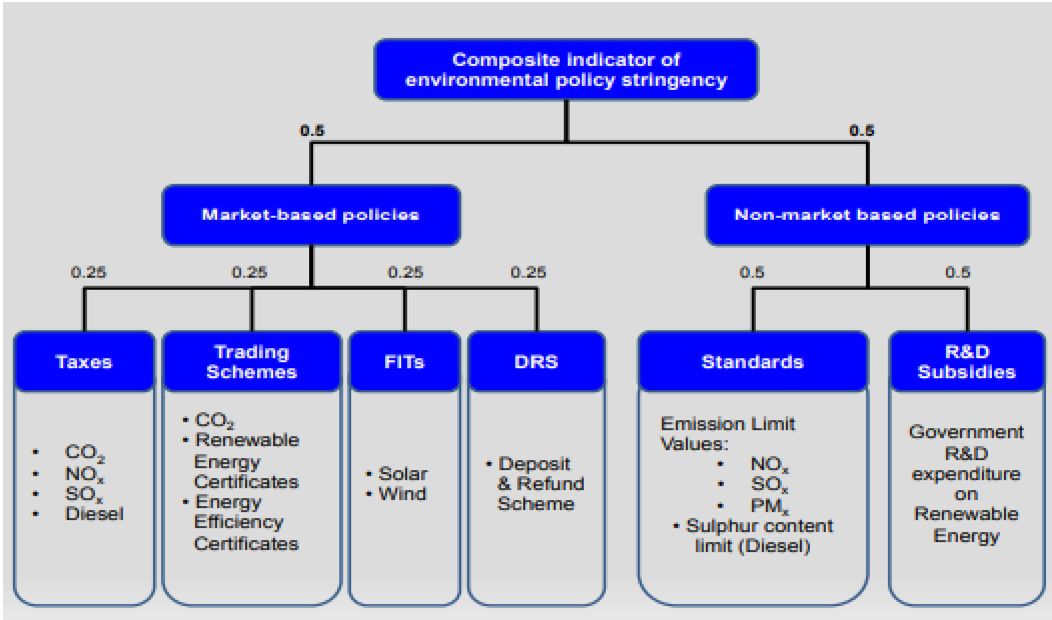

Figure 1 - Aggregation structure of the composite index of EPS

2. Private-sector cost measures

These measures rely on surveys of industries about their pollution abatement expenditures. The first and most complete of these data come from the US Pollution Abatement Costs and Expenditures (PACE) survey, conducted annually by the US Census Bureau from 1973 until 1994.

Many researchers used this database to try and measure environmental regulatory stringency in the US States. For example, Levinson's approach (1996) estimated starting from establishment-level PACE data how much manufacturers spent on pollution abatement in each state, taking into account other manufacturer characteristics such as the book value of capital, the number of production workers, value-added, an indicator for new plants, industry dummies and dummies for each US state.

$$\ln(PACE) = \alpha + \beta_1 lnK + \beta_2 lnL + \beta_3 lnVA + \beta_4 New + \sum_i \beta_5^i Ind_i + \sum_s \beta_6^s State_s + \epsilon$$

The state coefficient (β_6^s) are the key, if they are high, manufacturers spend relatively more on pollution abatement in that state. Thus, those coefficients can be seen as a measure of state regulatory stringency.

Another contribution is brought by Keller and Levinson (2002) who constructed a time-varying version of the index using published average PACE costs by industry and state. They computed the total costs per dollar of gross state product:

$$S_{st} = \frac{P_{st}}{Y_{st}}$$

Where P is the pollution abatement cost in state s in year t and Y is the gross state product in state s in year t.

They compared that value with the predicted value of abatement costs (weighted average of the national pollution abatement cost for each of 20 two-digit SIC industry codes, where the weights are the industries' shares of output in state s, Y_{sit}/Y_{it}.

Levinson and Keller's measure of environmental stringency is the ratio:

$$R_{st} = \frac{S_{st}}{S'_{st}} = \frac{\left[\frac{P_{st}}{Y_{st}}\right]}{\left[1/Y_{st} \sum_{i=1}^{20} \frac{Y_{sit} P_{it}}{Y_{it}}\right]}$$

So, if the ratio is greater than one, the state is spending more than expected given those states' industrial compositions. Vice versa, when it is smaller than one, manufacturers have lower abatement costs than expected ones.

This approach appears to be exactly the measure researchers are looking for; however, PACE collects data by directly asking managers at industrial firms to provide information. This is an issue because it is becoming difficult to gather information and maybe the data themselves are not always reliable.

Moreover, after years of regulation, environmental standards are now integrated into the design of products and processes and industries have adjusted their behavior in order to comply with the regulation. For example, they might have changed processes, energy sources, even end-products.

It may be difficult indeed to sort out costs incurred by environmental motives from the ones incurred for profit, the edges are often blurred and the interviewed may not be able to respond properly since indeed all activities and products are nowadays designed taking both aspects into account.

3. Shadow price approach

Some researchers have used economic theory and choices made by firms to calculate pollution abatement costs indirectly rather than using surveys.

In Van Soest et al.'s paper (2006) the shadow price of an input is defined as "the potential reduction in expenditures on other variable inputs that can be achieved by using an additional unit of the input under consideration (while maintaining the level of output)". As it is shown in *Figure 2*, the isoquant is the mathematical locus where the inputs used to produce the output Y_1. On the two-axis chart, we can imagine two inputs: labor and capital, material and energy, etc.

In a jurisdiction with no regulation, the price of emission (p_E) is zero, or very low. When this condition is satisfied, the prices of other inputs (Px) are high, as described by price ratio P1, since firms are seeking the maximum profit, they will choose to use more emissions (E1) and fewer other inputs. Viceversa, when the price of emission is higher and the regulations are stringent, the firm will choose lower emission (E2).

The price of emission is determined in part by existing regulations in various countries, like an explicit tax, or a hidden cost from the direct and indirect regulations imposed in each country. From this point of view, we can talk about the "*shadow price*" of pollution. This measure can be seen as a measure of environmental regulatory stringency.

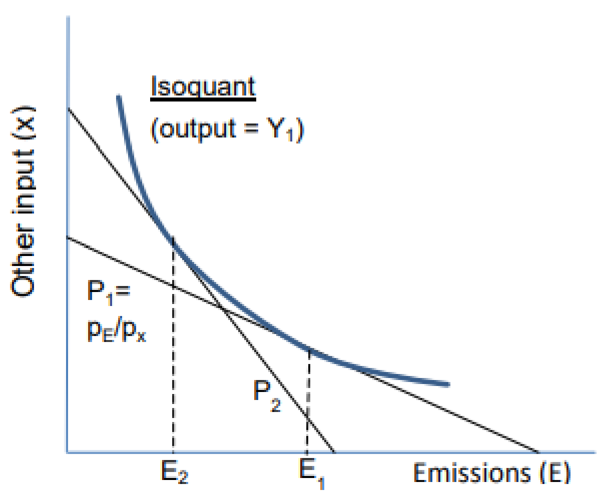

Figure 2- The shadow price approach

Coggins and Swinton (1996) used this approach to compute the shadow cost of sulfur dioxide (SO_2) emission at 14 coal-fired electric power plants in Wisconsin in the early 1990s.

This approach has several advantages: it is preferred by economists since they do not estimate demand for products by surveying customers, but instead, they adopt the *"revealed preference"* approach, studying actual choices in response to real price changes.
The shadow price approach does the same: it studies how firms take and adjust their production decision and it infers the emission price that would match the profit-maximizing behavior of the firms.

On the other hand, the shadow price is more complicated than using a survey on environmental measures and it will depend of course on how the cost and production functions are computed and on which are the inputs taken into account. Again, this would be a valid measure for existing firms, but not necessarily for new firms.

4. Emission-based approach [Brunel and Levinson, Measuring Environmental Regulatory Stringency, 2013]

The authors start from the same microeconomic principle behind the shadow-price approach, that firms are profit-maximizing and for that reason, they will use each factor of production until its marginal revenue product is equal to its price. Firms will then consider emission like any other production factor.

Without regulation, the price of emission would be really low and firms will take advantage of it until the marginal utility is close to zero.
As environmental regulation raises the price of emission, firms will adjust their input combination, switching from emissions to other production inputs.

To build a measure of regulatory stringency, the researchers compare emission intensity – emissions per dollar of value added – across industries and countries. Thus, the average value of emission intensity across industry is an emission-based measure of stringency for a given country.

Countries with high emission intensity have low costs of polluting, hence low stringency. On the other hand, where emission intensity is lower, regulations must be more stringent.

Let e_j be the emissions per dollar of value-added in jurisdiction j, averaged across all industries:

$$e_j = {E_j}/{V_j}$$

Where E_j and V_j are the total emissions and value-added in jurisdiction j, summed across all industries.

Let e_i be the emissions per dollar of value-added in industry i, averaged across all jurisdictions:

$$e_i = {E_i}/{V_i}$$

Where E_i and V_i are the total emissions and value-added in industry i, summed across all jurisdictions.

Then denote $\hat{e}_j$ as the predicted emissions per dollar of value-added in jurisdiction j, assuming each of its industries use the average emissions intensity for all jurisdictions.

$$\hat{e}_j = 1/V_j \sum_i V_{ij} e_i$$

This measure tries to predict j's emissions intensity based on its industrial composition and the average emissions intensity of those industries in other jurisdictions. Indeed, if a country is characterized by a lot of emission-intensive industries, $\hat{e}_j$ would be higher. Vice versa, if its industry composition is greener, $\hat{e}_j$ would be lower.

A measure of the stringency of regulation R_j is just the ratio between predicted emission intensity and actual emission intensity:

$$R_j = \frac{\hat{e}_j}{e_j}$$

Countries with higher abatement costs on their industries would have actual emissions lower than predicted, hence higher values for R_j, independently on the industrial composition. R_j can be computed for one single pollutant or media, it can be calculated across various pollutants and media to depict a more comprehensive measure of stringency, it can also be constructed on annual basis to observe how it changes over time.

Environmental Policy Stringency and Externalities: instruments for pollution control

In this brief discussion we will understand why emission taxes are needed to induce a correct behavior by both producers and consumers. To do this we will go through the basic Pareto Optimality model in the presence of externalities. Moreover, we will highlight the reasons why a price is charged to producers and the victims are not subjected to further compensation.

An important contribution in this direction was conducted by Baumol-Oates (1988)[19], this will help us to understand what prices and taxes are necessary to induce firms and individuals to behave in a manner compatible with Pareto Optimality requirements.

Following their work, we first define two conditions for an externality to occur:

- Condition 1: an externality is present whenever individual A's utility or production relationship include real variables, whose values are chosen by others without particular attention to the effect on A's welfare
- Condition 2: the decision maker, whose activity affects others' utility levels does not receive (pay) in compensation for this activity an amount equal in value to the resulting benefits (or cost) to others

It is common knowledge that unfortunately, whenever we talk about public goods, the ordinary price system is unable to provide an efficient outcome since the increase in the consumption of the good by an individual does not reduce its availability to others. For example, attending a firework show in a public square does not alter the quality of the show seen by other people.

At the same time, it is useless to charge for the consumption of such public goods, because the consumption of the good by an individual does not influence the level of satisfaction of anyone else.

We define depletable externalities the cases in which the additional consumption of a good by an individual lowers the availability to other people. Let us see an example: if A dumps trash on B's

[19] Baumol-Oates, Theory of Environmental Policy, 1988

property, then this trash cannot be deposited on C's land. In this case the externality effect is divisible among the victims.

Instead, we talk about public or undepletable externalities whenever the effect cannot be divided among victims.

The main role of policy makers is to set incentives to the parties facing an externality to induce socially optimal behavior. In our previous case, we want trash to be disposed in a way that is the least costly to society.

Let us analyze the case of public externality. Imagine a factory that is emitting CO2 to produce, all residents of the area suffer from the quality of air. The allocative problem in this case is to set an efficient level of smoke emission by the factory and to set an efficient level of defensive actions by the victims.

In a competitive setting the authors explain how the solution to this problem requires only a single policy measure: a Pigouvian tax (or effluent fee) on emitters (the ones who cause the negative externality) equal to marginal social damage. For example, the environmental authorities should impose a fee per unit of CO_2 emitted equal to the marginal damages accruing to all victims (firms and individuals).

According to this work, the damages suffered by the victims from the detrimental externality provide the correct incentives to induce them to undertake the efficient level of defensive activities.

Now we will discuss about a depletable externality, for example the trash disposal situation. In this case, an important aspect of the allocative problem is the choice of the most efficient disposal site. Again, according to the researchers, the best solution is to impose a Pigouvian charge equal to marginal social damage on the generator of the externality with no supplementary incentives for victims.

An important point here is that victims have no further compensation for these main reasons:

- They have a variety of responses to reduce the damages they suffer
- Moral hazard and excessive entry into the "victim activity"
- Coase's contention: the higher the number of residents in the proximity of the generator of the negative externality, the higher the Pigouvian fee charged to the factory

This simple example shows how externalities introduce distortions in the resource allocation problem. This is because the society fails to charge a price for a good. If we go deeper, we understand that no normal price could do this job: economic asymmetry is needed to impose a nonzero price to the generator of the externality and a zero price for the consumption of the externality. However, a standard situation is characterized by economic symmetry between consumer and producer and cannot induce an efficient behavior. The introduction of a Pigouvian tax (or subsidy) can provide the right incentives both to producers and victims.

How FDIs and Environmental Regulatory Stringency are related?

Researchers have investigated with both empirical and theoretical studies on the effects of local environmental regulations on investment flows [List and Co, 2000; Keller and Levinson, 2002][20,21]

In this thesis, I will replicate the work of Cole, Elliott, and Fredriksson[22] who tried to fill the gap in the literature and highlight what are the effects on local environmental policy, and the quality of foreign direct investments.

To answer this question, it is important to understand, through a simple model of government environmental policymaking that makes clear which are the political forces involved.

This theory applies to all cases of FDIs where the local firm repatriates the profits to its home jurisdiction. Local politicians are assumed to value bribes and aggregate social welfare [Grossman and Helpman, 1994][23]. We may consider the importance given to campaign contributions relative to social welfare as a measure of the corruptibility of local policymakers [Schulze and Ursprung, 2001][24]. The local market is in imperfect competition and contains both locally owned firms and foreign subsidiaries. All firms produce exclusively for the local market.

The authors explained a three-stage game as follows:

- Stage 1: all domestic and foreign firms exogenously from a lobby group, which first offers a protective bribe schedule to the domestic government (we ignore free-riding problems among firms)
- Stage 2: local government sets its optimal policy and collects the associated bribe
- Stage 3: firms set production output and abatement costs.

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[20] List, J. A. and Co, C. Y. (2000), The Effects of Environmental Regulations on Foreign Direct Investment, Journal of Environmental Economics and Management 40, 1–20.
[21] Keller, W. and Levinson, A. (2002), Environmental Regulations and FDI Inflows to the U.S. States, Review of Economics and Statistics 84, 691–703.
[22] M. A. Cole, R. J. R. Elliott and P. G. Fredriksson (2006), Endogenous Pollution Havens: Does FDI Influence Environmental Regulations?, Scand. J. of Economics 108(1), 157–178
[23] Grossman, G. M. and Helpman, E. (1994), Protection for Sale, American Economic Review 84, 833–850.
[24] Schulze, G. and Ursprung, H. (2001), The Political Economy of International Trade and the Environment, in G. Schulze and H. Ursprung (eds.), International Environmental Economics: A Survey of the Issues, Oxford University Press, Oxford

The establishment of an additional foreign plant, given the number of domestic firms, has two main effects on local policymaking. First, it increases the total output for the local market, thus there is a larger quantity to apply pollution tax. For this reason, the lobby increases its bribe to get a lower pollution tax. We will call this consequence of the FDI the “Bribery effect”

Second, in an imperfectly competitive market, the government has an incentive to lower the pollution tax below the first-best level (equal to marginal damage) in order to make firms produce more and increase consumer surplus.

An increase in the number of firms serving the market increases competition, hence it reduces the incentives for the government to reduce the pollution tax. This is the “Welfare effect” of FDIs which leads to a higher pollution tax.

The net effect of the two contributions depends on the degree of the corruptibility of the local government.

Thus, FDIs raise local environmental stringency when the degree of government corruptibility is low and they reduce the regulatory stringency when the local government is more corruptible.

Theoretical Model

Consider a small economy where production causes local pollution damage *s*. We define as N^D the number of domestic firms and N^F the number of foreign firms. Those actors are producing and competing in quantities in an imperfectly competitive local market.

The total number of firms operating in this particular market is: $N^D + N^F = N$ [Grossman and Helpman, 1996][25].

The number of total firms is exogenous, and, for simplicity's sake, we assume that the market is supplied exclusively by identical firms located within the jurisdiction's borders.

We may identify four types of agents: consumers, domestic producers, foreign producers, and the government. The population of consumers is normalized to 1.

The utility of the representative consumer is U = u(Q) – s, where Q is the consumption of the polluting good with price p = a – Q, where a > 0 describes the size of the local market. u(Q) is a concave, twice differentiable sub-utility function.

The government mitigates local emissions caused by local production through an emission tax, $t \in T \subset R_+$, per unit of pollution.

Output for each firm i is given by q_i. The gross profit function of firm *i* is given by:

$$\pi_i = p(Q)q_i - e(q_i, w_i) - s_i t - F, \qquad (1)$$

Where p(Q) is the inverse demand function, $Q = \sum_i q_i = Nq_i$, $e_i(q_I, w_i) = cq_I + gw_I$ is the cost function, w_i is the abatement expenses and g is the marginal abatement cost.

The pollution damage function can be written as $s_i = vq_i + \beta w_i^{-\gamma}$ which is increasing and linear in q and decreasing and concave in w, and where s_i must be at least equal to zero.

[25] Grossman, G. M. and Helpman, E. (1996), Foreign Investment with Endogenous Protection, in R. C. Feenstra, G. M. Grossman and D. A. Irwin (eds.), The Political Economy of Trade Policy, MIT Press, Cambridge, MA

From this starting point, we can say that pollution abatement exhibits diminishing returns. Moreover, it implies that marginal damage from pollution equals unity (since the population of consumers is normalized to 1) and that firms may reduce the negative impact of their production by both abatement costs and output reduction.

F is the fixed cost of production, and c, v, β, and γ are the positive parameters.

We apply the implicit function theorem to the FOCs of (1) and we obtain $dq_i/dt < 0$ and $dw_i/dt > 0$.

So, in the Nash equilibrium, the optimum level of firm i's output and abatement expense, given the pollution tax is $q_i = \frac{a-c-vt}{1+N}$ and $w_i = \left(\frac{\beta\gamma t}{g}\right)^{\frac{1}{1+\gamma}}$

We consider foreign firms' profits fully repatriated to the firms' home jurisdictions, so they do not contribute to the government's social welfare function.

The consumers' aggregate welfare equals:

$$W^{CO}(t) = \int_0^Q p(x)dx - p(Q)Q + N(t-1)s(q,w)$$

i.e. the sum of consumer surplus, tax revenues (redistributed equally to all consumers) diminished by the damage from pollution, respectively.

During the first stage of the game described, all domestic and foreign firms active in the local economy join the lobby and offer a prospective bribe schedule $C(t)$ to the government. The bribe is contingent on the government's decision of pollution tax policy.

In the second stage, the government selects its environmental policy and collects bribes from the lobbies. In the third stage, the firms set their output and abatement levels.

The lobby utility function can be written as follows (ignoring consumer surplus and revenues, since it contains a negligible number of individuals):

$$V(t) = (N^D + N^F)\pi$$

The government maximizes the weighted sum of political contributions received and aggregate social welfare, given by:

$$G(t) = C(t) + \alpha W^{A}(t)$$

Where α is strictly positive and describes the corruptibility level of the local government [Damania et al., 2003][26]. Aggregate social welfare takes into account only domestic firms' profit since foreign producers repatriate their profits to their home jurisdiction:

$$W^{A}(t) = W^{CO}(t) + N^{D}\pi$$

The subgame-perfect Nash equilibrium pollution tax t^*, satisfies the condition $\partial t + \alpha\left(\frac{\partial W^{A}(t^*)}{\partial t}\right) = 0$

If we take the partial derivatives of the expressions for the lobby welfare and the aggregate social welfare and we substitute the result into the equilibrium condition, we obtain:

$$-Ns - \alpha N^{D}s + \alpha N\left[s - \frac{vqN}{1+N} - (t-1)(\frac{v^2}{1+N} + \frac{(\beta\gamma)^2 w^{-(1+\gamma)}}{g(1+\gamma)}\right] = 0, \quad (2)$$

Where $-Ns - \alpha N^{D}s = A$ is the effect of the lobby group on the equilibrium tax and the remaining terms describe the government's consideration of consumers' welfare.

What happens in practice is that the lobby group bids for a lower pollution tax, the government lowers the pollution tax to raise consumer surplus, given the fact that the market is imperfectly competitive. The term A is clearly negative, so we can find that the term B= $\alpha N\left[s - \frac{vqN}{1+N} - (t-1)(\frac{v^2}{1+N} + \frac{(\beta\gamma)^2 w^{-(1+\gamma)}}{g(1+\gamma)}\right]$, is positive.

[26] Damania, R., Fredriksson, P. G. and List, J. A. (2003), Trade Liberalization, Corruption, and Environmental Policy Formation: Theory and Evidence, Journal of Environmental Economics and Management 46, 490–512.

The authors make the following assumptions on the equilibrium pollution tax:

Assumption 1: in equilibrium $t^* < 1$.

This assumption simplifies the following proposition, it simply says that t^* is lower than marginal social damage from pollution. Then:

Proposition 1. *In the political equilibrium, the pollution tax increases (decreases) with the number of foreign firms if the degree of corruptibility is sufficiently low (high).*

Proof: if we differentiate (2) we obtain

$$\frac{dt}{dN^F} = \frac{-s+\alpha\left(\beta w^{-\gamma}+\frac{vq(1+N(N-1))}{1+N}-\frac{(t-1)(\beta\gamma^2)w^{-(1+\gamma)}}{g(1+\gamma)}\right)}{-D} \tag{3}$$

Where D is the SOC of (2) and is assumed to be strictly negative. $-s < 0$ and the other terms are positive for assumption 1.

If we then compute the limits:

$$\lim_{\alpha\to 0}\frac{dt}{dN^F} < 0$$

$$\lim_{\alpha\to\infty}\frac{dt}{dN^F} > 0$$

As expected, the establishment of an additional foreign subsidiary, given the number of domestic firms, on environmental policy depends on the level of the corruptibility of the local policymakers. The overall impact is determined by two events:

1. An increase in the number of firms serving a market increases the pressure for lowering the pollution tax. This is because of the increase of the total output and so the stakes involved regarding pollution taxation increase for the lobby group. This yields to a less stringent policy and it is called as “Bribery effect” of FDIs

2. The increase in the number of total firms increases competition and lowers the incentives of the government to reduce the pollution tax, keep high the consumer surplus, and incentivize production output. This event is called the "Welfare effect" of FDI and causes policy stringency to increase.

When the level of corruptibility is high (α is low) the "Bribery effect" dominates the "Welfare effect" and the pollution tax will be lowered after the establishment of a new foreign subsidiary. On the other hand, when the government is less corruptible (α is high), the "Welfare effect" drives the decision of the policymakers towards a more stringent environmental policy.

Econometric Model and Data Analysis

After having discussed the main theories and the literature contributions about FDIs and environmental stringency, we now may go deeper in the focal point of this work which is the investigation about a possible correlation between these two metrics.

This section will then present the dataset used to conduct the analysis, the approach chosen to investigate, and the results obtained.

Data Description

The first step in order to create an effective econometric model is extracting data about the dependent variable, namely the measure of political stringency.

Dependent variable: *pol_string*

In Cole et al.'s work the measure of stringency was the number of grams of lead content per gallon of gasoline, but we chose a different variable that could be easier to understand.

In this case we decided to choose the OECD Environmental Policy Stringency Index (EPS) which is a country-specific and internationally-comparable measure. Stringency is defined as the degree to which environmental policies put an explicit or implicit price on polluting or environmentally harmful behavior [Gozluk, Garsous, 2016][27].

As already mentioned in the literature review, the index has values from 0 (less stringent) to 6 (highest level of stringency), and it covers 28 OECD and 6 BRIICS countries for the period 1990-2015. It is computed based on the degree of stringency of 14 environmental policy instruments, primarily related to climate and air pollution [Botta, Kozluk, 2014][28].

[27] Gozluk, Garsous, HOW STRINGENT ARE ENVIRONMENTAL POLICIES, OECD ®, 2016

[28] Botta, E. and T. Kozluk (2014), "Measuring Environmental Policy Stringency in OECD Countries: A Composite Index Approach", *OECD Economics Department Working Papers*, No. 1177, OECD Publishing,

We decided to utilize the OECD EPS measure since it is a simple index, but still based on actual policies that are important and relatively comparable across economies. Moreover, despite its simplicity, it offers coverage across countries and time, so it can be easily updated and expanded according to the data availability.

Once we defined the dependent variable, it is important to describe the regressors. These control variables are taken from the World Development Indicators (WDI) database and from the Worldwide Governance Indicators (WGI) database for what concerns the corruptibility measure.

Measure of Corruptibility: *control_corrupt*

To approximate the level of corruptibility of a country we chose the *Control of Corruption* indicator from the WGI database. This measure captures the perceptions of the extent to which public power is exercised for private gain, as well as "capture" of the state by elites and private interests. The estimate ranges approximately from -2.5 to 2.5.

Cole et al. decided to use instead the ''government honesty'' variable reported by the International Country Risk Guide.

Other control variables [29]

We used in this section the same dataset of the original paper.

1. **Fixed telephone subscriptions (per 100 people):** *fixed_phones*
   This measure refers to the sum of active number of analogue fixe telephone lines, voice-over-IP (VoIP) subscriptions, fixed wireless local loop (WLL) subscriptions, ISDN voice-channel equivalents and fixed public payphones.

2. **GDP (Current US $):** *gdp*
   GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products.

[29] https://databank.worldbank.org/source/world-development-indicators, Metadata

It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars. Dollar figures for GDP are converted from domestic currencies using single year official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used.

3. **Inflation, GDP deflator (annual %):** *inflation*

   Inflation as measured by the annual growth rate of the GDP implicit deflator shows the rate of price change in the economy as a whole. The GDP implicit deflator is the ratio of GDP in current local currency to GDP in constant local currency.

4. **Manufacturing, value added (Current US $):** *manuf_sh*

   Manufacturing refers to industries belonging to ISIC divisions 15-37. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3. Data are in current U.S. dollars.

5. **Population:** *pop*

   Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. The values shown are midyear estimates.

6. **Urban population share (% of total population):** *urban_sh*

   Urban population refers to people living in urban areas as defined by national statistical offices. The data are collected and smoothed by United Nations Population Division.

7. **Mobile cellular subscriptions (per 100 people)**: *mob_sub*

   Mobile cellular telephone subscriptions are subscriptions to a public mobile telephone service that provide access to the PSTN using cellular technology. The indicator includes (and is split into) the number of postpaid subscriptions, and the number of active prepaid accounts (i.e. that have been used during the last three months). The indicator applies to all mobile cellular subscriptions that offer voice communications. It excludes subscriptions via data cards or USB modems, subscriptions to public mobile data services, private trunked mobile radio, telepoint, radio paging and telemetry services.

8. **Labor force**: *lab_force*
   Labor force comprises people ages 15 and older who supply labor for the production of goods and services during a specified period. It includes people who are currently employed and people who are unemployed but seeking work as well as first-time job-seekers. Not everyone who works is included, however. Unpaid workers, family workers, and students are often omitted, and some countries do not count members of the armed forces. Labor force size tends to vary during the year as seasonal workers enter and leave.

FDI Data

Regarding the FDI data, we utilized the FDI Market database, a comprehensive database which offers a wide coverage of types of FDIs, number of FDIs and capital invested grouped by – in our case – the destination country of the investment.

Now we can go through briefly the variables utilized during the analysis, concerning the FDI measures.

1. **Capital Investment**: *CapitalInvestment*
   This measure represents the total capital invested on a certain destination country of the FDI. It is an important information in order to understand the magnitude of the inflows of money towards a certain country. We used this data to determine which host countries had had the largest inflows due to FDIs.
2. **FDI count:** *fdi_count*
   This measure represents the number of FDIs that have been undertaken for a certain destination country. It is relevant to understand the frequency of the investments by foreign countries towards a certain host country.
3. **Jobs Created:** *JobsCreated*

This measure has been utilized to understand one of the consequences of FDIs on host countries, namely the creation of new job opportunities

The FDI Market database provided the possibility to separate the investments according to the industry and the activity resulted from the money inflow. We have been able to categorize the number of FDIs, the capital invested, and the jobs created highlighting the main categories of activities that characterize a financial instrument such as an FDI.

In our analysis we distinguished the FDIs into the following categories:

a. Research and Development
b. Manufacturing
c. Managerial accounting
d. Banking Services
e. Logistics
f. Construction
g. Other

Since the theoretical model expected the effect of FDIs on environmental stringency to be ambiguous and dependent on the level of corruptibility of the host country, it is important to conduct a preliminary analysis and to cluster our dataset based on the measure we thought were significative.

In the following part we will discuss how investments are distributed according to the clusters we have created in order to highlight some interesting trends and draw some possible conclusions and explanations.

We started by looking at the distribution of the measure of corruptibility (*Figure 3*) so that we could identify the countries with the highest – and the lowest – control on corruptibility. This resulted in two clusters:

- Top 8 Countries for Average Corruptibility Control: Denmark, Finland, Sweden, Norway, Switzerland, Netherlands, Canada, Australia
- Worst 8 Countries for Average Corruptibility Control: Russia, Indonesia, China, India, Brazil, Turkey, Greece, South Africa

After that we investigated on the distribution of the Average Political Stringency across ISO codes (*Figure 4)* to see if we could find some first implications. Generally speaking, those countries with higher levels of corruptibility control have also higher levels of political stringency – as one could expect – and conversely the countries with a lower degree of corruptibility control have lower values of the EPS index. A particular case is represented by Korea, which shows a relatively low level of corruptibility control, but still a relatively high level of political stringency.

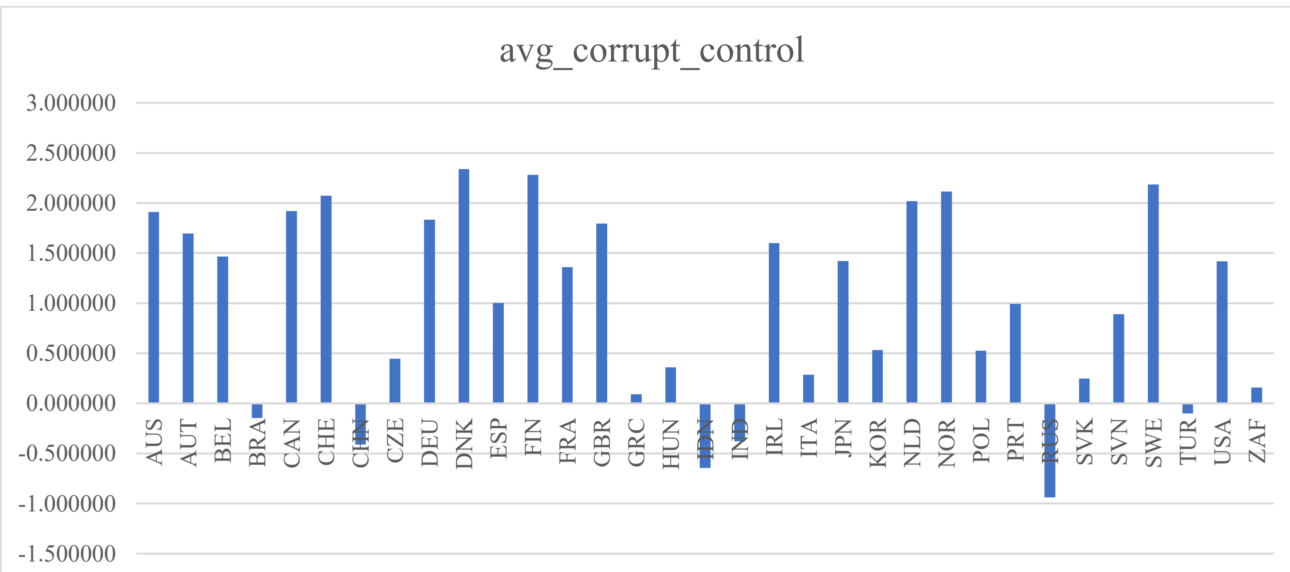

Figure 3 - Distribution of the Average Control of Corruptibility

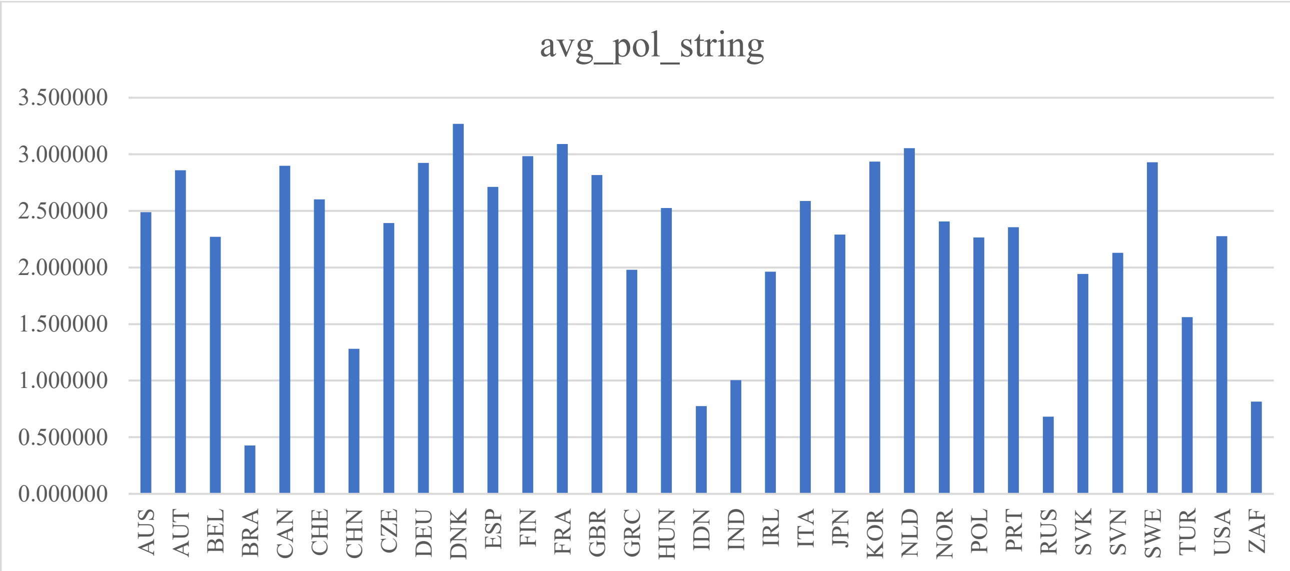

Figure 4 - Distribution of the Average Political Stringency

We continued our analysis by looking at the distribution of both FDI count and Capital Invested. This is interesting for two reasons:

1. Understand whether there is some trend related to political stringency, corruptibility control and FDI just by looking at the actual data
2. Seek for possible correlation between FDI count and capital invested

Figures 5 and 6 will help us understand what has been afore mentioned.

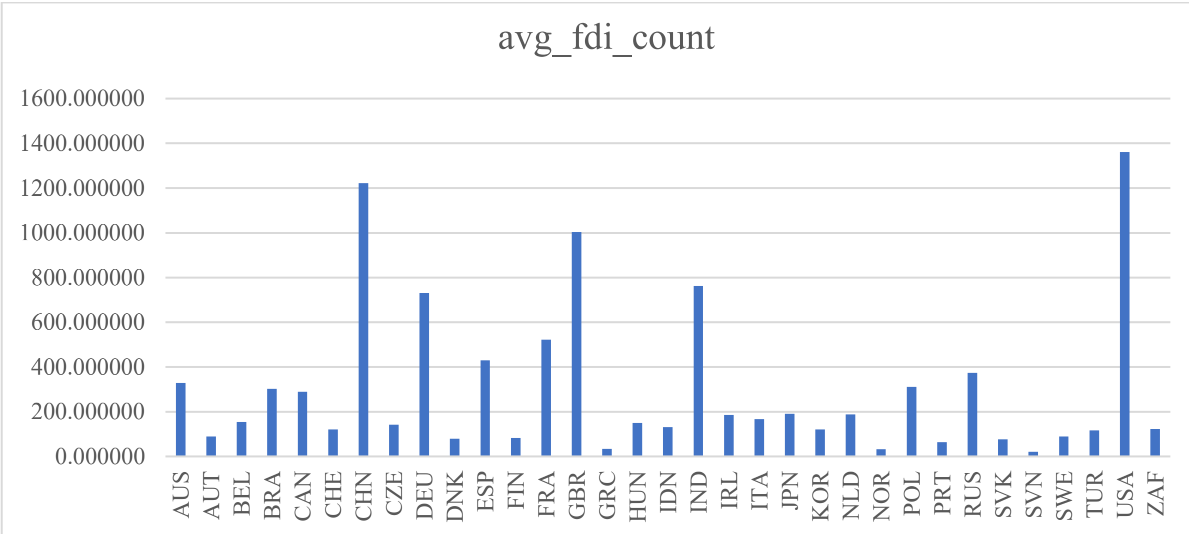

Figure 5 - Distribution of FDI count

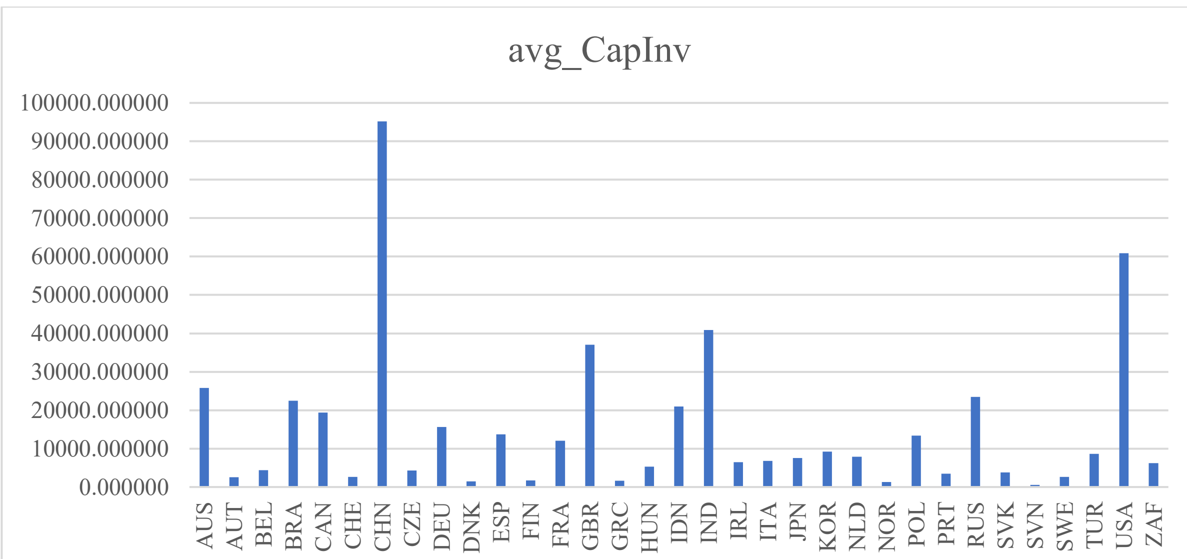

Figure 6 - Distribution of Capital Investment

As one can see, *Figures 5* and *6* reflect almost the same “shape” of distribution, thus countries with more investments have more capital invested by foreign jurisdictions.

Moreover, it can be seen that countries with relatively low level of corruptibility control tend to have relatively high level of capital invested through FDIs, the main example in this sub-category is China, but one could highlight also the situation of Russia, India, Indonesia, and Brazil. A special mention goes to Australia, which even if it has high degree of corruptibility control, it shows a high level of capital invested. I was interested in going deeper with the analysis of the distribution of investments and capital concerning these two countries.

In the following pie-charts (*Figure 7, 8, 9, 10)* we can have a look at how capital and investments are used differently for two countries with high level of capital invested, but two really distant degree of corruptibility control.

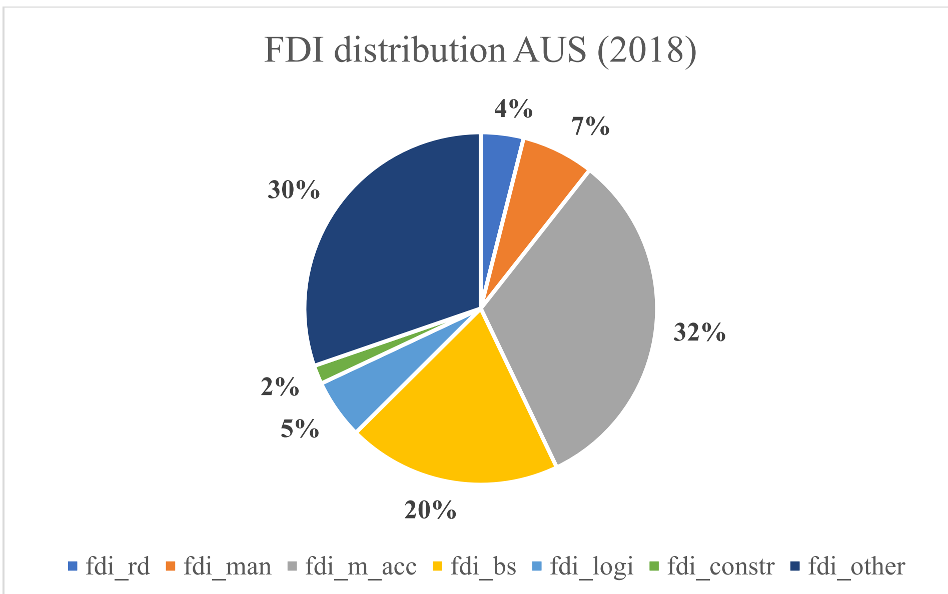

Figure 7 - FDI distribution in Australia in 2018

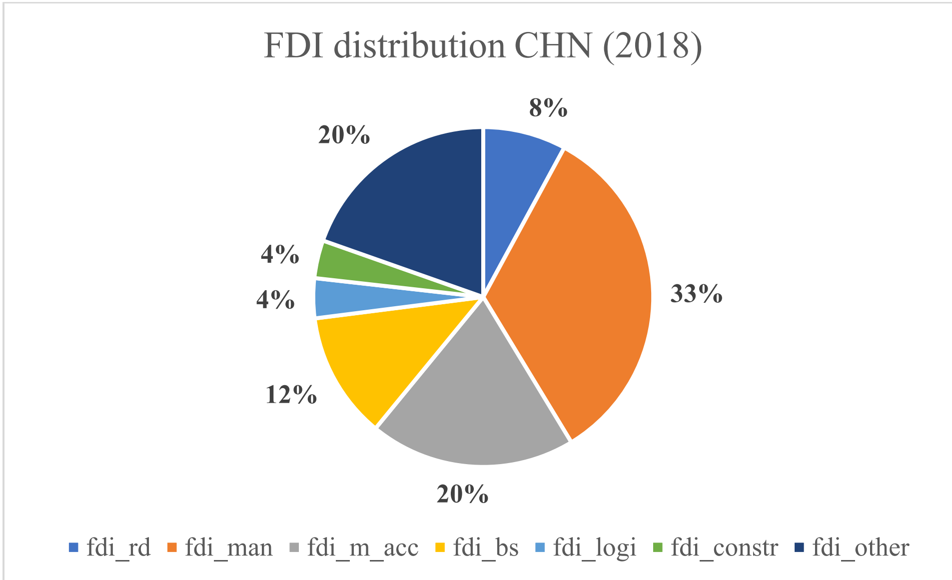

Figure 8 - FDI distribution in China in 2018

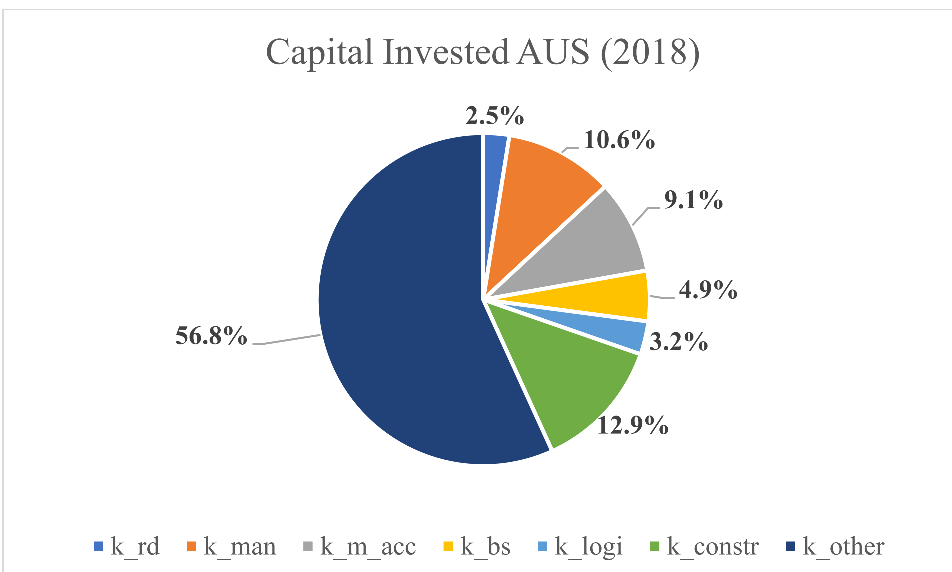

Figure 9 - Capital Invested distribution in Australia 2018

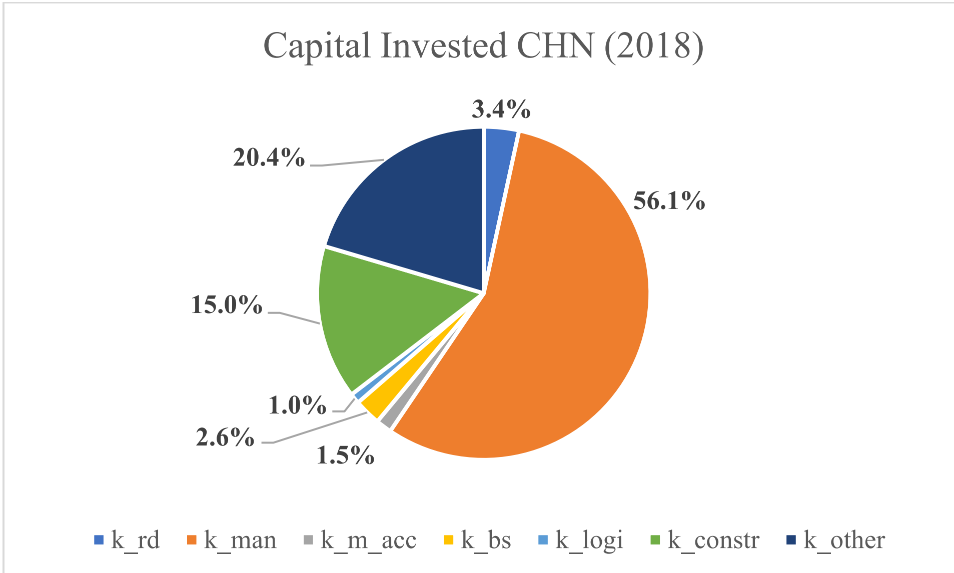

Figure 10 - Capital Invested distribution in China in 2018

These data reflect some important differences between the two countries. The highest number of FDIs towards China is related to manufacturing activities, whereas Australia reflects a high number of FDI regarding sales and marketing activities. Talking about capital flows, it is relevant the difference in the distribution of the two countries. Indeed, China has most of the total capital inflows coming from foreign countries towards manufacturing activities, while in Australia one can see a more even situation (if we do not take into account the category "other").

Another interesting couple of countries that I found interesting was France and Russia. Indeed, France and Russia are in the group of countries with relatively high number of FDIs, but France has a higher degree of political stringency, while Russia places itself towards the bottom of the EPS ranking.

Here I would like to report as usual the capital an FDI distribution (*Figure 11, 12, 13, 14)* for this interesting couple and try to see whether we can find some trend with respect to the other countries analyzed before.

From *Figure 11* and *13*, it is possible to observe how Russian distributions are more similar to Chinese distributions (*Figure 8, 10)* so we may say that for those countries whose degree of corruptibility control and whose level of political stringency are lower, FDIs and capital are more related to manufacturing activities. Conversely, especially if we look at the capital invested, we expect more FDIs regarding sales and marketing activities for those countries whose political stringency degree is higher.

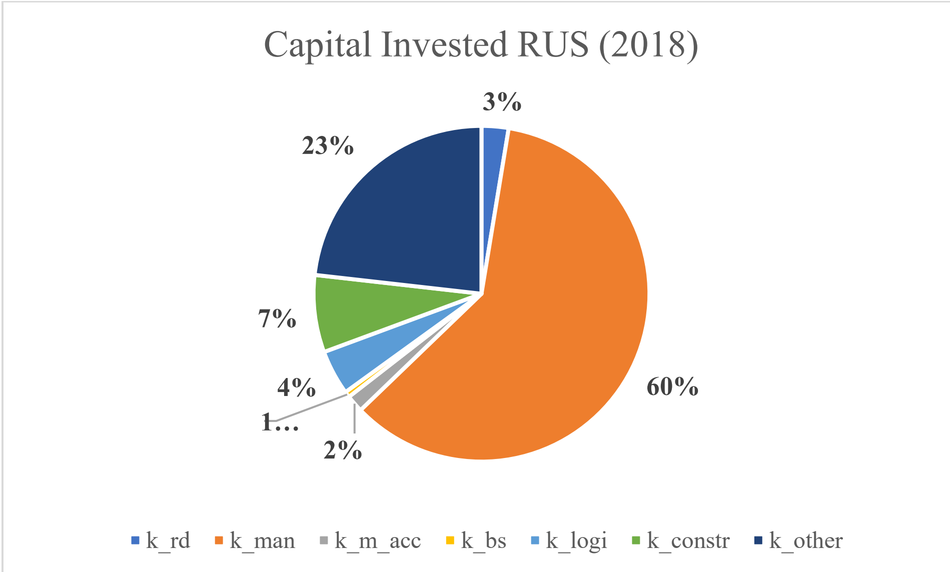

Figure 11 - Capital Invested distribution in Russia in 2018

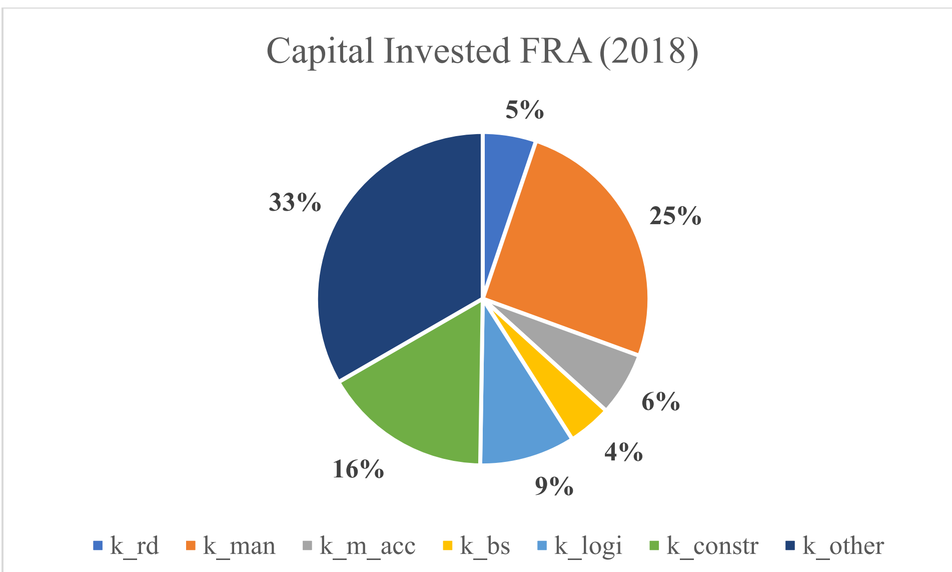

Figure 12 - Capital Invested distribution in France in 2018

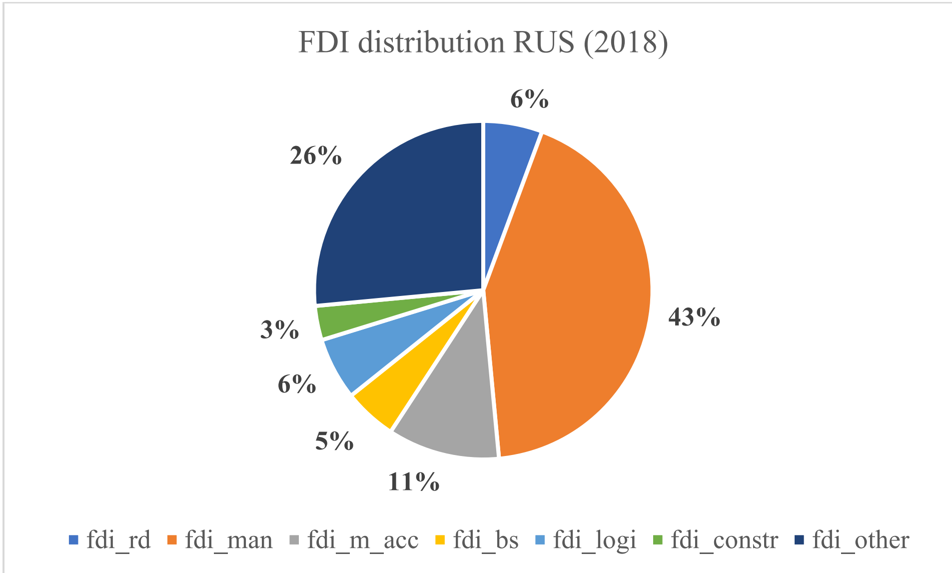

Figure 13 - FDI distribution in Russia in 2018

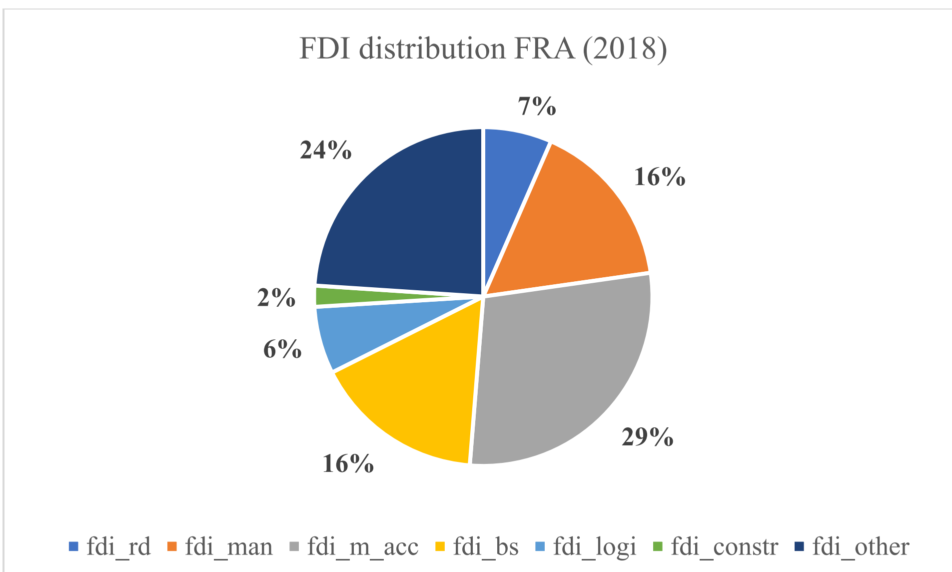

Figure 14 - FDI distribution in FRA in 2018

In *Figure 15* we can observe the behavior and the differences in graphical terms of the average EPS index for the best 8 countries, the worst 8 countries and the overall graph. We can find a very similar trend, probably because the same exogenous factors influenced almost every country in the same way considering the net effect. The encouraging trend shows how – as time is passing – we have a general increase in the political stringency. However, it is clearer how less controlled countries are below from the environmental stringency point of view, indeed in 2015 the average value of "Flop 8" countries is still lower than the one of the "Top 8" countries in 2003.

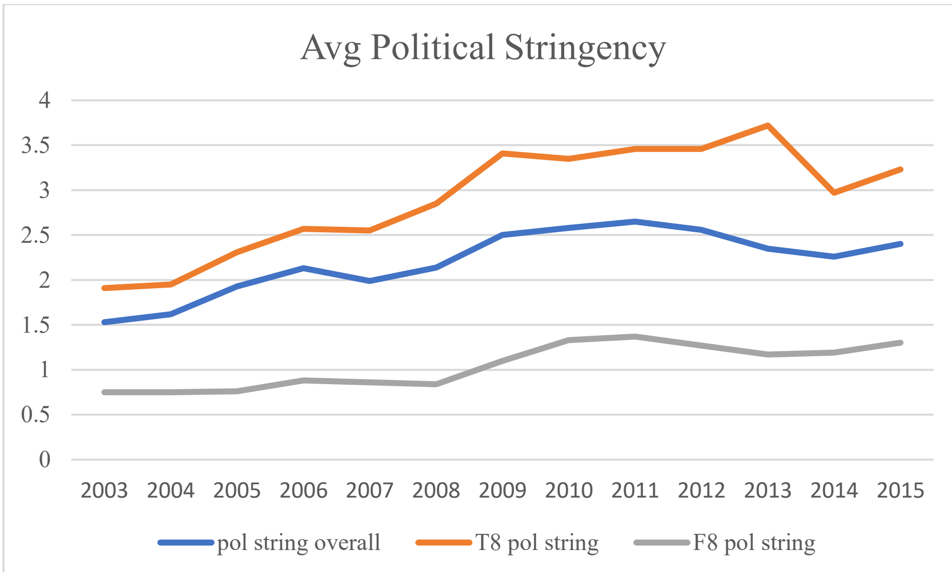

Figure 15 - Average Political Stringency vs time

As a conclusion, I would like to comment briefly these scatterplots concerning political stringency and control of corruptibility versus the two measures of FDIs – namely the FDI count and the capital investment.

Figures 16 and *17* reflect almost the same behaviour, we see that the more a country is severe from the environmental regulation perspective, the least the number of FDIs or the capital invested. We observe some outliers regarding high Capital Invested (or number of FDIs) in more "virtuous" countries, but generally the less the effect of political stringency, the higher the presence of FDIs towards a certain country.

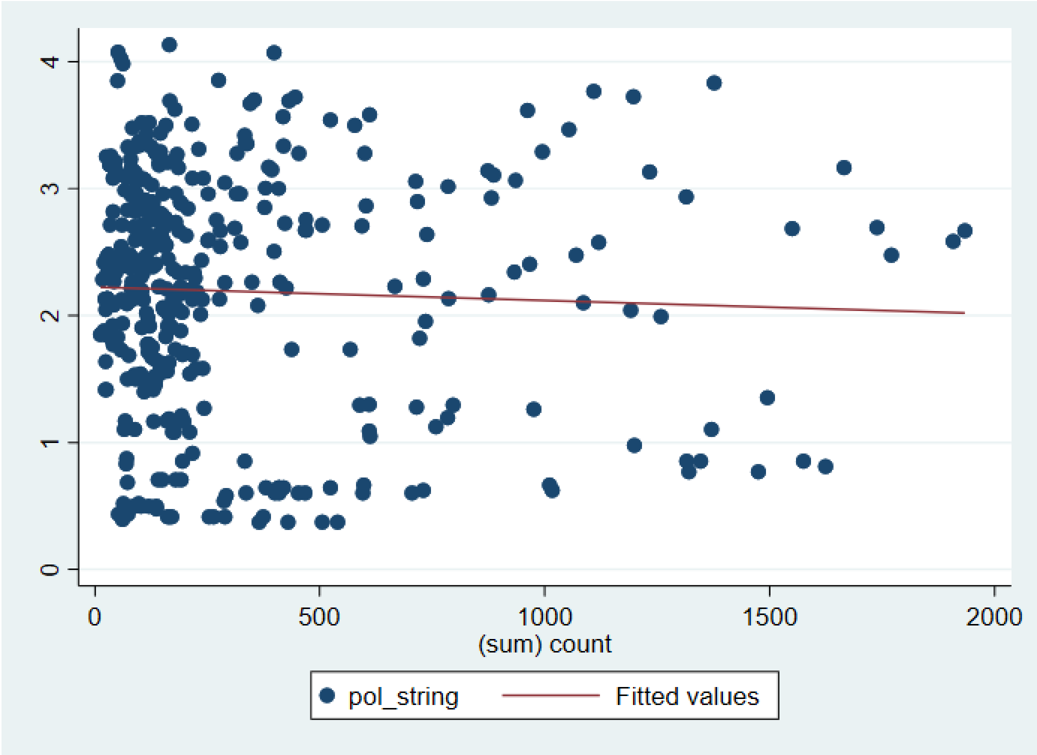

Figure 16 - Scatterplot Political Stringency vs FDI count

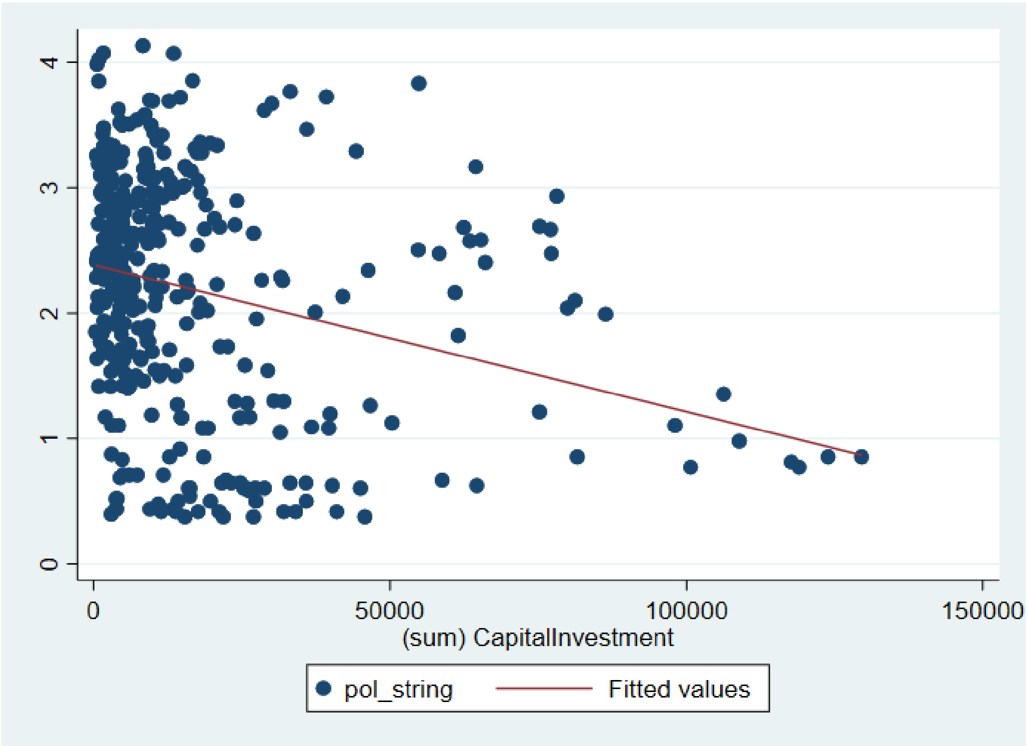

Figure 17 - Scatterplot Political Stringency vs Capital Investment

Figures 18 and *19* are also really similar, we can observe two zones in which really controlled countries and countries with really low control of corruption attract investors, and hence FDIs and capital. However, the majority of observation is located in the same zone reflecting a relatively low number of FDIs (and capital investment) with respect to the outliers. We can then highlight how the highest number of investments is related to relatively strict countries, but the higher quantity of capital flows towards less controlled jurisdictions.

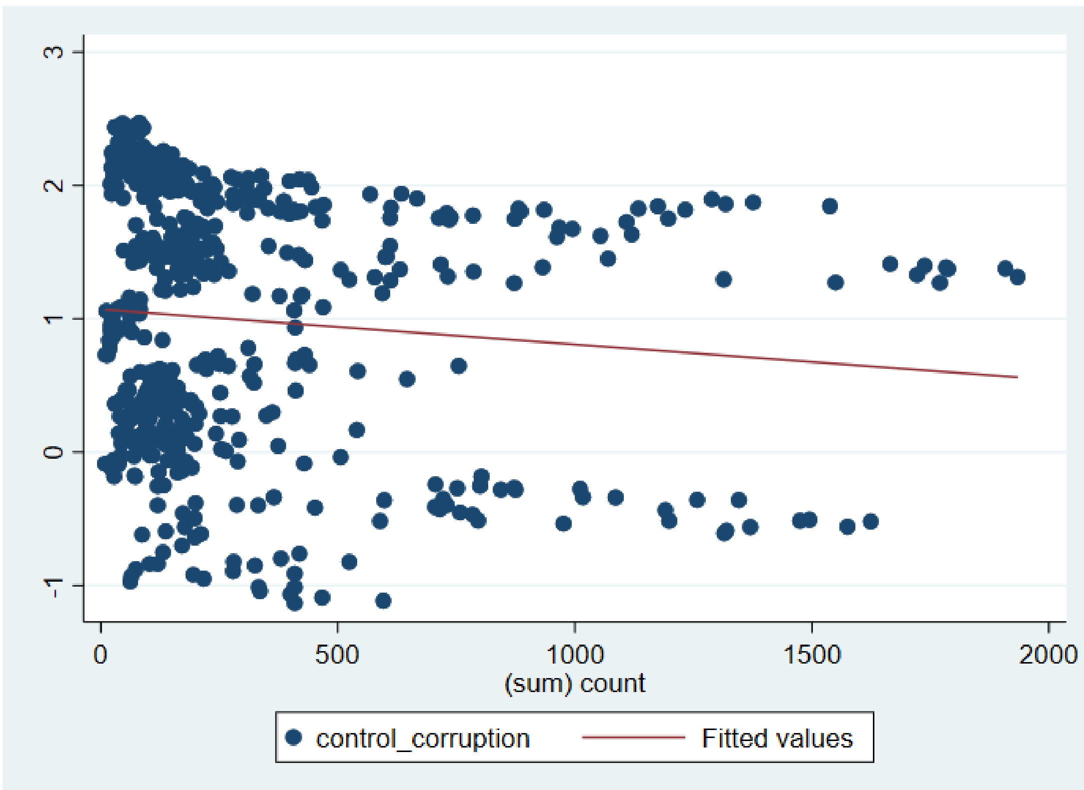

Figure 18 - Scatterplot Control of Corruption vs FDI count

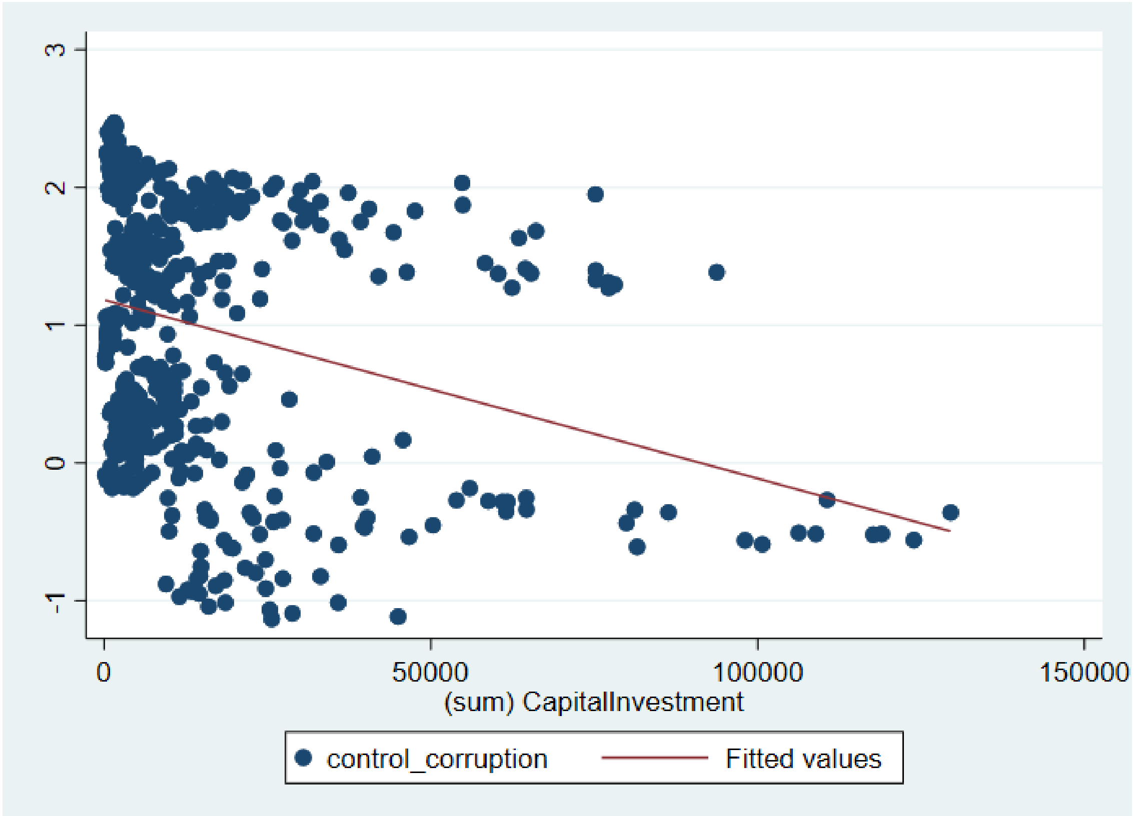

Figure 19 - Scatterplot Control of Corruption vs Capital Investment

Methodology

Now that we chose the regressors, the dependent variable, and we briefly discussed some interesting data and trends, it is important to go deeper into the data analysis, by explaining the methodology that has been adopted.

The databased constructed is a panel model, which is a set with measures that may change across years and iso code. We gathered data about 33 different countries over the period 2002-2020, i.e. for 19 years, so a measure could have a maximum of 627 observations (i=33, t=19 → $i \; x \; t \; = \; 627$).

The dataset is made of rows identified by the couple *iso* and *year* whereas the regressors are organized in columns.

Fortunately, by limiting the time window and by organizing the dataset in this way we managed to build a strongly balanced panel, which means that each measure is characterized by a number of observations close to the maximum level, limiting the number of missing values which may distort the data analysis.

Following the model proposed by Cole et Al.[30] we now look for the possible implication predicted by the mathematical model explained in the previous section and well summarized by Proposition 1.

We want to better understand the relationship between political stringency, FDIs and corruptibility and we utilized the following regression equation:

$$(FDI * CONTROL\ CORRUPTION)_{it} = \alpha_i + \gamma_t + \beta' X + \varepsilon_{it} \qquad (4)$$

The coefficient of interest is the interaction between the FDI measure (both the number of FDIs and the capital invested) in country i in the year t, α_i is the time-invariant country fixed effect, γ_t is a location-invariant time fixed effect, X is a vector of independent variables, and ε_{it} is the error term. This term is expected to be positive since an highly-controlled country hosting several FDIs will enhance the competitiveness of its home market and hence increase the level of the pollution tax for its production activities, as already stated in Proposition 1.

---

[30] M. A. Cole, R. J. R. Elliott and P. G. Fredriksson (2006), Endogenous Pollution Havens: Does FDI Influence Environmental Regulations?, Scand. J. of Economics 108(1), 157–178

Variable	Obs	Mean	Std. Dev.	Min	Max
pol_string	373	2.189969	0.9550116	0.375	4.133333
control_corrupt	627	0.979892	0.9577855	-1.14404	2.469991
fixed_phones	421	38.76071	16.65016	1.947865	73.24146
gdp	416	1.63E+12	2.84E+12	2.96E+10	1.82E+13
inflation	416	2.943212	3.532665	-5.21392	24.46009
manuf_sh	415	15.91694	5.616953	6.290283	34.90355
pop	416	1.31E+08	304000000	1995733	1.37E+09
urban_sh	416	71.95147	14.54528	28.572	97.876
mob_sub	512	105.9741	28.55893	3.030976	172.1218
lab_force	512	64300000	153000000	963181	7.87E+08
CapitalInvestment	525	14869.74	21024.09	149.8	129541.7
fdi_x_corrupt	525	265.7283	550.7673	-881.518	2837.096
CapInv_x_corrupt	525	9009.236	25048.85	-69351.1	146600.5
gdp2	416	1.07E+25	4.15E+25	8.78E+20	3.33E+26
urban_sh2	416	5388.07	1940.39	816.3592	9579.711
manuf_sh2	415	284.823	208.1442	39.56766	1218.258

Table 1 - Summary statistics

Results

Fixed-Effects Model – Complete Dataset

The first output shows a small positive effect of the interaction of the number of FDIs and the control of corruption and a small negative effect of FDI count towards the EPS index. This means that normally having more FDIs reduces the political stringency of the destination country, by the way the effect of the control of corruption offsets the negative impact of FDIs on the EPS index.

Another interesting comment is that we have a time effect, indeed we see how the coefficient related to the year increases as time passes. Conditional on fixed effects, time effects actually appear to be the main drivers of the variation in the environmental stringency index in our sample.

```
Fixed-effects (within) regression               Number of obs      =        329
Group variable: iso_code                        Number of groups   =         32

R-sq:                                           Obs per group:
     within  = 0.5684                                         min =          5
     between = 0.1656                                         avg =       10.3
     overall = 0.1151                                         max =         12

                                                F(21,31)           =      28.50
corr(u_i, Xb)  = -0.9845                        Prob > F           =     0.0000

                                   (Std. Err. adjusted for 32 clusters in iso_code)
```

pol_string	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
fdi_x_corrupt						
L1.	.0007082	.0002964	2.39	0.023	.0001037	.0013127
fdi_count						
L1.	-.0005925	.000257	-2.31	0.028	-.0011167	-.0000683
control_corruption						
L1.	.1830041	.2988954	0.61	0.545	-.4265972	.7926054
log_gdp						
L1.	.1830745	.3542707	0.52	0.609	-.5394654	.9056144
urban_sh						
L1.	-.1056938	.1568325	-0.67	0.505	-.4255557	.2141682
urban_sh2						
L1.	.0010019	.0011304	0.89	0.382	-.0013035	.0033074
log_pop						
L1.	2.609532	2.582238	1.01	0.320	-2.656977	7.876042
inflation						
L1.	.0113445	.011655	0.97	0.338	-.012426	.035115
mob_sub						
L1.	-.0029434	.0028882	-1.02	0.316	-.008834	.0029471
lab_force						
L1.	1.70e-09	1.39e-08	0.12	0.904	-2.67e-08	3.01e-08

Output 1a - Fixed-effects regression with FDI count

year						
2005	.3071286	.0760725	4.04	0.000	.1519777	.4622795
2006	.4638809	.1174448	3.95	0.000	.2243507	.7034111
2007	.3057921	.1657869	1.84	0.075	-.0323324	.6439166
2008	.4224738	.2233279	1.89	0.068	-.0330063	.877954
2009	.765788	.2767206	2.77	0.009	.2014125	1.330163
2010	.8421451	.267891	3.14	0.004	.2957777	1.388512
2011	.875856	.2972056	2.95	0.006	.2697013	1.482011
2012	.7623155	.3348141	2.28	0.030	.0794577	1.445173
2013	.8592608	.3688658	2.33	0.027	.106954	1.611568
2014	.735962	.4097781	1.80	0.082	-.0997859	1.57171
2015	.8130623	.4227713	1.92	0.064	-.0491854	1.67531
_cons	-46.65224	45.70545	-1.02	0.315	-139.8691	46.56465
sigma_u	4.9133735					
sigma_e	.34521406					
rho	.99508777	(fraction of variance due to u_i)				

Output 1b – Fixed-effects regression with FDI count, time effect detail

We can now see the results of the regression taking into consideration the capital invested. It is possible to see again a really low positive coefficient of the interaction between the capital invested and the control of corruption. As expected, an increase in the capital invested will lower the political stringency of a country but the corruption control effect can invert this trend and make the net effect positive. In a nutshell, the more capital flows towards a destination country, the lower will be its political stringency, but if the country is more controlled the more the capital invested the more stringent will be its regulations.

We may also observe the same time effect in the second part of the output, so we confirm what we saw in the graphs, i.e. the existence of an increasing trend of the EPS index throughout the years.

```
Fixed-effects (within) regression               Number of obs      =        329
Group variable: iso_code                        Number of groups   =         32

R-sq:                                           Obs per group:
     within  = 0.5601                                         min =          5
     between = 0.1655                                         avg =       10.3
     overall = 0.1138                                         max =         12

                                                F(21,31)           =      54.40
corr(u_i, Xb)  = -0.9818                        Prob > F           =     0.0000

                                 (Std. Err. adjusted for 32 clusters in iso_code)
```

pol_string	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
CapInv_x_corrupt						
L1.	5.92e-06	2.32e-06	2.55	0.016	1.19e-06	.0000106
CapitalInvestment						
L1.	-6.32e-06	3.45e-06	-1.83	0.077	-.0000134	7.18e-07
control_corruption						
L1.	.244287	.3078498	0.79	0.434	-.3835769	.8721508
log_gdp						
L1.	.2216746	.3810266	0.58	0.565	-.5554344	.9987835
urban_sh						
L1.	-.124465	.1702221	-0.73	0.470	-.4716353	.2227052
urban_sh2						
L1.	.0010946	.0012162	0.90	0.375	-.0013858	.0035751
log_pop						
L1.	2.462877	2.429921	1.01	0.319	-2.492979	7.418733
inflation						
L1.	.0123181	.0106261	1.16	0.255	-.009354	.0339903
mob_sub						
L1.	-.0048185	.0029957	-1.61	0.118	-.0109284	.0012913
lab_force						
L1.	-4.90e-10	1.57e-08	-0.03	0.975	-3.24e-08	3.15e-08

Output 2a – Fixed-effects regression with Capital Investment

year						
2005	.323279	.0784406	4.12	0.000	.1632984	.4832596
2006	.4947309	.1232754	4.01	0.000	.243309	.7461528
2007	.3587697	.1676073	2.14	0.040	.0169324	.700607
2008	.5081842	.2272763	2.24	0.033	.0446511	.9717173
2009	.8682159	.2799456	3.10	0.004	.297263	1.439169
2010	.9662372	.2655257	3.64	0.001	.4246939	1.50778
2011	.9902712	.2968228	3.34	0.002	.384897	1.595645
2012	.8916527	.3321997	2.68	0.012	.214127	1.569178
2013	1.025096	.3613365	2.84	0.008	.2881453	1.762047
2014	.9352184	.3913508	2.39	0.023	.1370531	1.733384
2015	1.052006	.3962804	2.65	0.012	.2437865	1.860225
_cons	-44.07451	43.21445	-1.02	0.316	-132.211	44.06195
sigma_u	4.5462401					
sigma_e	.34848718					
rho	.9941585	(fraction of variance due to u_i)				

Output 2b – Fixed-effects regression with Capital Investment, time effect detail

Instrumental Variables approach - Complete Dataset

Another important part of the analysis, following the approach conducted by Cole et al. is studying how FDI affect the EPS index with the instrumental variable approach. We replicated the same steps used by the researchers and we instrumented the FDI count (Capital Invested) and the interaction with the control of corruption using the mobile cellular subscriptions, the urban share (and its quadratic term), the number of fixed phones and the labour force.

We can comment the following outputs and draw some conclusions.

If we take into consideration the regression with the instrumented FDI count but without the fixed effects (*Output 3)*, we see that the interaction between FDI count and the control of corruption has a positive impact overall and is significant, to confirm what we found in the previous model. The other coefficients are non-significant, even the effect of both *fdi_count* and *control_corruption* taken separately. We denote by the way a positive impact of *log_pop* which means that an increase in population tends to enhance the political stringency of a certain jurisdiction.

Number of observations	N =		360
Number of regressors	K =		50
Number of endogenous regressors	K1 =		2
Number of instruments	L =		53
Number of excluded instruments	L1 =		5

IV (2SLS) estimation

Estimates efficient for homoskedasticity only
Statistics robust to heteroskedasticity

		Number of obs =	360
		F(49, 310) =	77.28
		Prob > F =	0.0000
Total (centered) SS	= 331.0524531	Centered R2 =	0.8408
Total (uncentered) SS	= 2093.603715	Uncentered R2 =	0.9748
Residual SS	= 52.70191844	Root MSE =	.3826

pol_string	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
fdi_count	-.0005231	.0004592	-1.14	0.255	-.0014231	.0003769
fdi_x_corrupt	.0018949	.0004091	4.63	0.000	.0010931	.0026967
control_corruption	.197605	.197024	1.00	0.316	-.1885548	.5837649
log_gdp	.0084945	.1552282	0.05	0.956	-.2957472	.3127362
inflation	.0013373	.010498	0.13	0.899	-.0192384	.0219129
log_pop	3.708032	1.584759	2.34	0.019	.6019617	6.814102
year						
2004	.0890788	.1067313	0.83	0.404	-.1201108	.2982683
2005	.3667323	.1094261	3.35	0.001	.1522612	.5812035
2006	.4900317	.1218467	4.02	0.000	.2512165	.7288468
2007	.2858266	.1441759	1.98	0.047	.0032471	.5684061
2008	.3616063	.167466	2.16	0.031	.033379	.6898335
2009	.7216627	.1672041	4.32	0.000	.3939485	1.049377
2010	.7504437	.1771833	4.24	0.000	.4031708	1.097717
2011	.7679697	.1950147	3.94	0.000	.385748	1.150191
2012	.6413109	.2056248	3.12	0.002	.2382937	1.044328
2013	.5591061	.2610483	2.14	0.032	.0474609	1.070751
2014	.321072	.2960488	1.08	0.278	-.259173	.901317
2015	.3547592	.3261176	1.09	0.277	-.2844196	.9939379

Output 3 - IV regression with FDI count

We may go through the same approach but using the Capital Investment as a measure of FDI. In this case we denote a significative positive effect of *control_corruption* towards political stringency, as expected a more controlled country tends to have higher political stringency degree. The capital investment has a negative effect on political stringency (significative at 10%), which means that the higher the capital flows towards a destination country, the lower will be its political stringency. Finally, we have a positive effect of *log_pop*, as in the previous model, and a negative effect of *log_gdp*.

```
Number of observations              N  =        360
Number of regressors                K  =         50
Number of endogenous regressors     K1 =          2
Number of instruments               L  =         53
Number of excluded instruments      L1 =          5

IV (2SLS) estimation

Estimates efficient for homoskedasticity only
Statistics robust to heteroskedasticity

                                                      Number of obs =      360
                                                      F( 49,   310) =    75.52
                                                      Prob > F      =   0.0000
Total (centered) SS     =  331.0524531                Centered R2   =   0.8804
Total (uncentered) SS   =  2093.603715                Uncentered R2 =   0.9811
Residual SS             =  39.59538984                Root MSE      =    .3316
```

pol_string	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
CapitalInvestment	-.0000111	6.19e-06	-1.79	0.073	-.0000232	1.05e-06
CapInv_x_corrupt	5.35e-06	8.05e-06	0.66	0.506	-.0000104	.0000211
control_corruption	.4808666	.1660659	2.90	0.004	.1553834	.8063497
log_gdp	-.3574928	.137766	-2.59	0.009	-.6275091	-.0874765
inflation	.0049563	.009806	0.51	0.613	-.0142632	.0241757
log_pop	3.336289	1.30943	2.55	0.011	.7698534	5.902725
year						
2004	.1520248	.1026302	1.48	0.139	-.0491267	.3531763
2005	.4717576	.0988881	4.77	0.000	.2779404	.6655748
2006	.6939969	.0918282	7.56	0.000	.5140169	.8739769
2007	.5908557	.1033084	5.72	0.000	.3883751	.7933364
2008	.8132569	.1229361	6.62	0.000	.5723065	1.054207
2009	1.126378	.1129797	9.97	0.000	.9049422	1.347815
2010	1.179713	.1178155	10.01	0.000	.9487985	1.410627
2011	1.272012	.1267945	10.03	0.000	1.023499	1.520524
2012	1.13107	.1345125	8.41	0.000	.8674304	1.39471
2013	1.28052	.1621406	7.90	0.000	.9627305	1.59831
2014	1.141904	.1590438	7.18	0.000	.8301837	1.453624
2015	1.249308	.1534822	8.14	0.000	.9484881	1.550127

Output 4 - IV regression with Capital Investment

Fixed-Effects Model – Top 8 Countries

To understand whether the results are confirmed or not and to try to enhance and exaggerate the expected implications reported in the mathematical model, i.e. that the net effect of FDIs towards the political stringency depends on the level of corruptibility of the host country, we decided for this thesis to replicate the analysis using two restricted databases.

Now we shall discuss the output produced. We start by replicating the same regression models we used for the complete panel and apply it to the dataset composed by the "Top 8" Countries with the highest degree of control of corruption.

The first output (*Output 5a and 5b*) shows a positive effect of the interaction of FDI count and control of corruption and a negative coefficient of the two regressors taken individually. This confirms what we understood from the complete dataset: the more the number of FDI, the less stringent the regulations but if the countries are particularly controlled, the increase in the number of FDIs makes the regulations more stringent.

We can observe a positive impact of *log_gdp* on the political stringency and a negative coefficient of *inflation*. The other terms are non-significative, and the time effect is less clear.

The second output instead (Output 6a and 6b) shows only a positive effect of *log_gdp* and *urban_sh* (with significance level of 10%) and a negative effect of the quadratic term *urban_sh2* which means that the urban population share has a positive impact on political stringency but with diminishing returns, so the more people live in urban areas the more stringent the regulation, but the marginal effect of a person more in this share is diminishing. In the same way, here the time effect is not present.

```
Fixed-effects (within) regression               Number of obs      =        78
Group variable: iso_code                        Number of groups   =         8

R-sq:                                           Obs per group:
     within  = 0.8835                                         min =          9
     between = 0.0023                                         avg =        9.8
     overall = 0.3131                                         max =         12

                                                F(7,7)            =          .
corr(u_i, Xb)  = -0.7155                        Prob > F          =          .

                                 (Std. Err. adjusted for 8 clusters in iso_code)
--------------------------------------------------------------------------------
                   |               Robust
        pol_string |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------------+------------------------------------------------------------
     fdi_x_corrupt |
               L1. |   .0171484    .005034     3.41   0.011     .0052448    .0290519
                   |
         fdi_count |
               L1. |  -.0358425   .0120668    -2.97   0.021    -.0643758   -.0073091
                   |
control_corruption |
               L1. |  -1.412669   .7587121    -1.86   0.105    -3.206738    .3813995
                   |
           log_gdp |
               L1. |   2.686473   1.036479     2.59   0.036     .2355897    5.137356
                   |
          urban_sh |
               L1. |    1.22876   1.576552     0.78   0.461    -2.499194    4.956713
                   |
         urban_sh2 |
               L1. |  -.0069051   .0093651    -0.74   0.485      -.02905    .0152399
                   |
           log_pop |
               L1. |  -2.770084    12.9752    -0.21   0.837    -33.45157     27.9114
                   |
         inflation |
               L1. |  -.0240224   .0101548    -2.37   0.050    -.0480347   -.0000102
                   |
           mob_sub |
               L1. |  -.0035744   .0084254    -0.42   0.684    -.0234973    .0163485
                   |
         lab_force |
               L1. |   1.76e-07   2.65e-07     0.66   0.528    -4.51e-07    8.02e-07
```

Output 15a – Fixed-effects Regression with FDI count, Top 8 Countries

```
                   |
              year |
              2005 |  -.0562593    .225239    -0.25   0.810    -.5888648    .4763462
              2006 |   .0262328   .2353559     0.11   0.914    -.5302954     .582761
              2007 |  -.2078513   .3036044    -0.68   0.516    -.9257616     .510059
              2008 |  -.3307656   .4274914    -0.77   0.464    -1.341622    .6800908
              2009 |  -.0322038   .5249218    -0.06   0.953    -1.273447    1.209039
              2010 |   .1539753   .6916109     0.22   0.830    -1.481425    1.789375
              2011 |   .1083981   .7820712     0.14   0.894    -1.740906    1.957703
              2012 |  -.1529188   .8856749    -0.17   0.868    -2.247207     1.94137
              2013 |   .1707915   1.081553     0.16   0.879    -2.386676    2.728259
              2014 |  -.0389674   1.082579    -0.04   0.972     -2.59886    2.520926
              2015 |   .6947488   1.167948     0.59   0.571     -2.06701    3.456508
                   |
             _cons |  -76.85158     178.33    -0.43   0.679     -498.535    344.8319
-------------------+------------------------------------------------------------
           sigma_u |   .7802126
           sigma_e |  .26740909
               rho |  .89487873   (fraction of variance due to u_i)
--------------------------------------------------------------------------------
```

Output 5b - Fixed effects Regression with FDI count, Top 8 Countries, time effect detail

```
Fixed-effects (within) regression               Number of obs     =         78
Group variable: iso_code                        Number of groups  =          8

R-sq:                                           Obs per group:
     within  = 0.8655                                         min =          9
     between = 0.0278                                         avg =        9.8
     overall = 0.2429                                         max =         12

                                                F(7,7)            =          .
corr(u_i, Xb)  = -0.8323                        Prob > F          =          .

                                 (Std. Err. adjusted for 8 clusters in iso_code)
```

pol_string	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
CapInv_x_corrupt L1.	.0000454	.0001002	0.45	0.664	-.0001915	.0002822
CapInv L1.	-.0000894	.0002013	-0.44	0.670	-.0005653	.0003866
control_corruption L1.	.1035473	.4989356	0.21	0.841	-1.076248	1.283342
log_gdp L1.	2.290477	1.092118	2.10	0.074	-.2919707	4.872924
urban_sh L1.	1.99859	1.003713	1.99	0.087	-.3748147	4.371994
urban_sh2 L1.	-.0115696	.0058889	-1.96	0.090	-.0254947	.0023554
log_pop L1.	-5.50876	13.42715	-0.41	0.694	-37.25892	26.2414
inflation L1.	-.0267912	.0163019	-1.64	0.144	-.065339	.0117566
mob_sub L1.	.0012972	.0076687	0.17	0.870	-.0168363	.0194307
lab_force L1.	3.06e-07	2.11e-07	1.45	0.191	-1.93e-07	8.04e-07

Output 6a - Fixed effects regression with Capital Investment, Top 8 Countries

year						
2005	-.003336	.221108	-0.02	0.988	-.5261734	.5195015
2006	.1163258	.2188257	0.53	0.611	-.4011148	.6337663
2007	-.1252548	.3412461	-0.37	0.724	-.9321737	.681664
2008	-.20582	.4055009	-0.51	0.627	-1.164677	.7530372
2009	.1299483	.5529321	0.24	0.821	-1.177528	1.437425
2010	.2524893	.6138265	0.41	0.693	-1.19898	1.703958
2011	.2337309	.7200709	0.32	0.755	-1.468966	1.936428
2012	-.005985	.8137732	-0.01	0.994	-1.930253	1.918283
2013	.031688	.8646572	0.04	0.972	-2.012901	2.076277
2014	-.655923	1.132647	-0.58	0.581	-3.334208	2.022361
2015	-.2300917	1.170194	-0.20	0.850	-2.997161	2.536977
_cons	-58.30918	183.8856	-0.32	0.760	-493.1295	376.5111
sigma_u	1.0670816					
sigma_e	.28722755					
rho	.93244171	(fraction of variance due to u_i)				

Output 6b - Fixed effects regression with Capital Investment, Top 8 Countries, time effect detail

Instrumental Variables Approach – Top 8 Countries

Applying the IV approach to this restricted dataset, we lose the majority of the significative results (see *Output 8* and *9)*, but we can find the negative effect of the inflation on the political stringency degree: the higher the inflation, the less stringent the regulations. As expected, the control of corruption has a positive impact on political stringency with significance level of 8.5%. If we consider only the *Output 8*, we confirm the positive effect of *log_gdp* on the EPS index.

IV (2SLS) estimation

Estimates efficient for homoskedasticity only
Statistics robust to heteroskedasticity

		Number of obs =	86
		F(25, 60) =	45.34
		Prob > F =	0.0000
Total (centered) SS	= 44.84592417	Centered R2 =	0.8683
Total (uncentered) SS	= 728.5925262	Uncentered R2 =	0.9919
Residual SS	= 5.905724993	Root MSE =	.2621

pol_string	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
fdi_count	.0164857	.0151613	1.09	0.277	-.0132299	.0462013
fdi_x_corrupt	-.006447	.0070644	-0.91	0.361	-.020293	.0073989
control_corruption	1.288874	.7493045	1.72	0.085	-.1797356	2.757484
log_gdp	.7529608	.7320166	1.03	0.304	-.6817654	2.187687
inflation	-.0379378	.01808	-2.10	0.036	-.0733739	-.0025017
log_pop	-3.333974	5.448088	-0.61	0.541	-14.01203	7.344083
year						
2004	-.0216681	.1510082	-0.14	0.886	-.3176388	.2743026
2005	.3661667	.1902612	1.92	0.054	-.0067384	.7390719
2006	.5093282	.2197556	2.32	0.020	.0786152	.9400412
2007	.3643315	.2969102	1.23	0.220	-.2176019	.9462649
2008	.6248257	.3571331	1.75	0.080	-.0751423	1.324794
2009	1.166227	.2672128	4.36	0.000	.6424999	1.689955
2010	1.100089	.3346495	3.29	0.001	.4441877	1.75599
2011	1.09611	.3445117	3.18	0.001	.420879	1.77134
2012	1.058217	.3017419	3.51	0.000	.4668133	1.64962
2013	1.127782	.3736957	3.02	0.003	.3953522	1.860213
2014	.0799358	.3725155	0.21	0.830	-.6501811	.8100528
2015	.9061007	.3705422	2.45	0.014	.1798514	1.63235

Output 7 - IV Regression with FDI Count, Top 8 Countries

IV (2SLS) estimation

Estimates efficient for homoskedasticity only
Statistics robust to heteroskedasticity

		Number of obs =	86
		F(25, 60) =	33.92
		Prob > F =	0.0000
Total (centered) SS =	44.84592417	Centered R2 =	0.8051
Total (uncentered) SS =	728.5925262	Uncentered R2 =	0.9880
Residual SS =	8.739972821	Root MSE =	.3188

pol_string	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
CapInv	-.0002797	.0002182	-1.28	0.200	-.0007074	.0001479
CapInv_x_corrupt	.0001534	.0001155	1.33	0.184	-.0000729	.0003798
control_corruption	-.3521181	.6465077	-0.54	0.586	-1.61925	.9150137
log_gdp	1.667113	.832954	2.00	0.045	.0345527	3.299673
inflation	-.0284221	.0223173	-1.27	0.203	-.0721631	.015319
log_pop	1.855172	5.956338	0.31	0.755	-9.819035	13.52938
year						
2004	-.0728134	.1660108	-0.44	0.661	-.3981885	.2525618
2005	.214061	.1947149	1.10	0.272	-.1675731	.5956952
2006	.2672876	.2065854	1.29	0.196	-.1376123	.6721876
2007	-.0046803	.3028918	-0.02	0.988	-.5983374	.5889768
2008	.0226887	.3917728	0.06	0.954	-.745172	.7905493
2009	.6869428	.2621025	2.62	0.009	.1732313	1.200654
2010	.4055066	.3699481	1.10	0.273	-.3195784	1.130592
2011	.4570416	.3602596	1.27	0.205	-.2490543	1.163138
2012	.5754369	.2889877	1.99	0.046	.0090314	1.141842
2013	1.077996	.5742689	1.88	0.060	-.0475508	2.203542
2014	.4057994	.4252203	0.95	0.340	-.4276171	1.239216
2015	.7074054	.4634252	1.53	0.127	-.2008912	1.615702

Output 8 - IV Regression with Capital Investment, Top 8 Countries

Fixed-Effects Model – Flop 8 Countries

We finally repeat our analysis for another restricted dataset representing the "Flop 8" countries whose degree of corruption control is relatively lower.

Output 9a,9b,10a and 10b confirm the positive effect of *urban_sh* with diminishing returns and the positive time effect on the degree of political stringency of the destination country of an FDI, so as time passes, we expect political stringency degree to increase even for more corrupted countries.

Unfortunately, all the other parameters are non-significative so we cannot draw any conclusion.

Fixed-effects (within) regression		Number of obs =	81
Group variable: iso_code		Number of groups =	7
R-sq:		Obs per group:	
within = 0.6826		min =	9
between = 0.6130		avg =	11.6
overall = 0.1861		max =	12
		F(6,6) =	.
corr(u_i, Xb) = -0.9463		Prob > F =	.

(Std. Err. adjusted for 7 clusters in iso_code)

pol_string	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
fdi_x_corrupt L1.	.0009476	.0005558	1.71	0.139	-.0004123	.0023075
fdi_count L1.	.0003445	.0002647	1.30	0.241	-.0003033	.0009922
control_corruption L1.	-.2757381	.3692619	-0.75	0.483	-1.179289	.6278133
log_gdp L1.	.1033396	.2519583	0.41	0.696	-.5131802	.7198594
urban_sh L1.	.3300449	.065111	5.07	0.002	.170724	.4893658
urban_sh2 L1.	-.0027165	.000677	-4.01	0.007	-.0043729	-.00106
log_pop L1.	1.331478	1.769833	0.75	0.480	-2.999148	5.662104
inflation L1.	-.0047547	.0104544	-0.45	0.665	-.0303358	.0208263
mob_sub L1.	-.0041389	.0039411	-1.05	0.334	-.0137824	.0055046
lab_force L1.	-4.86e-09	7.60e-09	-0.64	0.546	-2.35e-08	1.37e-08

Output 9a - Fixed-effects regression with FDI count, Flop 8 Countries

year						
2005	.0571491	.0714583	0.80	0.454	-.1177031	.2320013
2006	.0959163	.1572814	0.61	0.564	-.2889374	.4807699
2007	.0654374	.236812	0.28	0.792	-.5140207	.6448956
2008	.0580624	.289256	0.20	0.848	-.6497217	.7658464
2009	.362139	.4934658	0.73	0.491	-.8453283	1.569606
2010	.5072017	.5626952	0.90	0.402	-.869664	1.884067
2011	.5607714	.5841161	0.96	0.374	-.8685092	1.990052
2012	.4700701	.4824331	0.97	0.368	-.7104012	1.650541
2013	.449074	.5267561	0.85	0.427	-.8398517	1.738
2014	.4638588	.5646144	0.82	0.443	-.9177029	1.845421
2015	.583831	.5978228	0.98	0.366	-.8789886	2.046651
_cons	-35.34872	40.24083	-0.88	0.414	-133.8145	63.11705
sigma_u	1.7395355					
sigma_e	.24590332					
rho	.98040843	(fraction of variance due to u_i)				

Output 9b - Fixed-effects regression with FDI count, Flop 8 Countries, time effect detail

```
Fixed-effects (within) regression               Number of obs      =         81
Group variable: iso_code                        Number of groups   =          7

R-sq:                                           Obs per group:
     within  = 0.6884                                         min =          9
     between = 0.3020                                         avg =       11.6
     overall = 0.0791                                         max =         12

                                                F(6,6)             =          .
corr(u_i, Xb)  = -0.9710                        Prob > F           =          .

                                 (Std. Err. adjusted for 7 clusters in iso_code)
```

pol_string	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
CapInv_x_corrupt L1.	9.76e-06	.0000101	0.96	0.373	-.000015	.0000345
CapInv L1.	-2.57e-06	9.04e-06	-0.28	0.786	-.0000247	.0000195
control_corruption L1.	-.0513123	.4970739	-0.10	0.921	-1.267608	1.164984
log_gdp L1.	.0309037	.3150198	0.10	0.925	-.7399221	.8017295
urban_sh L1.	.2516887	.0604931	4.16	0.006	.1036674	.39971
urban_sh2 L1.	-.0020465	.0004592	-4.46	0.004	-.0031701	-.000923
log_pop L1.	1.831826	1.910947	0.96	0.375	-2.844094	6.507745
inflation L1.	-.0020895	.0103502	-0.20	0.847	-.0274155	.0232364
mob_sub L1.	-.0034772	.0035229	-0.99	0.362	-.0120975	.0051431
lab_force L1.	-2.34e-09	6.74e-09	-0.35	0.741	-1.88e-08	1.42e-08

Output 10a - Fixed-effects regression with Capital Investment, Flop 8 Countries

year						
2005	.0571491	.0714583	0.80	0.454	-.1177031	.2320013
2006	.0959163	.1572814	0.61	0.564	-.2889374	.4807699
2007	.0654374	.236812	0.28	0.792	-.5140207	.6448956
2008	.0580624	.289256	0.20	0.848	-.6497217	.7658464
2009	.362139	.4934658	0.73	0.491	-.8453283	1.569606
2010	.5072017	.5626952	0.90	0.402	-.869664	1.884067
2011	.5607714	.5841161	0.96	0.374	-.8685092	1.990052
2012	.4700701	.4824331	0.97	0.368	-.7104012	1.650541
2013	.449074	.5267561	0.85	0.427	-.8398517	1.738
2014	.4638588	.5646144	0.82	0.443	-.9177029	1.845421
2015	.583831	.5978228	0.98	0.366	-.8789886	2.046651
_cons	-35.34872	40.24083	-0.88	0.414	-133.8145	63.11705
sigma_u	1.7395355					
sigma_e	.24590332					
rho	.98040843	(fraction of variance due to u_i)				

Output 10b - Fixed-effects regression with Capital Investment, Flop 8 Countries, Time effect detail

Instrumental Variables Approach – Flop 8 Countries

In conclusion, we will analyse the last two outputs (*Output 11* and *12*) resulting from the application of IV approach to the "Flop 8" database.

Output 11 shows a negative impact of *fdi_count* on political stringency, as one could expect, but makes non significative the interaction between the FDI count and the corruption control. We may observe a positive impact of *log_pop* on the EPS index, the time effect is less prominent.

Output 12 confirms the negative impact of the Capital Investment on the political stringency degree of the destination country and the positive coefficient related to *log_pop*, moreover it adds the positive impact of *control_corruption* on the EPS index, as one could expect. This output reflects again a less prominent time effect.

IV (2SLS) estimation

Estimates efficient for homoskedasticity only
Statistics robust to heteroskedasticity

		Number of obs =	88
		F(24, 63) =	34.16
		Prob > F =	0.0000
Total (centered) SS	= 28.02973227	Centered R2 =	0.8062
Total (uncentered) SS	= 109.3771202	Uncentered R2 =	0.9503
Residual SS	= 5.433402335	Root MSE =	.2485

pol_string	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
fdi_count	-.0025207	.0007161	-3.52	0.000	-.0039242	-.0011172
fdi_x_corrupt	-.0003092	.0008758	-0.35	0.724	-.0020258	.0014074
control_corruption	.5511418	.418898	1.32	0.188	-.2698832	1.372167
log_gdp	-.1373459	.2117363	-0.65	0.517	-.5523413	.2776496
inflation	.0023296	.0122849	0.19	0.850	-.0217484	.0264077
log_pop	6.31102	1.765208	3.58	0.000	2.851276	9.770764
year						
2004	.0747704	.1178717	0.63	0.526	-.1562539	.3057947
2005	-.0406041	.1338508	-0.30	0.762	-.3029467	.2217386
2006	.1292631	.1557965	0.83	0.407	-.1760926	.4346187
2007	-.0370406	.1716379	-0.22	0.829	-.3734447	.2993634
2008	.2548145	.213657	1.19	0.233	-.1639456	.6735746
2009	.2383655	.2979828	0.80	0.424	-.3456702	.8224011
2010	.5060953	.2786452	1.82	0.069	-.0400393	1.05223
2011	.6944363	.3141642	2.21	0.027	.0786858	1.310187
2012	.4181805	.3475783	1.20	0.229	-.2630606	1.099422
2013	.2684362	.3920091	0.68	0.493	-.4998875	1.03676
2014	.0991856	.3843387	0.26	0.796	-.6541043	.8524756
2015	.0457645	.3743997	0.12	0.903	-.6880454	.7795743

Output 11 - IV Regression with FDI Count, Flop 8 Countries

IV (2SLS) estimation

Estimates efficient for homoskedasticity only
Statistics robust to heteroskedasticity

		Number of obs =	88
		F(24, 63) =	25.31
		Prob > F =	0.0000
Total (centered) SS =	28.02973227	Centered R2 =	0.7820
Total (uncentered) SS =	109.3771202	Uncentered R2 =	0.9441
Residual SS =	6.10970987	Root MSE =	.2635

pol_string	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
CapInv	-.000025	9.64e-06	-2.59	0.010	-.0000439	-6.09e-06
CapInv_x_corrupt	4.46e-07	.0000126	0.04	0.972	-.0000243	.0000251
control_corruption	.8375548	.4612036	1.82	0.069	-.0663876	1.741497
log_gdp	-.288197	.2497212	-1.15	0.248	-.7776415	.2012476
inflation	-.0071341	.0100973	-0.71	0.480	-.0269245	.0126563
log_pop	5.651431	1.962325	2.88	0.004	1.805344	9.497518
year						
2004	.0050333	.1404027	0.04	0.971	-.2701509	.2802176
2005	-.1061328	.1709783	-0.62	0.535	-.4412441	.2289786
2006	.1279345	.1690687	0.76	0.449	-.203434	.459303
2007	.130851	.1987275	0.66	0.510	-.2586478	.5203498
2008	.4663532	.2600018	1.79	0.073	-.0432409	.9759473
2009	.4984844	.2984891	1.67	0.095	-.0865435	1.083512
2010	.6488689	.3195189	2.03	0.042	.0226235	1.275114
2011	.7927056	.3571037	2.22	0.026	.0927953	1.492616
2012	.375374	.3848012	0.98	0.329	-.3788225	1.129571
2013	.2806035	.4046422	0.69	0.488	-.5124807	1.073688
2014	.1898418	.4130249	0.46	0.646	-.6196721	.9993557
2015	.3381864	.4110415	0.82	0.411	-.4674401	1.143813

Output 12 - IV Regression with Capital Investment, Flop 8 Countries

Conclusions

The literature analyzed deeply the effects of environmental regulation stringency on FDIs, but not the inverse relationship. Starting from the work of Cole et al. we decided to better understand what may happen if one takes another perspective analyzing the same measures and try to utilize more updated data that could give us some deeper insights.

The political economy model described by the researchers however did not find consistency with our empirical results since the expected effect of the interaction between the measure of FDI and the control of corruption is shown only if we take into consideration the number of FDIs and only for the least corrupted countries (see output 5a). This is of course a limited dataset which was intended to accentuate the expected effect and relationship described in the model by proposition 1.

We may conclude that, if we use a complete dataset, in which we take into consideration both corrupted and virtuous countries, the results may be uncertain, and the coefficients of interest are still almost negligible.

We then decided to better understand why the results were so dependent on the cluster of countries, and so we better investigate the instruments validity, strength, and exogeneity.

To check for weak instruments, we utilize the first-stage F-statistic and as a rule of thumb, if it is less than 10, then the set of instruments is weak. This situation will produce a biased Two-Stage Least Square (TSLS) estimator, and the statistical inferences will be misleading. In many cases we find that the test detected weak instruments in our dataset so, since we had many instruments and they are weak, it is recommended to exclude the weaker ones and see how the first-stage F will change.

An instrument is exogeneous if it is uncorrelated with the error term

$$corr\ (Z_{1i}, u_i) = 0, \dots, corr(Z_{mi}, u_i) = 0$$

If the instruments are correlated, it is impossible to isolate the component of X that is uncorrelated with the error term, so the estimated value of X is correlated with u and the TSLS is inconsistent. This is easy to understand when if you instrument the X with two valid instruments and compare two separate TSLS estimates you find very different results. We also used the J-test statistic to test overidentifying restrictions and better understand whether or not an instrument is invalid.

Here is reported the basic procedure to test overidentifying restrictions:

- Estimate the equation of interest using TSLS and all the m instruments,
- Compute the predicted $\hat{Y}$ using beta-hat-TSLS and the observed X's (not $\hat{X}$'s)
- Compute the residuals $\widehat{u_i} = Y_i - \widehat{Y_i}$
- Regress $\widehat{u_i}$ against $Z_{1i}, \dots, Z_{mi}, \; W_{1i}, \dots, W_{ri}$
- Compute the F-statistic testing the hypothesis that the coefficients on $Z_{1i}, \dots, Z_{mi}$, are all zero
- The J-statistic is J=mF

Here is reported the overview of the tests on the instruments and we may conclude that the instruments are weak and for a better analysis one should choose different instruments. This task could be quite challenging and however is out of scope of this thesis, which had the aim to replicate the study done by Cole et al. using a more recent dataset.

Test ID	**FDI measure**	**F-statistic**	**J-statistic (p-value)**
Complete Dataset	fdi_count	9.04	11%
Complete Dataset	CapitalInvestment	7.94	0%
Flop 8	fdi_count	8.05	15%
Flop 8	CapitalInvestment	7.88	25%
Top 8	fdi_count	5.79	17%
Top 8	CapitalInvestment	4.5	20%

Table 2 - F-statistic and J-statistic

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