Thesis Abstract

Since 1990's, environmental deterioration has obtained an increasing interest and it is one of the most important issue in the policy debate at the international level. Nevertheless, improvements have been made through, though this kind of problems still have negative effects on human and natural survival. Considering this scenario, governments have done important efforts in order to coordinate their policies towards the promotion of a sustainable development, by fostering an efficient use of natural resources and a reduction of emissions. This process is a long-term mechanism that needs changes in both consumption and production behaviours. Concerning production side, many studies have investigated the relationship between environmental issues, green policies and different economic factors, and many hypotheses have been formulated (Porter Hypothesis, Pollution Haven, etc.). Among these factors, trade and innovation have a relevant effect, so authorities should apply policies that encourage trade and innovation in a sustainable perspective. It is also true that empirical researches have underlined that the relationship among trade, innovation and environment is multi-directional. This means that producers have to manage trade and innovation by considering the environmental scenario but they should also take economic advantage from being green. In view of this, it is evident that the relationship among trade, innovation and sustainability is complex and requires an intensive collaboration between all stakeholders, from governments to consumers and firms.

By considering the worldwide importance of this relation, the present thesis aims at deeply investigating the interplay of environmental policies with the adoption of innovation and trade decision at firm level. It also has the objective of analysing the effect of trade and innovation on country level emissions. The thesis is divided into three chapters. In the first two chapters, micro level analyses have been conducted, both from theoretical and empirical perspectives, while in the third one a cross-country study has been done. The three chapters are hereafter described.

The first essay theoretically investigates the role of firm heterogeneity into the Porter Hypothesis dynamics. By using the version of Melitz's international trade model proposed by Helpman (2006), we study the effects of the introduction of an environmental tax on technology and trade decisions of firms. Specifically, we suppose that firms could be dirty or clean, depending on the adopted technology, when the government introduces an environmental tax. Clean firms adopt a total abatement technology so that they do not pay the tax. Firms can choose among three types of

technology (dirty-type, clean-type 1 and clean-type 2), which require a different amount of fixed and variable costs. Clean-type 2 technology is more complex than clean-type 1 one. Technology decision has an impact on firms' productivity, which subsequently affects their exporting propensity. This chapter suggests four important results. First, in a situation where all firms are dirty, governments could use the environmental tax as a good instrument for reducing pollution because it forces the least productive firms to leave the market, with a reduction of emissions and an improvement of the average productivity. Second, if firms may choose between a dirty and a clean technology, they are encouraged to adopt a clean technology when the value of the tax is sufficiently high. Since this kind of technology requires a higher level of fixed costs for its implementation, these costs can be compensated by some tax savings. Third, if we consider a scenario with clean-type 1 and clean-type 2 technologies, firms will opt for a more advanced technology if it is economically convenient. This means that firms introduce a complex abatement technology only when a highly-efficient firm is able to cope with it. Finally, in a scenario where all types of technology can be chosen by firms, the international organisation of production and technology adoption will depend on different aspects, such as the amount of the environmental tax, the relationship between variable and fixed costs that each technology requires.

The second study is conducted in order to empirically analyse Pollution Havens and Porter Hypothesis by accounting for the role of firm heterogeneity in trade, innovation and environmental regulation. Specifically, we econometrically test, with reference to CIS2008 and CIS2014 manufacturing German firms, the hypothesis of a negative impact of environmental regulation on exporting propensity and the vision of a positive effect of regulation on innovation and, indirectly, on trade performance. The empirical analysis demonstrates that the hypothesis of the Pollution Haven Effect is confirmed for German firms in CIS2014 and when an environmental taxation is implemented. Differently from the existing literature, which suggests that the introduction of an eco-regulation entails some additional compliance costs and, correspondingly, a decreases competitiveness, a not significant effect of policy on exporting propensity of firms is obtained for CIS2008 and CIS2014. Since we expect that regulations have a higher impact on firms' competitiveness in more pollutant sectors, we admit heterogeneous coefficients of the eco-regulation variable by sector emission intensity. Specifically, sectors are classified as green, grey and brown and results suggest that eco-regulation has a negative effect on exporting propensity in brown sectors only, though losing robustness over time from CIS2008 to CIS2014.

Moreover, we have found that eco-innovation positively affects the probability of exporting. Another important result concerns the effect of environmental regulation on eco-innovation adoption. In line with the related literature on the well-known *weak* Porter Hypothesis, we find that regulation is a

fundamental driver of innovation; the introduction of a new or a stringent environmental policy represents an incentive for firms to be innovative.

Since policy makers should consider that firms could react differently to regulation in the eco-regulation drawing process, the two perspectives are also tested on three subsamples: small, medium and large firms. This analysis is important because size represents another measure of firm's productivity, so of its efficiency level and competitive capacity. Concerning small firms, environmental policies do not affect trade propensity but are relevant for the introduction of eco-innovation. However, the latter positive effect of regulations must be associated with public financial incentives. For medium and large firms, we can state that the existence of a green policy brings firms to be non-exporters. In other words, medium, either brown or grey, firms are less competitive if an eco-regulation is imposed. However, environmental innovation adoption is driven by eco-regulation and is itself a driver for being an exporter.

The thesis is completed by a third macroeconomic level study, that aims at analysing different country characteristics, such as internationalisation and innovation profiles, which affect greenhouse gases and acidifying gases emissions in European Union countries. We decompose the overall level of emissions in scale, composition and technique effects by the Log Mean Divisia Index method. Then we investigate the determinants of each component by implementing a fixed effect Seemingly Unrelated Regression estimation. The analysis of different components is conducted through three steps. First, we investigate the effect of per capita income on air emissions. Specifically, we test the Environmental Kuznets Curve hypothesis, which underlines an inverted U-shaped relationship between income and pollution. By following the literature, as a second step, we account for the direct impact of other important economic factors in affecting the shape and turning point of the Kuznets curve, such as trade, eco-innovation, relative factor abundance and renewable energy use. Eco-innovation and renewable energy use can capture the technological progress of a country and the efficient use of resources. We expect that both variables positively contribute to the reduction of pollution. Furthermore, relative factor endowments, together with eco-innovation, is a fundamental measure of country comparative advantage. Trade has been taken into account because, as the existing empirical evidence shows, its effect on emission can be ambiguous, it could either increase or decrease pollution. Finally, as a third step, since trade has also an indirect effect on pollution through scale, composition and technique effects, we measure the trade-induced impact by adding some interaction terms. The econometric analysis of European Union countries data over 2008-2014 years show that all described economic factors differently affect the three above-mentioned effects and results are strictly related to the analysed type of pollutant. For greenhouse gases, the Environmental Kuznets Curve hypothesis cannot be rejected and is totally driven by the scale effect. This result is

not verified for acidifying gases emissions. Furthermore, trade directly increases the level of both air pollutants and this is connected with the scale effect. This means that trade contributes to an increase of domestic economic activity which is reflected into an expansion of production and emissions. Trade also has an indirect impact through income, relative factors endowments and renewable energy use on air emissions, which may be either positive or negative. As a final important result, we obtain that both pollutants show a general reduction over time, common to all European Union countries, and this trend is mainly driven by the technique effect. Thus, we can argue that the European Union common policy tools fostering environmental friendly technology have contributed to improve air quality, although the 2008 worldwide crisis has certainly contributed to this decreasing trend.