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THE ANALYSIS OF THE DOUBLE DIVIDEND FROM THE PERSPECTIVE OF PUBLIC AND PRIVATE FINANCE

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SUMMARY

The analysis of the double dividend from the perspective of public and private finance

The double dividend is a concept which emanates from the broader discussion on environmental policy. It posits simultaneous environmental and economic effects (dividends) of environmental taxation. The double dividend is the central concept of the thesis, which aims to reconceptualize the double dividend and provide empirical estimates of the double dividend at various levels. Reconceptualizing the double dividend to extend it from the public towards its private aspect is crucial for the green economy transition which requires vast funding needs. The aims of the thesis are thus twofold: to augment the concept of the double dividend and to provide empirical estimates on the effects of environmental policy (taxation) on the key policy variables and the financial attractiveness of sustainable finance so as to assess the tentative double dividend.

The double dividend term was explicitly coined in the beginning of the 1990s, a period associated with the rise of the well-being theory of sustainable development. Sustainable development appears towards the end of the 1980s as a response to the environmental movements of the 1960s. The double dividend posits environmental and economic benefits and thus falls within the broader economy-environment nexus. The concept first appears in relation to the introduction of environmental tax reforms across Europe in the 1990's, which posit simultaneous environmental and economic benefits (dividends). The double dividend is a term which emanates from environmental policy and is thus a public finance concept. However, the funding needs for the green economy transition and management trends provide the rationale for the reconceptualization of the double dividend towards the private sector.

Reconceptualizing the double dividend as a public and private finance concept is the first aim of the thesis. Empirical estimates for the effects of environmental policy are scarce, which represents a research niche. Thus, the second aim of the thesis is to provide ex-post empirical estimates of the double dividend at the national, sectoral and firm level. In relation to this, we pose the following research questions: (1) Can energy taxation deliver a double dividend through its effect on energy dependence and the balance of payments? (2) Has energy taxation delivered a double dividend in terms of economic variables such as employment and value added? (3) Is there a double dividend in private sustainable (renewable) finance in terms of the financial attractiveness of sustainable or renewable energy stocks?

The thesis has four main contributions. The first contribution is theoretical and relates to the first aim of the thesis, which is the reconceptualization of the double dividend towards its private aspect. The other contributions are empirical and relate to the three research questions listed above. This relates to the second aim of the thesis. The thesis is structured as follows: the first chapter covers the concept of the double dividend. The remaining two

chapters are devoted to the public and private finance aspects of the double dividend respectively.

The first chapter presents the double dividend as a concept within the economy-environment nexus. The double dividend is a relatively new concept, dating back to the 1990s. The overview of the economy-environment nexus covered either one of the two dimensions: economic or environmental. The first analysis of the two dimensions simultaneously appears towards the end of the 1970s but it was not explicitly formalized until the beginning of the 1990s with the double dividend concept. The latter entails simultaneous environmental and economic benefits from environmental taxation. The first chapter covers the reconceptualization of the double dividend and makes the argument that it is sensible to extend the concept towards the private sector as well. The latter is due to the vast funding needs for the green economy transition and contemporary management trends such as corporate social responsibility.

The next two chapters cover the public and private finance aspects of the double dividend. The economic dividend is covered empirically through the empirical analyses of the economic dividend at the national and sectoral level. The environmental dividend is analyzed implicitly. At the national level we analyze the effect of environmental taxation on the trade balance (research question no.1), whereas the sectoral level analysis entails the effect of environmental taxation on sectoral value-added and employment (research question no.2). The results show that the current account is relatively persistent (over 0.5). Moreover, there is a long-run effect of energy taxes on the trade balance between 3 and 4 percentage points for every 1 p.p. increase in the energy tax level. The sectoral level analysis indicates negative effects on sectoral value added and employment, in the industrial sector.

Chapter 3 covers the private finance aspects of the double dividend discussion. It comprises of an empirical analysis of the double dividend at the firm level. The environmental dividend is covered implicitly through the selection of sustainable and renewable energy indices. The analysis of the economic dividend entails a risk and returns analysis of sustainable and renewable energy indices (research question no.3). Differentiating between the two aspects is relevant, since firms in the renewable energy sector are inherently more exposed to risk than sustainable firms in general. The results indicate negative returns and high volatility for renewable energy indices, which is expected. There is no substantial effect of sustainability per se on sustainable indices. The results are relevant for policy makers since they indicate the need for greater public support for the nascent renewable energy-sector. The latter may change with the future development of technology as well as consistent policy support for environmentalism in general.

Keywords: double dividend, economic dividend, environmental dividend, environmental taxation, sustainability

POVZETEK

Analiza dvojne dividende z vidika javnih in zasebnih financ

Koncept dvojne dividende se pojavi v okviru polemike o okoljski politiki, ko ob uvedbi okoljskih davkov sočasno ustvarjamo okoljske in ekonomske koristi (dividende). Dvojna dividenda je osrednja tema doktorske naloge. Namen disertacije je nadgraditi obstoječe razumevanje dvojne dividende z izključno javnofinančnega vidika ter empirično proučiti dvojno dividendo na različnih ravneh. Razširjeno razumevanje dvojne dividende tudi z zasebno-finančnega vidika je ključnega pomena z vidika doseganja ciljev trajnostnega razvoja, saj slednji zahteva izdatna finančna sredstva. Prvi cilj naloge je celoviteje opredeliti dvojno dividendo. Drugi cilj disertacije je empirično oceniti morebitno dvojno dividendo z vidika učinkov okoljske politike (okoljski davki) na glavne cilje ekonomske politike ter na finančno privlačnost trajnostnih in obnovljivih naložb.

Dvojna dividenda se konceptualno prvič pojavi v začetku 90-ih letih preteklega stoletja v povezavi z naraščajočim pomenom teorije sonaravnega razvoja. Teorija trajnostnega razvoja se pojavi konec 80-ih let kot odgovor na naraščajoče okoljske izzive v 60-ih letih preteklega stoletja. Dvojna dividenda poudarja razumevanje odnosa med okoljem in ekonomijo ter kot takšna pomeni doseganje sočasnih ekonomskih in okoljskih koristi (dividende). Z vidika izvajanja politik dvojno dividendo povezujemo predvsem z okoljskimi davčnimi reformami v Evropi v 90-ih letih preteklega stoletja. Dvojna dividenda izhaja iz okoljske politike, zato gre v osnovi za javnofinančni pojem. Ob tem velja opozoriti, da zelena tranzicija zahteva izredno visoka finančna sredstva ter da sodobni menedžerski pristopi vse bolj poudarjajo družbeno odgovorno vedenje in poslovanje podjetij. Zaradi slednjega je potrebno nadgraditi obstoječe razumevanje dvojne dividende skozi večjo vlogo zasebnega sektorja.

Opredelitev dvojne dividende z javnofinančnega in zasebno-finančnega vidika je prvi cilj doktorske naloge. Drugi cilj je empirična proučitev dvojne dividende z vidika ex-post učinkov na nacionalni, sektorski in podjetniški ravni. Tovrstne analize so v znanstveno-raziskovalni literaturi redke, kar predstavlja določeno raziskovalno nišo. V nalogi so opredeljena tri raziskovalna vprašanja: (1) Ali okoljska obdavčitev ustvarja dvojno dividendo skozi vpliv na energetsko odvisnost in plačilno bilanco? (2) Ali okoljska obdavčitev ustvarja dvojno dividendo skozi vpliv na zaposlenost in dodano vrednost? (3) Ali obstaja dvojna dividenda z vidika finančne privlačnosti trajnostnih in obnovljivih naložb?

Doktorska naloga ima štiri glavne prispevke. Prvi prispevek je teoretske narave in izhaja iz prvega cilja naloge ter potrebe po celovitejši opredelitvi in razumevanju dvojne dividende. Poleg javnofinančnega vidika je namreč potrebno močneje poudariti in izpostaviti tudi njen zasebno-finančni vidik. Preostali prispevki so empirične narave in izhajajo iz raziskovalnih vprašanj in drugega cilja naloge. Doktorska naloga ima tri glavna poglavja. Prvo poglavje

je namenjeno opredelitvi dvojne dividende. Naslednji dve poglavji sta namenjeni empiričnemu preučevanju javnofinančnega in zasebno-finančnega vidika dvojne dividende.

V prvem poglavju opredelimo dvojno dividendo. Dvojna dividenda je relativno nov koncept, ki se pojavi v začetku 90-ih letih preteklega stoletja. Razumevanje odnosa med okoljem in ekonomijo ima dolgo zgodovino, toda zgodnje ideje težko povezujemo s konceptom dvojne dividende, saj so različni pristopi namenjali pozornost bodisi ekonomskemu bodisi okoljskemu vidiku. Prva poglobljena analiza obeh vidikov se je pojavila šele proti koncu 70-ih let, konceptualno pa se ideja dvojne dividende dokončno oblikuje šele v začetku 90-ih let preteklega stoletja. Dvojna dividenda predstavlja sočasne ekonomske in okoljske koristi (dividende), ki nastanejo zaradi uvedbe okoljskih davkov. V prvem poglavju so predstavljeni razlogi za drugačno opredelitev in razumevanje dvojne dividende skozi večjo vlogo zasebnega sektorja. Za učinkovito zeleno tranzicijo bomo potrebovali predvsem mnogo več zasebnih virov. Obenem sodobne menedžerske prakse vse bolj postavljajo v ospredje družbeno odgovorno delovanje podjetij.

Naslednji dve poglavji empirično preučujeta javnofinančni in zasebno-finančni vidik dvojne dividende. Ekonomska dividenda je analizirana empirično na nacionalni in sektorski ravni, medtem ko je okoljska dividenda obravnavana implicitno. Na nacionalni ravni v nalogi proučujemo učinek okoljske obdavčitve na energetsko odvisnost in trgovinsko bilanco države (raziskovalno vprašanje št. 1). Na sektorski ravni analiziramo učinek okoljske obdavčitve na dodano vrednost in zaposlenost (raziskovalno vprašanje št. 2). Rezultati kažejo, da je persistentnost plačilne bilance relativno visoka (nad 0,5) ter da obstaja dolgoročni vpliv energetskih davkov na trgovinsko bilanco v višini med 3 in 4 o. t. za vsako 1 o. t. povečanja okoljskega (energetskega) davka. Rezultati sektorske analize kažejo na negativne učinke v industrijskem sektorju pri dodani vrednosti in zaposlenosti.

Tretje poglavje proučuje zasebno-finančni vidik dvojne dividende ter vključuje empirično analizo ekonomske dividende na ravni podjetij skozi finančno analizo donosov trajnostnih indeksov in indeksov obnovljivih virov energije (raziskovalno vprašanje št. 3). Okoljska dividenda je skozi primerjalno analizo okoljskih učinkov pri obnovljivih virih energije obravnavana implicitno. Razlikovanje med obema sektorjema je pomembno, saj je sektor obnovljivih virov energije izpostavljen večjemu tveganju kot sektor t. i. trajnostnih podjetij. Rezultati kažejo negativne učinke na indekse delnic obnovljivih virov energije ter na visoko volatilnost, kar je v skladu s pričakovanji. Pri trajnostnih indeksih ni opazen značilen učinek trajnostne usmeritve. Rezultati so pomembni tudi za nosilce ekonomske politike, saj poudarjajo potrebo po večji javnofinančni podpori za sektor obnovljivih virov energije. Slednje se lahko spremeni zaradi vse hitrejšega razvoja tehnologije ali zaradi konsistentnosti okoljske politike.

Ključne besede: dvojna dividenda, ekonomska dividenda, okoljska dividenda, okoljska obdavčitev, trajnost.

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LIST OF ABBREVIATIONS

sl. – Slovene

AGIGL– (sl.Indeks Ardour Global Alternative Energy Index); Ardour Global Alternative Energy Index

CAPM – (sl.Model vrednotenja dolgoročnih naložb); Capital Asset Pricing Model

CCL – (sl.Dajatev na spremembo podnebja); Climate Change Levy

CSR – (sl.Družbena odgovornost podjetij); Corporate Social Responsibility

DJSI– (sl.Indeks trajnosti Dow Jones); Dow Jones Sustainability Index

ECO– (sl.Indeks Wilderhill Clean Energy); Wilderhill Clean Energy Index

EKC – (sl. Okoljska Kuznetsova krivulja); Environmental Kuznets Curve

ER– (sl.Presežni donos); Excess Return

ESG – (sl. ESG); Environmental, Social and Governance

ETR – (sl. Zelena proračunska reforma); Environmental Tax Reform

ETS – (sl.Sistem za trgovanje z emisijami); Emissions Trading System

EU – (sl. Evropska unija); European Union

FDI– (sl.Tuje direktne investicije); Foreign Direct Investment

GMM – (sl.Posplošena metoda momentov); Generalized Method of Moments

GSFI – (sl.Globalne sistemsko pomembne inštitucije); Globally Systemic Financial Institutions

HDI – (sl. Indeks človeškega razvoja); Human Development Index

IEA – (sl. Mednarodna Agencija za Okolje); International Environmental Agency

IMF –(sl.Mednarodni denarni sklad); International Monetary Fund

MRP – (sl.Premija tržnega tveganja); Market risk premium

NEX– (sl.Indeks Wilderhill New Energy Global Innovation); Wilderhill New Energy Global Innovation Index

OECD – (sl. Organizacija za ekonomsko sodelovanje in razvoj); Organization for

Economic Cooperation and Development

OLS – (sl.Metoda najmanjših kvadratov); Ordinary Least squares

PPP – (sl.Pariteta kupne moči); Purchasing Power Parity

ROA – (sl.Donos na sredstva); Return on Assets

ROE – (sl.Donos na kapital); Return on Equity

SRI– (sl.Družbeno odgovorno investiranje); Socially Responsible Investing

UN – (sl. Združeni narodi) ; United Nations

UNFCCC-(sl.Okvirna konvencija Združenih Narodov o spremembi podnebja); United Nations Framework for Cooperation on Climate

WHPRO– (sl.Indeks Wilderhill Progressive Energy); Wilderhill Progressive Energy Index

INTRODUCTION

A description of the topic area

Environmental policy is a topic which is garnering ever more attention from policymakers. This follows from the policy agenda for greening the economy. The initial attempts to formulate environmental policy date back to the beginning of the 1920s with the formulation of an environmental tax. The latter part of the 20th century will witness the economy-environment nexus as a recurring theme. The rise of welfare economics paves the way for the birth of environmental economics, which is the founding pillar of environmental policy. The social movements of environmentalism and sustainable development pave the way for today's agenda for greening the economy. Thus, the main topic area entails environmental economics and its policy prescriptions. The central policy in the environmental policy toolkit is environmental taxation due to its potential to offer a double dividend, i.e. simultaneous economic and environmental benefits (dividends). This is the main topic of interest.

Indeed the concept of the double dividend was the foundation for the environmental tax reforms conducted in the 1990s in some European countries. The tax reforms were implemented with various policy objectives such as higher growth and employment (economic dividend), a reduction in energy dependence or emissions to comply with the Kyoto agreement (environmental dividend). Nevertheless, the green economy transition comes with vast funding needs. Public finance constraints and the magnitude of the green economy transition imply a necessary role for private capital. Moreover, companies are responding to societal trends embracing environmentalism by incorporating corporate social responsibility in their business models accordingly. Thus, evaluating the potential for a double dividend associated with private (sustainable) finance is another avenue to be explored. The topic area is thereby extended from environmental economics and policy to (sustainable) finance.

The thesis presents three empirical analyses which are described in more detail in the methodological section in this chapter. The introductory chapter is organized as follows. The first section introduces the aims and research questions of the thesis. The second describes the methodology applied to the research questions. The third outlines the structure of the thesis.

Aims and research questions of the dissertation

The term double dividend appears originally in relation to public finance (Pearce, 1991). Namely, it is related to the simultaneous effects of environmental policy (taxes) on some of the key policy goals such as growth and employment. However, various international institutions estimate a larger need for funds to finance green growth and prevent disastrous

climate change effects. This indicates that public finance will not, indeed cannot be, the only recourse for achieving the double dividend. Moreover, the term "dividend" itself originates from the private sector. Conceptually, a double dividend can arise in the private sector as well due to higher stock prices for environmentally friendly firms. This is the idea behind the modern management trend of corporate social responsibility. Thus, there is an environmental and an economic (more precisely financial) dividend to be obtained in the private sector as well. This is another research niche to be explored.

The (re)conceptualization or augmentation of the double dividend discussion as a public and private sector concept is thus the first main contribution of the thesis. The other three contributions stem from the empirical analyses of the research questions posed below. As such, the first aim of the thesis is to explore both the public and private finance aspects of the double dividend since there are arguments to claim a double dividend in both sectors (contribution 1). The second aim is to provide empirical estimates of the double dividend at the national, sectoral and firm level contributions 2,3,4). This enables a general policy discussion of the public and private finance aspects of the double dividend at several levels. In relation to the augmented conceptualization of the double dividend, we formulate the following three research questions for this dissertation:

1) Can energy taxation deliver a double dividend through its effect on energy dependence and the balance of payments?

1) Has energy taxation delivered a double dividend through its effect on employment or value added?

2) Is there a double dividend in private sustainable (renewable) finance in terms of the financial attractiveness of sustainable or renewable energy stocks?

The public and private aspects of the double dividend debate can be easily related to the research questions. Namely, the first two research questions relate to the public aspect of the double dividend (the source of which is environmental taxation), whereas the third relates to the private aspect of the double dividend (voluntary initiatives related to sustainable investing or corporate environmental measures).

It should be mentioned that the empirical analyses focus on the economic dividend of environmental taxation, specifically energy taxation as it is the largest share of revenue from environmental taxation. Environmental taxation affects economic variables such as GDP, employment, innovation or productivity. Alternative channels include the effect on the current account through energy imports. Namely, the higher environmental tax serves to decrease energy consumption and thus energy imports (energy dependence) thereby improving the current account. The effect on the current account is covered in the first empirical analysis, whereas the effect on value added and employment is covered within the second empirical analysis in this dissertation.

The environmental dividend of environmental taxation is covered through case studies or assumed implicitly. The case studies cover the countries in the European Union (hereinafter: EU) which have implemented a comprehensive environmental tax reform (hereinafter: ETR), thus allowing us to observe the environmental effect of environmental taxation. A positive environmental effect, i.e. a decrease in emissions, is observed across the EU as well (Withana et al., 2013), which is a region with comprehensive and consistent environmental taxation. The latter is also the reason for our geographic focus on the EU for two of the three empirical analyses. The case studies fit within the public policy aspects of the double dividend, as they show the environmental effect of environmental taxation.

The environmental dividend within the private sector is in turn assumed implicitly, as the stocks analyzed are either sustainable stocks or renewable energy stocks. Thus, they contribute to an environmental dividend by default, as they would be excluded from the indices within the sample otherwise. The economic dividend entails the risk and return profile of sustainable and renewable energy stocks, so as to gauge the financial attractiveness of sustainable finance. This provides an insight in the double dividend potential within private finance.

Description of the methodology

In relation to the public aspect of the double dividend, this thesis aims to contribute to the existing knowledge about the effects of environmental policy by examining the ex-post effects of environmental taxation. This relates to the first two research questions. The first empirical analysis of the economic dividend tries to identify the effect of environmental taxes on energy dependence, the current account, or the trade balance, which is a national level analysis. Environmental taxes might affect the trade balance due to energy imports, as was the case in Finland (Andersen et al., 2007). Energy taxation might deliver a revenue-neutral yet trade-positive reform in the structure of taxation. The revenue neutrality follows from a simultaneous increase in environmental taxation coupled with a decrease in other (e.g. labor) taxation, whereas the trade effect follows from the positive impact on the trade balance through energy imports for example. This is especially relevant in a European policy context as European public finances are under strain and both fiscal and current accounts are monitored under the Macroeconomic Imbalance Procedure. Indeed, a balanced balance of payments is one of the goals in economic policy making, in addition to high growth and low inflation and unemployment.

Thus, the first research question tries to identify the effect of environmental taxes on the current account and energy dependence as the first empirical analysis. The methodology used for the first research question is a dynamic panel data analysis of environmental taxes and the current accounts of the whole sample of EU countries over the period 1990-2012. Dynamic panel data is suitable for this analysis due to the persistency of the current account.

Moreover, there are fundamental variables within the underlying savings-investment identity in macroeconomics which determines the current account. These variables are structural and persistent such as productivity or the structure of the population. Indeed, dynamic panels are a classical methodological approach in current account regressions. A novelty in this analysis is a model for energy dependency which also reflects exports so it is modelled as a separate equation which does not feed into the current account equation. This enables a gauge into the source for the potential effect on the current account. Moreover, we present estimates before and after the crisis so as to gauge the potential impact of the crisis. A dynamic panel allows for the estimation of the long and short run effects of the crisis in relation to the current account. The results of this analysis are included in Chapter 2, Section 2.

The second research question aims to tackle the effects of environmental taxes at a more disaggregated level. Thus, the second empirical analysis tries to identify effects of environmental taxes on sectoral-level variables such as employment and value-added which is essentially an empirical analysis of the economic dividend. Indeed, employment and GDP are one of the key economic variables and official policy targets. Environmental taxation, if well-designed, can generally lead to positive effects on employment and GDP (which is the sum of value-added), but sectoral effects need to be considered as well (Withana et al., 2013). Thus, there is a need for more disaggregated analysis. As stated earlier, such disaggregated analysis was more pernicious previously due to lack of data availability.

The availability of somewhat longer time series nowadays eases this constraint. Moreover, the sample includes sectoral data for all EU countries over the period 1995-2015, thus allowing us to estimate the effects before and after the crisis. Thus, it is a panel analysis, conducted with greater data granularity, covering a longer time horizon extending beyond the crisis. The longer sample enables testing for the effects of the crisis and the long-term effects of the environmental tax reform. The effects of the crisis are estimated using a Chow test which tests for structural breaks in the coefficients before and after the crisis. The long-term effects of the environmental tax reforms are estimated using interaction terms for the reform (comprehensively conducted in six EU countries). The results of this analysis are presented in Chapter 3, Section 3.

The third research question relates to the private finance aspects of the double dividend. The private finance aspect, specifically the economic dividend, is analyzed using financial data from sustainability indices. Thus, the third empirical analysis aims to evaluate the risk and return within sustainable and renewable energy indices. Evaluating the risk-return profiles of sustainable and renewable indices is relevant for the double dividend discussion, as the green economy transition will require ample amounts of funding. Enticing the private sector to invest is thus imperative. Differentiating between various types of environmental indices

is relevant as not all sustainability indices have the same profiles, as they reflect different underlying profiles, even in terms of environmentalism.

The third empirical analysis focuses on the extensions of the basic Capital Asset Pricing Model (hereinafter: CAPM) model with multiple factors. The sample includes the DJSI sustainable indices and a range of renewable energy indices from 2006-2016. The basic model posits that returns depend on the market risk factor (systemic risk) and idiosyncratic risk. The model has been further extended to account for other factors as well such as firm value, firm size or trend. The last empirical analysis will evaluate the economic dividend in sustainable finance by assessing the risk-return profile of sustainable stocks and renewable energy stocks on the extended factor models. Similar analyses can be found in Henriques and Sadorsky (2008) or Bohl, Kaufmann, and Stephan (2013). The results of the analysis at the firm level are presented in Chapter 4, Section 2.

Contributions of the thesis

The methodologies described above relate to the empirical contributions of the thesis. These follow from the augmented concept of the double dividend based on its public and private finance aspects. The contributions of the thesis are described in continuation.

The first contribution is the (re)conceptualization of the double dividend concept to integrate its public and private sector finance aspects. The double dividend is usually related to welfare and employment effects due to changes in the structure of taxation. . This is a public finance aspect of the double dividend reviewed in Chapter 1. Nevertheless, the green economy transition will require ample funding which cannot be provided by the public sector alone. Moreover, changes in market preferences as observed through a rise in corporate social responsibility and sustainable finance indicate that there is room to speak of an economic and an environmental dividend in the private sector as well. This implies an extension of the initial double dividend concept based on public finance aspects (in terms of policies and target variables) towards an augmented concept which entails its private finance aspects as well. Expanding the discussion of the double dividend towards the private finance sector enables an even broader, systemic view of the double dividend discussion. The following three contributions are empirical.

The first empirical analysis provides the effects of environmental taxation on the current account, thus it relates to the public finance aspects of the double dividend. The main contribution of the first analysis is the estimation of an additional channel for the double dividend within the EU as a representative region for environmental policy over a longer time period (1990-2012). This is a novel channel in the literature which has not been estimated so far to the best of the authors' knowledge. The effects on the current account and energy dependence stem from changes in energy consumption due to energy taxes, as higher energy taxes may decrease energy consumption and thus improve the current account

balance. Moreover, the effect of the crisis is studied as well as the long-run effects of energy taxes on the current account. The limitations of this analysis refer to only using the environmental tax as a variable of interest, thus not taking interaction effects between various environmental policies into account. Moreover, the model is estimated using national level data, but estimating a larger, hierarchical model could be a plausible extension to include sectoral effects directly as well. This would enable a deeper insight into the possible channels for a double dividend arising from interaction effects among policies as well as spill-overs across various levels or sectors.

The second empirical analysis provides the effects of environmental taxation on value added and employment, thus it is a disaggregated analysis on the public finance aspects of the double dividend. The main contribution of the second analysis is the estimation of the effect of environmental taxes on value added and employment at the sectoral level for all EU countries over the period of 1995-2015. Moreover, the analysis evaluates the long and the short term effects of environmental taxation, as well as the effect of the crisis. This is the first comprehensive analysis of a flagship EU environmental policy on a longer sample at a disaggregated level to the best of the authors' knowledge. The limitations are similar as with the previous analysis as interaction effects among other environmental policies are not taken into account. Moreover, the energy tax data is aggregated among groups of sectors (industries vs. services for example). Further analysis could focus on sectoral level estimation at the lowest level of disaggregation, such as firm level data. As stated earlier, such disaggregated analysis was more pernicious previously due to lack of data availability.

The third empirical analysis provides a gauge of the risk and return associated with sustainable and renewable energy indices, thus it relates to the private finance aspects of the double dividend. The main contribution of the third analysis is the application of a classical methodology to a range of indices which includes both sustainable and renewable energy indices. This allows for a differentiation between the risk and return on sustainable and renewable energy indices, as the two have different risk-return profiles. This is a novel approach to the analysis as the literature typically analyses corporate social responsibility in general although there are various notions of green. Namely, the renewable energy sector is nascent and thus exposed to inherently greater volatility. Moreover, the estimates are based on a sample extending beyond the crisis, from October 2006 to June 2016. The limitation of this analysis is the range of variables considered. Namely, the analysis could be disaggregated further by analyzing the constituent firms of the indices with specific firm-level variables.

Integrating the policy implications from all three empirical analyses on all three levels (national, sectoral, firm) leads to systemic policy implications for the double dividend policy discussion in the future. Based on the reconceptualization of the double dividend, a comprehensive discussion should entail both the public and private finance aspects of the double dividend, as suggested in this thesis.

Structure of the thesis

The thesis is organized as follows: Chapter 1 is a theoretical introduction to the concept of the double dividend. The chapter opens with an overview of the economy-environment nexus, so as to provide the general context of the double dividend discussion. The second section overviews the existing conceptualization of the double dividend. The third section of Chapter 1 provides the basis for the reconceptualization or augmentation of the double dividend by extending it to private finance. This relates to the need for private investment and theoretical potential for the double dividend. The latter stems from the economic benefits (dividends) associated with corporate social responsibility and sustainable finance in general. The chapter closes with the reconceptualization of the double dividend and its relation to the empirical questions in the dissertation.

The following two chapters, Chapters 2 and 3 analyze the public and private finance aspects of the double dividend respectively. Chapter 2 relates to the public finance aspects of the double dividend. It opens with a review of the economic and environmental aspects of the environmental tax reforms to date in Section 1. The review of the environmental effects in the ETR countries covers the environmental dividend. The following two sections contain the empirical analyses of the economic dividend associated with environmental taxation at the national and sectoral level.

Section 2 of Chapter 2 thus presents the results of the analysis at the national level, whereas Section 3 of Chapter 2 presents the results at the sectoral level. The national level analysis entails an evaluation of the effect of environmental taxes on energy dependence and the current account balance. The sectoral level analysis entails an evaluation of the effect of environmental taxes on value added and employment. Thus, the analyses cover the public finance aspects of the double dividend as the environmental policy emanates from the public sector and the variables studied are among the key policy goals.

Chapter 3 relates to the private finance aspects of the double dividend at the firm level. It is divided in two sections, each pertaining to the environmental and economic aspects of the double dividend in the private sector. The environmental dividend is covered by reviewing the environmental effects of renewable energy in Section 1 of Chapter 3. Namely, renewable energy is a central element of the green economy transition. It is also the theme which has garnered the most attention and investment in recent years. Thus, it is sensible to evaluate the environmental dividend associated with measures emanating from the private sector in relation to renewable energy, as one of the key tenets in the private sector's green blueprint.

Moreover, although the chapter is devoted to the private finance aspects, the environmental dividend analysis is always at the public level, i.e. in relation to emissions. The environmental dividend is always public as the environment is a public good, thus the environmental effects overview is at the national level. Section 2 of Chapter 3 contains the

empirical analysis of the risk-return profile of sustainable and renewable energy indices. The analysis covers the private finance aspects of the double dividend as the policy emanates from the private sector. Moreover, risk and return are the key financial variables of interest from investors' point of view. The last chapter is the concluding chapter.

1 THE CONCEPT OF THE DOUBLE DIVIDEND

1.1 The economy-environment nexus

Safeguarding the environment has increased in policy importance in the past couple of decades, placing it among the key policy goals along with economic growth. As a result, the economy-environment nexus has also been researched more amply in this period. The double dividend concept is a variant of the economy-environment nexus which refers to the simultaneous economic and environmental benefits (dividends) of environmental taxation. It appears in the 1990s with the discussion of environmental taxes and environmental tax reforms. The aim is to provide an environmental benefit in terms of an improvement in air quality and an economic dividend in terms of higher welfare. As such, the double dividend concept emanates from the public sector but there are grounds to augment its conceptualization towards the private sector as well.

The following section aims to summarize the key developments in the economy-environment nexus research so as to provide the general context for the double dividend as the main topic of interest in this thesis. The early research within the economy-environment nexus can be related to the double dividend as well, although not explicitly. Namely, the early research on public policy analyzed environmental taxes but this was typically due to either the environmental or the economic dividend and not the double dividend entailing both simultaneously. Explicit considerations of a double dividend appeared in the early 1990s which is when the term was coined.

The economy-environment nexus appears already in classical economists work as Malthus (1798) had predicted that increased population growth would lead to famines and deprivation assuming limited resources. An additional effect of limited resources is the effect on rents, as limited resources and varying soil fertility would lead to economic rents. This is the idea set forth by Ricardo (1817). Furthermore, Smith (1776) acknowledges the idea of a "public interest" which could be related to the broader theory of public goods and externalities, whereas Ricardo analyses the effect of scarcity on rents. Nevertheless, early classical economists such as Smith or Ricardo did not make explicit references to the environment, or analyze the link between the quality of the environment and economic growth. Indeed, Malthus posits that there will be no economic growth due to scarcity of resources, but technological growth was absent in this analysis. Thus, neither the economic nor the environmental dividend were analyzed in relation to taxation or formalized as pursuing economic or environmental dividends in this early work.

Resource economics and the study of resource rents (prices) specifically had been studied in other early work by Gray (1914) and Hotelling (1931) which could be related to the economy-environment nexus in general. Resource economics studies price changes in relation to the economic scarcity of an exhaustible resource. Prices increase with the rate of extraction (depletion) of a resource, since the resource becomes scarcer. Thus, there are economic and environmental effects with varying signs (positive or negative). The classical school and the resource economics strands are thus the first strands within the economy-environment nexus literature, but they do not analyze the double dividend as such.

The first analysis which entails some aspect of the double dividend is the analysis of the 1920s. Namely, Pigou (1920) discusses an optimal environmental tax on production which serves to ensure an environmental dividend primarily. The environmental tax aims to correct for externalities, which are an example of a market failure. A related market failure in the environmental literature is also referred to as the "Tragedy of the Commons" (Hardin, 1968). Externalities appear due to overproduction since the level of production is determined considering only the private and not the total social cost. Considering the total social cost leads to a lower level of production, which is essentially the aim of the corrective environmental tax. The economic benefits in the form of tax revenues are secondary and constitute an economic dividend, although this was not formalized as such.

Ramsey (1927) in turn discusses a tax which should be raised on goods with low price elasticity, such as energy consumption, so as to maximize revenues. This constitutes an economic dividend. In fact, at the time of conception, both authors' work was intended to either decrease environmental degradation or increase government revenues by reducing tax distortions. The early accounts of the economy-environment nexus thus show that although research was conducted on policies (taxation) which would ensure either dimension, they did not focus on the simultaneous achievement of both goals. Thus, their primary goal was not proposing policies for the operationalization of the economy-environment nexus, or indeed ensuring double dividends.

The environmentalist movements of the 1960s served to raise the importance of the environment for policy makers whose primary goal is economic growth. The environmentalist movements of the 1960s set the ground for the seminal work by the Club of Rome (Meadows, Meadows, & Behrens, 1972) which had resurrected the Malthusian predictions of limits to growth. The Club of Rome's work suggests that higher growth will imply ever less resources for the future, reiterating the Malthusian predictions of ensuing scarcity. Subsequently, the oil crises of the 1970s have also served to reinforce environmentalism as they showed the necessity for considering alternative avenues to growth which are not as dependent on fossil fuels and by extension fossil fuels' suppliers. Thus, socio-economic events seemed to suggest an ever increasing importance of the environment for policy making as well. The 1960s did not propose formal solutions for the

double dividend in terms of policy prescriptions, rather they were important for emphasizing the environmental imperative, i.e. the importance of ensuring environmental dividends.

The earliest account of a double dividend, although implicit appears in the 1970s. Sandmo (1975) relates the two taxation principles of Pigou and Ramsey and shows how to combine the Ramsey rules for taxing commodities with the Pigouvian rules for taxation according to their marginal environmental damages. Thus, it combines the economic dividend which stems from tax revenue maximization with the Ramsey taxes and the environmental dividend with the Pigouvian corrective environmental taxes. This is one of the earliest accounts of a double dividend along with the work done by Tullock (1967) although it is not formalized as such. Nevertheless, it is an implicit formulation for the double dividend since they analyze taxation and simultaneous economic and environmental dividends. Moreover, it was important to set the ground for future research.

Although the impetus for academic research of the economy-environment nexus appears as early as the 1960s, the greatest push for the economy-environment nexus research occurs with the sustainable development movement of the late 1980s. Sustainability centers around three dimensions: economic, environmental and social. Since the environment is the focal point of sustainability and economic growth is one of the key policy goals, the emergence of sustainable development implies a stronger impetus for the economy-environment nexus research. This is formally conceptualized within the United Nations (hereinafter: UN) Brundtland report "Our Common Future" following a conference in Rio De Janeiro, Brazil, in 1987. The report conceptualizes sustainable development as the ability to serve this generation's needs without endangering other generations' needs (UN, 1987).

This report is an important milestone and a turning point for environmental policy for several reasons. First of all, while there are grassroots movements in the 1970s, the acknowledgement of the dangers of climate change is on a different level. Second, sustainable development was itself introduced as a holistic theory of well-being intended to address environmental concerns. The term itself had been conceptually introduced a decade earlier at the 1972 UN conference on the Human environment held in Stockholm. Placing environmental concerns at the forefront is one of the distinguishing features of sustainable development. Previous accounts of well-being did not focus on the environment. This is the second reason why the Brundtland report represents a milestone since it formalizes the economy-environment policy nexus. Subsequent policy frameworks for sustainable development retain the economy-environment nexus as a focal point. Thus, the economy-environment nexus and the double dividend by extension are embedded in the broader overarching concept of sustainable development.

Considering the new policy imperatives which formalize the importance of the environment within the concept of sustainable development, the economy-environment nexus research

and the double dividend research by extension gain traction in the 1990s. The economy-environment nexus or the pollution-income relationship appears in the Grossman and Krueger (1995) paper which looks at the relationship between growth and pollution. It is then that the Environmental Kuznets curve (hereinafter: EKC) appears (Panayotou, 1995), which means that the quality of the environment initially declines only to improve further on, similar to the original Kuznets curve (Kuznets, 1934). Namely, emissions increase initially due to higher economic growth but decline at higher growth rates. Thus, an inverted letter U relationship between emissions and income is intuitive to be expected. Sustained economic growth with lower emissions constitutes a double dividend in the EKC. The EKC phrases the environmental dividend in terms of emissions although it could relate to the broader set of environmental indicators (see Kaika and Zervas (2013).

The formalization of the economy-environment nexus within the EKC is relevant for policy as it serves to inform the policy discussion that environmental preservation requires active policies. Namely, the environmental dividend is assumed to occur as a by-product of economic growth and not due to specific fiscal incentives (taxation or other policies) as in the double dividend literature. Thus, the EKC is a strand within the economy-environment nexus but it does not posit simultaneous economic and environmental benefits (dividends). This is the key difference between the double dividend and the EKC conceptually. Nevertheless, both embody the economy-environment nexus.

Another strand within the economy-environment nexus literature comprises of the work on environmental policy which embodies simultaneous economic growth and environmental protection. The double dividend discussion appears within this strand formally. Formally, the double dividend discussion appears in the 1990s as a reflection on environmental taxation (Pearce, 1991) which entails simultaneous environmental and economic benefits (dividends). The double dividend can appear in a strong or weak form (Goulder, 1995). Both forms of the double dividend answer two different questions, the first deals with government funding and the second with redistribution of existing taxes. The strong form of the double dividend states that it is better to increase environmental taxes rather than labor taxes to raise government revenues. The weak form deals with the use of the tax revenues. It states that it is better to use the revenues from an increase in environmental taxes to finance a decrease in labor taxes, as revenue-recycling would be less distortionary relative to lump-sum transfers. This work is related to the environmental tax reforms of the 1990s which are built on the premise of a double dividend arising from tax revenue-recycling.

Another formulation of the economy-environment nexus is the Porter and Van Der Linde (1995) hypothesis which refers to the economic dividends of environmental regulation in general. The Porter hypothesis states that well-designed environmental regulation will induce environmental innovation and productivity, thereby increasing firms' competitiveness. The double dividend is a more timid version of the Porter hypothesis

(Andersen et al., 2007), as it refers to one aspect of environmental policy and frames the economic effects in terms of welfare, compared to the Porter hypothesis which frames the economic effects in terms of competitiveness. The latter can entail productivity, innovation or employment (Sato & Dechezleprêtre, 2014).

The Porter hypothesis posits that productivity and innovation may increase provided well-designed environmental regulations. Thus, the focus of research in the economy-environment nexus have typically been public policies albeit from a different perspective. Namely, the Porter hypothesis relates to the effects of environmental policy on firm-level variables, whereas the double dividend discussion entails the effects of environmental policy on macro-level target variables. Moreover, the Porter hypothesis analyzes the effects of regulation and not revenue-raising fiscal instruments.

A more recent and specifically policy-oriented formulation of the economy-environment nexus is the OECD's green growth policy agenda. The OECD states that "green growth has not been conceived as a replacement for sustainable development, but should rather be considered a subset of it", since "it is narrower in scope, entailing an operational policy agenda that can help achieve concrete, measurable progress at the interface between the economy and the environment" (OECD, 2011). As such, it entails simultaneous economic growth and environmental quality, unlike the EKC which posits that environmental quality follows as a consequence of higher economic growth. To measure progress towards green growth, the OECD has proposed a set of 26 indicators which monitor the: i) environmental and resource productivity of the economy, ii) the natural asset base, iii) the environmental dimension of the quality of life and iv) the economic opportunities and policy responses. Whereas the first three segments are predominantly environmental and descriptive of the state of the economy, the fourth involves policy or the driver of environmental outcomes and is thus the key segment of interest.

In relation to the latter, environmental taxes or tradable pollution permits should be a central element of the policy mix (OECD, 2011). Environmental taxation is one of the key policies in the green growth policy agenda due to the potential for double dividends. Nevertheless, sustainable development and the green growth agenda (i.e. the green economy transition) require ample funding and deep-rooted changes in the current business models as well. This would necessitate a greater involvement of the private sector which has to be enticed to adopt or invest in green technologies. Adopting environmental technologies or incorporating some form of environmentally friendly policies is an integral part of corporate social responsibility.

Corporate social responsibility is a recent management trend, aiming to implement in practice the principles of sustainable development at the corporate level. Conceptually, it appears as early as the 1950s with the notion of social responsibility (Bowen, 1953). A

subsequent formulation by Drucker (1984) relates the notions of profitability and responsibility explicitly. Corporate social responsibility can be related to both the financial and the real sector. It can entail deep changes in the financial system in terms of greening the financial system, or smaller changes aimed at implementing environmentalism in the corporate strategy.

Although the latter does not entail deep changes in the business model, it represents some form of environmentalism at the corporate level which may lead to positive effects on financial variables such as stock returns or the value of the firm. This would comprise a double dividend which emanates from the private sector (financial or real), since the environmental measure is initiated voluntarily by the private sector and not imposed by policymakers. Thus, it would be natural to extend the analysis of the double dividend beyond the public sector only and towards the private sector which is also where the term dividend originates from.

The conceptual overview shows that the economy-environment nexus literature comprises of various concepts which do not necessarily entail simultaneous environmental and economic dividends (such as the EKC or the initial taxation analyses). The double dividend concept and the overarching green growth concept in turn entail simultaneous economic and environmental benefits. Moreover, the economy-environment nexus has been gradually expanded to entail the private aspect as well. Indeed, the economy-environment nexus has moved from a discussion of taxation (public finance) to corporate social responsibility in the real and financial sector (private finance). The double dividend should be extended towards the private sector as well, as there could be simultaneous economic and environmental dividends from private sector policies as well. This thesis aims to integrate the public and private aspects of the double dividend discussion and provide some empirical estimates so as to inform the policy debate. The chapter proceeds with an overview of the existing definitions of the double dividend and a proposed augmented reconceptualization to entail its private finance aspects as well.

1.2 The double dividend and its public finance aspects

The double dividend formalizes tentative economic and environmental benefits from environmental policy intended to correct for environmental problems. It first appears in the 1990s with Pearce's proposition of a double dividend. The term continues to gain traction throughout the 1990s with the discussion of environmental tax reforms. An environmental tax or fiscal reform stands for the "changes in the national tax system where the burden of taxes shifts from economic functions, sometimes called 'goods', such as labor (personal income tax), capital (corporate income tax) and consumption (value added tax and other indirect taxes), to activities that lead to environmental pressures and natural resource use, sometimes called "bads" (EEA, 2005). The environmental tax reforms in the 1990's entail

comprehensive reforms of the national tax system by increasing taxes on pollution and decreasing taxes on labor. The latter is to deliver an economic dividend in terms of the effects on the main policy variables such as productivity, national output, employment, energy consumption and the balance of payments.

Table 1 reviews the literature on the double dividend in environmental taxation according to the method used, the characterization of the double dividend and the main results. Some studies refer to the double dividend explicitly and characterize it as an environmental and an efficiency dividend (Chiroleu-Assouline & Fodha, 2014; De Miguel & Manzano, 2011; Oueslati, 2014). The aim of the table is to show the various definitions of the double dividend so as to identify the common characterization and main drawbacks. Moreover, studies differ in the research methodology applied. Some studies are theoretical/policy papers (Pearce, 1991), others entail ex-ante modelling exercises in terms of a theoretical model with utility equations or numerical simulations (De Miguel & Manzano, 2011) based on specific parameters, or ex-post results such as panel data analysis (Commins, Lyons, Schiffbauer, & Tol, 2009).

Table 1 Double dividend literature

Authors	Method	Double dividend characterization	Double dividend results
Pearce (1991)	Theoretical paper (ex-ante)	-Environmental dividend refers to a reduction in carbon emissions and externalities -Economic dividend refers to a reduction in tax distortions	Double dividend hinges on elasticity of energy demand
Bovenberg and De Mooij (1994)	Theoretical model (ex-ante)	-Environmental dividend refers to environmental quality -Economic dividend is an increase in utility and employment	-Employment depends on the response of the labor supply (tax interaction effect) -Double dividend exists in its weak form, if revenues are returned through revenue-recycling
Goulder (1995)	Theoretical model (ex-ante)	-Economic dividend refers to welfare effects and costs of environmental policy	Weak dividend refers to the use of pollution tax revenues, strong dividend refers to overall costs of environmental policy
Andersen et al. (2007)	Numerical model (ex-ante)	-Economic dividend in terms of welfare effects (less distortionary taxes), higher employment and efficiency (higher competitiveness) -Environmental dividend from a correction of market failures (lower external costs)	ETR leads to lower fuel demand, lower emissions and higher GDP across the ETR countries

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Authors	Method	Double dividend characterization	Double dividend results
Karydas and Zhang (2017)	Numerical model (ex-ante)	-Growth dividend from wider effects of substitution from income taxes -Further social and economic dividends (distorting taxation and technical change)	Potential for a double dividend from changes in the structure of taxation, highest if redistributing using capital taxation
De Miguel, Montero, and Bajona (2015)	Numerical model (ex-ante)	-The environmental dividend stems from a reduction in pollution -The economic dividend is an efficiency dividend (higher tax efficiency and welfare)	Double dividend exists but support differs among social groups, young favor green tax reforms more than old generations
Oueslati (2014)	Numerical model (ex-ante)	- An environmental dividend from an improvement in the environment -An economic dividend as a reduction in the distortion arising from labor or capital taxation	Potential double dividend in terms of long-run growth and welfare, but high initial costs
Freire-González (2018)	Numerical model (ex-ante)	-An environmental dividend from a reduction in environmental costs -An economic dividend from a positive welfare effect due to higher efficiency	Double dividend can be achieved, with positive GDP effects in the medium term (up to 5 years)
Chiroleu-Assouline and Fodha (2014)	Numerical model (ex-ante)	-An environmental dividend from an improvement in overall environmental quality -An economic dividend from a less distortionary tax system	Progressive environmental taxes can make the reform even more efficient
Giménez and Rodríguez (2010)	Numerical model (ex-ante)	-First dividend refers to welfare gains from a reduction in external costs (Pigou's tax) as the environmental dividend -The second dividend refers to the welfare effect from revenue-recycling as the economic dividend	Positive effects on welfare from an ETR in the US
Groothuis (2016)	Numerical model (ex-ante)	-Improving the environment as the environmental dividend -Creating jobs as the economic dividend	Substantial positive effects on GDP in the EU-28 from a combined environmental tax and VAT reform

Source: Own work

The double dividend first appears in Pearce (1991) who states that environmental taxes provide environmental dividends and additional revenues which is an economic dividend. Table 1 shows that the economic dividend is the focal point of the research on the double dividend, whereas the environmental dividend is assumed implicitly. The environmental dividend stems mainly from a reduction in energy consumption and a reduction in pollution as an improvement in overall environmental quality (De Miguel & Manzano, 2011; Jones, Keen, & Strand, 2012; Siegmeier et al., 2015). The broader literature typically characterizes the economic dividend as a welfare dividend or as an employment dividend (Bovenberg & De Mooij, 1994).

The literature typically states that the environmental dividend follows as a result of the decreased energy consumption and emissions due to higher environmental taxes (De Miguel & Manzano, 2011; Jones et al., 2012; Siegmeier et al., 2015). The environmental dividend is not clearly defined and is rather assumed implicitly. It stems from a reduction in pollution (De Miguel & Manzano, 2011) or an improvement in overall environmental quality (Chiroleu-Assouline & Fodha, 2014). The environmental dividend can be further related to climate change mitigation and a reduction in the costs of mitigation (Jones et al., 2012). Giménez and Rodríguez (2010) relate the reduction in costs to the net external costs in Pigou (1920)'s tax. Some studies are more concrete in evaluating the environmental dividend in terms of emissions reductions (Andersen et al., 2007; De Miguel & Manzano, 2011), but this is scarce.

The welfare effect stems from higher utility due to lower tax distortions and higher efficiency of the tax system. Some authors refer to the economic dividend as a welfare or utility gain (Bovenberg & De Mooij, 1994; Goulder, 1995; Siegmeier et al., 2015), others phrase it as an efficiency dividend (Andersen et al., 2007; De Miguel & Manzano, 2011; De Miguel et al., 2015; Freire-González, 2018; Jones et al., 2012), whereas others characterize the economic dividend as a less distortionary tax system (Andersen et al., 2007; Bovenberg & De Mooij, 1994; Chiroleu-Assouline & Fodha, 2014; Giménez & Rodríguez, 2010; Karydas & Zhang, 2017; Oueslati, 2014; Pearce, 1991). These are synonyms which stem from the revenue-recycling effect which reduces the existing tax distortions, thereby increasing the efficiency of taxation, thus increasing utility and welfare.

Thus, the economic dividend is primarily characterized as a welfare or utility gain, or an efficiency improvement from the reduction in distortion from the initial structure of taxation. The seminal works by Bovenberg and De Mooij (1994) and Goulder (1995) analyze the welfare effects of environmental tax reforms. This relates to two main effects, the revenue-recycling effect and the tax interaction effect.

Goulder (1995) characterizes a strong and weak form of the double dividend. The weak form of the double dividend is related to the use of the tax revenue and the revenue-recycling

effect. The revenue-recycling effect appears with a revenue-neutral tax reform when an environmental tax is raised whilst decreasing another distortionary tax, for example labor. The reduction in the distortionary tax contributes to a welfare gain (higher employment) and thus an economic dividend. The economic dividend thus appears if there is an initial inefficiency in the tax system. The weak form states that it is better to use the tax revenues to reduce the tax distortion rather than return the revenues in a lump-sum fashion. The strong dividend implies net positive benefits and goes beyond the reduction in costs in terms of welfare costs from the tax distortion to claim net benefits from the reform.

Nevertheless, Bovenberg and De Mooij (1994) argue that the economic dividend (in terms of employment) depends on the response of the labor supply. Namely, an environmental tax raises prices in general, which leads to an implicit tax on other factors of production, specifically it is an implicit tax on labor. This is referred to as the tax interaction effect which leads to an offsetting effect to the revenue-recycling effect. This increases the tax distortion. The interactions between these two effects are in turn one of the factors for the economic dividend.

Subsequent work points out that distortion from the tax system need not come from labor taxation only. Oueslati (2014) defines the economic dividend as a reduction in distortion from labor and capital taxation. Karydas and Zhang (2017) refer to a growth dividend which refers to wider effects of substitution from income taxes, as well as social and economic dividends from smaller distortions from taxation. Some authors relate the economic dividend to employment effects (Andersen et al., 2007; Commins et al., 2009) or competitiveness effects in terms of price changes (Andersen et al., 2007; Groothuis, 2016; Rocchi, Serrano, & Roca, 2014).

The previous discussion places the double dividend in relation to environmental taxation and specifically environmental tax reforms. This is due to early work on the double dividend which entails the work on the revenue-recycling and the tax-interaction effects. This work relates the double dividend, specifically the economic dividend to welfare and utility gains from lower tax distortions. The double dividend can be related to other variables as well. More specifically, we can relate it to concrete policy goals, such as growth, productivity, employment and the trade balance.

Thus, the double dividend is a concept which emanates primarily from the public sector in terms of the underlying environmental policy (environmental taxation) and target variables (among the key policy goals). It targets an economic and an environmental dividend simultaneously. As such, it belongs to the broader concept of green growth or the economy-environment nexus in the sustainability literature.

Expanding the public finance subset of the double dividend to specific policy variables other than welfare enables an operationalization of the concept. Namely, the literature review

shows that most of the studies on the double dividend are ex-ante studies which focus on utility or welfare effects. For operational purposes, the double dividend discussion needs to be rephrased towards tangible and measurable economic effects of public policy on concrete policy variables. These may include growth, productivity, innovation, employment or the trade balance. Moreover, they can be analyzed at various levels and at various time horizons.

Relating it to a broader set of economic variables relates the double dividend to the Porter hypothesis. The double dividend can be thought of as a more timid version of the Porter hypothesis, since it targets welfare and not the broader concept of competitiveness. Nevertheless, there are some studies which link environmental taxation to competitiveness, in terms of the effects on prices or employment as reviewed in Table 1. For example, Rocchi et al. (2014) find a small effect on prices following an energy tax reform. Commins et al. (2009) find small negative effects in the industrial sector. The Porter hypothesis is more general in turn and refers to the effects of the broader environmental regulation policy set at the firm level. Thus, it entails both public and private sector aspects, although these are not public and private finance aspects as they do not analyze a fiscal instrument which raises revenues (taxes) or environmental measures and their financial effects in the private sector.

The previous literature overview shows that the definitions of the double dividend entail two dividends associated with changes in environmental taxation, an environmental and an economic one. The environmental dividend is rarely explored and is typically assumed implicitly. The economic one is stated as welfare gains stemming from environmental tax reforms (Bovenberg & De Mooij, 1994). Concrete policy proposals relate the welfare gains to GDP and employment (Andersen et al., 2007). Thus, the literature overview shows that the double dividend is an inherently public finance concept in terms of the underlying policy (environmental tax) and the target variables (growth, employment). Moreover, it entails the simultaneous targeting of an environmental and economic dividend.

There are various drawbacks with the double dividend characterizations in the literature. First of all, the double dividend is an inherently public finance concept in terms of the underlying policy and target variables. Nevertheless, the characterization of the target variables is unclear. Early research relates the double dividend to welfare effects, although for practical purposes the double dividends needs to be restated in terms of tangible and concrete policy goals. Subsequent research ameliorates this to an extent, yet there are not many ex-post studies on the topic. Thus, the characterization of the economic dividend is unclear in terms of target variables. The dissonance between the characterization of the double dividend target variables leads to a practical problem in evaluating the economic dividend. Thus, this thesis applies a more practical approach in terms of the target variables studied.

Second, the double dividend relates to the effects of environmental taxation, although newer versions of the economy-environment nexus speak of dividends in relation to the broader environmental policy set (such as environmental regulations). In that sense, operationalizing the double dividend to account for the newer concepts such as green growth may lead to a mix-up in the characterizations of the Porter hypothesis and the double dividend. For this reason, it is better to frame the double dividend discussion in relation to taxation only in terms of its public finance aspects. This is the approach in this thesis as well.

Furthermore, the double dividend concept entails two dividends, an environmental and an economic dividend. Nevertheless, the environmental dividend is rarely characterized or estimated. Some studies calculate the reduction in emissions but most studies focus on the economic dividend. Evaluating the environmental dividend is necessary as well. Namely, environmental policy may lead to a rebound effect which may deteriorate environmental quality over the whole policy horizon. Environmental policy raises prices of pollutants in the first stage, which could lead to lower demand for energy which decreases prices. The reduction in price induces higher demand in the subsequent stages, thus leading to a potentially negative effect on environmental quality overall (Sinn, 2017).

Moreover, the environmental dividend need not be restricted to a reduction in emissions only and may relate to a broader set of environmental quality. Thus, the magnitude of the environmental dividend can be estimated using a wider set of environmental quality indicators. Arguably, this is a challenging task in terms of indicators, but it serves to illustrate the complexity of the concept. Thus, there are at least two issues with the environmental dividend which is its lack of characterization and estimation.

Finally, the double dividend is inherently related to public finance since it is based on taxation. The purpose of environmental taxation is to tackle climate change (the environmental dividend) and improve the efficiency of the tax system, increase GDP or employment (the economic dividend). Both points relate to the transition to a green economy which will require ample funding and investment in new and existing infrastructure. However, public funds are constrained by rules on budget deficits and debt and are insufficient. Moreover, the green economy transition opens new markets and business opportunities for firms due to changes in consumers' preferences.

Thus, there are additional arguments for greater private sector involvement such as associated economic/financial dividends with corporate social responsibility. In the financial sector, there may be additional benefits associated with investing in sustainable finance as a sign of the vast changes taking place in both the real and the financial sector. Based on this reasoning, the conceptualization for the double dividend in this thesis aims to integrate both the public and the private finance aspects for the double dividend discussion.

Thus, there are various drawbacks to the characterization of the double dividend, both in terms of the economic and the environmental dividend. The elusive characterization of the economic dividend implies a more pernicious assessment of the impact of environmental policy, for example taxes. Ex-post studies are a research niche as well. Furthermore, perhaps the most serious conceptual drawback is the analysis of public policy measures only. The magnitude of the funding required for the green economy transition implies that this is the most relevant drawback in light of today's economic and environmental challenges. Thus, the following section reviews the rationale for greater private sector involvement, as the basis for the reconceptualization of the double dividend to account for its private finance aspects.

1.3 Private finance as the missing link

A part of the reason why private finance aspects should feature in the double dividend discussion is the need for investment, as shown in the next subsection. Another reason is the actual theoretical potential for a double dividend, due to the link between environmental and financial performance at the firm level. The link is discussed within the corporate social responsibility literature and sustainable investing, since environmentally friendly measures can lead to greater value of the firm or higher stock returns. This is empirically analyzed in further chapters, but the discussion begins even within this section.

1.3.1 The need for private investment

Financing the green growth transition will require large funds. Initial estimates by the International Environmental Agency (hereinafter: IEA) indicated investment needs of 24 trillion USD in order to achieve green growth in the next 10 decades. This is around 2% of global GDP, in accordance with the Stern Report (Stern, 2006). More recent estimates of more ambitious climate goals indicate a stark increase in investment needs up to 2050, of 46 trillion USD more in a low-carbon scenario compared to the baseline. This amounts to approximately 1 trillion USD a year.

Other estimates by the WEF and Bloomberg New Energy Finance indicate an investment need of 500 billion USD a year up to 2020 to reach the current climate goals of keeping global warming below 2 degrees. The HSBC is more in line with the IEA estimates of investment needs of around 10 trillion USD in the current decade, around 1 trillion $ a year (UNEP, 2011). The European Commission estimates that 1.5 to 2 trillion EUR are needed to meet the European 2020 Strategy for smart, sustainable and inclusive growth (EC, 2017b). Similar estimates ensue for low-carbon scenarios up to 2050, with investment needs estimates of 1.42 trillion EUR annually between 2030 and 2050 (EC, 2018). Thus, low-carbon scenarios indicate substantial investment needs of around 1 trillion USD per year.

A further issue is already existing infrastructure which leads to the problem of lock-in, i.e. existing infrastructure is causing emissions which cannot be reduced unless the infrastructure is changed. At a global level, the IEA estimates that an additional 36 trillion US will have to be invested in energy systems in the next four decades, in order to contain temperature increases at 2-2.5% (IEA, 2012). This increase is already underway due to already released emissions. European Union investment needs for avoiding lock-in or obsoleteness in infrastructure and technologies are estimated at 193 billion EUR per year for 2011-2030 (excluding transport). The low energy and energy efficiency needs in turn are estimated at 230 billion EUR (Samaniego & Schneider, 2015). . Other modelling estimates are in line with these investment needs and estimate additional annual investment needs between 176 billion EUR and 290 billion EUR (EC, 2018). Furthermore, these needs differ among Member States, with wealthier countries needing 3.1-7.6 billion per year and up to three times more in less affluent economies (EC, 2015).

Thus, it is clear that investment needs for greening the economy are large. With the public sector in crisis, it is becoming questionable how to achieve this transition. Namely, average public debt in the EU is 86.7% as of end-2017 compared to 93.06% as of mid-2016 (ECB, 2018). Thus, it remains at a high level. Even if it is to decrease, the decrease will most likely occur at a slower pace than is needed. Hence, another solution has appeared which is involving the private sector. This brings large opportunities and high costs. Undoubtedly though, it resolves the issue of whether there will be enough capital to finance the transition in the first place. The issues lie elsewhere, as explained further on. Indeed, analyzing the private sector aspect of green growth and by extension the double dividend is one of the contributions of this thesis.

A new solution has thus appeared and it involves private finance or institutional investors. Institutional investors (hedge funds, pension funds etc.) are estimated to have had 84.9 USD trillion assets under management as of 2016 (PwC, 2017). It seems this number is more than enough to finance the green economy transition. However, significant subtractions have to be made in terms of availability of funds for long-term investment (Kaminker & Stewart, 2012). Further subtractions need to be made due to short-term liabilities which are already there and further trends in financial markets in general such as legislative changes (discussed further in detail below). We thus arrive at significantly lower figures.

Furthermore, this is only potential long-term capital. What will be crucial is raising awareness of the opportunities associated with clean energy investment and changing the perception that these are costs. Reform of the current finance architecture will likely be needed as well. The evolution of multilateral climate finance begins with the adoption of the United Nations Framework for Cooperation on Climate (hereinafter: UNFCCC) which is the Change adopted in 1992. The Global Environment Facility is adopted as the financial mechanism of the Framework in 1994, although established already in 1991. It aims to

provide funding to developing countries and transition countries for additional or incremental costs incurred with transforming a project of national benefit to one with global environmental benefit.

What follows is the signature of the Kyoto agreement in 1997, with agreements to cut greenhouse gas emissions by 20% from their level of 1990 by 2005. A Special Climate Change Fund and a Least Developed Countries Fund are established in order to help focus on national adaptation programs for low income countries in 2001. The World Bank establishes Climate Investment Funds outside of the UNFCCC signaling a first step in climate finance outside of the auspices of the UN. It is also worth mentioning that the World Bank has been the promoter of green bonds so this is an important step in the right direction for multilateral climate finance.

The global financial crisis hits in 2007/2008 which seems to give a larger impetus for private finance. The Copenhagen Accord is signed in 2009 with a commitment to Fast Start Finance for provision of 30 billion $ between 2010 and 2012. A further 100 billion $ are to be mobilized in public and private finance by 2020. Furthermore, countries pledge to rationalize fossil fuel subsidies. Climate finance continues to be an issue and the UNFCCC establishes a Green Climate Fund for this purpose (Nakhooda, Watson, & Schalatek, 2016). The previous instrument which was the Fast Start Finance ends without any particularly strong foothold on climate finance. The First and Second Ministerial Dialogues on Climate Finance are held in 2013 and 2014 which is when mobilization for the Green Climate Fund also begins. Although countries have committed funds within this framework, disbursement of funds has been slower (Climate Funds Initiative, 2015). This reinforces the need for more private finance within the climate finance architecture.

The potential of sustainable finance lies in three particular instruments which can be utilized to mobilize private finance (green bonds, yield-cos and the already established project finance). This might not come directly in the form of a green fund, but even more modest projects related to energy efficiency for example. Two novel instruments (green bonds and yield-cos) appear in the literature on mobilizing private capital finance for climate change. This is a private finance aspect for the double dividend, related to the private financial sector. This is necessary so as to provide a financial architecture for a double dividend.

Another aspect relates to firms in the real sector and the effects of implementing environmentally-conscious changes. Whereas private financial sector approaches are still nascent and thus lack comparative research, the real sector has implemented environmental and/or social concerns to a greater extent. Thus, there is more comparative research for the effects of the latter. The next section outlines the case for a double dividend in the real sector, whereas the third outlines the changes in the financial sector which provide grounds for a double dividend.

1.3.2 Corporate social responsibility and the double dividend

The previous section outlined the need for greater private sector involvement in the green transition. The private sector needs to be enticed to incorporate environmental measures within firms' business models voluntarily, thus contributing to less pollution and/or greater technology deployment. Additionally, the private sector may be driving the green transition with firms which are at the technological forefront. The former is embedded within the management theory of corporate social responsibility.

Corporate social responsibility is a business strategy which is based on the three tenets of sustainability of economy, society and environment. The latter is the focal point of the trend, thus ensuring an environmental dividend. The economic dividend is disputable, but research increasingly shows that greater corporate social responsibility leads to positive effects on various financial variables. The following section outlines the case for a double dividend within the private sector.

The environmental dividend relates to environmental quality as was the case earlier, whereas the economic dividend is a financial dividend, in terms of stock prices or tangible effects such as returns on investment at the firm level. This differs from the economic dividend in the public sector, which may refer to tangible and measurable effects at the national/sectoral level such as employment effects, current account, productivity, new jobs in the green energy sector, or less tangible (and more abstract) effects such as reduction of tax inefficiency and welfare effects.

The other aspect is related to the breadth of instruments available. Whereas the public sector instruments available consist of market-based instruments (taxes or pollution permits), the private sector has various economic agents and thus a myriad of approaches and instruments. Thus, one aspect relates to the financial sector (banks and institutional investors). There are changes underway related to discussions for a sustainable financial reform or use of green financial instruments. The other aspect relates to the real sector (firms).

The corporate social responsibility (hereinafter: CSR) trend is a management trend, defined as a company's status and activities with regard to its perceived obligations toward society (Sen & Bhattacharya, 2001). It is a broader trend which does not focus on environmental problems exclusively. The discussion of corporate social responsibility at the firm level would be analogous to the broader discussion of sustainable development and green growth at the national level.

CSR has been amply researched and shown to have positive effects in the business literature. These include enhanced company evaluations and purchase intentions (Sen & Bhattacharya, 2001). CSR towards all stakeholders affects brand equity positively (Wang, Chen, Yu, & Hsiao, 2015). Servaes and Tamayo (2013) distinguish between business environments with

high and low customer awareness, stating that CSR benefits firms in high customer awareness environments. In general though, there is a channel through which CSR can benefit all firms due to its effect as an insurance policy. For example, firms that invested in CSR did not suffer as large a decline in stock prices following a product recall (Minor & Morgan, 2011). Furthermore, firms that follow CSR have stronger marketing tactics. In general, CSR has been a buzz-word and its positive effects are corroborated by academic research.

The effects of CSR on firm performance have led to a growing interest to analyze the economic and financial performance of CSR (Fatemi, Fooladi, & Tehranian, 2015). If CSR was something that previously belonged to the business ethics and strategic management literature, it has now increasingly found its place among finance studies as well. CSR affects firm performance positively, although there seems to be an optimal level of business expenditures for CSR. Thus, CSR improves financial performance if these expenditures are low, but beyond a certain level, performance decreases.

These benefits are reminiscent of the double dividend discussion earlier. The public finance aspect of the double dividends states that environmental taxes may lead to higher employment and greater competitiveness, along with an improvement in environmental quality. If CSR is understood as actions that involve environmental and social sustainability, there is a case to claim a double dividend at the firm level as well. One dividend is financial/economic in terms of improved financial performance and the second is social or environmental.

Table 2 lists studies that support the proposition that there is a double dividend in the private sector as well. Table 2 summarizes the economic effect, whereas the environmental effect is assumed implicitly as the authors generally study firms with high environmental scores. Therefore, we see that there is room to speak of a double dividend in the private sector as well. This is due to various channels. A positive environmental-financial performance link may be observed through higher returns (Deng, Kang, & Low, 2013; Dimson, Karakas, & Li, 2015) and value of the firm (Gillan, Hartzell, Koch, & Starks, 2010; Jiao, 2010) or lower costs (Chava, 2014).

Table 2 CSR and financial performance studies overview

Author(s)	Effect (economic dividend)
Plumlee, Brown, Hayes, and Marshal (2010)	Cheaper equity financing and higher cash flows for firms with strong CSR.
Gillan et al. (2010)	CSR has a positive effect on firm value and firms with good environmental scores have higher returns on assets.
Jiao (2010)	CSR has a positive effect on firm value expressed as the Aggregate of strength and weakness scores refers to how well the firm satisfies its stakeholders (employees, customers, environment).
Mănescu (2011)	Community relations have positive effect on risk-adjusted stock returns.
Harjoto and Jo (2011)	CSR, as measured through internal and external monitoring of corporate governance, has a positive effect on operating performance and firm value.
Margolis, Walsh, and Elfeinbein (2012)	Small but positive effect on financial performance (a meta-analysis of studies on CSR and corporate financial performance)
Eccles, Ioannou, and Serafeim (2012)	High sustainability firms outperform low sustainability firms with similar characteristics in the long run, in terms of returns and accounting ratios such as ROA and ROE.
Deng et al. (2013)	CSR, is found to lead to higher merger announcement returns and post-merger long-term performance, implying that the market values CSR with a lag.
Chava (2014)	Higher cost of capital for firms with environmental concerns which do not undergo environmental screens such as emissions tests or chemical check-ups.
Dimson, Karakas, and Li (2015)	4% abnormal return for firms with successful CSR engagement events (on average 1.4%)

Source: Own work

As the first section has shown, the green transition will require large funds which implies a need for funding from the private sector as well. The broader corporate social responsibility trend has extended the discussion of the public aspect of the double dividend towards the private financial sector as well. Moreover, a new sustainable finance architecture is emerging as well, entailing banks and institutional investors through a sustainable financial reform and new green instruments. The next section overviews these developments.

1.3.3 The financial sector and the double dividend

The previous section outlined the case for a double dividend in the real sector with the emergence of corporate social responsibility which incorporates environmental policies. The corporate social responsibility trend has affected firms in the real sector but it has extended towards the financial sector as well. Moreover, there are new instruments within the financial sector to support the green economy transition which can provide a double dividend. The case for a double dividend in this case is clear, as the environmental dividend arises from investment in environmental projects, and the economic/financial dividend arises from the actual return on investment. Thus, this section overviews the case for a double dividend in the financial sector.

As a management trend, CSR has affected various economic agents, even financial institutions which were one of the architects of the financial meltdown of 2007. Banks have been publishing such reports even prior to the crisis. Post-crisis, it seems to be rebranded to sustainability reports. A term which has appeared in relation to this switch is sustainable financial reform. Namely, this is one of the first approaches outlined here for the private finance approaches. It relates to the changes in the private financial sector, or the general financial architecture for green growth and double dividends by extension.

Another approach is sustainable finance which entails green investments, for example equity investments in sustainable companies or green bonds. The case for a double dividend is clear in this case, as the environmental dividend arises from investment in environmental projects, and the economic/financial dividend arises from the actual return on investment. Thus, this section overviews the case for a double dividend in the financial sector.

a) Sustainable financial reform

A sustainable financial reform refers to the reform of corporate financial institutions in such a way so as to align them better with what sustainability principles require. It implies a reform in the incentives and regulations in financial institutions so as to have financial development which would go along with socioeconomic/environmental development. Thus, it relates conceptually to a double dividend, as it entails financial and environmental benefits. Whereas financial development detracts from growth in the business as usual scenario, it aids growth in the sustainable development scenario with a sustainable financial reform by imposing social and environmental outcomes. Thus, the environmental impact is smaller compared to the social and economic one within the general sustainability framework. Nevertheless, the impact is positive, compared to the negative impact in the business as usual scenario (UNEP, 2015).

Several aspects are relevant in achieving this. One aspect is the guidance provided by the supervisory institutions such as the central bank. There may be a mandate for central banks in the green transition and climate change in general in terms of risk monitoring and risk mitigation. Namely, climate change brings physical risks and transition risks associated with the green economy transition. Physical risks relate to the costs associated with damages induced by climate events, whereas transition risks relate to costs associated with changes in consumers' preferences, policy or technology, leading to stranded assets. There are multiple avenues for central bank involvement such as supporting sustainable finance in terms of risk mitigation or risk monitoring depending on the magnitude of physical or transition risks (Monnin, 2018). The current estimates seem to indicate an increase in physical risks due to an increase in weather-related events (ECB, 2019), as well as a likely increase in transition risk due to energy transition policies and changed market preferences.

Another aspect is financial institutions' voluntary response to the green economy transition in terms of voluntary environmental strategies, measures or investments (sustainable finance). There has been an overall increase in corporate social responsibility reports by financial institutions. For example, the Dutch RBS publishes an annual corporate social responsibility report (renamed to sustainability report in 2009). Sustainability is about fair banking, supporting enterprises, employee engagement, safety and security and global citizenship which entails lending by abiding to international codes of practice such as the Equator Principles and the United Nations Global Compact. Lending for energy efficient projects and supporting renewable energy producers is one of their commitments, although admittedly their energy clients are mainly in the fossil fuel industry business. Almost all globally systemic financial institutions publish sustainability reports. However, they tend to publish them as separate reports and not integrated reports (UNEP, 2016).

Sustainability also entails lowering the institutions' own carbon footprint or implementing environmental management schemes. For example, a growing number of financial institutions across Europe have the voluntary system environmental management system which is a precursor to the environmental standards ISO 14000 and ISO 14001. Environmental audit is another trend. Although a growing number of financial institutions are incorporating sustainability as part of their marketing strategy for a decade now (Kumar, Rahman, Kazmi, & Goyal, 2012), not all have the same incentives to embed sustainability in their business models. For example, insurance companies are more exposed to climate change risks than other financial institutions, due to the reimbursement for damages.

Nevertheless, there are general issues with the implementation of sustainability. Namely, 89.7% of the largest 29 banks worldwide have stand-alone sustainability reports, which may suggest that sustainability is not the core concern. Of these 29 banks, 22 have quantitative environmental management targets and only 12 have certified environmental management systems. As far as the principles go, some 60% or around 17 banks have sustainability

principles. However, the problem with these principles is that they do not have enforcement mechanisms as they are voluntary.

Furthermore, around half of the sample of 29 banks have a board committee that addresses sustainability, but only about a quarter of these banks have a senior management committee responsible for sustainability. Another issue is remuneration which is generally tied to sustainability, but only as far as the social aspect is concerned. Thus, it is tied to sustainability, but predominantly using measures such as customer satisfaction and to a lesser extent employee satisfaction as well (UNEP, 2016). This change is in its nascent phase. Therefore, the environmental dimension is not necessarily the main dimension in corporate sustainable measures.

Another deeper change in the sustainable financial reform has been the emergence of sustainable banking. It differs from the previous changes because it is fundamentally encompassing for all banking activities. Whereas commercial financial institutions which do business as usual might be socially and environmentally aware, sustainable financial institutions incorporate this in every segment of their operations.

Namely, these banks would typically decline loans if they deem that the borrower's activities will have negative social or environmental effects. Furthermore, all of the principles listed above need to be embedded in the banking culture. Adding to the case for a sustainable financial reform, a comparison between sustainable banks and Globally Systemic Financial Institutions (hereinafter: GSFI) reveals that the total growth rate of loans for these banks is higher for the sustainable banks than for the GFSI's over the period of 2003-2012. Sustainable banks also have higher return on assets (hereinafter: ROA) and return on equity (hereinafter: ROE) ratios during the crisis, whereas on average they perform similarly in terms of ROA, but are inferior in terms of ROE (GABV, 2013).

The numbers are clearly affected by the onset of the financial crisis. However, they are still revealing of the stability role of sustainable banks. Although we cannot expect that the financial system will be dominated by sustainable banks, they might have a stabilizing role. Other agents in the financial sector include (institutional) investors, which leads to socially and environmentally responsible investing. This can be investment in green/environmentally friendly projects by investing capital in two new instruments (green bond, green yield-co) developed for this purpose, or investing in stocks of firms which embed CSR in their business strategy. The returns from such projects provide grounds for claiming a double dividend in the private financial sector as well.

b) Green financial instruments

There are two new financial instruments specifically designed for environmental projects: green bonds and yield-cos. These are relevant for the financial architecture for the double

dividend. Green bonds are simply put the same as ordinary bonds except they are issued for a specifically environmental purpose. The market for green bonds started in 2007 when the European Investment Bank and the World Bank issued triple A rated green bonds (CBI, 2014). It took off one year after this when the first corporate bonds were issued as well. As of 2013, municipal bonds have also been issued. The largest take-off for the market though was from 2014 to 2015, from 11 billion to 42 billion issued in green bonds in 2013 and 2015 respectively (CBI, 2017). As can be seen the green bond market is growing rapidly. Most of these bonds have been plain bonds, meaning there is no securitization involved. They have the same credit ratings as other bonds from the same issuer. Given how investors holding 45 trillion of assets under management have made public commitments to public sustainable investment, there are expectations that the market will grow.

Moreover, the European Commission has been active in developing a standard for investing in green bonds which further supports the policy outlook. Developing a green bond standard is relevant for the supply of green bonds, as there is insufficient supply on the green bond market in recent years. This is due to the costs and reputational risks associated with issuing green bonds. This highlights the necessity of instituting a standard which is transparent and comprehensive. External verifications is an option and there are existing green bond taxonomies to address this issue (EC, 2019b). It is encouraging that the issue is on the supply rather than on the demand side as it implies that there is interest in sustainable finance. This is essentially the private finance aspect of the double dividend, due to the (voluntary) interest for sustainable finance in search of simultaneous economic (financial) dividends associated with projects which deliver environmental dividends.

The imbalance in supply and demand on the green bond market is an example of potential niches for public-private synergies. Namely, the public sector can assist in the development of the green bond market by developing a green bond standard and providing a pipeline of environmental projects. It is imperative to address the projects with the highest climate/environmental urgency and viability. These considerations can be addressed and indeed ensured most effectively by engaging the public sector, which is typically the carrier of this function.

Currently, most of the green bonds issued are plain vanilla bond, specifically the “use of proceeds” bond, which means that the proceeds (revenues raised) are earmarked or planned specifically for green projects. This contributes to further transparency. Moreover, the investment in the bond is secure due to full debt recourse to the issuer as the credit rating of the bond is linked to the credit rating of the issuer.

Another type of green bond is the “use of proceeds” revenue bond whose debt recourse is linked to both the rating of the issuer and the revenues/success of the project. Thus, it is

somewhat more risky than the first type as it depends on the revenues of the project as well. The revenues are earmarked for green projects as well.

The third type is the project bond where the debt recourse is related to the project only, thus relying on the success of the environmental project for its revenues. Project bonds are typically issued to finance large-scale green projects supported by multilateral financial institutions which contributes to the overall rating of the bond. The proceeds are ring-fenced, i.e. specifically dedicated to the green project in question. The last type involves financial innovation and bundling of various green projects, thus decreasing risk through diversification at least in theory. The securitized green bond is suitable for small, retail investors who do not have time to screen green projects but would invest green. Moreover, it is designed to finance small-scale, green projects which would obtain cheaper funding with a bundle of other green projects. The differences between various types of green bonds are delineated in Table 3 below.

Table 3 Green bonds overview

Type of green bonds	Use of proceeds	Debt recourse
Green "Use of Proceeds"Bond	Earmarked for green projects	Standard/full recourse to the issuer; therefore the same credit rating applies as to issuers' other bonds
Green "Use of Proceeds" Revenue Bond	Earmarked for green projects	Revenue streams from the issuers through fees, taxes etc. are the collateral for the debt
Green Project Bond	Ring-fenced for the specific underlying green project	Re-course is only to the project's assets and balance sheet
Green Securitized Bond	Either earmarked or directly used for a project	Re-course is to a group of projects that have been grouped together

Source: CBI (2016)

Green bonds are an increasingly popular instrument, due to their simplicity in offering double dividends. The double dividend here consists of an economic dividend in terms of a stable income, whereas the environmental dividend is due to investment of capital in environmental projects. As can be seen from Table 3 , there are various types of green bonds which may rely on the total credit rating of the issuer or the project only. Securitization is another potential avenue since it enables small retail investors' access to green projects. Earmarking or ring-fencing are typical features as they guarantee that the funds will be used

for environmental projects. Although this instrument is presented as a private finance aspect, it need not be. Namely, Poland is the first country in the world to issue a green sovereign bond. Thus, this is an instrument which can transcend both, i.e. integrate both the public and private finance aspects of the double dividend.

The market for green bonds is growing at double-digit figures and currently stands at a cumulative 202 billion $ (CBI, 2019). This is negligible in comparison to the total bond issuance. Nevertheless, it is encouraging that that the demand for green bonds exceeds the supply of green bonds as it indicates unsaturated market potential. It further indicates the necessity for greater public sector involvement as there are various reasons for the lack of supply. These include the costs of verification for green bonds, potential reputational costs associated with the environmental project or simply a lack of pipeline for environmental projects. The public sector can help alleviate at least two of these concerns as it can help provide a pipeline of projects and subsidize the cost of verification or introduce a public verification body.

Another instrument that has been increasingly mentioned in relation to climate change finance have been yield-cos, which are an equity instrument unlike green bonds which are a debt instrument. As will be seen, the issues related to yield-cos are perhaps more pernicious than they are for green bonds. Yield-cos are equity instruments which are somewhat more complicated conceptually than bonds and therefore more risky. Yield-cos are designed as investment funds that pool several projects together, usually large funds, and pay out dividends to shareholders from the cash flows generated from these projects. The underlying motive for establishing a yield-co is to attract more capital at a lower cost by bundling several projects together. Thus, a yield-co seems somewhat reminiscent of securitization already.

The cost of capital is further decreased due to the nature of projects involved. Namely, yield-cos have been popular with utility companies, for example for their renewable projects spin-offs. Since cash flows from these projects are thought to be more stable and less volatile compared to individual fossil fuels projects, there is less risk involved which lowers the cost of capital. Combining both factors together effectively means that a project finance premium for single projects can be successfully avoided (NCE, 2014).

Yield-cos have been especially popular in the past couple of years. The market capitalization of the 12 largest yield-cos was estimated to be around 28 billion dollars as of end-July 2015 which is more than 50% than what these companies raised in their initial public offerings (BNEF, 2017). There have been examples of yield-cos which have postponed their initial public offering, fearing market conditions, thus the yield-co market is not all blooming. Furthermore, US based yield-cos have seen a decline in their share prices of up to 60% in

2015 (CPI, 2016). Nevertheless, they have also seen large increases in dividends per share overall.

This equity instrument thus clearly has benefits in terms of the double dividend discussion as it has allowed for dividend per share gains and lower cost of capital by successfully bundling projects together. Nevertheless, the yield-co has its issues. There are differences as well between US and Europe based yield-cos which may further affect investors' outlook on the yield-co. A further issue in relation to its potential is the limit in financing as an issuance of a yield-co typically requires larger amounts of capital. This is not the case with green bonds, which can in principle be municipal even for small amounts of capital.

There are multiple issues in relation to yield-cos. One derives from its principal advantage which makes them more favorable over fossil fuel projects. Yield-cos are thought to be more suitable for renewable projects as these cash-flows are more stable. However, this carries an assumption of consistent regulatory policies which support renewables as well. The UK has announced for example that it will stop exempting electricity from renewable sources (McCrone & Liebreich, 2015). Changes in regulatory policies may affect the stability of yield-cos.

Another issue related to yield-cos is the stability of the stream of revenues, i.e. will there be sufficient projects from which to generate stable cash-flows because it is possible that a project gets saturated. This issue is resolvable though because yield-cos typically come with clauses that state that the yield-co is the first to be entitled to any other renewable projects of the utility company, the so called right to first offer clause (Kaminker & Stewart, 2012). Nevertheless, this still hinges on the assumption that the utility company for example will continue with its commitment to renewables.

A related issue is whether the cash-flows generated from yield-cos are reinvested in the renewable business or green business underlying the yield-co or are used mostly for dividends. In fact, this is the key difference between yield-cos in the US and EU, with the latter paying out a smaller share of cash-flows as dividends (McCrone & Liebreich, 2015). This has led to US yield-cos being observed as growth instruments, whereas EU yield-cos are seen as truer commitments to renewables (McCrone & Liebreich, 2015).

Perhaps the biggest issue in relation to yield-cos is the sustainability of the double dividend. Namely, the double dividend in this case is high dividend per share growth for example 10-15% as well. This is likely unsustainable in the medium to long run. Furthermore, an even greater problem is the rise in interest rates (BNEF, 2017). Yield-cos had their rise in popularity in a low interest rate environment, but this is subject to change and it is unclear what that implies for the outlook on this instrument.

To sum up, we have looked at green finance so far and established that here is a need for it. A part of this need will be addressed through banks which will likely green their credit portfolios. The bulk of this need though has to be supported by suitable instruments as well. Two instruments that have been related to climate finance have been green bonds and yield-cos. Whereas green bonds are simpler, yield-cos are a new instrument which may be precarious. As can be observed, this might be ameliorated as well by using up the clauses for investment and not paying out mostly everything as dividends, which is the difference between EU and US yield-cos for example. Green finance thus offers viable solutions to the climate finance problem which cannot be solved through the EU Emissions Trading Scheme (hereinafter: ETS) and environmental taxation. As such, it offers a double dividend by default since it provides a coupon payment (economic dividend) related to an environmental project (environmental dividend). Moreover, it provides the tools for a financial architecture for a green economy.

However, sizeable challenges and opportunities remain, valid for both instruments and indeed the general outlook for environmental finance. Some of the opportunities include policy initiatives such as the EU Investment Plan, which has a long-term focus, which is favorable for green projects or the establishment of an EU High Commission for Sustainable Finance. The latter is actively involved in designing a green taxonomy and a comprehensive sustainable finance framework. Other opportunities for the development of environmental finance include the protracted period of low interest rates and the emergence of new investment principles such as the environmental, social and governance (hereinafter: ESG) principles. There are potential pitfalls such as policy risk and the slow speed of transition.

There are sizeable opportunities and challenges, yet given the investment needs, it is also clear that there is a need for synergy between various economic agents (firms and investors) or sectors such as the real sector and the financial sector. This section has outlined the changes in the financial sector which is a prerequisite for a thorough change in the real sector, which depends on the financial architecture and provision of capital or green funding. Firms which use this capital in turn have the potential to reap a double dividend as well, by engaging in corporate social responsibility. This will act as a catalyst to further financial reform, thus setting a virtuous cycle in motion for the green economy transition. Thus, private sector involvement will depend crucially on the double dividend and the synergies between the real and the financial sector.

To sum up, this section referred to the private finance aspect of the double dividend. There is a case to be made for a double dividend in the private sector as well, although the term has been coined in relation to public finance aspects (Pearce, 1991). The aim of this thesis is to integrate the public and the private finance aspects of the double dividend. Namely, the review in this section showed that there are grounds to posit a double dividend in the private sector as well. Thus, the next section presents the augmented concept of the double dividend

which integrates the public and private finance aspects, thus building on the earlier double dividend concepts.

1.4 Reconceptualizing the double dividend

The double dividend is a concept which embodies the economy-environment nexus, refers to environmental taxation and posits simultaneous economic and environmental benefits (dividends). This is the public finance aspect of the double dividend discussion as it entails public environmental policy and target variables which relate to the key policy goals. The section presents the augmented concept of the double dividend which integrates its public and private finance aspects. The economic dividend from environmental taxation is typically stated as a welfare or employment effect in the academic literature, although research on the double dividend relates it to tangible effects on GDP and employment. Thus, the characterization of the double dividend is an issue which calls for a more practical approach to the double dividend discussion as explained in Section 1.2. Furthermore, the lack of ex-post estimates is an existing research niche within the realm of the existing double dividend conceptualizations. Moreover, there are further research niches related to the private finance aspects of the double dividend.

The private finance aspects of the double dividend are based on the environmental-financial performance link which is an embodiment of the economy-environment nexus at the corporate level. The private finance aspects of the double dividend entail simultaneous economic (financial) and environmental dividends associated with voluntary environmental policies. Indeed, the existence of simultaneous economic and environmental dividends is the reason for the voluntary private sector involvement, which relies on financial incentives, i.e. dividends. These are additional channels for the double dividend which represents a further research niche.

The augmented concept of the double dividend entails both public and private finance aspects depending on the sector which initiates the policy and the target variable. The double dividend entails simultaneous economic and environmental benefits (dividends). The double dividend is associated with environmental policy (taxation) within public finance, whereas it is associated with voluntary environmental measures (corporate social responsibility or sustainable investing) within private finance. The target variables within public finance measures include GDP, employment, the trade balance or productivity as some of the main policy goals. Additional target variables may include emissions as a part of the broader sustainable development or green growth framework. Private finance target variables include higher returns, value of the firm, cost of equity or lower risk as a result of environmental measures, thus embodying the link between environmental and financial performance (See Table 2).

The double dividend concept itself is subject to various drawbacks relating to both the economic and the environmental dividend. Some of these can be ameliorated with the augmented concept of the double dividend. Crucially, the augmented concept of the double dividend integrates both the public and the private finance aspects of the discussion. The conceptual synergy (public and private) is necessary for a comprehensive assessment of the double dividend. The augmented concept of the double dividend can serve to ameliorate the initial drawback of the double dividend which is the elusive conceptualization in terms of target variables and subsequently the lack of ex-post estimates. In light of this, the following section presents the research approach for this thesis.

1.5 Research approach

The lack of concrete policy variables and ex-post estimates is an existing research niche within the realm of the existing double dividend conceptualizations. Moreover, there are further research niches related to the private finance aspects of the double dividend. There is substantial research on the public finance aspects of the double dividend. The empirical literature has focused on both the effects of environmental regulations and taxation. The latter has been underresearched and consists mostly of ex-ante simulation studies on the effects of environmental tax reforms. The literature on specific environmental regulations and their effects on the industry level is part of the literature analyzing the Porter hypothesis. This is an initial insight in both public and private sector aspects, but it does not entail financial aspects, thus it belongs to the realm of environmental regulation. The studies in this strand are mostly sectoral analyses of specific regulations with inconclusive results (Ambec, Cohen, Elgie, & Lanoie, 2013), covering a particular sector and not the whole economy. Thus, there are research niches in the studies on environmental taxation and regulation.

The environmental tax reforms of the 1990s were based on the double dividend, i.e. the notion of economic and environmental benefits. Some countries implemented the ETR reforms aiming for the economic dividend, in terms of higher GDP growth or higher employment. Other countries, for ex. Finland, had introduced environmental taxation to target fossil fuel imports, i.e. energy dependency, since the oil shocks had increased the sensitivity to oil price shocks. The UK for example had introduced the reform to comply with the Kyoto objectives, thus the objective was environmental.

Despite the introduction of the reforms, there has been comparatively little research on the effects of environmental taxation and indeed the reforms (De Miguel & Manzano, 2011; Oueslati, 2015). There are various studies which aim to assess the effects empirically. A notable example is the COMETR study on the competitiveness effects of the reform (Andersen et al., 2007), estimating the effects on GDP, employment and imports .

Nevertheless, it is a simulation study providing ex-ante results, which do not extend beyond the crisis.

A newer version based on the same model finds substantially larger effects on GDP (Groothuis, 2016), but it assumes a different revenue recycling mechanism (using both labor and value added taxes). It is once again based on ex-ante results. There are other national case studies of the reforms, but they do not offer conclusive evidence in favor or against the double dividend. Thus, this dissertation aims to fills this research niche by providing ex-post empirical estimates of the various channels of the double dividend.

The traditional channel for the double dividend is the effect on GDP and employment, although the effect on energy imports and thus the current account is not new theoretically. Empirically, it is an additional channel for the double dividend, as the decline in energy dependency (imports) and thus the positive effect on the current account constitutes an economic dividend. This channel has not been assessed empirically to the best of the author's knowledge. The literature on the current account does not account for the effect of energy taxes explicitly, although oil prices are acknowledged to be a determinant. Thus, this is a research niche for the public finance aspects of the double dividend. The empirical estimates for this additional channel are provided in the thesis (research question no. 1). Furthermore, this is estimated using ex-post data for environmental taxation for the European Union which has a comprehensive environmental taxation framework allowing for a rich panel. The results are presented in Section 2 of Chapter 2.

Furthermore, the research on the double dividend can be enriched for greater granularity of the analysis, i.e. the level of disaggregation of the data. With regards to the effects on the key policy variables typically analyzed in the literature, many of the studies listed above analyze samples with environmental regulations covering one sector or type of sector only. For example, studies on regulations such as the Clean Air Act and other environmental regulations in the United States do not find conclusive evidence for the effects on productivity (Ryan, 2012; Sato & Dechezleprêtre, 2014).

The effects on other key policy variables such as employment are equivocal as well (Commins et al., 2009; Deschenes, 2010). Anger and Oberndorfer (2008) and Commins et al. (2009) analyze the EU ETS at the sectoral level, but find no statistically significant effects for employment. The latter study finds a negative effect on employment, which is corroborated in the studies by Aldy and Pizer (2011) and Deschenes (2010) as well who analyze the effects of electricity prices and a carbon tax respectively. Indeed, the lack of evidence for a positive effect could imply that there is no free lunch as suggested by Ambec et al. (2013).

The studies listed above provide micro-level estimates within specific sectors but it does not provide a cross-sectoral overview of the effects of environmental regulations or

environmental taxation. Moreover, the effects of these studies are ambiguous and do not provide unequivocal evidence for or against the double dividend, thus representing a further research niche for the public finance aspects of the double dividend, specifically in relation to environmental taxation. The sectoral effects of environmental taxation on key policy variables such as employment and value added (GDP) are estimated within the second empirical analysis (research question no.2) for the EU-28 countries.

These are the public finance aspects of the double dividend discussion related to policy measures (environmental taxes) and the main policy goals. The public finance aspect of the double dividend is analyzed empirically within the first two research questions which entail the effects of environmental taxation on the current account (national level) and value added and employment (sectoral level). The results of the empirical analyses can be found in Sections 2 and 3 of Chapter 2.

However, the vast investment needs for the green economy transition and the rise of environmentalism in corporate management imply a greater involvement of the private sector in the green economy transition. This implies that it is sensible to extend the concept of the double dividend towards the private sector so as to entail both its public and private finance aspects. This is the basis for the third research question related to the private finance aspects, i.e. the economic dividend associated with sustainable finance, the results of which can be found in Chapter 3.

Extending the concept of the double dividend towards the private sector is sensible as dividends can appear in relation to policies emanating from the private sector as well. As discussed in the previous section, these are policies stemming from various initiatives related to corporate social responsibility in the real or financial sector. As shown in the previous section, these initiatives build on the economy-environment nexus in the private sector realm, i.e. they build on the environmental-financial performance link.

The current literature on the environmental-financial performance link analyzes the financial effects of modern management practices such as CSR. The literature on CSR has been overviewed in Section 1.3.2. Various studies find a positive effect of CSR on firm value (Gillan et al., 2010; Jiao, 2010). The effect of environmental performance can be observed through higher stock returns as well (Dimson et al., 2015). Sustainable banks are reported to have had higher returns on assets and returns on equity during the crisis than global financial systemic institutions (GABV, 2013).

Although the literature studies the effect of sustainability, it does not distinguish between the various dimensions of sustainability or environmentalism. Thus, CSR can entail employee satisfaction, environmental measures, community support measures etc. The CSR literature is therefore indicative as a preliminary gauge of the environmental-financial

performance link, although the link itself is not the focal point of the analyses (Eccles et al., 2012; Plumlee, Brown, Hayes, & Marshal, 2010).

Studying the various notions of sustainability is important so as to distinguish the environmental dimension from the other sustainability dimensions. Some studies analyze the environmental dimensions specifically (Chava, 2014; Gillan et al., 2010). Nevertheless, there are further segmentations within the environmental-financial performance link. This relates to the various notions of green. Namely, some firms adopt environmental policies as part of a broader sustainable strategy, whereas others are at the forefront of the green economy transition operating in the green economy sectors such as renewable energy. Since the green economy transition comes with high funding needs, it is necessary to analyze the risk-return profile of these investments.

The renewable energy sector has been traditionally exposed to great volatility as studied in Bohl et al. (2013) and Sadorsky (2012) who find a bubble in the returns for renewable energy prior to the global crisis and high market risk respectively. Private sector involvement is crucial here, as the sector traditionally relies on public support. Thus, the research should be extended to account for the post-crisis period and the differences in the risk-return profiles for sustainable and renewable energy investments. Namely, the current literature studies either sustainability or renewable energy investments (Bohl, Kaufmann, & Siklos, 2015) although a comprehensive analysis of the environmental-financial performance link requires both.

Differentiating between the various dimensions of sustainability and environmentalism is a relevant research niche in terms of the double dividend associated with private finance, which we aim to fill with the third empirical analysis. Enticing private capital to invest in renewable energy requires a positive risk-return profile. Risk and return are two crucial dimensions to investing which are typically studied within the financial markets research literature. This literature typically studies returns in relation to broader market factors as suggested by Fama and French (1992) and extended by Carhart (1997) and Fama and French (2015).

The third empirical analysis within this thesis (research question no. 3) applies these multi-factor models to various sustainability and renewable energy indices so as to capture the potential differences in the risk-return profile. Thus, Chapter 3 analyzes the link between environmental and financial performance as a gauge of the incentives for the private sector's involvement in the green economy transition. This concludes the conceptualization of the double dividend within this first chapter as a public and private finance concept. The following Chapter 2 covers the public finance aspects of the double dividend, whereas Chapter 3 covers the private finance aspects of the double dividend.

2 PUBLIC FINANCE ASPECTS OF THE DOUBLE DIVIDEND

The previous chapter introduced the conceptualization of the double dividend. The double dividend is based on environmental policy, specifically taxation, and aims to achieve simultaneous environmental and economic dividends. This is the public finance aspect of the double dividend. The economic dividend itself is an elusive concept as shown in the review in the previous chapter. Thus, it is important to phrase it in terms of tangible policy goals. This was the aim of the environmental tax reforms which aimed to achieve higher GDP growth and employment. This chapter analyzes the public policy aspect of the double dividend in particular and is divided in three broader sections. The first assesses the double dividend within the Environmental Tax Reforms to date. The environmental dividend analysis consists of a case-study analysis of the environmental effects of environmental taxation in the ETR countries.

The second and third analyze the economic dividend at the national and sectoral level respectively for a panel of the EU-28 countries for the 1995-2015 period. The economic dividend at the national level is the effect on the current account and energy dependence. Indeed, this has been one of the motivating factors for ETR's across Europe in the 1990s. The economic dividend at the sectoral level is the effect on value added and employment. Since we are analyzing environmental policy (environmental taxes) and the effect on key economic policy variables, this constitutes an empirical analysis of the public finance aspects of the double dividend. The ex-post analysis is done at the EU level since it has comprehensive environmental taxation for over two decades.

2.1 Environmental tax reforms

2.1.1 ETR and the double dividend

A full-fledged ETR has so far been conducted in six European countries only: Finland, Sweden, Denmark, UK, the Netherlands and Germany. Whereas other countries in the EU have environmental taxes, they have not conducted an environmental tax reform. An environmental tax reform as defined earlier has to involve a tax shifting element which makes it more comprehensive than merely instituting environmental taxes. Generally, although the specific reasons for the tax shifting differ case by case, they are usually motivated by economic concerns or dividends (e.g. growth, employment, fuel imports and the effect on the current account). The environmental benefit or dividend is an additional benefit, although often not the prime reason for the reform. The following section reviews the environmental tax reforms to date in six EU countries.

a) Denmark

The Danish experience with environmental taxation dates back to the oil shocks of the 1970s. Denmark introduced an energy tax on fossil fuels so as to decrease consumption in the wake of the oil crisis. Denmark introduced a carbon tax for households in 1992 and extended it to include industry as well in 1993. Thus, the Danish ETR can be divided in at least two phases, the 1972-1996 phase which affected mostly households and the 1996-2000 phase which affected industry as well (Andersen et al., 2007). Denmark froze the carbon tax in 2001 but announced a range of environmental tax increases in 2010.

The objective of the ETR was primarily economic, so as to reduce the current account deficit in the balance of payments, with an added economic benefit. The ETR aspect of the Danish experience with environmental taxes is in the decrease of marginal tax rates on personal income from 1994-1998.

b) Finland

Finland was the first country to introduce a carbon tax in the 1970s. Environmental taxes in Finland were raised to decrease imported electricity. The reduction of imported energy and thus the improvement in the current account is one key benefit of the Finnish ETR. Unlike Denmark, Finland taxed industries first and then included households as well. The energy tax structure has been more or less the same.

Similarly to Denmark, the objective of the Finnish ETR was to help alleviate economic concerns (IEEP, 2013;Speck & Jilhova, 2009). The tax shift was to reduce the tax burden on labor so as to encourage employment and thus achieve an economic dividend. Thus, the environmental dividend is an added side benefit. A similar motivation ensued in 2011 when energy tax rates were raised to help offset revenue losses caused by the abolishment of national pension contributions by employers (Sairinen, 2012).

c) Germany

Germany introduced the ETR in 1999. It was meant to be gradually introduced between 1999 and 2003. A major success of the German ETR has been the political acceptance associated with it. Most of the revenue gained from the German ETR is recycled for pensions which has made it acceptable for both parts of the political spectrum.

Similarly to Denmark and Finland, the German ETR has also originated due to potential economic dividends, specifically related to fiscal objectives. Although successful politically, the German ETR can be criticized for the degree of laxness in the system. It was initially introduced gradually, but there were no major radical increases thereafter.

d) The Netherlands

The Netherlands introduced the Regulatory Tax in 1996, to be renamed to an energy tax later. The tax covers small-scale consumers and is recycled back in the system. A notable feature of the Dutch ETR is indexation with inflation (IEEP, 2013). This is relatively rare (within the EU countries) and it has the benefit of stable real tax revenues and stable impact on relative prices and thus behavior (EC, 2012).

In addition, unlike the first three countries the objective of the Dutch ETR was primarily environmental, so as to allow the country to fulfill its Kyoto obligations. The aim of the ETR is an economic dividend as well as there is tax revenue recycling. Budget discussions in 2012 over a looming budget deficit led to an increase in some energy taxes. The Dutch ETR has been regressive by design, but the government has implemented offsetting measures.

e) Sweden

Sweden introduced a carbon tax in 1991. From 2001-2010 Sweden announced the implementation of a 10 year tax shifting program divided in two phases. The first phase was meant to decrease personal income tax rates and the second to reduce burdens on low and medium wage earners (Speck & Jilhova, 2009). The motivation behind the Swedish ETR is both an economic and environmental dividend, due to strong oil dependency in the 1970s and thus higher vulnerability to prices and the economic downturn in the 1990s. The measures were also envisioned to encourage and smooth the green economy transition. However, the tax shifting program was abandoned in 2007.

f) UK

The UK's ETR consists of the Climate Change Levy (hereinafter: CCL) introduced in 2001. The CCL still stands and will be extended to introduce a carbon price floor so as to provide a signal for low-carbon investments. The British ETR burdens energy intensive firms more than labor intensive firms which is a sign that there has been tax shifting (Withana et al., 2013). The motivation behind the British ETR has been primarily environmental so as to allow it to meet its targets under the Kyoto agreement. In terms of the economic dividend, the CCL has been slightly revenue negative.

As can be seen from the brief descriptions above, countries' motivation for the ETR has been mostly economic. Indeed, the Scandinavian countries were among the first to consider environmental taxation because of balance of payments (current account) concerns due to sensitivity to oil shocks as energy-importing countries. Economic concerns such as budget deficits and unemployment are the other main motivation for environmental taxation. Namely, employment may increase if labor taxes decrease with a revenue-neutral increase in environmental taxes.

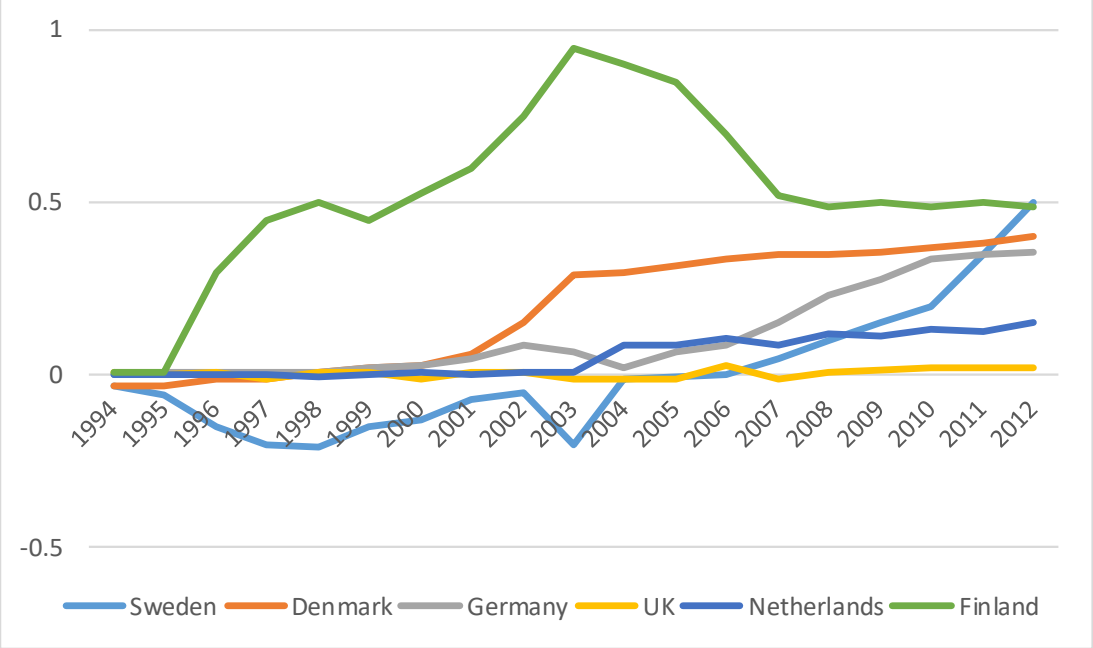
The environmental benefits are typically seen as an added bonus and while important so as to allow meeting of Kyoto targets, they have not been the prime driver of the tax change. This is true for four out of six countries: Finland, Denmark, Germany and Sweden. After reviewing their objective for the reform, the following looks into their effects in terms of double dividend (economic and environmental effects) before proceeding to the consistency and potential of the environmental tax policy.

a) The economic dividend in the ETR countries

The economic performance is mostly measured ex-ante through modelling. The estimates for the effect on GDP from the ETR reform are given in Table 4. Arguably, there are other economic dividends beyond the effect on GDP, but GDP is the key policy variable and as such has been analyzed in various studies. As can be seen the effects on GDP are mostly positive. This was estimated also through the COMETR study meant to assess the effects of the ETR (Andersen et al., 2007) shown in Figure 1.

Figure 1 shows the effect of ETR on GDP in the six ETR countries as estimated in the COMETR report. The figure shows the percentage point difference between GDP growth in the baseline and the counterfactual case (with the ETR reform). As can be seen, GDP growth can be positive and with a difference of up to 1 p.p. when accounting for an ETR. Nevertheless, the effect is not uniform and it depends on the policy design, with frontloaded effects in certain cases, for example Sweden.

Figure 1 The effect of ETR on GDP in the baseline and counterfactual scenario (in % points)



Source: Andersen et al. (2007)

The strongest positive effects appear in Finland and Denmark which introduced the ETR to alleviate economic concerns. The UK was one of the last countries to introduce the reform. Moreover, the objective of the UK reform was primarily environmental and the reform itself was also slightly revenue-negative. Thus, there are no substantial effects on GDP. As evident from Table 4, the positive effects on GDP amount to 0.5 p.p. Nevertheless, most of these studies were conducted prior to the crisis.

Table 4 Economic effects of an ETR

Country	Economic effect (GDP)	Ex-ante/Ex-post
Denmark	Overall positive impact on growth but with an estimated -0.03% effect on GDP from 2000-2005.	Ex-post (Ecologic, 2007)
Finland	ETR leads to positive GDP growth (0.5% on average) in 2012, it is positive even without revenue recycling	Ex-ante (Andersen et al., 2007)
Germany	GDP would be 0.45% higher in 2003, 0.3% higher in 2005 and 0.13% higher in 2010	Ex-ante (Withana et al., 2013)
The Netherlands	Small positive impact on GDP up to 0.2 %	Ex-ante (Andersen et al., 2007)
Sweden	ETR leads to 0.5% increase in GDP in the long run, in the short term there are economic losses	Ex-ante (Andersen et al., 2007)
UK	GDP would be only 0.06% higher than without the CCL by 2010	Ex-ante (Econometrica, 2005)
EU-27	2% higher employment and 2.9% higher GDP growth in 2020	Ex-ante (Groothuis (2016)

Source: Own work

A subsequent study using a large-scale econometric model on a panel of EU countries finds substantial positive effects over a medium-term horizon (Groothuis, 2016). The positive effects ensue from a scenario based on fundamental changes in the tax code. The challenge of substituting a wide-base tax (labor) for a narrow-base tax (environmental) is resolved by including smaller increases in other wide-base taxes such as the value-added tax to close the gap. This implies that the viability of the economic effects depends crucially on the amount of tax shifting, the time frame and the consistency of the tax policy in general.

Although the ETR seems to have led to an increase in GDP, an increase in GDP might be appropriated by an increase in energy use. Therefore, perhaps what is even more important is the interaction between the economic dimension and the environmental one. Namely, it is important to see whether emissions decreased along with an increase in economic growth, i.e. whether economic growth has decoupled from energy use and thus emissions. In this respect, it is useful to observe the trend in emissions from energy-intensive industries as these are a key contributor to overall emissions (Eurostat, 2019a), as well as the general trend in renewable energy. The latter serves as an offsetting factor.

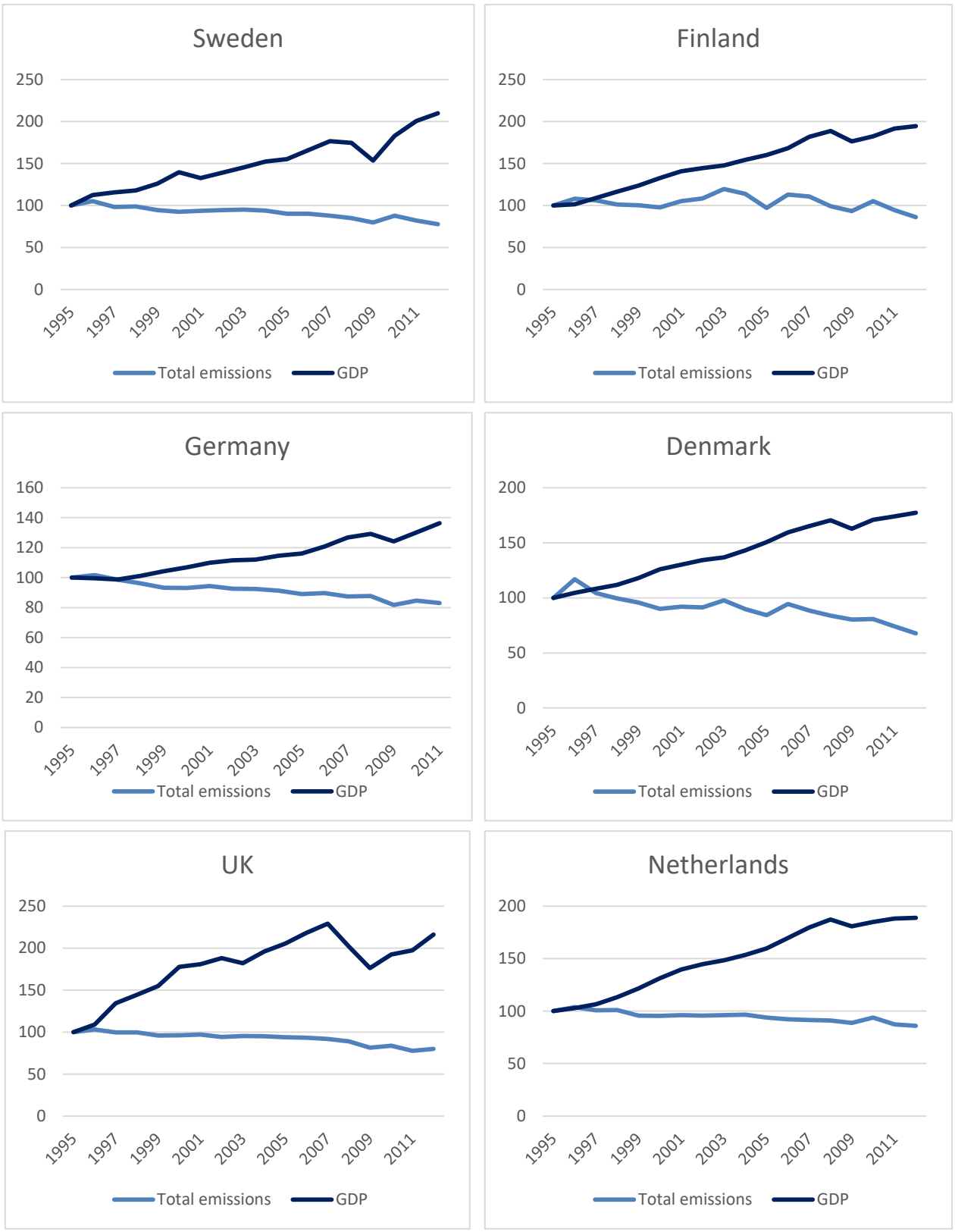
b) The environmental dividend in the ETR countries

Decoupling occurs when GDP grows but this growth is not appropriated by a growth in emissions. In other words, decoupling occurs when the correlation between emission and GDP growth is no longer positive (Cohen, Jalles, Loungani, & Marto, 2018). To observe decoupling we could look at emissions and GDP.

Figure 2 shows emissions and GDP through time for the six countries through time. Both emissions and GDP are expressed as an index with base year 1995. As can be seen from Figure 1, all countries have achieved decoupling and their emissions have been decreasing, evident from the diverging trend lines in the two data series. Denmark is the country with the biggest progress as emissions have nearly halved in the 20 year period observed. Finland's emissions are on a decreasing path but it is not as steep as other countries'.

The differences between countries can be explained by various factors and the ETR is likely not the exclusive factor behind the decoupling. Moreover, there are country level differences in the ETR agendas in terms of the time horizon, consistency and scope of the reform, as well as other structural reforms. Nevertheless, the graphs are illustrative in terms of whether the ETR has served its initial purpose in terms of breaking the correlation between economic growth and emissions. Stronger claims on causation require further insights which are beyond the aim of this section which serves as a preliminary gauge of the initial purpose of the ETR.

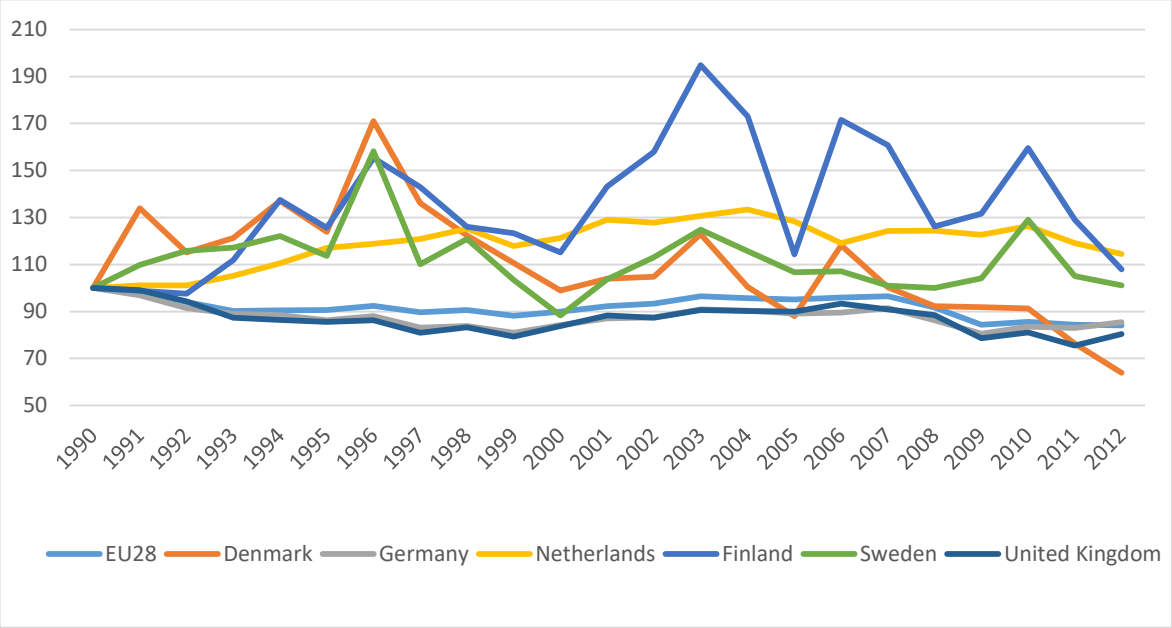
Figure 2 Decoupling between emissions and GDP (index 1995=100) in ETR countries



Source: Eurostat (2015d)

Whereas total emissions have been declining, not all countries have been equally strict with domestic industries due to competitiveness concerns. Thus, what is perhaps more informative than total emissions are the emissions from energy industries as well, as these are a key contributing sector to overall emissions. The following Figure 3 shows the emissions from energy industries for the six countries. Figure 3 shows emissions as an index with base year 1990. Thus, a value higher than 100 indicates an increase in emissions from energy industries relative to 1990.

Figure 3 Emissions from energy industries in ETR countries (1990=100)

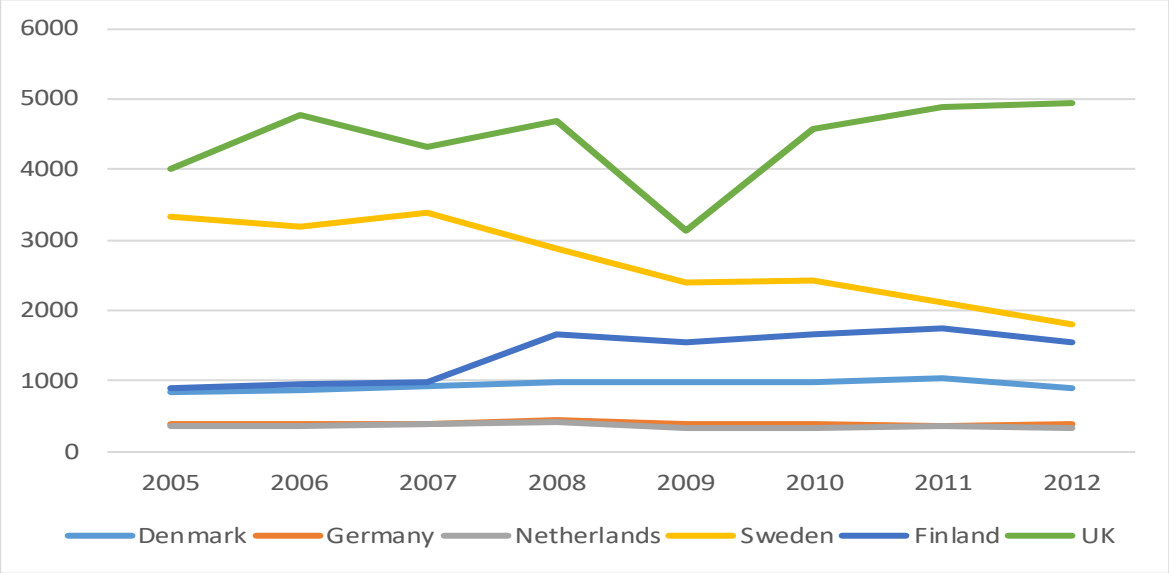


Source: Eurostat (2015d)

As can be clearly seen from Figure 3, although there is decoupling, there is a clear increase in emissions from energy industries even in ETR countries. Germany, UK and Denmark have decreased their emissions from energy industries relative to 1990. The other countries have increased their emissions and as the index shows, at times even quite substantially and more than 50%, for example Finland during the crisis. The previous observation is not surprising in light of the support that energy intensive industries get.

Although competitiveness effects are considered to be of no concern or modest if they are, countries have been favoring domestic industries nonetheless. This can be seen clearly from the following Figure 4 which explains the somewhat paradoxical observation above. Namely, energy intensive industries are among the biggest polluters and their emissions have been increasing, although total emissions seem to be declining. Figure 4 shows fossil fuel subsidies in millions euros by country from 2005-2012.

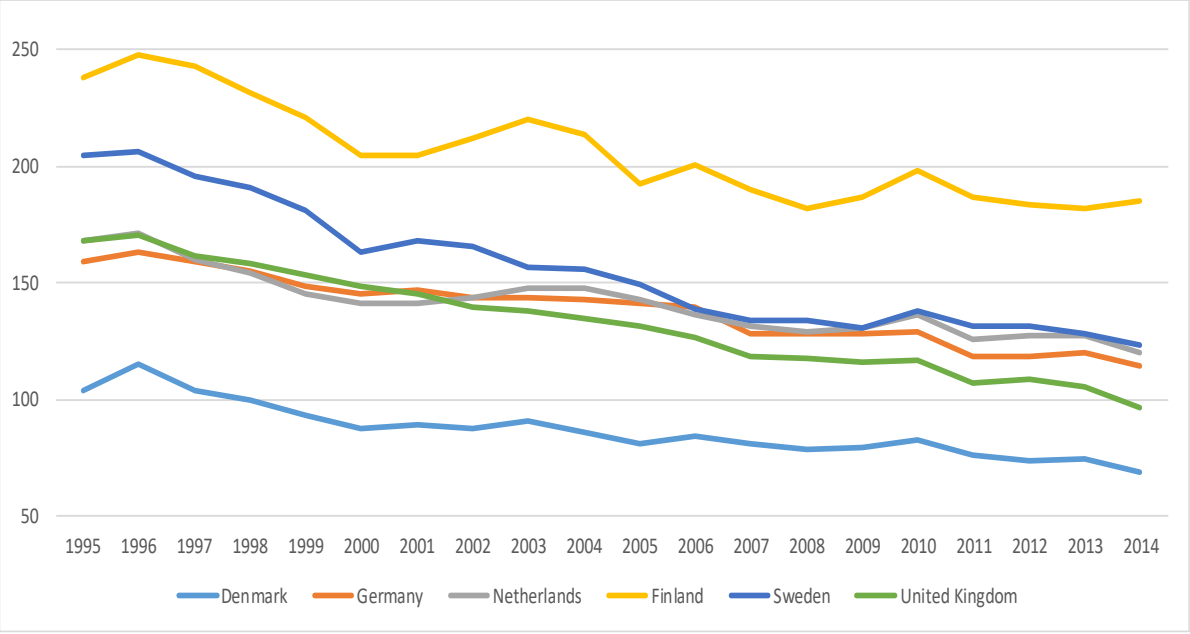
Figure 4 Fossil fuel subsidies in ETR countries in millions euros



Source: OECD (2015b)

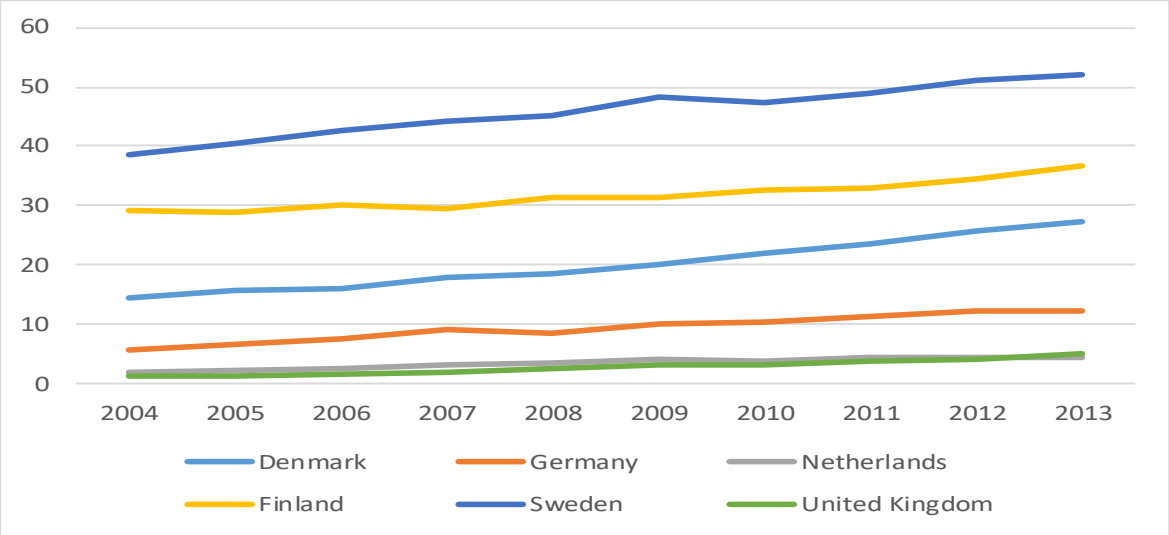
As can be seen, Sweden is the only country which has sharply reduced its environmentally harmful subsidies. Finland was pointed out previously as an example of a country with increases in emissions from energy industries. The data for the fossil fuel subsidies explains this finding as it shows the increase in subsidies around the crisis. Data for Germany is scarcely available. Although emissions from energy intensive industries seem to be increasing, there is a positive trend in energy intensity (expressed in kg of oil per 1000 euros) and in the overall structure of energy consumption as shown in Figure 5 and Figure 6.

Figure 5 Energy intensity in ETR countries in terms of kg of oil per 1000 euros



Source: Eurostat (2015b)

Figure 6 Share of renewable energy use in electricity use (in %)



Source: Eurostat (2015f)

Namely, Figure 5 and Figure 6 show a negative trend in energy intensity, which implies a more efficient use of energy per unit of economic output. In addition, the share of renewable energy in electricity consumption has been growing steadily, which indicates structural changes and greening of the energy mix. Both findings indicate that there is a case for an environmental dividend associated with environmental taxes and an ETR. Namely, emissions have decoupled from GDP, even though in some countries the change seems to occur somewhat later, as is the case with Finland. Furthermore, energy intensity and the share of renewable energy are decreasing and increasing respectively, which seems to support the claim that the EU's environmental policies are indeed effective in terms of delivering an environmental dividend.

However, the general conclusion that there is a positive environmental dividend (in terms of emissions) does not imply that the current environmental fiscal policy setup is optimal. Namely, as could be seen from Figure 3, emissions from energy industries have increased. Moreover, even though there are environmental taxes, fossil fuel subsidies are another active policy which offsets the incentive effects from environmental taxes. This leads to suboptimal investment and consumption decisions and an inefficient allocation of resources (Bárány & Grigonytė, 2015). Although the database for some countries (Germany for example) is somewhat lacking, the issue of fossil fuel subsidies to energy industries is a contentious one which calls into question the whole EU environmental framework.

Indeed, further fiscal reform is needed, as countries are still subsidizing fossil fuels heavily (OECD, 2017). This might have negative implications for the double dividend, as its success depends on the implementation of the policy and the incentives it provides for a change in agents' economic behavior. Policy should be coherent in that it does not offset the incentives

from its environmental tax policy with its fossil fuel subsidies. The next section reviews the policy potential of environmental taxes in light of these and other challenges.

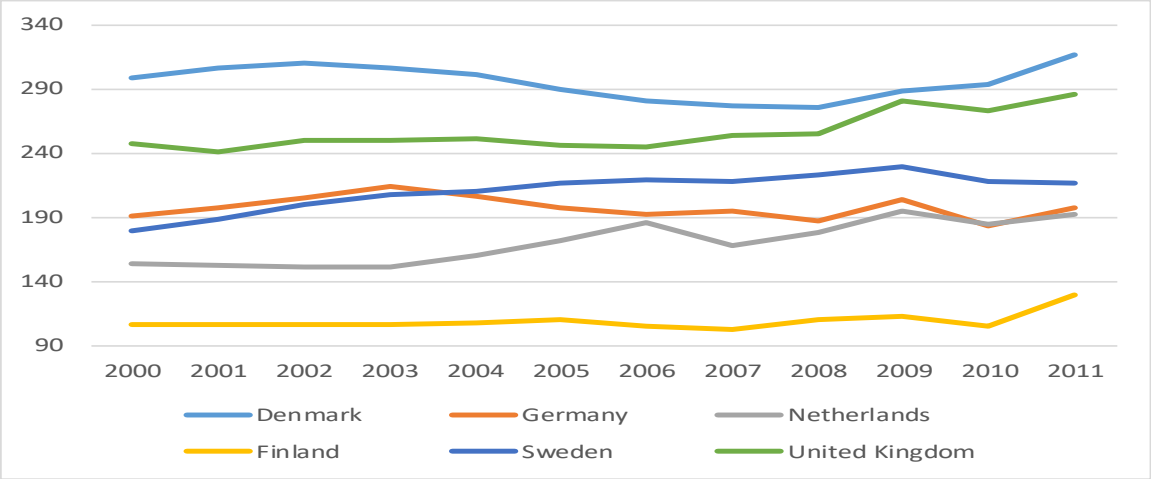
2.1.2 ETR trends and policy potential for a double dividend

The following sections look at the overall trend and new potential for the green ETR. Environmental taxes were popular during the downturn in the 1990s, this is especially true for the Scandinavian countries. Environmental taxation trends should be observed, since they have implications for the double dividend discussion. First of all, policy should be consistent so as to ensure environmental and economic dividends over the long run. Namely, if changes to the tax code are considered transitory, there may not be substantial changes or incentives to change economic behavior. Second, the shares of taxation are informative for the future potential for a double dividend, if there is room to increase taxation further.

The following section overviews the implicit energy tax, labor and capital rates in the ETR countries and the structure of taxation in the ETR countries. The evolution of the implicit energy tax rate is important because it provides an insight in the policy design and policy consistency through time. The trends in the implicit labor and capital tax rates, as well as the evolution of the structure of taxation are informative for a gauge of the alternative policy paths, i.e. which taxes are to be increased or decreased with another ETR wave.

Observing the ETR countries' tax indicators gives a mixed signal regarding their consistency. One could look at the nominal tax rates but arguably the implicit tax rates are more informative as they provide a share of the implicit taxes in total consumption, thus providing a more realistic picture. Figure 7 shows the levels of implicit energy taxes in the six ETR countries studied. Namely, energy taxes are the most important environmental tax, in terms of revenue share in overall environmental taxes. The implicit energy tax is expressed in euro per tonne of oil equivalent.

Figure 7 Implicit energy tax in the ETR countries (euros per tonne of oil equivalent)



Source: (Eurostat, 2015e)

As can be seen, the implicit energy tax rates vary substantially throughout the years. The UK has the most dramatic increase in the implicit tax rate in the past decade. Thus, it is not surprising that studies for the UK find regressiveness of energy taxes. The UK and Denmark are the two countries with the highest tax rates. The Swedish implicit tax rate is not as high but it is rising consistently, as opposed to the British and Danish ones. As can be seen, the Danish one has a dramatic decrease after its second phase. The British one also decreases in the middle of the crisis. The Dutch and Finnish rates are rising through time with a more pronounced increase in previous years for the Finnish one. The cross-country variability implies that there is room for further improvement in environmental tax reforms, as the double dividend depends crucially on policy consistency.

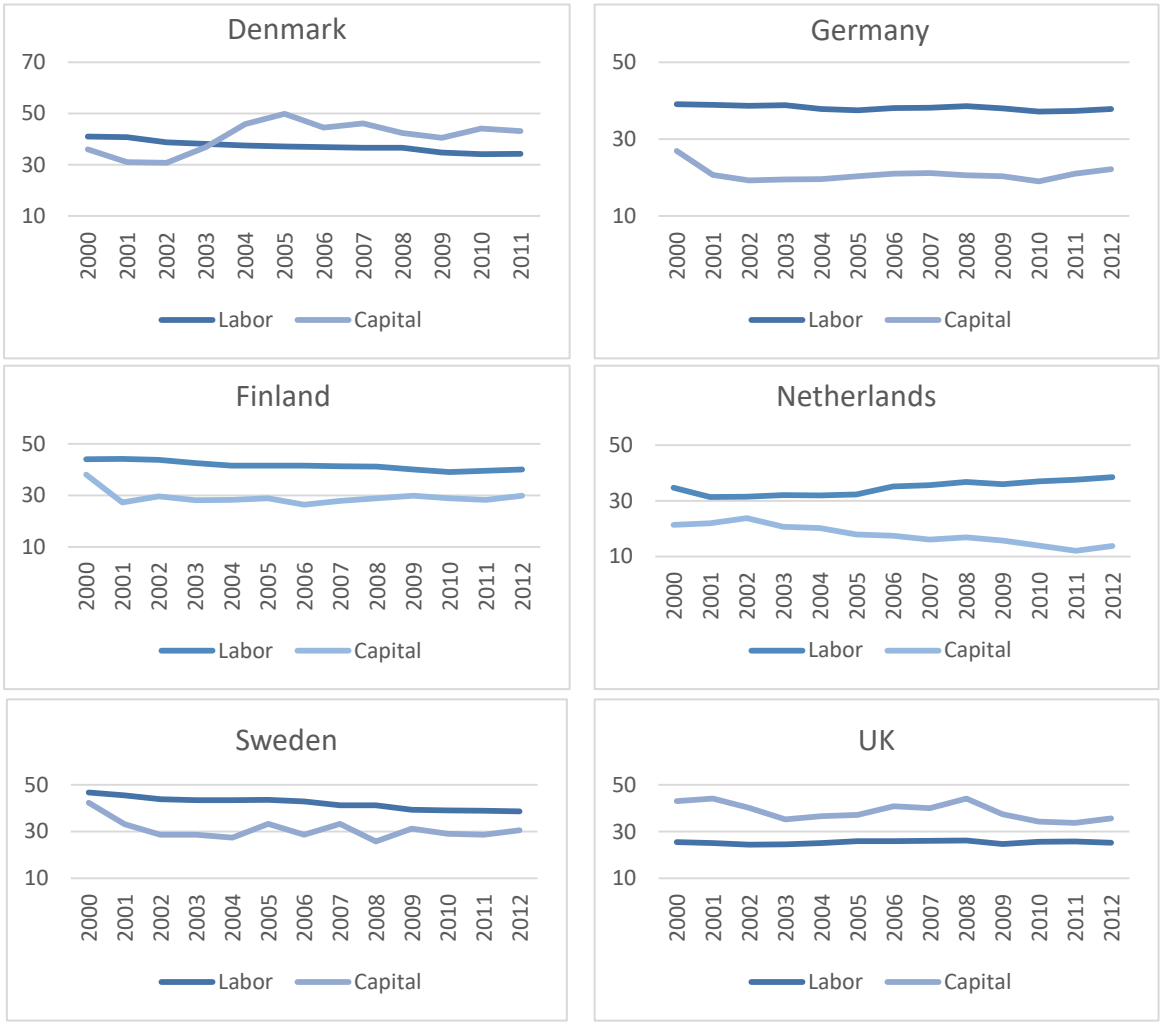
Another important aspect for the credibility and consistency of the ETR is the evolution of labor taxes through time. Namely, the ETR envisioned tax shifting from labor taxes to environmental taxes so as to achieve economic dividends. Inconsistent trends in labor taxation would imply an inconsistent ETR and thus uncertain implications for the ETR policy outlook. In that case, the policy potential cannot be assessed to its full extent.

Figure 8 shows the evolution of labor taxes and capital taxes through time so as to identify which is more sensible to be decreased. In general, it would be sensible to decrease labor taxes in Europe as the burden is higher, but the ETR does not prescribe a decrease in the labor tax necessarily. The ETR definition applies to any tax shift program, be it through labor or through capital taxation.

The graphs in Figure 8 show a stark difference between the implicit tax rates on labor and on capital. These are calculated as the share of the tax revenues in the total tax base from the tax category (labor or capital). Furthermore, not all countries have implicit rates on labor which exceed the rates on capital. This indicates that a one-size fits all approach of decreasing labor taxes might not be sensible in all countries as the tax inefficiency might arise from capital taxation. Thus, the ETR tax shifting may be conducted through shifts in labor or capital taxation, depending on country specificities. Subsequently, the economic dividend in terms of efficiency gains can be obtained with varying policy paths.

Overall though, in light of the discussion on the ETR above, we can see that there has not been extensive tax shifting through the years in some countries. For Denmark the decrease has been modest. In the case of the Netherlands, the implicit tax on labor has actually increased. That coupled with the general observation that the Dutch ETR has not been regressive possibly indicates a tax shifting to the high-income households. However, this is still inconsistent with the general spirit of the ETR. Thus, there is further potential for an ETR reform which could provide viable decreases in the labor tax burden and higher employment. Consequently, there is further room for a double dividend.

Figure 8 Implicit labor and capital taxation in ETR countries (in %)



Source: Eurostat (2015a)

Finally, the last indicator to evaluate the consistency of these countries is the evolution of the shares of labor and environmental taxes in total taxation. The following Figure 9 illustrates the share of labor and environmental taxation in total taxation through time for the six ETR countries on average.

As can be seen from Figure 9, the labor tax has not decreased dramatically and is still a very large share of the revenue needed for public finance. This leads to the future potential of the ETR, because it envisions the replacement of a wide base tax with a narrow base tax. In the context of the double dividend, it implies that environmental taxation may not be increased substantially, as its revenue potential is limited. Namely, it is more difficult to ensure revenue neutrality by raising taxes on a small base, than decreasing taxes on a wide base. As can be seen, the average share of green taxes as a % of total taxation has not risen dramatically in the past decade. It is typically below 10% in the ETR countries and this leaves room for discussion for further increases.

Figure 9 Structure of taxation in ETR countries (in %)

Source: Eurostat (2015a)

Thus, the preliminary implications from the comparison of environmental policies and tax rates across countries implies that there is room for further environmental tax reforms and thus double dividends. Namely, enticing firms to invest depends crucially on the policy horizon and consistency which can be improved as indicated by the implicit energy tax rates. The environmental tax reforms may be based on different tax reductions depending on the country specificities in relation to tax inefficiencies. Although there is a limit to the viability of substituting wide base taxes (labor) with narrow based taxes (environmental), there is room for further increases. An alternative is an additional increase in another wide-base tax (for ex. VAT) as analysed in Groothuis (2016). Nevertheless, this would likely pose econometric issues in estimating the source of the effect.

There are various reasons for another wave of environmental policy reform (and increase). Given public debt challenges, the state of the labor market and pension needs raising environmental tax revenues seems justified. Another factor that supports a policy maneuver of that kind is the price of oil. The prices of oil have been steadily declining over the past years, which makes it an excellent opportunity to strengthen the ETR agenda. A further argument which justifies increasing energy tax rates is the effect on the balance of payments, specifically the current account. Indeed, this was the motivation for environmental taxation in the Scandinavian countries, in the Danish case as early as the oil shocks of the 20th century. Increasing energy tax rates would lead to lower consumption and thus lower energy dependence in the energy-dependent EU. This would show as an improvement in the current account in the balance of payments, due to the decline in exports.

However, this should likely be conducted slowly since convergence in EU countries is still not as fast. For example, the Energy Directive contains minimum tax rate prescriptions for

countries and a clause that these tax rates should increase with the length of the EU membership (Andersen & Ekins, 2009). A similar policy prescription can be made regarding energy tax rates. Thus, there are several economic arguments for a second ETR across the EU, albeit with a differing speed. If the first wave of ETR was motivated by economic and environmental concerns, the importance of the latter has likely subsided as emissions have decreased in most countries.

Thus, the second ETR will likely prioritize the economic over the environmental dividend. The second ETR's might be predominantly economically motivated due to the state of public finances, the trends in oil prices and energy dependence, as well as the general state of the current account for many countries in EU. The latter represents an additional channel for the economic dividend of the ETR reform, beyond the classic fiscal impact. An encouraging factor is that the first ETR's did not have negative economic effects, although it is difficult to claim that they were substantially positive, as can be seen in Table 4.

Namely, many of these results are ex-ante modelling results, thus leaving room for discussion for possible negative effects. Moreover, even if there is no adverse economic impact, the potential of the ETR depends on social effects as well. Although the topic of the thesis is the double dividend, which focuses on the economic and environmental dimension, the potential for the double dividend is related to the social aspects of the reforms as well. Namely, the potential of a policy depends strongly on the political acceptance for those changes. Furthermore, the social effects matter for the economic dividend as well, as they show what kind of economic dividend if any is obtained. Thus, whereas a dividend may be obtained at the aggregate level, it might not be desirable if it promotes inequality. Table 5 lists the social effects in the six ETR countries.

Reviewing the social effects in the 6 ETR countries, there is some evidence of adverse effects. Pertaining to energy taxes, these adverse effects may result in energy poverty or tax regresiveness. An ETR is regressive by default because lower income classes typically spend a larger share of their income on energy. Thus, any increases in energy rates or environmentally related charges tend to burden them more, leading to regressiveness. The final degree of regressiveness depends on several factors: consumers' price responsiveness and changes in economic behavior, tax shifting from producers to consumers and the design of the system (Kosonen, 2012).

The empirical results clash for some countries. For Denmark the carbon tax is found to be regressive. There is a higher direct tax burden on rural households since they spend more on motorized fuel. However, this is partially offset due to lower indirect tax payments as their consumption on other energy intensive goods is lower. Energy and pollution taxes are regressive as well. For Finland there is a negative impact on low income households, although it depends on the tax analyzed (transport tax is not regressive as opposed to energy

and carbon taxes). The ETR is regressive in Germany and Sweden as well, although some studies find no regressive impact in Sweden for the transport tax. For the Netherlands, ETR's regressivity would be true by design. However, the Netherlands is an exception to the rule due to recycling measures such as tax free allowances, tax reductions and ceilings. The UK's ETR is partially regressive (Kosonen, 2012) due to the regressive effect of energy taxes, although there is no evidence of regressiveness of the CCL, likely because it does not cover households (Withana et al., 2013). The transport tax is also not regressive.

Table 5 Social effects in the ETR countries

Country	Social effects
Denmark	-The carbon tax is found to be regressive rural households which spend more on motorized fuel have a higher direct tax burden, but partially offset by lower indirect tax payments (Wier, Birr-Pedersen, Jacobsen, & Klok, 2012). -Energy taxes are more regressive (Jacobsen, Birr-Pedersen, & Wier, 2001), than pollution taxes.
Finland	-Carbon and energy taxes have negative impact on low income households (Sairinen, 2012) -Transport taxes are not regressive as share increases from lowest deciles to middle-income deciles (Tuuli, 2009).
Germany	ETR is regressive, although in general the system is revenue neutral for private households due to lower social security contributions (Bach, 2009).
Sweden	-Negative impact of ETR on low income households (Withana et al., 2013). -Transport taxes not regressive as share increases from lowest deciles to middle-income deciles (Ahola, Carlsson, & Sterner, 2009).
Netherlands	Introduced recycling measures such as tax free allowances, tax reductions and ceilings which reduce the regressivity inherent in the system, net effect almost neutral (Withana et al., 2013).
United Kingdom	-CCL is not regressive as it does not apply to households (Withana et al., 2013) -Transport tax is not regressive (Johnstone & Alavalapati, 1998) -Energy tax is regressive (Barker & Kohler, 1998).

Source: Own work

Thus, from the available studies it seems to be that carbon and energy taxes are regressive, whereas transport taxes are not. This is intuitive as energy taxes tax energy use, whereas transport taxes are typically related to various permits and licenses. This implies that ETR and environmental taxes in general are regressive, as energy taxes are the largest fiscal component of the several types of taxes. In light of the previous discussion on the potential of environmental taxation, these findings indicate that greater attention should be paid to the design of the system to ameliorate the social effects.

In light of today's economic challenges, the looming pension crisis, the EU's energy dependence, oil prices and current accounts give further rationale for the economic benefit from increases in environmental taxation. Namely, environmental taxation provides a source of additional budget revenue. Earmarking environmental taxation revenue for pensions might help make it more politically acceptable. Furthermore, environmental taxation might help alleviate the energy dependence challenges as well as the current account imbalances through the effect on energy imports. Thus, an increase in employment is not the only rationale for an increase in environmental taxation or an ETR, although it remains a valid and crucial policy concern due to the state of the post-crisis labor market.

The aforementioned are alternative channels for the double dividend which may lead to positive implications for the double dividend discussion, depending on their validity. The existence of alternative channels for an economic dividend might alleviate both social and economic concerns since they might make environmental taxation more politically acceptable due to its economic effects. Thus, there is potential for the ETR as an environmental policy, but this potential depends on the social and economic effects which accompany it. There are adverse social effects which will need to be dealt with, although the analysis itself is beyond the aim of this thesis.

Regarding the discussion of the economic effects and thus the double dividend, more research needs to be conducted on the actual economic effects of the ETR. First of all, the economic effects estimated in the literature to date show small, positive effects on GDP, which implies that there is room to discuss economic dividends. Second, studies refer mostly to ex-ante modelling results at the national level, thus ex-post results are needed to further support the case for a double dividend from environmental taxation.

Preferably, the analysis should be conducted at a more disaggregated level with higher granularity, for example sectoral or firm-level, depending on data availability. Finally, labor tax revenues greatly exceed environmental tax revenues, as shown in Figure 9. This implies that there is room to increase environmental tax revenues further, which will be relevant especially in the context of today's economic challenges related to public debt, the state of the labor market, energy dependence and the upcoming pension crises in EU countries to name a few.

The aim of the next sections is thus to analyze the economic effects of environmental taxation empirically for panel of 28 EU countries from 1990-2012. As such they cover the public aspect of the double dividend, stemming from a public policy measure (environmental taxes) targeting some of the key policy variables. The analyses are conducted at the national and sectoral level. Namely, there are several key variables of interest, such as the effect on the balance of payments, employment and value-added. The latter two are analyzed at the sectoral level, whereas the former is a national level concept which cannot be disaggregated any further.

2.2 The effects of environmental taxes on energy dependence and the current account

The previous sections discussed the results and potential for another ETR reform and thus a double dividend. Environmental taxation has an environmental effect, as is evident in the European Union. The economic benefits are not so clear and there are various social effects as well. The social effects themselves imply that the potential for another wave of environmental taxation might be limited. Namely, if there are concerns for economic and social effects, then the scope of taxation changes will be smaller. Arguably, this need not be the case since ex-post analysis at various levels is lacking. Furthermore, there may be alternative channels for the economic dividend, as the next section will aim to show.

One of these alternative effects is the effect on energy dependency and the current account as one of the key goals of economic policy. Namely, environmental taxation might affect energy imports (and thus energy dependency) and by extension the current account. Assessing the effect on energy dependence is necessary so as to shed light on the channel for the effect of energy taxation on energy dependence and the current account. Both the energy dependence and the current account are relevant as they reflect the international economic flows of the country. Moreover, the issue is relevant for the broader energy security and geopolitical concerns for Europe.

Assessing the effect on the current account is thus the aim of the following section which is one of the first empirical analyses on the topic to the best of the author's knowledge. The analysis uses national level data for the EU-28 countries from 1990-2012 to assess the effect of energy taxes on energy dependence and the current account, thus corresponding to the first research question. The section is organized as follows. The section opens with a literature review on the current account determinants and energy taxation. Energy taxes represent the greatest share of total environmental taxes collected with a share of 75.9% in total environmental tax revenue in the EU in 2017 (Eurostat, 2019b). The chapter proceeds with an explanation of the data and methodology and the results for the effects on energy dependence and the current account. The results are discussed before concluding and proceeding to the sectoral level analysis.

2.2.1 Literature review

The failure to find conclusive evidence for the positive effects of environmental policy, specifically environmental taxes had led to a loss in policy appeal of this instrument (Goodstein, 2003). Moreover, the debate typically moves in the other direction where the concern is about negative effects on competitiveness, productivity, employment and other relevant economic variables, which has led to gradual green tax reforms proposals (De Miguel & Manzano, 2011). This is the double dividend discussion associated with environmental policy in general. Further issues with environmental taxes include social aspects such as regressiveness (Chiroleu-Assouline & Fodha, 2014) which differs among countries.

Several studies have evaluated the effect of environmental policy on productivity, employment and other economic variables so far (H. S. R. Chan, Li, & Zhang, 2013; Greenstone, List, & Syverson, 2012; Grether, Mathys, & De Melo, 2012) but the results are not conclusive. By extension, the double dividend discussion is inconclusive and thus not as appealing for policy makers. Nevertheless, environmental taxation features taxation as a central element of the policy mix in the more recent green growth policy agenda instead. Thus, it is worthwhile to look into the ex-post effects of environmental taxation. The environmental policy of interest in this thesis is energy taxation, which has been associated with the double dividend.

Seeking alternative channels for the effects of energy taxation such as the effect on energy dependence and the current account serves to inform the general double dividend discussion. Energy taxes have been related to renewable energy consumption and competitiveness. Energy taxes stimulate renewables in theory (Barradale, 2010) as they provide incentives for renewable energy production. Y.-H. Zhao (2011) analyzes a panel of 21 OECD countries and 9 energy intensive industries and finds that carbon taxes have a negative impact on the international competitiveness of energy intensive industries. Other empirical analyses on environmental taxes have been within the scope of modelling efforts for the ETR such as the COMETR study (Andersen et al., 2007) which finds that energy taxes decrease fossil fuel imports.

The finding that energy taxes affect energy imports has been corroborated by other studies as well. For example, Pollit et al. (2012) find that raising energy taxes decreases imports Since energy taxes affect renewable energy consumption, they have the potential to affect energy dependence as well. Namely, if energy consumption does not rise drastically, then increased renewable energy consumption means less imported energy. Further, the IEEP study commissioned to evaluate the success of ETRs in Europe finds that environmental taxes can be used to improve energy efficiency and through this reduce the dependence on imported oil (Withana et al., 2013) .

Alternatively, the effect is through energy prices, as environmentally motivated taxes on energy use cause demand and prices to decline (Lighthart, 1998). The fact that energy taxes reduce energy consumption, in particular imported energy consumption for net energy importers, implies an effect on the current account balance. Indeed, reducing oil dependence has been one of the reasons for the introduction of energy taxes (Withana et al., 2013). Denmark for example introduced fuel taxes to reduce the deficit in the balance of payments. The COMETR study (Andersen et al., 2007) finds that the Finnish balance of payments has improved due to lower fossil fuel imports due to environmental taxes.

Thus, the effect through energy security and dependence is one of the channels for an effect of energy taxes on the current account. There are various approaches to measuring energy security and energy dependence is one of the aspects of the wider energy security specter as suggested in Kruyt, van Vuuren, de Vries, and Groenenberg (2009). The literature has conceptualized energy security in terms of various dimensions. These relate to the economic, social and regulatory landscape of the country (Ang, Choong, & Ng, 2015; Augutis, Krikstolaitis, Maritsauskas, & Peciulyte, 2012). As such, we can relate energy dependency to the broader energy consumption literature which has traditionally focused on the relation between GDP growth and energy consumption (Menegaki, 2014; Mercan & Karakaya, 2015) which is typically positive.

Specifically, output growth affects the demand for oil and by extension oil imports (X. Zhao & Wu, 2007). Fuel prices also affect energy imports as they affect the demand for fuel (Berkhout, Ferrer-i-Carbonell, & Muskens, 2004; Small, 2012) and the demand for clean technologies (Triguero, Moreno-Mondéjar, & Davia, 2014). A study for the U.S. shows that regulatory standards and fuel taxes combined would also decrease oil imports substantially (O'Rear, Sarica, & Tyner, 2015).

Energy dependence may not be the only channel through which energy taxes may affect the current account balance. Research on the current account (Allegret, Couharde, Coulibaly, & Mignon, 2014; Clower & Ito, 2011; Gossé & Serranito, 2014) shows there are several determinants of the current account balance. The aim of this section is to review the determinants for the current account as the main variable of interest of the analysis. These are factors that affect savings and investments and through them the current account balance, as given by the main macroeconomic identity that excess private savings over investments are used to finance either excess public expenditure or sent abroad as capital outflows. This is known as the macroeconomic savings-investment identity.

Financial deepening is a factor which affects the current account balance. It could have both a positive and negative effect. It might affect the current account balance positively because it increases the depth and sophistication of the financial system, but it might also affect it negatively if individuals are faced with borrowing constraints which are accommodated by the financial system. Empirically, financial deepening has been shown to have a positive

effect on the current account balance of developing economies (Chinn & Prasad, 2000) . The former can be modelled through various indicators such as the size of credit extended to the private sector (Chinn & Ito, 2008) or FDI, as a precursor to financial development and further reflecting the openness of the economy (Desbordes & Wei, 2017).

Another factor which might affect the current account balance is fiscal policy. Feldstein (1986) posits a theory of twin deficits, because a budget deficit raises interest rates which crowds out investments and contributes to currency appreciation, thus leading to a current account deficit as well. This argument has been challenged though as there is evidence of a twin divergence instead of twin deficits (Kim & Roubini, 2008). The reason for the contrasting conclusions results from two opposing effects, a crowding out effect which has a negative effect on the current account balance and a Ricardian savings effect, since households increase private saving to compensate for the public dissaving. Thus, the net result is uncertain and depends on the share of spender and saver households. The latter would exhibit Ricardian savings in times of public dissaving. Empirically, the budget balance has a positive effect on the current account balance (Chinn & Ito, 2008).

The composition of the population matters for savings from another aspect as well. Namely, countries with large dependency ratios are likely countries with lower savings rates, because a larger share of the population is in the borrowing stage of their life, according to the lifecycle hypothesis (Modigliani & Ando, 1963). Thus, these countries would have lower savings and be more likely to experience a current account deficit (Gossé & Serranito, 2014). Empirically, the dependency ratio has a negative effect on the current account balance, as predicted by theory (Chinn & Prasad, 2000).

Apart from being informative about savings and investments in an economy, the current account balance reflects productivity and competitiveness (Bussière, Fratzscher, & Müller, 2010; Genberg & Swoboda, 1994). Thus, productivity and competitiveness are determinants of the current account balance as well. With regards to productivity, the intuitive effect on the current account is positive, but it is not necessarily so. Namely, permanently larger productivity may mean more investments which are presumably seeking higher yields and these higher yields in turn attract capital inflows which is actually a deterioration in the current account balance. Thus, the effect is conditional on the gains from capital.

Competitiveness is reflected in the terms of trade or the real exchange rate. With regards to the terms of trade, better terms of trade improve the current account balance, at least in the short run, since income is temporarily increased above its permanent level and savings increase due to consumption smoothing (Gossé & Serranito, 2014) . Although intuitive, this effect might not exist as well. That is because if there is a permanent increase in the terms of trade, there is no effect on savings, as the increase in income from terms of trade goes directly to permanent income, thereby not affecting savings or even reducing them.

Furthermore, it is not only the level of terms of trade but their volatility as well which might determine the current account balance (Chinn & Prasad, 2000) . This is because higher volatility of terms of trade implies an unstable environment, thereby decreasing capital inflows. Alternatively, if investors seek to diversify risk by investing in economies that are volatile in different directions, then volatile terms of trade might actually increase capital inflows (Aizenman, 1994) .

Finally, determinants of the current account include prices of energy (Das, 2016; Withana et al., 2013). Oil prices might affect current account balances in both oil-importing and oil-exporting countries. Sachs (1981) has analyzed whether there was a stronger effect on current account balances from a decline in investments or rising oil prices for the period following the oil price shocks. Investments are more important than oil prices. Oil prices affect current account balances in oil-exporting economies, due to the terms of trade mentioned above.

However, the effect depends on financial deepening. This is because in the case of financial deepening, the positive effect on the current account balance from higher oil prices is attenuated as the oil revenues are channeled towards domestic investments and not savings, thereby attenuating the otherwise positive effect (Allegret et al., 2014). The effect then depends on the variable chosen for financial development, as financial development could refer to private sector credit or foreign direct investment, as both increase as a consequence of financial deepening. Furthermore, oil prices affect the current account balances of oil-importing countries that are heavily energy-dependent. Financial development interferes with this effect as well because it allows for international risk-sharing and capital inflows in times of rising prices which sustain the deficit (Özlale & Pekkurnaz, 2010).

The previous review of current account determinants is the basis for other potential channels for the effects of energy taxes on the current account balance. Energy taxes are an example of fiscal policy, but they reflect the stance of environmental policy specifically. Thus, it is important to control for both energy taxes and the overall budget balance. However, energy taxes can be implemented as revenue neutral packages, thus substantial effects of energy taxes on the budget balance and through it on the current account may not be expected. Thus, the budget balance is more likely to reflect fundamental determinants such as saving or investment, stemming from the main macroeconomic identity. Furthermore, there are additional indirect channels for the effect on the current account, as energy taxes may affect productivity and competitiveness. Indeed, losing international competitiveness which is shown as a reduction in exports in energy-intensive industries has been a key concern.

Finally, energy taxes affect energy prices which is the effect already identified. Given how studies find conflicting or negligible results about the effects of energy taxes on competitiveness, the latter effect seems more substantial. Furthermore, analyzing it aims to fill a gap in the empirical literature, as previous data availability allowed for simulation

analysis of energy taxes. It has now been almost two decades which makes panel data analysis possible. Given the renewed interest in environmental taxation, seeking an alternative positive effect on the current account balance is relevant for policy as well.

Ultimately, analyzing the effect of energy taxes serves to inform the double dividend discussion. Energy taxation is one of the most widely-used environmental policy instruments in the group of market-based environmental policy instruments. Analyzing the effect of energy taxation on the current account balance informs the policy discussion. Namely, it allows us to gauge whether there are alternative channels which could support the introduction of another wave of environmental taxation, in addition to energy security concerns. Thus, this analysis will focus on the effect of energy taxes on energy dependence and the current account balance as an attempt to extend the broader double dividend discussion related to public policy. The next section presents the methodology.

2.2.2 Data & methodology

The data for this analysis is taken mostly from Eurostat, as the most relevant statistical office for the EU-28. The period analyzed is 1990-2012, as the prolonged economic contraction in Europe has caused a rapid improvement in some countries' balances of payments which were not due to improved fundamentals. Namely, economic contractions cause a decline in imports, since domestic income is a determinant of imports. This improves the current account but may not associated with the underlying fundamentals.

Oil prices are taken from the Energy Information Administration. Where possible, they are substituted with import prices estimated by the OECD for a group of countries. GDP in Purchasing Power Parity (hereinafter: PPP), expressed in millions current international dollars) and the GDP growth rate are taken from the World Economic Outlook of the International Monetary Fund (hereinafter: IMF). The rest of the variables are taken from the Eurostat. Energy taxes refer to the share of energy tax revenues as % of GDP. There are several other taxes that belong to the group of environmental taxes (pollution, resource taxes for example). However, this study uses energy taxes as the most representative group of taxes due to their revenue-share in overall environmental taxes.

Another indicator used for energy taxes is the implicit energy tax defined as the ratio between energy tax revenues and final energy consumption. Arguably, both of these taxes are deficient in showing the variation in the level of energy taxes across countries as they may increase due to more revenues being collected as a result of higher energy consumption and not necessarily due to a higher energy tax rate. This may lead to an upwards bias.

However, given the lack of suitable comparable indicators for energy taxes, we choose to forego this limitation. Moreover, high energy consumption will affect both the numerator (energy tax revenues) and the denominator (GDP growth) as energy consumption is an input

in production, thus the potential upwards bias will be small. Another relevant energy indicator is the energy dependence indicator which shows the share of net imports in final energy consumption.

The other indicators used refer to the current account balance and its determinants. These are variables which stem from the main macroeconomic savings-investment identity explained in the literature review. The identity states that the excess of private savings over private investments is used to finance either the budget deficit or net exports. Thus, the current account determinants include a variety of economic and macro-financial variables, reflecting the composition of the balance of payments as well.

The other variables used within this analysis are thus the current account balance (as % of GDP), incoming foreign direct investment (hereinafter: FDI) stocks in millions EUR, budget balance (as % of GDP), old age dependency ratio (number of persons aged 65 and over, over the number of persons aged between 15 and 64), volume of production index (IP), labor productivity index and the real effective exchange rate index (reer) as two competitiveness variables. Table 6 lists the summary statistics.

This analysis uses a classical methodology for the estimation of variables which are in theory persistent, a dynamic panel data model. Energy dependency is persistent due to the inelasticity of energy demand (Labandeira, Labeaga, & Lopez-Otero, 2017), thus it implies that high energy dependency can be expected to persist or pass-through in the following years.

The current account is persistent in theory as it depends on variables which reflect the main savings-investment identity which have to do with country competitiveness and productivity. Since these are variables which reflect country-specific trends which do not improve immediately, it follows that there is a degree of persistency in the current account as well. The persistence in the current account is a well-documented empirical fact in the current account literature as well (Calderon, Chong, & Loayza, 2000), although it depends on the sample analyzed with developed countries typically exhibiting higher persistence than developing countries. This is due to the various factors affecting the current account balance which include macroeconomic and financial variables, among which variables related to external financing. Since this is likely more volatile for developing countries, it follows that the persistence is lower as well, as the underlying variables are more volatile to begin with.

Since this is an estimation on a sample of EU countries, we expect high persistence as the sample includes developed countries integrated in a trade union. Nevertheless, the crisis may have altered the persistence parameter in the current account. Namely, the crisis has potentially exacerbated countries' competitiveness and funding issues. Increased market volatility as well as deeper economic contractions may have decreased the persistence parameter, depending on the vulnerability of the country and its resilience to adverse

economic conditions. The following Table 6 lists the summary statistics for the analyzed sample.

Table 6 Summary statistics

Variable/Statistic	N	Mean	Std. Dev.	Min	Max
CA (current account)	393	-1.894	5.706	-17.2	12.6
Energy tax (share of GDP)	492	1.900	0.486	0.46	3.43
Implicit energy tax	492	127.0177	67.392	9.49	316.44
IP (production index)	498	93.75	19.953	20.16	130.02
Budget balance	490	-2.877	3.439	-15.2	6.9
FDI stocks	440	133364.3	194646	707	1147472
Reer	527	97.321	13.663	35.28	158.34
Old age dependency	626	22.190	3.59	15.4	32
Labor productivity	469	92.068	11.118	52.3	111.3
Energy dependence	632	55.536	29.0735	-49.8	112.5
GDP in PPP	600	462646.7	695899.1	7849	3557467
Oil price	632	33.601	22.175	10.271	89.975

Source: Eurostat (2015c), EIA (2015), IMF (2017), OECD (2015a), Own work

We estimate two equations: one for energy dependence and one for the current account. The reason for the estimation of two equations is that both reflect exports and imports, thus energy dependence should be modelled separately. Nevertheless, both indicators reflect the international economic flows of the countries in question. In general, the effect on the current account is explicable through the effect of energy dependence since energy imports or exports are a component in the current account.

$$Endep_{it} = \beta_0 + \beta_1 Entax_{i,t-1} + \beta_2 GDP_{i,t} + \beta_3 Oilprice_{i,t-1} + \beta_4 Reer_{it} + \alpha_i + \varepsilon_{it} \quad (1)$$

The energy dependence equation is formulated based on demand-side variables, as energy dependence for energy importers increases with increased consumption. It states that energy dependence (Endep) depends on the level of energy taxes (Entax), the real effective exchange rate, GDP and the price of oil. Energy dependence is one of the indicators for energy security which can be conceptualized as availability, affordability, accessibility and acceptability of energy (Cherp & Jewell, 2014).

The energy dependency equation combines these considerations and posits that energy dependency is a function of income, the real effective exchange rate, energy taxes and the price of oil, thus encompassing the first two A's of energy security, affordability and availability. Alternatively, it captures the economic and regulatory factors in the broader concepts for energy security (Ang et al., 2015). Higher incomes, an appreciation in the currency and lower taxes imply greater affordability, whereas lower oil prices imply greater availability.

It should be noted that modelling energy dependency is not the prime goal of this analysis as it is intended to show whether this is one of the channels for the potential effect of energy taxes on the current account. Namely, the double dividend literature posits that there could be economic dividends from energy taxation such as the potential effects on the current account balance (Andersen et al., 2007).

The expected effect of energy taxation on energy dependency is thus negative, but could be insignificant or negligible due to a rebound effect. The rebound effect refers to the rebound in energy consumption following a decline in energy demand associated from a tax increase or other regulation which would decrease energy prices and thus increase energy demand in the next stage (Small & Van Dender, 2007). Moreover, energy dependency could have high persistency due to habit formation. Thus, we estimate a dynamic equation as well. The model requires a specification of the exogenous and the variables to be instrumented. The energy tax variables are specified as exogenous with the remaining variables instrumented as suggested in the system-GMM estimator.

$$Endep_{it} = \beta_0 + \beta_1 Endep_{i,t-1} + \beta_2 Entax_{i,t-1} + \beta_3 GDP_{i,t} + \beta_4 Oilprice_{i,t-1} + \beta_5 Reer_{it} + \alpha_i + \varepsilon_{it} \quad (2)$$

The current account equation is in turn based on the determinants in previous work (Chinn & Prasad, 2000), as well as general variables which affect the main macroeconomic identity for aggregate savings and investment. This is the typical approach in the literature (Clower & Ito, 2011; Das, 2016). Studies differ depending on the variables used and the sample analyzed, as developing countries samples tend to include variables related to the foreign exchange rate regime or various controls for financial variables. In general, studies include macroeconomic and financial variables (See literature review below).

Calderon et al. (2000) model the current account balance as a function of domestic economic conditions (output gap, output growth, fiscal policy), external indicators (real effective exchange rate, balance of payments controls) and indicators for the evolution of the world economy. They also include controls for the lagged values of the real effective exchange rate, so as to capture possible J curve effects. This refers to an initial deterioration in the current account following a depreciation which should improve the trade balance. Due to trade contracts which cannot be adjusted immediately for the effects of the exchange rate (depreciation), the current account first deteriorates before improving further on.

Aristovnik (2006) uses a similar approach analyzing current account balances in transition economies as a function of internal economic conditions (GDP, budget balance, old age dependency), the external sector (external debt and openness to trade) and the evolution of the world economy. More recently, Ya-Qiong and Rui (2013) include the fiscal balance, labor productivity, consumption and investment, the real effective exchange rate and various indicators for financial market development for a mixed sample of developed and developing countries. Das (2016) includes commodity prices, GDP growth, the real effective exchange rate, net foreign assets and an exchange rate stability index for a dynamic panel analysis of a sample including both developed and developing countries. The list of variables thus differs across studies perhaps in relation to the degree of analysis for financial development or additional control variables for the exchange rate regime depending on the sample analyzed but the main equation is specified as a function of variables which affect the savings-investment identity. This can be found in earlier studies as well (Chinn & Prasad, 2000).

This analysis follows the literature in terms of modelling the current account balance as a function of variables from the main savings-investment identity. Thus, the main macroeconomic variables are: the volume of production, budget balance, the old age dependency ratio, energy taxation and labor productivity. The financial variables included are the real effective exchange rate and foreign direct investment (FDI). FDI is a variable which captures the financial development of a country, as there is a strong positive association between financial development and FDI, since the former is a precursor for the latter due to indirect promotion of manufacturing activity and increased access to external finance (Desbordes & Wei, 2017).

Since the sample is a sample of developed countries which are deeply integrated in a trade union, we do not control for other variables affecting financial development such as financial stability or exchange rate differentiation. As is evident from the literature review, studies differ among the variables used depending on the sample and the variables deemed to reflect the savings-investment identity, but they necessarily include macroeconomic variables controlling for internal conditions and some financial variables to capture the structure of the balance of payments as well.

Besides the variables listed above, we also test for the significance of the lagged real effective exchange rate and the lagged FDI variable. The former is due to the J-curve as explained earlier and the latter is due to the structure of the balance of payments, as FDI flows will affect the balance negatively by construction as they appear on the financial-capital account. A potential source of concern could be reverse causality due to changes in energy taxation as a result of changes in the current account. Since this is annual data from national accounts, changes in energy taxes are unlikely to occur in the same year due to lags in data publication and subsequent implementation. Thus, we do not control for this apart from testing for instrument validity (endogeneity tests).

Furthermore, the period analyzed is only until 2012 but we include the estimates before and after the crisis as well. Namely, the European economies witnessed a double-dip recession with the onset of the European debt crisis. This required strict austerity measures which caused a contraction in imports and a rapid improvement in the current account balances which was not due to an improvement in the underlying variables of the savings-investment identity. Further, the sovereign debt crisis in the euro-zone poses modelling difficulties in terms of disentangling the effects of the crisis, as it is a W crisis. Thus, the period analyzed extends until 2012 but we include both the pre and post crisis estimates as the crisis may have caused an improvement in the current account balances due to the mere contraction in economic activity and by extension imports.

Thus, the current account balance (CA) depends on the volume of production (IP), labor productivity (Laborprod), the share of energy taxes as a % of GDP (Entax) or the implicit energy tax rate (Imptax), foreign direct investment (FDI), the budget balance (Budgetbal), the old age dependency ratio (Oldagedep) and the real effective exchange rate (Reer). Prices are lagged one period due to concerns for reverse causality. Since the current account is defined as % of GDP, all other variables defined as % of GDP are lagged one period to avoid estimation bias. The estimation involves estimating a dynamic panel using the first lag of the dependent variable whose coefficient is the persistence parameter, or the correlation between the dependent variable in period t and period t-1. We estimate the following equations using two variables for cost competitiveness (labor productivity or the real effective exchange rate):

$$CA_{it} = \beta_0 + \beta_1 CA_{i,t-1} + \beta_2 IP_{i,t-1} + \beta_3 Laborprod_{it} + \beta_4 Entax_{i,t-1} + \beta_5 FDI_{i,t} + \beta_6 FDI_{i,t-1} + \beta_7 Budgetbal_{i,t-1} + \beta_8 Oldagedep_{it} + \alpha_i + \varepsilon_{it} \quad (3)$$

$$CA_{it} = \beta_0 + \beta_1 CA_{i,t-1} + \beta_2 IP_{i,t-1} + \beta_3 Reer_{it} + \beta_4 Reer_{i,t-1} + \beta_5 Entax_{i,t-1} + \beta_6 FDI_{i,t} + \beta_7 FDI_{i,t-1} + \beta_8 Budgetbal_{i,t-1} + \beta_9 Oldagedep_{it} + \alpha_i + \varepsilon_{it}$$

(4)

When estimating dynamic panel models, one has the choice between three models. They differ in the instruments they specify for the first lag of the dependent variable to avoid endogeneity issues. One approach is to use only the second lag level of the dependent variable as in Anderson and Hsiao (1981). An alternative is to use all the lagged levels (starting and including lagged level two) of the dependent variable (Arellano & Bond, 1991). Bond & Blundell's system GMM approach consists of estimating the equation in levels and using lagged differences as instruments (Blundell & Bond, 1998).

However, if we expect high correlation between the dependent variable in time t and time t-1, the first two models are unreliable, which leaves the system or Bond-Blundell estimator. To discriminate between the models, we have to check for instrument validity, namely if the instruments are not correlated with the error term, so as to avoid endogeneity issues. For this purpose, we use the Hansen (1982) test which posits instrument validity under the null hypothesis. The model requires further specification of the independent variables in terms of predetermined (exogenous) variables and instrumented variables, so as to avoid a proliferation of instruments. The competitiveness variables (real effective exchange rate, labor productivity) have been instrumented as suggested in the system GMM estimator, whereas the remaining variables are treated as exogenous.

The second issue might be remaining autocorrelation which might bias our estimates. For this purpose, we use the Arellano and Bond (1991) tests for serial autocorrelation of orders 1 and 2, which are typically used in dynamic panel data settings. It should also be borne in mind that a dynamic model reflects short-run effects, whereas a static model reflects long-run effects. The long-run effects can be estimated from the dynamic model as well, using the well-known multiplier model as in Abbassi and Linzert (2011). This entails estimating the following equation after the dynamic panel estimation for each long-run coefficient of interest. Assuming a dependency parameter γ and a short-run effect $\beta s_{,i}$, per variable i as estimated with a dynamic panel, the long-run coefficient of interest $\beta l_{,i}$ per variable i is given by:

$$\beta l_i = \frac{\beta s_i}{1 - \gamma}$$

(5)

For the sake of simplicity, all the coefficients in the equations above are denoted by β_i, but it is clear from the model specification that they refer to short-run effects as the specified

model is a dynamic model. The long-run effects are estimated for the current account as the main variable of interest. The energy dependency equation is an intermediate equation to evaluate the effects of energy taxation on energy dependence, but the current account could in theory deteriorate even if there is a decline in the share of energy dependency if the overall energy consumption is increasing such that the overall energy imports are increasing. Thus, the main equation of interest is the current account balance. The following section presents the results of estimation of the energy dependence equation.

2.2.3 Energy taxes and energy dependence

The results from estimation of the static and dynamic models of the effect of energy taxes on energy dependence are shown in Table 7. The economic dividend of environmental taxation consists of lower energy imports and energy dependency. Namely, this is one of the channels for the effect on the current account. Columns 1 & 3 are models which include the implicit energy tax as an indicator variable for energy taxes, whereas columns 2 & 4 include the share of energy tax revenues in GDP as an indicator variable for energy taxes. The results indicate that energy taxes have a negative effect on energy dependence, which is theoretically expected due to lower energy consumption. The effect is not robust to a static vs. dynamic specification, which could be due to high persistence.

The first and second model are the static models with fixed effects. Robust standard errors are reported for the fixed effects model as the Breusch-Pagan LM and the Wald test for autocorrelation and heteroscedasticity indicate that there is cause for concern. In both cases, the Hausman test shows that the fixed effects model is preferable to the random effects model, although the p-value when using the Hausman test is higher than 5% confidence level. Nevertheless, the p-value from the Wald test statistic for overall significance of the regression was high as well, thus implying that the random effects model is not suitable.

Regarding a possible bias in the coefficients arguably, the larger the energy dependence, the larger the energy tax revenues. This is true if energy dependence leads to greater consumption. The bias which could arise from this would be positive, but the coefficients on both energy tax as share of GDP and as an implicit tax are both negative, which implies that there is no bias. Moreover, as explained earlier, the upwards bias will be small as higher energy consumption is associated with higher GDP (Kasman & Duman, 2015) . The results are shown in Table 7.

The results are significant only for the energy tax as share of GDP. The other coefficients have signs that are theoretically reasonable. Richer countries are more energy dependent, arguably because their consumption is higher. Although a positive coefficient is reasonable here, a negative coefficient would be reasonable as well, as wealthier countries might be more prone to invest in renewables thereby decreasing their energy dependence. On average

though, the wealthier the country in the previous year, the larger its energy dependence this year.

Table 7 Energy dependence results

Energy dependence	(1)	(2)	(3)	(4)
Energy dependence$_{t-1}$			**0.873*** **	**0.869*** **
			(0.103)	(0.0968)
GDP in PPP	**7.593*** **	**7.354*** **	**1.800**	**1.396**
	(2.729)	(2.671)	(1.113)	(1.109)
Energy tax$_{t-1}$		**-3.907*** **		**-2.282**
		(1.132)		(2.050)
Implicit energy tax	**-0.0123**		**-0.0126**	
	(0.0136)		(0.0149)	
Oil price$_{t-1}$	**0.00444**	**-0.0105**	**-0.0211**	**-0.0279**
	(0.0328)	(0.0326)	(0.0206)	(0.0212)
Reer	**-0.155*** **	**-0.140*** **	**0.0355**	**0.0435**
	(0.0384)	(0.0381)	(0.0425)	(0.0423)
Constant	-20.30	-12.33	-15.91	-8.604
	(30.58)	(30.14)	(11.49)	(12.06)
Observations	457	457	427	430
R-squared	0.051	0.075		
Fixed effects	Yes	Yes	Yes	Yes
Specification tests (p-values)				
Arellano-Bond(1)			0.185	0.178
Arellano-Bond(2)			0.137	0.115
Hansen			0.99	0.999

Source: Eurostat (2015c), EIA (2015), IMF (2017), OECD (2015a), Own work

Columns 3 & 4 present the results of estimation of the system Generalized Method of Moments (hereinafter: GMM) estimator. We use this estimator only since the other are unreliable for econometric estimation if the persistence is high and energy dependence is suspected to be high. Therefore, the most reliable estimates are from the system estimators. A drawback of this method is the proliferation of instruments which we have reduced by collapsing the instrument matrix. The Hansen test which is robust but sensitive to the number of instruments does not reject the null hypothesis for validity of the instruments. Table 8 shows the p-values from the main specification tests.

Table 8 Specification tests (p-values) static model

Specification tests (p-value)	Energy revenues	Implicit energy tax
Hausman	0.0005	0.001
F-test	0.00	0.00
Breusch-Pagan LM	0.00	0.00
Modified Wald	0.00	0.00

Source: Own work

The results from this Bond-Blundell estimation indicate a rather high estimate for energy dependence persistence and all the other variables lose their significance. A high persistence parameter is in line with expectations due to high habit formation and the inelasticity of demand for energy (Labandeira et al., 2017). To check for robustness, another indicator is used for energy taxes – the implicit energy tax rate as another comparable indicator of energy taxes. However, we get a similar result even in this case as with energy taxes as a share of GDP. Namely, the energy persistence parameter is still very high and the rest of the variables are not significant. The price coefficients have a negative sign as expected although the implicit tax rate sign changes signs but is close to zero. Therefore, after accounting for persistence, the rest of the variables lose their significance. This result has relevant policy implications, as it means that any environmental policy designed to affect energy dependence will have to be persistent itself with a strong commitment over a longer period, as there is a very strong habit element, as implied by the high persistence parameter.

To check the validity of this model, apart from checking the validity of the instruments, specification tests are employed for first and second order autocorrelation, as the system estimation is performed under the assumption of no serial correlation. The only real concern is second-order autocorrelation. However, the null of no second-order autocorrelation is not rejected. Therefore the model is well-specified, as far as the autocorrelation and heteroscedasticity issues go. Comparing these results with the previous ones by using a different indicator, there is no major difference. We lose significance for all the other variables, given the high persistence parameter.

The previous Table 7 showed the estimates from the static and dynamic model for energy dependence. Energy taxes should have a negative effect on energy dependence as they affect the price. The coefficient on energy taxes was negative and significant in the static model, and negative but not statistically significant in the Bond-Blundell estimation for energy persistence. The implicit energy tax rate had the expected negative sign in both models, but it was not significant.

In contrast, energy taxes should have a positive effect on the current account balance as by decreasing consumption, it is likely that they decrease imported energy as well. This is the

alternative channel for the economic dividend through the effect on the current account. The analysis in the following section relates to the public finance aspects of the double dividend discussion as it entails the effects of environmental policy on a crucial policy variable within the balance of payments. The tables in the next section present the estimates of the dynamic model for the current account.

2.2.4 Energy taxes and the current account

The following section presents the results on the current account models. The dynamic model reflects short-run effects. The long-run effects can be derived from the dynamic model, which is the modelling approach chosen here. We expect a positive sign for energy taxes as explained earlier. Labor productivity could have a positive sign as the larger the productivity, the larger the export potential due to lower costs and thus the larger the current account balance. Alternatively, productivity shocks have also been associated with current account deficits as in the US (Bussière et al., 2010). The real effective exchange rate should have a negative sign at least in the first period as a loss of competitiveness is related to a deterioration in the current account. The sign for the lagged variable is expected to be positive due to a balancing effect through the J curve, as explained earlier. FDI is expected to have a positive sign as it improves the export potential of the country.

The old age dependency ratio is expected to have a negative sign as the older the population, the lower the aggregate savings and thus the current account balance which reflects excess savings. Nevertheless, considering that this is a sample of EU countries, it could be that aggregate savings are higher due to an older population. Industrial production is likely to have a negative sign as it should reflect GDP growth. The budget balance is related to the twin deficit hypothesis as explained in the literature review. Namely, a positive budget balance implies higher public savings and thus an improved current account balance. The results are shown in Table 9.

The results show a moderately high persistence parameter and a positive effect of energy taxation on the current account, as expected. The persistence parameter is not as high as could be expected considering that this is a sample of developed countries. Nevertheless, the persistence parameter is estimated on a sample which includes some post-crisis years as well. As explained earlier, the crisis has exacerbated countries' external positions vulnerability, thus decreasing the parameter. Severe economic contractions may have contributed to a lower persistence parameter as well. As will be seen in continuation, the pre-crisis sample estimates show indeed a higher persistence parameter.

Table 9 Current account dynamic model estimates

CA	(1)	(2)	(3)	(4)
CA_{t-1}	**0.437*** **	**0.349*** **	**0.559*** **	**0.424*** **
	(0.128)	(0.107)	(0.173)	(0.136)
Energy tax_{t-1}	**2.240** **		**1.960**	
	(1.006)		(1.388)	
Implicit energy tax		**3.152*** **		**2.341** **
		(1.139)		(1.108)
IP_{t-1}	**-0.0294**	**-0.0834** **	**0.0847**	**0.0278**
	(0.0225)	(0.0393)	(0.0877)	(0.0828)
FDI incoming	**-0.697**	**0.371**	**-1.320**	**-0.520**
	(1.019)	(1.200)	(1.028)	(1.029)
FDI $incoming_{t-1}$	**1.467**	**0.0736**	**1.863***	**0.816**
	(0.927)	(1.071)	(1.076)	(0.924)
Budget $balance_{t-1}$	**0.411*** **	**0.454*** **	**0.259**	**0.387** **
	(0.123)	(0.106)	(0.170)	(0.159)
Reer	**-0.145** **	**-0.0872***		
	(0.0647)	(0.0496)		
$Reer_{t-1}$	**0.184*** **	**0.164*** **		
	(0.0695)	(0.0558)		
Old age dependency ratio	**0.0441**	**0.129**	**-0.0597**	**0.0236**
	(0.0928)	(0.107)	(0.115)	(0.119)
Labor productivity			**-0.183**	**-0.121**
			(0.240)	(0.228)
Observations	315	312	314	311
Fixed effects	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes
Specification tests (p-value)				
Arellano-Bond (1)	0.007	0.003	0.124	0.04
Arellano-Bond (2)	0.012	0.006	0.176	0.04
Hansen	0.999	0.999	0.999	0.999

Source: Eurostat (2015c), EIA (2015), IMF (2017), OECD (2015a), Own work

Further, FDI has a negative sign which may be in line with theory at least as far as the balance of payments is concerned. Namely, if FDI is coming in to finance the capital account deficit leading to an increase in the capital account, then its effect on the current account is

negative. The lag of FDI though has a positive effect which is theoretically plausible as it takes some time before increased FDI actually improves competitiveness. Arguably, even a one period lag might not be as informative, although including more lags leads to potential issues with lag selection such as the theoretical basis or a loss of degrees of freedom.

The old age dependency ratio has a surprising sign as dependency is expected to lead to lower savings and therefore a downward pressure on the current account balance. However, if these are individuals with higher incomes and savings due to larger GDP/capita incomes in Europe, then the sign of the coefficient may be explicable due to the positive savings effect. The coefficient on the volume of production index has a negative sign as well, as the greater the volume of production and growth, the greater the imports.

With regards to the model selection, the fixed effects model is once again preferred to the random effects model. Columns 1&3 present the estimates of the current account static model with fixed effects with clustered standard errors in parentheses, as there is both heteroscedasticity and autocorrelation, using the share of energy revenues in GDP. Columns 2 & 4 repeat the estimation using the implicit energy tax. Overall, most of the variables have the expected signs or at least theoretically plausible. As can be seen from columns 2 & 4, the finding that energy taxes have a positive effect on the current account balance is robust to using a different indicator for energy taxes. The results are valid econometrically as evident from the Sargan test for the validity of instruments. The overall model specification is also valid as judged by the F-statistic, whose associated p-value is 0.

To check for the robustness of these results, the estimation is performed again using the implicit tax on energy instead of the share of energy taxes in GDP. The results do not change qualitatively for the estimates on the energy tax variables, the lagged real effective exchange rate and the budget balance, which have positive and significant signs as in the previous estimation results. The coefficients on the old age dependency ratio and labor productivity are in line with theory, but are not significant. The persistence parameter is high and significant. The coefficient on industrial production is negative and statistically significant in the specification with the implicit energy tax. The coefficients on FDI switch signs and do not keep the significance across all specifications.

As explained earlier, the dynamic model coefficients provide the short-run effects of the variables. The multiplier model can be used to calculate the long-run effects which would be obtained with a static model. Thus, this is obtained as the product of the multiplier term which depends on the persistency parameter for the current account balance and the initial coefficient on the variable. The long-run coefficients for the variables in the four estimations are shown in Table 10.

Table 10 Long-run effects on the current account

CA	(1)	(2)	(3)	(4)
Energy tax$_{t-1}$	**3.979*** **		**4.446***	
	(1.487)		(2.280)	
Implicit energy tax		**4.840*** **		**4.065*** **
		(1.536)		(1.555)
Budget balance$_{t-1}$	**0.730*** **	**0.696*** **	**0.586** **	**0.672*** **
	(0.168)	(0.178)	(0.269)	(0.231)
IP$_{t-1}$	**-0.0523**	**-0.128** **	**0.192**	**0.0483**
	(0.0419)	(0.0542)	(0.179)	(0.143)
FDI incoming	**-1.238**	**0.570**	**-2.993**	**-0.903**
	(1.892)	(1.821)	(2.257)	(1.804)
FDI incoming$_{t-1}$	**2.605**	**0.113**	**4.224** **	**1.416**
	(1.761)	(1.648)	(2.025)	(1.612)
Reer	**-0.257*** **	**-0.134***		
	(0.0789)	(0.0702)		
Reer$_{t-1}$	**0.327*** **	**0.252*** **		
	(0.0784)	(0.0707)		
Old age dependency ratio	**0.0784**	**0.197**	**-0.135**	**0.0410**
	(0.169)	(0.163)	(0.252)	(0.208)
Labor productivity			**-0.415**	**-0.210**
			(0.485)	(0.384)

Source: Eurostat (2015c), EIA (2015), IMF (2017), OECD (2015a), Own work

The estimates for the long-run effects imply a positive and statistically significant effect of energy taxation on the current account, regardless of the energy tax variable used. Both of the coefficients' magnitude is in the order of 4 p.p., i.e. an increase in the energy tax rate or share of GDP by 1% would increase the current account balance by around 4 p.p.. The estimate is large and would imply a quick fix for countries which are struggling with their current account balances. Nevertheless, a 1% increase in the energy tax revenues or implicit energy tax rate is a difficult move politically, but illustrates that even a small change could contribute to a substantial improvement in the current account. Thus, countries could use environmental taxation as a complementary policy in the policy toolkit to address balance of payments issues.

Regarding the other coefficients, there seems to be some evidence for a long-run twin deficit hypothesis, as is evident from Table 10. The coefficient on the budget balance is positive and significant across all specifications which corroborates the twin deficit hypothesis. Thus, improving the budget balance serves to improve the trade balance and the effect is valid in the long-run as well. This is a relevant policy result to address fiscal issues.

Moreover, the real effective exchange rate appreciation deteriorates the current account balance initially, but there seems to be a quick adjustment in the next period as is evident from the significance of the lag coefficient. In the long-run, there is some evidence for a positive effect of FDI and a negative effect of industrial production on the current account and no evidence for an effect of the old age dependency ratio and labor productivity.

The estimates show that there is room to speak of long-run effects of energy taxation. Moreover, the persistence coefficient for the current account indicates high persistence which implies the need for consistent policy. As explained earlier, the sample runs until 2012 which is when the EU experienced repeated economic turmoil and a double-dip recession (Pierluigi & Sonderman, 2018). Since the sample includes the global financial crisis which could have affected the persistence parameter and the effects of other variables as well, we estimate the same equation for the current account using the pre-crisis sample up to 2008.

The crisis could have affected the estimates through various channels. Some countries experienced deep economic contractions, which could have affected the current account despite no fundamental changes in the underlying variables of the current account (savings-investment identity), as the current account is typically slow to adjust (Clarida, Goretti, & Taylor, 2007; C. Freund & Warnock, 2007). Moreover, budget balances change during economic turmoil as policy responds to the crisis, foreign direct investment dries up and the crisis could be observed as an overall productivity shock or demand shock revealing underlying vulnerabilities and inherent differences. The results are shown in Table 11.

The estimates reveal comparable effects of energy taxation on the current account. There is evidence for a twin deficit hypothesis, as the budget balance coefficient is positive and statistically significant. Moreover, a deterioration in competitiveness seen through a real effective exchange rate appreciation is associated with a deterioration in the current account balance, which is quick to adjust as in the whole sample estimates. Nevertheless, most of the coefficients lose their significance. The main difference seems to be in the persistence parameter. Namely, the estimates on the pre-crisis sample indicate a substantially higher persistence parameter in the magnitude of 0.8. This could be interpreted as a high persistence parameter associated with a sample of developed countries, but the sample includes converging countries as well.

Table 11 Current account dynamic model estimates (pre-crisis sample)

CA	(1)	(2)	(3)	(4)
CA_{t-1}	**0.875*** **	**0.838*** **	**0.751*** **	**0.712*** **
	(0.121)	(0.0962)	(0.134)	(0.150)
Energy tax_{t-1}	**0.817**		**1.136**	
	(0.796)		(0.871)	
Implicit energy		**1.614** **		**1.937** **
tax		(0.697)		(0.971)
IP_{t-1}	**-0.0248**	**-0.0441** **	**-0.0270**	**-0.0847** **
	(0.0155)	(0.0196)	(0.0297)	(0.0344)
FDI incoming	**0.159**	**0.789**	**-0.187**	**0.608**
	(1.004)	(1.146)	(0.865)	(0.920)
FDI $incoming_{t-1}$	**0.174**	**-0.645**	**0.550**	**-0.524**
	(0.904)	(1.071)	(0.870)	(0.865)
Budget $balance_{t-1}$	**0.0631**	**0.0654**	**0.176**	**0.179**
	(0.117)	(0.0879)	(0.148)	(0.148)
Reer	**-0.00359**	**0.0223**		
	(0.0544)	(0.0404)		
$Reer_{t-1}$	**0.0551**	**0.0206**		
	(0.0543)	(0.0429)		
Old age	**0.0356**	**0.0840**	**0.0119**	**0.114**
dependency ratio	(0.0648)	(0.0732)	(0.0995)	(0.116)
Labor			**0.0970**	**0.179** **
productivity			(0.0873)	(0.0907)
Observations	208	205	207	204
Fixed effects	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes
Specification tests (p-value)				
Arellano-Bond (1)	0.341	0.186	0.175	0.163
Arellano-Bond (2)	0.917	0.552	0.453	0.336
Hansen	0.993	0.986	1	0.999

Source: Eurostat (2015c), EIA (2015), IMF (2017), OECD (2015a), Own work

Alternatively, the higher persistence parameter in the pre-crisis sample estimates compared to the whole sample estimates implies that the crisis served to emphasize countries' balances of payments issues, at least in the initial period. Thus, persistence parameters decreased during the crisis. The (surplus) countries with solid external positions likely retained their positions, whereas the (deficit) countries with weaker external positions were exposed to financial markets' loss in confidence and thus greater external pressure in the balance of payments. This likely led to a decrease in the persistence parameter owing to a sharp reversal in the trade balance due to a deep economic contraction.

2.2.5 Discussion and conclusion

The results from the energy dependency equation showed that there is some evidence of a negative effect of energy taxes on energy dependence, as shown in Section 2.2.3. This was analyzed through both a static and a dynamic model. The static model showed that energy taxes and the real effective exchange rate have a negative effect on energy dependence, whereas GDP in PPP has a positive effect, confirming that countries which are richer are larger energy consumers. The results on the oil price were negative but not significant in the static model.

The dynamic model showed in turn that there is high persistence in energy dependence, which is in line with other findings in the literature (Fallahi, Karimi, & Voia, 2016) which may have both positive and negative policy implications. It might be interpreted negatively as it implies that policies undertaken this year will likely have a small effect if there is strong habit formation, as suggested by an autoregressive parameter that is higher than 0.8. It might be interpreted positively as it implies that a large enough shock will persist and the effects will transmit to subsequent periods.

Although informative, the energy dependency equation is an auxiliary equation aiming to shed light on the potential channels for an effect on the current account. The main variable of interest and model is the current account. The results on the current account provide stronger evidence for a positive effect of energy taxation on the current account balance. The magnitude differs depending on the energy tax variable used, but the sign is positive regardless of whether we use the energy tax share in GDP or the implicit energy tax. Both the significance and the magnitude differ depending on the variable and the model used. Energy taxation has a positive effect in the long-run model regardless of the variable used, which indicates robust statistical evidence for an effect on the current account balance in the long-run as well.

The positive effect from both indicators is evidence for the economic dividend within the double dividend discussion. Thus, this is an alternative channel for the double dividend (the environmental dividend is assumed to be implicit). The magnitude is comparable across both estimations and is around 4 p.p. in the long-run. As evident from the short run estimates in Table 9, an increase of 1% in the energy tax rate leads to an increase in the current account balance by around 1 p.p.. The statistical significance of the results shows compelling evidence for the economic dividend.

However, considering that most countries have energy tax shares in the magnitude of 1-3.5% of GDP p/a implies that a 1 p.p. change in the annual share is unrealistic. Thus, substantial improvements using energy taxation are possible, but they require politically challenging increases in the rate of taxation. Thus, there is an effect on the current account

balance, but its magnitude is moderate considering modest or gradual changes in energy taxation.

The results on the persistence parameter are generally comparable to the literature. Namely, we find high persistence in the current account, in the range of 0.5 to 0.8. The literature on current accounts does not always estimate persistency through a dynamic model and analyzes a static model. More recent studies such as the panel-VAR methodology employed by Elgin and Kuzubas (2013) or the dynamic system-GMM used in this analysis finds comparable results for the persistence of the current account. Elgin and Kuzubas (2013) find a persistence coefficient of 0.83 in their high-income country sample, whereas Das (2016) finds a persistence coefficient of 0.74 using a methodology comparable to the one used in this paper.

Thus, the results on the current account persistence confirm the theory that current account balances are persistent, thus requiring time to smooth out any external imbalances. Moral-Benito and Roehn (2016) report that a current account imbalance is 65% smoothed out over a 10-year period. However, they utilize a Bayesian model averaging methodology which estimates several models at the same time, thus averaging the value of the coefficients across different models. The results are therefore not comparable quantitatively.

Qualitatively, our results corroborate the finding of a persistence in the current account. Nevertheless, the estimates on the pre-crisis sample and the whole sample indicate a stark difference in the persistence parameter before and after the crisis. This indicates that the crisis has exacerbated issues with countries' external positions, as it has increased the sensitivity in countries' persistence parameters. This has relevant ramifications for further crisis resolution mechanisms, which will need to be more balanced and spread out over a longer horizon to avoid sharp reversals in the current account balance.

Regarding the other variables, we have extended the list of determinants in the fiscal policy group, by controlling for the green aspect of taxation. This is another contribution of this analysis. Namely, studies to date have generally utilized the budget balance as a determinant of the current account. A positive effect is found in various studies (Chinn & Prasad, 2000; Elgin & Kuzubas, 2013; Caroline Freund, 2005; Moral-Benito & Roehn, 2016). Chinn and Ito (2008) utilize a panel methodology closer to ours and find an effect in the magnitude of 0.10-0.49 p.p.. We find a positive effect in most of the specifications. The magnitude in the static model is comparable to the magnitude cited in Chinn and Ito (2008) static model. The effect in the dynamic model corroborates the twin deficit hypothesis.

The other variables have their expected signs. The volume of production index has a negative effect on the current account balance, whereas a loss of competitiveness as reflected in a higher real effective exchange rate is associated with current account deterioration. The real effective exchange rate effect is negative in studies so far, which is in-line with theory. A novelty in our analysis is that we control for the real effective exchange rate in two

consecutive periods. Thus, although a loss in competitiveness is initially associated with a deteriorated current account balance, an adjustment seems to occur relatively quickly, such that the negative effect is offset within a relatively short period of time. Thus, the effect of the lagged real effective exchange rate is positive.

The other variables include the old age dependency ratio which has a positive effect. In theory, the old age dependency ratio should affect the current account balance negatively, as it implies that a larger share of the population is in a borrowing stage (Chinn & Prasad, 2000). However, the results from estimation show a positive effect, which could be due to higher aggregate savings in the EU in general. Incoming FDI has a varying effect depending on whether a lag is used or not. Thus, the lagged FDI is consistent with the literature that relates financial development to the current account.

Overall, the results on the current account are in line with the literature. Moreover, the energy tax variables indicate a positive effect on the current account balance. Crucially, they extend to the long-run as well. The effects are moderate to substantial, depending on the extent of changes in the tax code. Nevertheless, the positive effect has clear policy implications that it is economically sensible to increase energy taxation. In the context of the double dividend discussion, there is a double dividend through an alternative channel not discussed so far. Namely, the double dividend has been related to output and employment effects (Andersen et al., 2007; Commins et al., 2009) and not the external trade balance. The analysis above showed that there is an economic dividend in terms of a positive effect on the current account.

There is a further benefit in terms of the double dividend discussion specifically related to the trade balance. Namely, countries with external imbalances have been subject to supervision by relevant institutions so as to carry out the necessary economic reforms to improve the trade balance (EC, 2019a). The positive effect from energy taxation on the current account not only improves the current account, but also helps avoid more severe restrictive measures aimed at improving the trade balance or the budget balance. The latter is the twin deficit hypothesis, which is corroborated with the positive coefficient on the budget balance across various specifications. Thus, overall we could speak of a positive effect stemming from GDP growth as well and avoiding harsher policies aimed at balancing the economy or public finances. Achieving this positive effect depends on the environmental policy stance, as well as on the persistence parameter and its sensitivity to economic conditions. Higher persistency in the current account implies the need for a consistent environmental policy with a longer policy horizon.

This additional benefit clearly stems from the European Union countries as their balances of payments are monitored for macroeconomic imbalances. Indeed, the research in this study is conducted on a sample of European Union countries which could limit the generalization to other countries. More generally, it could be extended to any other country with trade

imbalances, subject to supervision by international financial institutions. Focusing on the European Union countries is a limitation in another aspect. Namely, it provides results for a developed group of countries only.

However, energy taxation has social issues such as regressiveness which may represent a greater issue in less developed countries. Thus, this policy implication might not be valid for those countries, as high energy taxation might only exacerbate social and economic issues such as inequality. Policy makers should carefully weigh the pros' and cons' associated with energy taxation and the severity of their imbalances.

Another limitation of the study is the choice of variables which has excluded variables such as the terms of trade or financial openness. We have chosen these variables due to: i) data limitations and ii) the homogeneity of the trade bloc. Namely, using terms of trade data which is not readily available for all EU countries over all years would have imposed an additional data limitation on the sample. Regarding the other variables, they have been excluded, as the EU is a relatively homogeneous trade bloc which is open to financial markets and trade. Including those variables as well would have implied less degrees of freedom in a sample that is already relatively small. Thus, future studies should strive to circumvent this problem. Moreover, an inherent limitation in econometric policy studies is the potential endogeneity problem in terms of reverse causality between the explained target variable and the explanatory policy variable.

To sum up, energy taxes have been amply researched, mostly in the context of an Environmental Tax Reform. This has led to studies being mostly done using modelling strategies, whereas panel data analysis has been lagging behind. This has led to a gap of ex-ante and ex-post analysis, to the best of our knowledge. The aim of this analysis was to fill this gap. Estimation was done for both energy dependence and the current account as there are theoretical reasons to believe energy taxes would affect energy dependence negatively and the current account positively. This is particularly relevant for energy importing countries, such as the bloc of European Union countries.

Overall, these results seem to support empirically what others have suggested for the link between energy taxes and energy imports and extend its relevance to the current account. Namely, there is an alternative channel for the double dividend through the potential effect on energy dependence and the current account. The results on the energy dependence equation and the persistence parameters in both equations imply that policy has to be persistent as well and design energy policy over a longer policy horizon. More specifically, the high persistence parameter in energy dependence implies that any changes made should be done persistently themselves as well due to habit formation in energy consumption. The relatively high persistence parameter on the current account indicates that changes in environmental policy should not be too gradual to avoid them fading out due to a large persistence parameter. However, the persistence parameter was not as high as the energy

dependence persistence parameter. Moreover, the crisis seems to have decreased the current account persistence parameter.

Nevertheless, there is robust statistical evidence to claim an economic dividend due to the positive effect of energy taxes on the current account balance. An encouraging result is the validity of the effect in the long-run. Thus, the result is informative more broadly for the double dividend discussion. The environmental dividend is assumed in turn and is reviewed in Section 2.1.

Future research avenues including differentiating between energy prices, perhaps using a weighted index depending on the energy import mix, as the current variable had energy dependence from tonnes of oil equivalent. Future research could also address the issue of reverse causality in terms of the endogeneity of policy variables by modelling a system of equations. In addition, the relationship between energy taxes and energy dependence should be explored in other (blocks of) countries to evaluate whether this effect is only due to the price effect or is in part behavioral as well due to the European Union's flagship green leader positioning through investments in renewable energy. This section has thus presented the results on the economic dividend at the national level. The next section presents the results of the effect of environmental taxation on value added and employment at the sectoral level.

2.3 The effects of environmental taxes on value added and employment

The previous section showed that implicit taxes on energy at the national level have a positive effect on the balance of payments. This chapter aims to make an empirical contribution by analyzing the effect of environmental taxes on value added and employment using data at the sectoral level. The estimates provide a gauge of the economic dividend at the sectoral level. This relates to the second research question on the effects of environmental taxation on value added and employment. This is a relevant empirical question for the double dividend debate, its public finance aspect specifically. Moreover, the level of aggregation (sectoral) enables further policy implications. The relatively longer sample running after the crisis enables long-run estimates for the effects of the crisis, as well as the long-run effects of the ETR. The chapter is organized as follows: the first section presents a brief literature review as to the effects of environmental policy on the sectoral level, the second section presents the data and methodology, the third section presents the results and the fourth concludes.

2.3.1 Literature review

The effects of environmental taxes or even more broadly environmental policy on economic variables at the firm-level or sectoral-level appear as early as 1983 in the literature (Gollop & Roberts, 1983). Variables typically analyzed within this body of literature include productivity, employment and the pollution-haven hypothesis. Theoretically, there are several potential effects of environmental policy on sectoral economic variables. The initial

effect is expected to be negative since environmental policy imposes new costs, due to pollution fees per unit of pollution or pollution abatement costs for new equipment. This effect varies with the composition of the initial labor and capital in the first place. The final effect is not necessarily negative, as old capital might be replaced with new capital which is environmentally friendly and more productive overall (Barbera & McConnell, 1990). Moreover, labor costs might increase, but overall productivity will also depend on the skill-set of the new workers as well as the policy design. For example, increasing environmental taxes in a revenue-neutral fashion (by decreasing labor taxes) might induce positive net effects.

These are direct effects on productivity. Indirect effects include the effects on other inputs, workers' productivity and innovation. Namely, productivity may decrease in an unregulated industry due to an increase in input costs in a regulated industry. It may also go up if environmental policies result in cleaner water, thereby reducing the costs for water supply firms to purify it themselves (Jaffe, Peterson, Portney, & Stavins, 1995). Other indirect effects may arise through workers' health or innovation. Productivity may increase if workers work in a cleaner environment (Ostrom, 1990). In addition, the last indirect effect is the Porter hypothesis introduced in the first chapter (Porter, 1991). By the Porter hypothesis, environmental policy might increase productivity, if it induces environmental innovation.

However, there are theoretical objections to it as well. First of all, the free-lunch argument implies that if firms had a way to increase productivity, they would have used it earlier. Second, the hypothesis hinges on the assumption that policy makers know more about firms' behavior than managers and are able to design the right policies which will stimulate innovation. If policy makers have information constraints, arguably even greater than firms', then the viability of these well-designed policies is questionable which leads back to the second caveat. The theoretical plausibility of the Porter hypothesis need not be undermined by the considerations above. Namely, the free-lunch argument assumes rationality which is questionable for two reasons (Ambec et al., 2013). First of all, there are behavioral concerns in decision making. Second, there are market failures and knowledge spill-overs which impede innovation.

Earlier research on the initial environmental regulation such as the Clean Air Act and other environmental regulations in the United States find conflicting evidence for the effects on productivity (Sato & Dechezleprêtre, 2014).The effect on productivity is positive in a later study by Ryan (2012), whereas Greenstone et al. (2012) find a decline in TFP for regulated firms. Recently, there have been some attempts at sector-wide analysis, owing to the sector-wide coverage of the EU ETS and environmental taxation in the European Union. Thus, H. S. R. Chan et al. (2013) analyze the EU ETS and find negative effects of the EU ETS for the power sector. Commins et al. (2009) analyze a broader sample of European sectors and find a positive effect of energy taxes on TFP.

The effects on employment are somewhat more unanimous, as they are generally negative or statistically inconclusive. Greenstone (2002) finds negative effects on manufacturing jobs due to the Clean Air Act. Anger and Oberndorfer (2008) find no statistically significant effects on employment from the EU ETS. An identical result appears in Commins et al. (2009). Energy taxation in turn has a negative effect on employment. Negative effects on employment are found in Aldy and Pizer (2011) and Deschenes (2010) as well. The environmental policies analyzed include electricity prices and a carbon tax, respectively.

As can be seen, most of these analyses are sectoral, yet they cover a fragment of the sectors. Namely, they typically refer to the sector being subjected to the environmental regulation. This is a remark valid for most of the papers. Several papers (H. S. R. Chan et al., 2013; Commins et al., 2009) analyze the pan-European environmental regulations such as environmental taxes or the EU ETS. Although Commins et al. (2009) analyze environmental taxation, they do so on a shorter sample, using a dataset which is plagued by missing data issues.

Leiter, Parolini, and Winner (2011) analyze the effect of environmental regulation including taxes on investment in European manufacturing industries between 1998 and 2007. Kneller and Manderson (2012) analyze the effect of pollution abatement costs on R&D in the UK manufacturing industry between 2000 and 2006. A wider sample for the same time period is found in Franco and Marin (2013) who analyze the effect of energy taxation on innovation and productivity in 7 European countries.

Thus, although they are broader in scope in terms of the environmental regulation and the sectors affected by it, they only include samples up to the crisis. A more recent study (Costa-Campi, Garcia-Quevedo, & Martinez-Ros, 2017) analyzes the effect of environmental regulation on R&D expenditure on a sample which extends beyond the crisis, but includes only Spanish manufacturing industries.

The time period under consideration does not include the crisis as stated earlier. Extending the sample beyond the crisis is thus one of the contributions of the following analysis. Furthermore, although the studies cited above analyze the effect of environmental regulation at the sectoral level and include environmental/energy taxation as the independent variable, they typically only look at the variables within the Porter hypothesis. The Porter (1991) hypothesis speaks of the effect of environmental regulation on innovation. However, the effect on employment is of central interest within the context of the double dividend discussion and environmental tax reforms.

Namely, the defining feature of the ETR is the substitution of labor taxation with environmental taxation, so as to stimulate employment. Indeed, higher employment and thus welfare is one of the channels for the double dividend. The aforementioned studies typically analyze the effect on innovation and productivity, whereas the effect on employment is neglected. As such, they generally go under the heading of the Porter hypothesis rather than

the double dividend. Arguably, the studies contribute to the double dividend discussion but they are lacking in one variable which is the employment variable-one of the main channels for the double dividend (Bovenberg & De Mooij, 1994). Commins et al. (2009) analyze the effect on both innovation and employment.

The following analysis aims to make a contribution in this respect as well. Namely, we analyze the effect of energy taxation on both value-added and employment on a sample of 34 NACE Rev2 European sectors from 1995-2015. Both variables are central variables in the double dividend discussion. Furthermore, we use energy tax data at the sectoral level for all sectors (beyond manufacturing). The reason for this is that although manufacturing is the sector most burdened by energy taxation due to its energy intensity, other sectors in the economy including services bear a burden of energy taxation (for ex.service industries such as healthcare, public defense or administration).

Furthermore, although they may not be as affected by energy taxation, they are affected by labor taxation which is the premise around the ETR. Thus, we are interested in the effects on all sectors and not just the industrial sector as all may be affected by an ETR. Moreover, we estimate the effects of the crisis, as well as the long-run effects of the ETR. The latter is relevant so as to show whether the effects of the ETR are centered in a period or are spread out over the period of the reform. The next section describes the data and methodology.

2.3.2 Data & methodology

This empirical analysis will use data from the EU-KLEMS database, which is a joint project by the European Commission and the European Commission. There have been three releases of the EU-KLEMS database from 1995-2015. This analysis uses the most recent dataset, updated in September 2017, including datasets for almost all the EU-28 countries, excluding Croatia due to data availability. The analysis uses data compiled on capital and output available from the project website. All variables have been expressed in euros.

We use the following variables: value added (in millions of EUR), employment (in 000's), FDI (stocks) and investment in capital (volume in EUR) for the economic variables. The energy tax variables included are the implicit energy tax (EUR per tonne of oil equivalent) and the share of energy tax paid by the corresponding sector (in %). There are 34 subsectors in total, classified according to the NACE-2 revised code.

The energy tax sectoral share is broken down to 6 sectors (agriculture, industry, construction, retail trade, transport and storage and services) and this is also the level of aggregation for the analysis. Furthermore, the regression tables contain the results for industry, services and the remaining sectors, as an additional aggregation which is helpful for gauging the effect on energy intensive vs. labor intensive sectors. The following Table 12 and Table 13 list the structure of the dataset and the summary statistics for the variables.

Table 12 Sectoral structure of the dataset

Sector	Frequency	Relative frequency	Cumulative frequency
Agriculture	460	3.26	3.26
Industry	5,921	42.03	45.29
Construction	461	3.27	48.56
Wholesale and retail trade	1,209	8.58	57.14
Transportation	715	5.07	62.22
Services	5,323	37.78	100

Source: (Jager, 2017), Own work

As can be seen, most of the observations (sectors) come from the industrial sector. The construction and agriculture sectors are underrepresented each. This is due to the NACE Rev2 classification, which contains a smaller number of subsectors within them compared to the industrial sectors. Table 13 lists the summary statistics for the five variables used.

Table 13 Summary statistics

Variable/Statistic	N	Mean	Std. dev.	Min	Max
Value added	13925	13131.64	28600.64	0.1	289623
Empl.	13205	272.53	555.98	0.01	5618
FDI	11064	152098.4	206468.9	707	1147472
Implicit tax energy	13030	172.6591	81.1838	17.25	441.56
Energy share tax	6718	11.32	7.01	0	50.1
TFP	7071	111.99	311.41	1.25	13078.55
Capital investment	10717	12507.98	58608.3	0.1	1523938
Tertiary educ.	14063	21.28	7.55	6	39.6

Source: Jager (2017), Eurostat (2015c) , Own work

The five variables are used in the following econometric specifications:

$$VA_{it} = \beta_0 + \beta_1 Capital_{it} + \beta_2 Emp_{i,t-1} + \beta_3 energytax_{it} + \beta_4 ETR_{it} + \beta_5 Tert\_edu_{it} + \alpha_i + \varepsilon_{it} \quad (6)$$

The specification follows microeconomic theory, more specifically the Cobb-Douglas function, which specifies output to be a function of input variables, capital, employment and

policy variables. The inclusion of capital and employment is standard as these are production inputs. The equation is extended to include an additional type of capital, human capital. All inputs to production (capital, employment) are expected to have positive signs, although the sign of human capital may differ across sectors. Namely, advanced economies with higher shares of tertiary education tend to have larger service sectors compared to their manufacturing sectors.

The environmental tax variables are the energy tax share paid by the corresponding sector and the implicit energy tax, so as to evaluate the sensitivity of the results to a different tax variable. Reverse causality concerns of the effect of value added or employment on taxes would imply taking lagged values or applying other transformations. We do not control for this due to lags in the data publication which implies that the tax changes prior to the change in the economic variable studied. As an additional control and robustness check, we test for instrument validity. Moreover, there are further controls for environmental policy, since this is the main issue of interest. These are an environmental tax reform dummy (1 only for the countries specified in the ETR Section of this chapter) and interaction terms to capture the long-run effects. The ETR dummies are 1 from the first year of the reform, typically before 2000.

One additional control is included for the level of tertiary education as a human capital variable in the production function and FDI investments in the employment equation. Since there is potential endogeneity in the value added equation especially, we estimate the equation using instrumental variables regression using the first and second lags of employment as instruments for employment. These are valid instruments as the results show in continuation. The function for employment is specified using similar reasoning.

$$Employment_{it} = \beta_0 + \beta_1 Capital_{it} + \beta_2 TFP_{it} + \beta_3 energytax_{it} + \beta_4 ETR_{it} + \beta_5 FDI_{it} + \alpha_i + \varepsilon_{it} \quad (7)$$

The specification of the model follows Ladu (2005), who specifies employment to be a function of past employment, capital and total factor productivity. Other approaches include modelling employment as a function of various policy variables such as employment protection, union membership rates, product market stringency and the output gap (Bassanini & Duval, 2006). At the sectoral level, Hall, Lotti, and Mairesse (2007) specify employment as a function of product and process innovation for a sample of manufacturing firms. More recent work involves modelling the feedback loop, i.e. the effect of employment on productivity (Dew-Becker & Gordon, 2012; McMillan, Rodrik, & Verduzco-Gallo, 2014).

Since the research question is the effect of energy taxation on employment, we follow the classic approach of estimating the demand for labor equation similar to Ladu (2005). The model is a static panel, since we are estimating the effects before and after the crisis. This is econometrically simpler with a static panel due to the interaction terms. The issue of endogeneity is circumvented since the employment equation does not depend on value added itself, but the contemporaneous exogenous shock to value added, total factor productivity. This is therefore a determinant of the demand for employment but since it is exogenous in the production function it does not cause endogeneity issues in the estimation of the employment function.

Demand for an input is thus a function of the complementary inputs used (capital), output (productivity) and the regulatory environment (environmental taxes). The coefficients for capital and FDI are expected to be positive, whereas the effect of productivity is likely to be negative due to substitution effects. Both equations are estimated using fixed effects, as the result of economic intuition and a formal Hausman test.

Furthermore, the sample allows for an estimation of the effects of the crisis. These are estimated using the Chow test which is the basic equation augmented for the interaction terms with a post-crisis dummy. In addition, we use the autoregressive distributed lag approach to estimate the long-run effects of policy changes (Avila & Strauch, 2003; Hemmelgarn & Teichmann, 2013).

The approach is based on the inclusion of lagged policy variables. Since the variable of interest are energy taxes and the effect of the ETR, the long-term effects variable includes the lagged interaction term for energy taxes and the ETR up to and including a lag of 8 as this is typically the duration of the business cycle. Arguably, there are additional variables which could be included as controls, but the country heterogeneity is taken into account with the use of fixed effects. Moreover, the inclusion of additional policy variables beyond the ones of interest would decrease the degrees of freedom, particularly in specifications such as the Chow test.

2.3.3 Environmental taxation and value added

The results from estimation for the effect of environmental taxation on value added differ by sectors. The most affected sector is the industrial sector. The results from estimation using the share of energy tax revenues paid by the sector as the energy tax variable are given in Table 14. The first three columns show the results of estimation on various subsamples. The first is the industrial sector, the second is the wholesale, retail trade and transportation sector. The third is the service sector, whereas the fourth refers to the whole sample.

The results show a substantial negative effect of environmental taxation on the industrial sector. This is evident from the coefficients on energy taxation, as well as the coefficient on

the ETR dummy. Both coefficients are negative and statistically significant. By contrast, the coefficient for the services sector is positive and significant for the energy taxation variable, whereas the ETR dummy loses significance. The other coefficients have their expected signs as capital investment and employment have positive and statistically significant coefficients as expected from theory.

Table 14 Value added results (1)

Variable/ Model	(1) Industry	(2) Other	(3) Services	(4) All
Empl.	**0.584*** **	**0.927*** **	**0.565*** **	**0.683*** **
	(0.0714)	(0.0839)	(0.0564)	(0.0337)
Cap_inv	**0.0774*** **	**0.0290**	**0.0407*** **	**0.0533*** **
	(0.0206)	(0.0214)	(0.0140)	(0.0112)
Tertiary	**-0.00418**	**-0.00162**	**-0.00220**	**-0.00310***
edu	(0.00351)	(0.00387)	(0.00181)	(0.00177)
FDI	**0.0461**	**0.105*** **	**0.110*** **	**0.0966*** **
	(0.0300)	(0.0236)	(0.0145)	(0.0132)
ETR	**-0.0792** **	**-0.0129**	**-0.0247**	**-0.0481** **
	(0.0352)	(0.0330)	(0.0317)	(0.0208)
Energy tax	**-0.0121*** **	**0.0177*** **	**0.00656** **	**0.000533**
Share	(0.00299)	(0.00545)	(0.00282)	(0.00184)
Observations	1,655	825	1,795	4,275
R-squared	0.281	0.511	0.690	0.448
Specification tests				
Sargan	0.3036	0.8198	0.4740	0.3840
Endogeneity	0.5854	0.6081	0.0354	0.5003
Fixed effects	yes	yes	yes	yes
Time dummies	yes	yes	yes	yes

Source: Jager (2017), Eurostat (2015c) , Own work

Repeating the estimation using the implicit energy tax as a variable produces the following results shown in Table 15. The results show that environmental taxation (share of energy taxes per sector) has a particularly negative effect on the industrial sector, but it depends on the specification. Namely, the energy tax variable has a negative and significant effect on the industrial sector when using the energy tax share paid by the sector as the energy tax variable. The coefficient on energy taxes implies that a 1% increase in the burden of taxation (share of energy tax revenues paid by the corresponding sector), decreases value added by

1.2% on average. The effect is positive and significant when using the national implicit energy tax rate, thus the result is sensitive to the specification.

Nevertheless, the implicit energy tax rate reflects the national implicit energy tax rate, whereas the energy tax share reflects sectoral conditions. Thus, the latter is more reliable for discerning the sectoral effects. The positive coefficient of the implicit energy tax rate could reflect the fact that countries with higher value added set higher energy tax rates because it is politically more acceptable to increase energy taxes in a stable and growing economy. The coefficients on the energy tax variable (share of paying sector) for the other sectors are positive and statistically significant. All the implicit energy tax coefficients are positive and statistically significant. The magnitude of the implicit energy tax coefficient implies an increase in the magnitude of 0.2% for a 1% increase in the national implicit energy tax rate.

Table 15 Value added results (2)

Variable/ Model	(1) Industry	(2) Other	(3) Services	(4) All
Empl.	**0.690*** **	**0.786*** **	**0.536*** **	**0.682*** **
	(0.0418)	(0.0573)	(0.0346)	(0.0212)
Cap_inv	**0.135*** **	**0.116*** **	**0.0491*** **	**0.0983*** **
	(0.0165)	(0.0204)	(0.0121)	(0.00967)
Tertiary	**-0.00648** **	**-0.000154**	**-0.00403** **	**-0.00416*** **
edu	(0.00258)	(0.00322)	(0.00166)	(0.00140)
FDI	**0.172*** **	**0.131*** **	**0.210*** **	**0.175*** **
	(0.0124)	(0.0209)	(0.00950)	(0.00782)
ETR	**-0.0905*** **	**-0.0930*** **	**-0.0760*** **	**-0.0889*** **
	(0.0236)	(0.0280)	(0.0248)	(0.0148)
Implicit energy	**0.233*** **	**0.201*** **	**0.148*** **	**0.200*** **
tax	(0.0443)	(0.0494)	(0.0274)	(0.0226)
Observations	3,046	1,487	3,297	7,830
R-squared	0.514	0.650	0.822	0.673
Specification tests				
Sargan	0.5980	0.6864	0.7897	0.5893
Endogeneity	0.3371	0.3934	0.1927	0.8291
Fixed effects	yes	yes	yes	yes
Time dummies	yes	yes	yes	yes

Source: Jager (2017), Eurostat (2015c) , Own work

The coefficient on the ETR is negative and statistically significant in the specification with the share of energy taxes for the industrial sector only. It is negative and significant across all sectors when estimating using the implicit energy tax. Thus, there is substantial evidence

for a negative effect of the ETR on the industrial sector, whereas the results for the other sectors depend on the specification. The negative effects of the ETR are decomposed in continuation using the lags of the interaction terms between the ETR and the energy tax rates.

The other variables have their expected signs. Employment and capital investment have a positive effect on value added and this holds true across all specifications. Capital investment has a stronger effect in the industrial sector. Human capital accumulation, i.e. the share of the population with a tertiary education has a negative and significant effect on the industrial sector, whereas the other sectors have a negative coefficient but the statistical significance varies across coefficients. This is likely due to a growing service sector with a better educated labor force. Namely, advanced economies typically have larger services sectors compared to manufacturing. It should be mentioned that part of the effect of tertiary education is captured through FDI, thus the somewhat counterintuitive result of a negative effect on the service sector. This is due to greater FDI flowing in countries with greater human capital (Akin & Vlad, 2011; Zhang & Markusen, 1999) .

The results are robust to endogeneity issues as is evident from a high Sargan statistic which implies that we cannot reject the null hypothesis for instrument validity. Overall, these results indicate that an ETR had a negative effect on value added. This can be seen in the negative coefficients in the regression Table 14 and Table 15, amounting to approximately -8% using the energy tax variable. The coefficient on the energy tax variable itself varies depending on whether we use the energy tax share paid or the implicit energy tax. The industrial sector is negatively affected by the energy tax share paid, whereas there is a positive effect on the other sectors.

As part of a sensitivity analysis, the results are estimated taking the crisis into account as well and any possible structural changes. The crisis may have altered the coefficients as it might have increased the sensitivity of value added to energy tax rates, since the economic contraction implies greater financial constraints and an overall decline in demand.

The structural change in the coefficients is tested with a Chow test which tests the same model with the interaction terms with a crisis dummy. The crisis dummy (post-crisis or PC) is 1 from 2009 onwards and 0 otherwise. Thus, if the term is significant it indicates the presence of structural effects/changes, as it would be a coefficient which only lights up or has an effect in the post-crisis years. The results are shown in Table 16 and Table 17.

The results do not change qualitatively for capital and employment, as can be seen by the positive and significant coefficients after the crisis for the industrial sector. The coefficients on tertiary education are not significant across all specifications, whereas the results on energy taxes indicate a negative effect in the industrial sector. Moreover, the post-crisis coefficient (Energytaxes*PC) is negative and significant, thus indicating greater sensitivity

to energy taxes after the crisis. The ETR dummy reverts sign after the crisis for the industrial sector, although the net effect is negative. The coefficients on both the energy tax share and the ETR dummy indicate a positive effect for the service sector.

Table 16 Value added Chow test (1)

Variables/ Model	(1) Industry	(2) Other	(3) Services	(4) All
Cap_inv	**0.110*** **	**0.0677*** **	**0.0537*** **	**0.0794*** **
	(0.0214)	(0.0249)	(0.0158)	(0.0120)
Cap_inv*PC	**0.0165** **	**-0.000183**	**-0.00208**	**0.00509***
	(0.00670)	(0.00671)	(0.00340)	(0.00300)
Emp_{t-1}	**0.430*** **	**0.707*** **	**0.459*** **	**0.546*** **
	(0.0627)	(0.0785)	(0.0431)	(0.0304)
Emp*PC	**0.0504*** **	**-0.0117**	**0.00232**	**0.0180*** **
	(0.0150)	(0.0119)	(0.00455)	(0.00622)
ETR	**-0.106*** **	**0.00499**	**-0.0152**	**-0.0542*** **
	(0.0367)	(0.0320)	(0.0299)	(0.0207)
ETR*PC	**0.00765**	**0.0128**	**0.0718*** **	**0.0308***
	(0.0291)	(0.0431)	(0.0237)	(0.0159)
Energy tax	**-0.00733*** **	**0.0208*** **	**0.00999*** **	**0.00291**
share	(0.00284)	(0.00564)	(0.00322)	(0.00203)
Energy_tax*PC	**-0.00363***	**0.000517**	**-0.00401**	**0.00104**
	(0.00190)	(0.00259)	(0.00248)	(0.000882)
FDI	**0.0548**	**0.104*** **	**0.123*** **	**0.104*** **
	(0.0360)	(0.0262)	(0.0156)	(0.0154)
FDI*PC	**-0.0542*** **	**0.00277**	**-0.00985** **	**-0.0235*** **
	(0.00875)	(0.00760)	(0.00464)	(0.00382)
Tert	**0.000201**	**0.000108**	**-0.000397**	**0.00136**
	(0.00398)	(0.00407)	(0.00227)	(0.00200)
Tert*PC	**0.00519** **	**-0.00226**	**-0.00236***	**0.000329**
	(0.00245)	(0.00299)	(0.00123)	(0.00122)
PC dummy	0.267***	0.0806	0.211***	0.121**
	(0.0779)	(0.103)	(0.0737)	(0.0508)
Observations	1,659	825	1,797	4,281
R-squared	0.300	0.466	0.693	0.433
Specification				
Fixed effects	yes	yes	yes	yes
Time dummies	yes	yes	yes	yes

Source: Jager (2017), Eurostat (2015c) , Own work

The results indicate some evidence for structural changes. Specifically, in relation to the energy tax, there is a further decline in the coefficient and thus a more pronounced negative effect of energy taxes on the industrial sector after the crisis. FDI seems to have a more pronounced negative effect after the crisis in both specifications (the energy tax share and

the implicit energy tax rate as an energy tax variable). The results change qualitatively when estimating the same equation using the implicit energy tax rate as is evident from Table 17.

Table 17 Value added Chow test (2)

Variables/ Model	(1) Industry	(2) Other	(3) Services	(4) All
Cap_inv	**0.158*** **	**0.140*** **	**0.0679*** **	**0.121*** **
	(0.0163)	(0.0197)	(0.0123)	(0.00941)
Cap_inv*PC	**0.0271*** **	**0.0275*** **	**-0.00526***	**0.0140*** **
	(0.00631)	(0.00758)	(0.00314)	(0.00293)
Emp_{t-1}	**0.580*** **	**0.706*** **	**0.477*** **	**0.598*** **
	(0.0361)	(0.0472)	(0.0266)	(0.0178)
Emp*PC	**0.0196***	**-0.0444*** **	**0.00846** **	**0.00390**
	(0.0115)	(0.00973)	(0.00389)	(0.00501)
ETR	**-0.0985*** **	**-0.0812*** **	**-0.106*** **	**-0.100*** **
	(0.0221)	(0.0238)	(0.0208)	(0.0130)
ETR*PC	**0.0890*** **	**0.0776** **	**0.0673*** **	**0.0769*** **
	(0.0226)	(0.0312)	(0.0142)	(0.0121)
Implicit energy tax	**0.236*** **	**0.231*** **	**0.124*** **	**0.197*** **
	(0.0367)	(0.0446)	(0.0235)	(0.0197)
Implicit energy tax*PC	**-0.244*** **	**-0.222*** **	**-0.115*** **	**-0.182*** **
	(0.0383)	(0.0342)	(0.0190)	(0.0178)
FDI	**0.119*** **	**0.0991*** **	**0.182*** **	**0.135*** **
	(0.0141)	(0.0211)	(0.0104)	(0.00843)
FDI*PC	**-0.0269*** **	**0.0154***	**-0.0176*** **	**-0.0177*** **
	(0.00848)	(0.00807)	(0.00416)	(0.00381)
Tert	**-0.00181**	**0.00294**	**-0.00348** **	**-0.00116**
	(0.00236)	(0.00294)	(0.00163)	(0.00136)
Tert*PC	**0.00110**	**-0.00729*** **	**0.000304**	**-0.000756**
	(0.00207)	(0.00208)	(0.00112)	(0.000961)
PC dummy	1.252***	1.127***	0.756***	1.002***
	(0.169)	(0.170)	(0.101)	(0.0858)
Observations	3,182	1,544	3,436	8,162
R-squared	**0.546**	**0.666**	**0.838**	**0.692**
Specification				
Fixed effects	yes	yes	yes	yes
Time dummies	yes	yes	yes	yes

Source: Jager (2017), Eurostat (2015c) , Own work

The implicit energy tax rate coefficient changes sign after the crisis. The other variables have their expected signs as capital investment has the strongest effect in the industrial

sector. In this case, there is a stark switching in signs before and after the crisis, with a negative effect of the overall ETR reform, comparable to the results using the energy tax specification. Since the coefficient of the ETR turns positive after the crisis, it may indicate structural effects of the ETR in terms of improved resilience to the crisis.

A similar effect appears in the industrial sector using the energy tax share as a variable, as evident in Table 16, but it is not significant. Thus, there is insufficient evidence to claim substantial effects of the ETR in terms of improved crisis resilience. Moreover, the positive effect of the implicit energy tax rate is offset after the crisis. Capital investment and employment have the expected positive and statistically significant signs.

We could test additionally for the long-run effects of the ETR, as some coefficients were negative and significant, particularly for the industrial sector. Further, it is a complement to the long-run estimates for the effects of energy taxes in the current account model. Thus, we would have the long-run effects at the national and sectoral level which would further inform the double dividend discussion.

The modelling approach for the long-term estimates consists of the estimation of the initial value added function with the inclusion of lagged interaction terms between the ETR dummy and the energy tax share or rate. We include up to 8 lags of the interaction terms to capture the whole business cycle as in Avila and Strauch (2003). The results are shown in Table 18.

This is particularly relevant for policy design as it enables an insight into the concentration of the ETR effects, i.e. whether they dissipate through time or they are persistent. The results do not indicate any particular concentration of the effects or changes in the magnitude. There seems to be some evidence for positive effects in the services sector in the first year which turn negative in the long-run. This could be due to the expiration of the labor market policies associated with the ETR.

Namely, the ETR is designed in such a way so as to decrease the burden on labor, but the flaw in this methodology is that the ETR variable is a dummy variable for whether the country has undertaken the reform or not. Arguably, the intensity of the ETR is captured through the energy tax variable. This indicates the need for improved policy variables and the interactions between them. The remaining coefficients are generally in line with the previous estimates.

Table 18 Value added long-run effects (1)

Variables/ Model	(1) Industry	(2) Other	(3) Services	(4) All
Employment	**0.425****	**0.635****	**0.717*****	**0.698*****
	(0.205)	(0.295)	(0.116)	(0.105)
Cap_inv	**0.170*****	**-0.0937****	**0.0625*****	**0.0804*****
	(0.0591)	(0.0467)	(0.0223)	(0.0290)
FDI	**-0.0352**	**0.151**	**-0.0647**	**0.0347**
	(0.111)	(0.167)	(0.0480)	(0.0602)
Tert_edu	**0.00522**	**0.0138**	**0.00388**	**0.00584***
	(0.00643)	(0.00887)	(0.00243)	(0.00353)
Energy tax share	**-0.00693**	**-0.0318****	**-0.0179****	**-0.00747**
	(0.0200)	(0.0161)	(0.00707)	(0.00707)
ETR*Enshare	**0.0317**	**0.00139**	**0.0332*****	**0.0315*****
	(0.0244)	(0.0264)	(0.00913)	(0.0106)
ETR*Ensharet-1	**0.00820**	**0.0423**	**-0.00187**	**0.00512**
	(0.0179)	(0.0330)	(0.00765)	(0.00928)
ETR*Ensharet-2	**-0.000225**	**0.00872**	**-0.00729**	**-0.00179**
	(0.0166)	(0.0290)	(0.0106)	(0.00983)
ETR*Ensharet-3	**0.00773**	**0.00956**	**0.00200**	**0.0125**
	(0.0168)	(0.0332)	(0.00907)	(0.00930)
ETR*Ensharet-4	**0.00412**	**-0.0695***	**-0.00855**	**0.00248**
	(0.0242)	(0.0390)	(0.00744)	(0.00845)
ETR*Ensharet-5	**-0.0293****	**-0.0158**	**-0.00514**	**-0.00959**
	(0.0137)	(0.0332)	(0.00765)	(0.00718)
ETR*Ensharet-6	**-0.000534**	**-0.0441**	**0.0126***	**0.00963**
	(0.0147)	(0.0335)	(0.00768)	(0.00770)
ETR*Ensharet-7	**-0.00532**	**-0.00510**	**-0.0147*****	**-0.00762*****
	(0.00447)	(0.00785)	(0.00233)	(0.00261)
ETR*Ensharet-8	**-0.000474**	**-0.00635**	**-0.00546*****	**-0.00320**
	(0.00544)	(0.00642)	(0.00163)	(0.00216)
Observations	424	210	414	1,048
R-squared	0.285	0.385	0.607	0.292
Specification				
Fixed effects	yes	Yes	yes	yes
Time dummies	yes	Yes	yes	yes

Source: Jager (2017), Eurostat (2015c) , Own work

Repeating the estimation using the national implicit energy tax rate produces the following results shown in Table 19. There is no compelling evidence for concentrated effects at a particular horizon. The finding of a significant effect in the services sector with altering signs at different horizons is corroborated in this specification as well. This is evident by a positive coefficient on the interaction term in the initial period compared to lags 7 and 8. The results on the industrial sector are not significant similarly to the previous specification. The other variables retain their expected signs.

Table 19 Value added long-run effects (2)

Variables/ Model	(1) Industry	(2) Other	(3) Services	(4) All
Employment	**0.486*** **	**0.780*** **	**0.654*** **	**0.639*** **
	(0.0791)	(0.0804)	(0.0566)	(0.0366)
Cap_inv	**0.111*** **	**0.0873*** **	**0.0807*** **	**0.0981*** **
	(0.0231)	(0.0204)	(0.0144)	(0.0129)
FDI	**0.228*** **	**0.156*** **	**0.168*** **	**0.185*** **
	(0.0270)	(0.0235)	(0.0160)	(0.0128)
Tert_edu	**0.000561**	**-0.00199**	**0.00262**	**0.00125**
	(0.00528)	(0.00448)	(0.00209)	(0.00236)
ETR*Imptax	**-0.0359**	**0.241** **	**0.226*** **	**0.103**
	(0.151)	(0.110)	(0.0670)	(0.0723)
ETR*Imptax$_{t-1}$	**-0.181**	**0.00182**	**-0.0541**	**-0.0931**
	(0.145)	(0.107)	(0.0603)	(0.0698)
ETR*Imptax$_{t-2}$	**0.181**	**-0.00606**	**-0.220*** **	**-0.00378**
	(0.185)	(0.146)	(0.0736)	(0.0899)
ETR*Imptax$_{t-3}$	**0.345**	**0.0942**	**0.0857**	**0.178***
	(0.212)	(0.171)	(0.0808)	(0.102)
ETR*Imptax$_{t-4}$	**-0.0806**	**0.0194**	**0.0604**	**-0.0156**
	(0.194)	(0.171)	(0.0732)	(0.0947)
ETR*Imptax$_{t-5}$	**0.00400**	**0.00210**	**0.00147**	**0.00266**
	(0.00590)	(0.00618)	(0.00356)	(0.00320)
ETR*Imptax$_{t-6}$	**-0.00737**	**-0.00600**	**-0.00659** **	**-0.00671** **
	(0.00533)	(0.00591)	(0.00332)	(0.00290)
ETR*Imptax$_{t-7}$	**-0.00439**	**-0.0129*** **	**-0.0133*** **	**-0.00993*** **
	(0.00549)	(0.00488)	(0.00284)	(0.00280)
ETR*Imptax$_{t-8}$	**0.00937** **	**-0.00396**	**-0.00599*** **	**0.000515**
	(0.00475)	(0.00318)	(0.00194)	(0.00229)
Imptax	**-0.228*** **	**-0.208*** **	**-0.153*** **	**-0.183*** **
	(0.0750)	(0.0591)	(0.0416)	(0.0350)
Observations	1,896	932	2,037	4,865
R-squared	0.299	0.539	0.695	0.457
Specification				
Fixed effects	yes	yes	Yes	yes
Time dummies	yes	Yes	Yes	yes

Source: Jager (2017), Eurostat (2015c) , Own work

Thus, the observation of an altering coefficient for the services sector holds in the implicit energy taxation specification as well. The R-squared is over 0.6 in this specification as well, thus indicating that there are grounds to discuss long-term changes in the ETR effects. The lack of concentration and significance for the results in the industrial sector are encouraging for the double dividend discussion, as they may imply that the strong negative coefficient in

the initial specification arose from country specifics which were the reason for the ETR in the first place. These would be selection issues which cannot be addressed solely by an ETR. Alternatively, the effects are spread out over the years or offset by other policies.

The results have various implications for the double dividend discussion. Although the manufacturing sector is the one most exposed to energy tax changes due to its energy-intensity, an ETR changes both energy taxation and other types of taxation (for example labor taxation). This means that there should or at least could be an effect in theory on all sectors, even the less energy-intensive sectors such as services. The effect on the manufacturing sector will in turn depend on the offsetting policies and adjustment periods. However, the results show that having an ETR did not affect value-added positively. In fact, the effect has been negative and statistically significant over several specifications.

This might be interpreted as an inconsistent ETR, therefore only revealing a selection issue, i.e. the countries with competitiveness issues are the ones who implemented an ETR. Indeed, the theoretical review showed that the motivation for the ETR has been economic as well. Thus, there is no clear positive effect on value-added from having an ETR. Nevertheless, the results show that the ETR does not have particularly strong long-run effects or frontloaded negative effects upon the introduction of the reform.

Moreover, environmental taxes have a negative effect in the industrial sector when using the energy tax share as the energy tax variable. The effect of environmental taxes is positive on all sectors when using the national implicit energy tax rate which could reflect that countries with higher value added set higher energy tax rates. The negative effect on the industrial sector shows the impetus for greater innovation in sectors which face higher abatement costs. Another key consideration in the double dividend discussion is the effect on employment. The next section presents the results from estimation for the employment equation.

2.3.4 Employment and environmental taxation

The results from estimation from the value added equation show a negative effect of environmental taxation on value added in the industrial sector, whereas there is inconclusive evidence for the effects on the other sectors. Namely, the coefficients on energy taxes are positive and significant regardless of the variable used, but the coefficients on the ETR dummy have varying signs and significance. This does not provide strong support for environmental tax reforms. In the context of the double dividend, not only is there no evidence for a double dividend in terms of output, but there seems to be a negative effect when observing the effect of the ETR. However, the estimates from the lagged interaction terms indicate that the effects are not concentrated in some periods. The double dividend discussion though centers around other effects as well, such as the effects on employment. Although in theory the environmental tax reform affects both output and employment, it should affect employment primarily as it is envisioned as a substitution from labor to

environmental taxation. The following section shows the results for the employment equation, which portray a different picture.

Table 20 Employment equation (1)

Variables/ Model	(1) Industry	(2) Other	(3) Services	(4) All
Cap_inv	**0.141*** **	**0.0799*** **	**0.0698*** **	**0.124*** **
	(0.0182)	(0.0237)	(0.0190)	(0.0153)
FDI	**0.0711*** **	**0.0129**	**0.0259***	**0.0471*** **
	(0.0160)	(0.0164)	(0.0152)	(0.0111)
TFP	**-0.0878*** **	**-0.155*** **	**-0.198*** **	**-0.110*** **
	(0.0186)	(0.0280)	(0.0525)	(0.0222)
Energy tax	**0.00255***	**0.00984*** **	**-0.00204**	**0.00121**
Share	(0.00154)	(0.00277)	(0.00226)	(0.00122)
ETR	**-0.103*** **	**0.0317**	**0.0518** **	**-0.0144**
	(0.0327)	(0.0243)	(0.0231)	(0.0257)
Observations	1,390	556	1,361	3,307
R-squared	0.515	0.204	0.351	0.182
Specification				
Fixed effects	yes	yes	yes	yes
Time dummies	yes	yes	yes	yes

Source: Jager (2017), Eurostat (2015c) , Own work

The results on the employment equation using the energy tax share imply a positive effect of energy taxes on employment. Capital and FDI have the expected positive signs, with a stronger effect on manufacturing. The results of total factor productivity which represents exogenous shocks to productivity indicate that productivity shocks affect employment negatively. This is in line with expectations as the increase in productivity contributes to a lower demand for labor.

The ETR has a negative effect on employment in the industrial sector and a positive effect in the service sector. This is likely due to the overall burden for energy-intensive industries, as there is a positive effect on employment due to lower tax burdens but a negative indirect effect as well as the energy tax is a burden which may decrease production and therefore the demand for labor. This is in line with the results in the previous section, namely that the greater the burden on the industrial sector, the lower the value added. Thus, there is a positive direct effect as indicated by the positive coefficient in the service sector for example which does not have the negative indirect effect from production as in the industrial sector for example. The magnitude of the ETR effect is comparable to the results in the value added equation. The results from the estimation of the employment equation using the implicit energy tax as the energy tax variable are comparable to the results using the energy tax share. Namely, capital and FDI have positive effects on employment, whereas exogenous shocks

to productivity decrease the demand for labor. The national implicit energy tax affects employment negatively, an increase in the implicit energy tax by 1% decreases employment by -0.06% to -0.22%.

Table 21 Employment equation (2)

Variables/ Model	(1) Industry	(2) Other	(3) Services	(4) All
Cap_inv	**0.188*** **	**0.132*** **	**0.134*** **	**0.200*** **
	(0.0143)	(0.0201)	(0.0191)	(0.0124)
FDI	**0.0363*** **	**0.0271** **	**0.0573*** **	**0.0418*** **
	(0.0105)	(0.0137)	(0.0124)	(0.00775)
TFP	**-0.0264***	**-0.134*** **	**-0.208*** **	**-0.115*** **
	(0.0137)	(0.0252)	(0.0273)	(0.0150)
ETR	**-0.0631*** **	**-0.0195**	**0.0583*** **	**-0.00533**
	(0.0190)	(0.0184)	(0.0168)	(0.0142)
Implicit energy tax	**-0.0646** **	**-0.150*** **	**-0.229*** **	**-0.116*** **
	(0.0295)	(0.0501)	(0.0356)	(0.0230)
Observations	2,447	911	2,332	5,690
R-squared	0.425	0.180	0.473	0.234
Specification				
Fixed effects	yes	yes	yes	yes
Time dummies	yes	yes	yes	yes

Source: Jager (2017), Eurostat (2015c) , Own work

By comparison, the results using the energy tax share as a variable indicate a positive or negative effect on employment depending on the sector of 0.2% in absolute terms,or up to 1% in the remaining sectors. These results show that the effects on employment are negligible even if positive. Admittedly, there is a substantial effect in the magnitude of 5% or 10% depending on the specification (implicit energy tax rate or the energy tax share respectively) when considering the ETR dummy variable. This is relevant for the double dividend discussion as it may capture other policy variables which complement the ETR or in fact offset it such as fossil fuel subsidies for example. Thus, the evidence seems to indicate small effects on employment with varying signs. The ETR effects vary across sectors (positive effects for industry and negative effects for services) and the energy tax variable. This indicates the importance of policy design for the double dividend.

The results represent preliminary attempts to shed light on the potential economic dividend associated with energy taxation. The implications of the results for the double dividend are that the economic dividend from an ETR reform is small. Alternatively, the costs of environmental taxation in terms of loss of employment is low as well as the negative effects on employment amount to -0.11 for a 1% increase in the national implicit energy tax rate. Thus, there is mixed evidence for the economic dividend, depending on whether the country has conducted an ETR.

Further issues warrant attention in this analysis, such as the crisis and the horizon of the effects. Thus, following the methodology outlined in the value added section, we estimate the results controlling for the crisis and the long-run effects of environmental policy by including the lagged policy variables (ETR*energy tax). The results are presented in Table 22 and Table 23, and discussed below. The energy tax variable coefficient changes sign before and after the crisis and it is significant. It implies that a 1% increase the energy tax share decreases employment by 0.3%. This implies that the crisis has exacerbated the vulnerability of the industrial sector, thus highlighting the importance of public support in the energy transition period as it is essentially another period of restructuring.

Table 22 Employment equation Chow test (1)

Variables/Model	(1) Industry	(2) Other	(3) Services	(4) All
Cap_inv	**0.109*** **	**0.0785*** **	**0.0702*** **	**0.104*** **
	(0.0173)	(0.0271)	(0.0172)	(0.0153)
Cap_inv*PC	**0.0959*** **	**0.00424**	**0.0135**	**0.0448*** **
	(0.0187)	(0.0198)	(0.0163)	(0.0126)
FDI	**0.0326*** **	**0.00716***	**-0.00344**	**0.0226*** **
	(0.00490)	(0.00432)	(0.00302)	(0.00265)
FDI*PC	**0.00907** **	**-0.00164**	**-0.000856**	**-0.000872**
	(0.00441)	(0.00508)	(0.00322)	(0.00261)
TFP	**-0.0913*** **	**-0.206*** **	**-0.324*** **	**-0.116*** **
	(0.0157)	(0.0337)	(0.0328)	(0.0233)
TFP*PC	**0.0373*** **	**0.212*** **	**0.407*** **	**0.0624** **
	(0.0138)	(0.0520)	(0.0431)	(0.0290)
ETR	**-0.0931*** **	**0.0295**	**0.0608*** **	**-0.0130**
	(0.0313)	(0.0247)	(0.0235)	(0.0250)
ETR*PC	**-0.0424*** **	**-0.0135**	**-0.0194**	**-0.0261*** **
	(0.0129)	(0.0192)	(0.0131)	(0.00887)
Energy tax share	**0.00809*** **	**0.00929*** **	**-0.00558** **	**0.00511*** **
	(0.00195)	(0.00281)	(0.00244)	(0.00122)
Energy tax*PC	**-0.00350*** **	**0.000241**	**0.00323***	**-0.00386*** **
	(0.00111)	(0.00120)	(0.00187)	(0.000541)
PC dummy	-0.587***	-1.053***	-1.854***	-0.452***
	(0.103)	(0.242)	(0.208)	(0.141)
Observations	1,390	556	1,361	3,307
R-squared	**0.554**	**0.246**	**0.417**	**0.230**
Specification				
Fixed effects	yes	yes	yes	yes
Time dummies	yes	yes	yes	yes

Source: Jager (2017), Eurostat (2015c) , Own work

The other sectors' results do not change qualitatively compared to the previous estimation. The coefficient for the service sector changes sign after the crisis as well, but the net effect remains negative as in the pre-crisis period and the previous estimation. Capital investment has a positive effect on all sectors, whereas productivity affects employment negatively in most sectors (except services). The effect of FDI on employment is positive and statistically significant for the industrial sector only, whereas it is positive but not significant for some of the other sectors.

Total factor productivity affects employment negatively and this holds true across most specifications. The results imply that a 1% increase in TFP before the crisis decreases employment by 0.1% in the industrial sector to 0.3% in the service sector. The estimated effects of TFP after the crisis are positive which could be interpreted as post-crisis adjustment. Namely, the crisis and post-crisis period are periods of economic restructuring during which productivity shocks may affect employment positively due to reallocation of labor to more productive sectors. This is an interesting effect which warrants further attention in future research. It is explicable with Schumpeter (1942)'s creative destruction explanation of a crisis, i.e. a period with intensive resource allocation. Repeating the estimation with the implicit energy tax produces the following results shown in Table 23.

Table 23 Employment equation Chow test (2)

Variables/Model	(1) Industry	(2) Other	(3) Services	(4) All
Cap_inv	**0.161*** **	**0.128*** **	**0.133*** **	**0.179*** **
	(0.0140)	(0.0216)	(0.0184)	(0.0125)
Cap_inv*PC	**0.0369*** **	**0.00290**	**-0.00668***	**0.0271*** **
	(0.00407)	(0.00540)	(0.00375)	(0.00287)
FDI	**0.0243** **	**0.0177**	**0.0644*** **	**0.0285*** **
	(0.0122)	(0.0185)	(0.0154)	(0.00971)
FDI*PC	**0.000481**	**-0.0138** **	**0.00996** **	**-0.00318**
	(0.00458)	(0.00640)	(0.00432)	(0.00331)
TFP	**-0.0360** **	**-0.146*** **	**-0.246*** **	**-0.122*** **
	(0.0140)	(0.0262)	(0.0234)	(0.0145)
TFP*PC	**0.00360**	**0.113***	**0.366*** **	**0.0754** **
	(0.0339)	(0.0592)	(0.0435)	(0.0322)
ETR	**-0.0729*** **	**-0.0214**	**0.0590*** **	**-0.0121**
	(0.0183)	(0.0187)	(0.0168)	(0.0139)
ETR*PC	**0.0406*** **	**0.0488** **	**-0.00663**	**0.0273*** **
	(0.0114)	(0.0202)	(0.0118)	(0.00911)
Implicit energy tax	**-0.0981*** **	**-0.159*** **	**-0.219*** **	**-0.141*** **
	(0.0299)	(0.0515)	(0.0372)	(0.0237)
Implicit energy tax*PC	**-0.123*** **	**-0.0314**	**-0.0340***	**-0.0960*** **
	(0.0246)	(0.0281)	(0.0204)	(0.0171)
PC dummy	0.248	-0.267	-1.546***	-0.0565
	(0.170)	(0.293)	(0.203)	(0.158)
Observations	2,447	911	2,332	5,690
R-squared	**0.458**	**0.200**	**0.490**	**0.257**
Specification				
Fixed effects	yes	yes	yes	yes
Time dummies	yes	yes	yes	yes

Source: Jager (2017), Eurostat (2015c) , Own work

Capital and FDI have positive effects on employment, as in the previous specification. Using the implicit energy tax as the energy tax variable implies that a 1% increase in FDI benefits employment in the service sector the most, up to 0.06%. The ETR has a negative effect on employment in the industrial sector, up to -3% (the sum of the pre-crisis and post-crisis estimate), whereas the effect is positive for the service sector. This is comparable to the results using the energy tax share as the energy tax variable. A negative effect of the ETR

on employment is corroborated as in the estimation using the energy tax share as the energy tax variable.

The effects of energy taxes on employment depend on the specification, thus suggesting caution in interpreting the substantial negative effect from the ETR, as it could be picking up on the effects of other energy policy variables or selection issues. Fixed effects do control for the unobserved country heterogeneity but the energy tax variables themselves are not the actual tax rate. Even the implicit energy tax rate is calculated as the average tax rate on total energy consumption. The issue of bias due to the use of proxy variables for energy taxes and policy is discussed in the discussion section. An additional issue of interest is the long-run effect of the ETR, estimated using the same estimation procedure as in the value added equation. The results are presented in Table 24 and Table 25.

Table 24 Employment long-run effects (1)

Variable/ Model	(1) Industry	(2) Other	(3) Services	(4) All
Cap_inv	**0.118*** **	**-0.0157**	**0.0142**	**0.0803*** **
	(0.0197)	(0.0253)	(0.0157)	(0.0136)
FDI	**0.0202**	**-0.0806**	**-0.143*** **	**-0.00344**
	(0.0612)	(0.0659)	(0.0427)	(0.0367)
TFP	**-0.0774*** **	**-0.0659**	**-0.106***	**-0.0616*** **
	(0.0244)	(0.0435)	(0.0574)	(0.0223)
Energy tax share	**-0.00530**	**-0.0156**	**-0.0235*** **	**-0.00704***
	(0.00536)	(0.0125)	(0.00538)	(0.00368)
ETR*Ensha	**0.00601**	**0.0165**	**0.0182*** **	**-0.00825**
	(0.00919)	(0.0157)	(0.00674)	(0.00630)
ETR*Ensha$_{t-1}$	**0.00192**	**0.0195**	**-0.00850***	**0.00506**
	(0.00837)	(0.0144)	(0.00455)	(0.00529)
ETR*Ensha$_{t-2}$	**0.00870**	**-0.00574**	**-0.00632**	**0.0168*** **
	(0.00763)	(0.0113)	(0.00598)	(0.00476)
ETR*Ensha$_{t-3}$	**0.0201*** **	**0.00265**	**-0.00362**	**0.0113** **
	(0.00752)	(0.0162)	(0.00520)	(0.00441)
ETR*Ensha$_{t-4}$	**0.0305*** **	**-0.00222**	**-0.00710**	**0.00613**
	(0.00843)	(0.0128)	(0.00454)	(0.00392)
ETR*Ensha$_{t-5}$	**0.0150** **	**-0.0153**	**-0.00203**	**0.00178**
	(0.00629)	(0.0146)	(0.00469)	(0.00376)
ETR*Ensha$_{t-6}$	**0.00581**	**-0.0135**	**-0.00699**	**0.00219**
	(0.00795)	(0.0151)	(0.00447)	(0.00369)
ETR*Ensha$_{t-7}$	**-0.00341***	**-0.00123**	**-0.00213**	**-0.00205**
	(0.00197)	(0.00291)	(0.00176)	(0.00133)
ETR*Ensha$_{t-8}$	**-0.00337***	**0.00352**	**-0.00236** **	**0.000951**
	(0.00173)	(0.00237)	(0.00118)	(0.000901)
Observations	412	170	390	972
R-squared	0.527	0.324	0.225	0.258
Specification				
Fixed effects	yes	yes	yes	yes
Time dummies	yes	yes	yes	yes

Source: Jager (2017), Eurostat (2015c) , Own work

The results indicate positive effects on employment at the beginning of the horizon, starting from the second year, with dissipating effects which turn negative towards the end of the

horizon. The results imply that for the ETR countries, the end of the horizon i.e. the turning of the business cycle (on average) results in a 0.23% decrease in employment in the service sector. This is an encouraging result as it shows that energy taxes could be used to stimulate short-term employment. Total factor productivity has a displacing effect on jobs as the coefficient is once again negative and statistically significant, as in the general specification without long-term interaction effects. Capital investment affects employment positively and the effect is the strongest for employment in the industrial sector. The estimated results using the implicit energy tax rate as the energy tax variable are shown in Table 25 below.

Table 25 Employment long-run effects (2)

Variable/ Model	(1) Industry	(2) Other	(3) Services	(4) All
Cap_inv	**0.106*** **	**0.0803** **	**0.0544*** **	**0.0979*** **
	(0.0140)	(0.0320)	(0.0149)	(0.0111)
FDI	**0.0473*** **	**0.0534** **	**0.0484*** **	**0.0506*** **
	(0.0182)	(0.0221)	(0.0150)	(0.0109)
TFP	**-0.0294***	**-0.0747*** **	**-0.133** **	**-0.0583*** **
	(0.0155)	(0.0271)	(0.0541)	(0.0142)
Implicit energy tax	**0.0286**	**-0.0852**	**-0.0886**	**-0.0271**
	(0.0558)	(0.0750)	(0.0556)	(0.0390)
ETR*Imptax	**-0.0203**	**0.0576**	**0.0706**	**0.0263**
	(0.0816)	(0.109)	(0.0758)	(0.0552)
ETR*Imptax$_{t-1}$	**-0.0184**	**-0.0841**	**0.0148**	**-0.0267**
	(0.0699)	(0.0901)	(0.0658)	(0.0469)
ETR*Imptax$_{t-2}$	**-0.0832**	**-0.0649**	**0.0500**	**-0.0111**
	(0.0833)	(0.104)	(0.0747)	(0.0552)
ETR*Imptax$_{t-3}$	**0.194***	**0.141**	**-0.0273**	**0.0798**
	(0.105)	(0.107)	(0.0860)	(0.0673)
ETR*Imptax$_{t-4}$	**0.0879**	**0.0384**	**-0.0738**	**0.0266**
	(0.0988)	(0.102)	(0.0721)	(0.0610)
ETR*Imptax$_{t-5}$	**0.00255**	**-0.00126**	**0.00200**	**0.00169**
	(0.00457)	(0.00353)	(0.00371)	(0.00295)
ETR*Imptax$_{t-6}$	**-0.00495**	**-0.00426**	**-0.00194**	**-0.00378***
	(0.00313)	(0.00368)	(0.00269)	(0.00210)
ETR*Imptax$_{t-7}$	**0.00144**	**0.00251**	**0.00100**	**0.00145**
	(0.00253)	(0.00355)	(0.00246)	(0.00176)
ETR*Imptax$_{t-8}$	**0.00327**	**0.00114**	**-0.00116**	**0.000897**
	(0.00225)	(0.00291)	(0.00222)	(0.00157)
Observations	1,504	571	1,457	3,532
R-squared	0.381	0.162	0.276	0.148
Specification				
Fixed effects	yes	yes	yes	yes
Time dummies	yes	yes	yes	yes

Source: Jager (2017), Eurostat (2015c) , Own work

The results show a frontloaded negative effect of energy taxes on employment which turns positive towards the middle of the horizon. The negative effect corroborates the findings in

the initial specification without time interaction effects. Thus, the result of energy taxes on employment depends on the specification. There seems to be a positive and significant frontloaded effect in the industrial sector when using the energy tax share as the tax variable. The effect on employment is frontloaded and negative when using the implicit energy tax rate but it is not significant. There is no significance for the other sectors either.

Thus, there is no conclusive evidence for negative long-run effects of the ETR reform. The other variables have the same signs as in the estimation using the energy tax variable, as capital investment and TFP have positive and negative effects respectively. The effect of FDI changes sign and affects employment positively, consistent with the previous findings across various specifications including the main equation and the Chow test.

2.3.5 Discussion and conclusion

The previous sections presented the results from estimation on the employment and the value added equation. This provides a gauge of the economic dividend associated with environmental taxation, or the public finance aspects of the double dividend. Furthermore, two energy tax variables were used: the share of energy taxes paid by the sector and the level of the implicit energy tax. The sectors were broken down to an industrial sector, the services sector and all other sectors. The results from estimation show that energy taxes have a negative effect on both value added and employment in the industrial sector, but this depends on the variable used. Namely, the ETR and the energy tax share have negative effects, whereas the implicit energy tax has positive effects. The negative effect in the industrial sector is the strongest compared to other sectors. This implies that support for the industrial sector is likely still necessary, given the previous negative effects. Furthermore, an ETR hurts both value added and employment in this sector, regardless of the variable used. This could be due to the design of the ETR and its consistency.

These findings can be related to the broader literature on the effect of environmental regulation and energy taxation on productivity, innovation and employment. Namely, various studies (Costa-Campi et al., 2017; Kneller & Manderson, 2012) find a positive effect of environmental regulation on R&D expenditures. Costa-Campi et al. (2017) and Franco and Marin (2013) find positive effects of environmental taxation on innovation. Arguably, both are conducted on samples prior to the crisis, with the former including only Spanish sectors. However, they do reveal a positive effect on innovation which could be explained by the negative effect on value-added. Namely, the more constrained firms are, the more likely they are to invest in environmental technologies.

Kneller and Manderson (2012) find a different effect of environmental regulation (pollution abatement costs) on innovation expenditures depending on the cost constraints. Manufacturing industries with low abatement costs divert resources away from environmental innovation to cover pollution abatement costs directly. Conversely,

environmental regulation has a positive effect on environmental innovation in manufacturing industries with high abatement costs. The estimates above corroborate these findings. Namely, the strongest negative effect on value added appears in the industrial sector, compared to other sectors. The effect on employment is negative across all sectors when using the implicit energy tax share variable. A negative effect on employment is found in Commins et al. (2009). The results corroborate the finding that energy taxes stimulate substituting labor for capital.

In light of the double dividend discussion it implies that there are economic effects which are most pronounced in the energy-intensive industries as expected. These can be offset to the extent that they stimulate innovation as suggested in previous literature. However, the total negative effect of the ETR on value added as well as the negative coefficients from energy taxes as a corresponding share seem to suggest that the stimulus in environmental innovation is not enough to offset the negative effects on value-added. Thus, although environmental innovation is stimulated, it is not substantial enough.

Furthermore, the effects on employment have policy implications for the outlook on the ETR as a policy. ETR's are centered on the premise of higher employment and thus welfare by substituting environmental "bads", i.e. pollution, with economic goods such as labor. However, the negative effects on employment seem to indicate that the prospects for an ETR are negative as there was a negative effect in general in countries with environmental taxation and countries with ETR's, at least as far as the energy-intensive industries are concerned.

A further factor which should be considered is the potential bias of the results. Namely, the analysis uses the implicit energy tax or the energy tax revenue share. The overall coefficients for energy taxes could be subject to a downwards or upwards bias depending on the industry. Namely, ideally we should use the energy tax rate per corresponding sector, weighted for the energy resource mix. This bias is somewhat attenuated with the use of energy taxes paid by the corresponding sector.

Nevertheless, there is a small upwards bias in the coefficients for energy taxes related to the industrial sectors, as they typically have the largest share relative to the other sectors. The share of energy taxes paid relative to their own value added is likely smaller, as it represents a portion of their total expenses. On the contrary, the coefficients for the other sectors have a small downwards bias as their energy expenses are likely to be smaller. Nevertheless, this is arguably a negligible bias as their expenses are nonetheless small as is their share in the total revenues paid by the corresponding sector. Thus, the results for the industrial sector are gloomier compared to the other sectors' estimates, but they are somewhat exacerbated by the choice of variables.

The results on the other sectors are not as gloomy. The coefficients for energy taxes in the value added equation for the other sectors are positive and statistically significant, regardless of whether we use the share paid by the sector or the level of the implicit energy tax. An ETR has negative effects on value added regardless of the variable used. A similar result for the ETR ensues when estimating the employment equation for the industrial sector, whereas there is some evidence for a positive effect in the services sector. The coefficients for energy taxes depend on the variable used, thus the results are inconclusive. Commins et al. (2009) estimate an employment equation specified as a function of tax rates in the current and the previous period, labor cost and the ETS. The energy tax coefficient switches signs across periods and is positive in the first and negative in the second period.

A study using manufacturing data from UK firms and the climate change levy corroborates this result (Martin, de Preux, & Wagner, 2014). A small, negative effect of energy prices on employment in the magnitude of -0.2% for a 1% increase in energy prices is found in Marin and Vona (2017) for a sample of French manufacturing firms. Another study using German microeconometric data finds no negative effect of the German electricity tax introduced in 1999 (as part of the ETR) on employment and by extension no statistical evidence for a reduction in the tax.

The microeconometric studies cannot be directly comparable with our results as they cover the manufacturing sector only and may capture country-specific elements. Nevertheless, they shed light on the inconclusiveness of the results which is at least true for the industrial sector in this analysis as well. Furthermore, the absence of a strong conclusive effect in a mixed sample and the presence of negative effects in some micro-level studies may show that energy taxes may exacerbate country-specific economic issues related to employment rather than create them.

The coefficients on the other variables indicate a negative effect of productivity shocks on employment which is in line with the broader literature (Autor & Salomons, 2018; Ladu, 2005; Michelis, Estevao, & Wilson, 2013). The magnitude of the coefficient on TFP is -0.1 on the whole sample and is thus substantially smaller than the estimated -0.3 in Michelis et al. (2013). The difference is likely due to the sample analyzed which extends beyond the crisis which is when the effect of TFP on employment turns positive, as shown in Table 22 and Table 23. Moreover, the estimation equation includes more variables in this specification as the research question is estimating the demand for labor equation and the effect of energy taxes. The literature has mostly focused on analyzing the trade-off between productivity and employment(Dew-Becker & Gordon, 2012).

These results show that there is some evidence for negative effects on both value added and employment. This is particularly true for the industrial sector when using either variable. When it comes to the services and the retail sector, an ETR has a negative effect on value

added but the result does not hold true across all specifications. The effect on employment is also not statistically significant across all specifications and sectors. The implicit energy tax has a negative effect on employment in all sectors, whereas the ETR's effect depends on the sector. The effect for the industrial sector is negative, whereas the effect on the services sector is positive and significant. Thus, in light of the double dividend discussion, there is no evidence for a double dividend in the industrial sector, but some evidence for negative effects. There is also no conclusive evidence for substantial negative effects in the other sectors (retail and services).

Since advanced economies are predominantly service-oriented, the prospects for an ETR are not as gloomy, as the larger part of the economy does not show a substantial effect. Nevertheless, one of the tenets of an ETR is greater employment. These results show that there is no statistical evidence that a double dividend ensues, at least not from the employment channel. There is also no conclusive evidence for substantial negative effects in the other major sectors.

Therefore, new ETR's can proceed in theory, but it should be noted that they are not a free lunch. The cost for environmental protection through an ETR will thus be some effects on value-added and employment in the industrial sector. Other sectors which are not as burdened with energy taxation but could benefit from lower labor taxation do not show substantial benefits either. Thus, proponents of an ETR should not overpromise as so far it has not delivered.

Furthermore, public support should be provided for the industrial sector. This is particularly relevant in times of economic turmoil. Namely, the estimates from the Chow test indicate a more pronounced negative effect of energy taxation on value added and employment in the industrial sector. This is true regardless of the indicator used for environmental taxes. The results for the other sectors are not conclusive, although there seems to be some evidence for a positive effect in the service sector. This points to the need for greater support from policy for energy-intensive industries.

Nevertheless, the results do not show persistent long-run effects or frontloaded effects of the ETR reform in either sector, which is encouraging. Namely, it is easier for firms to adjust to smaller, continuous effects rather than concentrated effects in a particular horizon. Thus, policy should support those sectors which are more vulnerable to the energy transition and changes in environmental policy. Moreover, environmental policy itself should be consistent and based on longer policy horizon. This is relevant for the economic dividend to avoid concentrated effects, but generally for the environmental dividend as well in terms of continuous emissions reductions.

Although the results show a general unfavorable picture for environmental taxation, there are multiple research avenues to be pursued. One limitation of the study could be its

exclusive focus on energy taxation as the most widely used policy instrument. Another limitation of the study is the level of disaggregation, as sectors have been grouped as industrial or service sectors. Furthermore, an inherent limitation of econometric policy studies is the potential endogeneity of the policy (explanatory) variables which are treated as exogenous. Namely, these could be implemented or designed given the state of the explained variable in the model, implying reverse causality.

Future research could differentiate among various types of environmental policies and their effects on value added, employment or innovation. In relation to the latter, future research could discern the effects on various types of innovation for example. Finally, this study is a sectoral level analysis conducted separately from the national level analysis. Another avenue for future research could be estimating hierarchical models, i.e. a multi-level analysis of the sectoral and national level in the same model. Future research could also aim to model a system of equations which would capture potential feedback effects between the policy variables and the target variables.

To sum up, this section showed the results of estimation of the value added and the employment equation on a sample of EU sectors using the EU-KLEMS database. As such, it is the complement to the empirical analysis in the previous section conducted at the national level. Both constitute the empirical part of the public finance aspect of the double dividend. The following chapters analyze the private finance aspects of the double dividend.

3 PRIVATE FINANCE AS A SOURCE OF THE DOUBLE DIVIDEND

The first chapter introduced the conceptual basis for the reconceptualization of the double dividend towards the private sector. This can include sustainable financial reforms, financial instruments or corporate social responsibility. The reason for this extension is the need for funding for the green economy transition, as well as the potential for lower risk and higher returns (dividend). One of the key features of the green economy transition has been renewable energy.

The use of renewable energy features as one of the goals in the EU2020 sustainability goals (EC, 2017a). Indeed, one of the goals is that at least 20% of the total energy consumption shall come from renewable energy sources. Some countries, notably Germany in its EnergieWende, have provided extensive support for renewable energy. Renewables have thus become an integral part of the transition to a green economy which will require ample funding. The public sector is already supporting the renewable energy sector with subsidies, but the magnitude of the energy challenges which lie ahead necessitate private capital as well. Enticing private capital to invest in renewable energy so as to achieve the energy consumption goals set forth by policymakers will be one of the determinants of the success of the green economy transition.

Namely, investing in renewable energy can deliver a double dividend and is thus imperative for the green economy transition. The environmental dividend is implicit, whereas the economic dividend is a financial dividend depending on the risk-return profile of the investments in question. The latter is the key issue analyzed in this section with major implications for the double dividend discussion. This section aims to explore this further. It is divided in two subsections, each analyzing the environmental and the economic dividends respectively.

The environmental dividend is analyzed by assessing the environmental impact of renewable energy technologies, which are an integral part of sustainability which entails three dimensions. Thus, covering the environmental impact of renewables covers the environmental dividend for both sustainability and renewable energy investment. The economic dividend is evaluated through the risk-return profiles of sustainability and renewable energy indices which are assessed individually. Namely, the two are likely to differ as renewable energy is a subset of the overarching sustainability concept.

3.1 Renewable energy and the environmental dividend

Renewable energy features as a prominent policy feature across many countries. It is plausible that it provides an environmental dividend, although it is not completely straightforward, as will be shown in the following section. As stated in the introductory chapter, these sections are a synthesis of existing research and not empirical contributions to the literature. Nevertheless, they are equally important in the double dividend discussion as they provide the basis for delivering the double dividend.

Furthermore, it is worth elaborating on another point. This section covers the environmental dividend in relation to the private finance aspects of the double dividend. The environmental dividend associated with renewable energy is used to make the case for a double dividend related to its private finance aspects. Since the environment is a public good, the evaluation of the potential environmental dividend even within the private sector will always be inherently public. Namely, energy use goals and energy indicators are published at the national level. Reporting on environmental impacts at the firm level is at an early stage, covered within non-financial corporate disclosures.

Thus, the analysis of the environmental dividend even within an analysis of the private finance aspects will be inherently public since the environment is a public good. Namely, there are public and private finance aspects to the economic dividend since it is related to providing funding and assessing the effects of the provision of those funds (for example energy tax collection and sectoral effects). The environmental dividend is thus typically public, but it is nevertheless useful to assess the environmental dividend of the proposed direction which is to be supported through private finance (in this case renewables).

Although it seems plausible that renewable energy provides an environmental dividend, there are various aspects to the environmental impact. One aspect is the effect on emissions, which seems relatively straightforward, as these are relatively clean technologies. Other aspects of the environmental impact include the effect on land use and ecosystems. Although there are several types of renewable energy technologies (solar, wind power, geothermal energy, biomass and hydropower), studies on renewable technologies show that renewables have a lower carbon footprint in terms of energy produced (Markandya & Wilkinson, 2007). Although true by default in technical studies, economic studies on the relationship between renewable energy consumption and emissions do not always support these findings. Studies generally find that greater energy consumption leads to greater emissions. The first chapter introduced the Environmental Kuznets curve which posits that higher GDP/capita leads to lower emissions. Even more recent extensions to the EKC include controlling for the energy mix ((Bölük & Mert, 2014; Marrero, 2010)). Not all of these studies find conclusive evidence for the EKC and the relationship between renewable energy consumption and emissions.

Marrero (2010) estimate the EKC for 24 European countries between 1990 and 2006 and find no statistical significance for a downwards sloping EKC. They control for the energy mix and find that renewables are superior in terms of emissions decrease in comparison to nuclear, gas and petroleum. Bölük and Mert (2014) study a sample of 16 European Union countries as well for the period between 1990 and 2008. They break down final energy consumption in renewable and fossil fuel energy consumption. However, they do not find statistical evidence for the EKC.

This is a negative aspect of the outlook for renewables, since it implies that even if policy were successful in increasing the use of renewables in the energy mix, we will not necessarily decrease carbon emissions. Namely, although renewable energy technologies have lower life-cycle carbon emissions, the total change in emissions might be positive if the change in energy consumption is faster than the change in the share of renewables.

A possible limitation of these studies is that they do not control for technology or trade openness which are other factors which affect the EKC. Other studies which do control for these factors as well as the energy mix include Dogan and Seker (2016). They study a sample of EU countries from 1985-2011 and find that renewable energy and trade mitigate carbon emissions while non-renewable energy increases carbon emissions. They find evidence for the EKC in a similar study for the countries listed highest in the Renewable Energy country attractiveness index, from 1980-2012. Bilgili, Kocak, and Bulut (2016) find evidence for the EKC as well on a sample of OECD countries. The share of renewable energy affects emissions negatively in both studies.

Other studies done for the EU countries do find evidence for the EKC. Kasman and Duman (2015) estimate the EKC for EU candidate and new member countries and find evidence for the EKC on sample running between 1995 and 2010. Lopez-Menendez, Perez, and Moreno (2014) estimate the EKC on a sample of the EU-27 from 1996-2010 and find that the EKC exists for countries which have high renewable energy intensity, whereas it does not hold for countries which have low renewable energy intensity. This is an additional term in the EKC estimation, as apart from controlling for the energy mix as done in the studies cited above, there is an additional control for the energy intensity.

This finding might help explain the discrepancy in the findings for renewable energy and its effect on emissions within the EKC curve. Namely, the studies listed above mostly analyze the EU as a region, yet they find conflicting results. It can be observed that the studies which find inconclusive evidence on the EKC are studies conducted on samples which do not include the crisis. However, there is a substantial acceleration in the use of renewable electricity in the EU countries during and after the crisis as shown in Table 26.

Table 26 Share of renewable energy use in electricity, transport and gross final consumption of energy in the EU (in %)

Segment	2005	2006	2007	2008	2009	2010	2011	2012	2013	Target
Electricity	14.83	15.36	16.09	16.99	19	19.67	21.7	23.5	25.38	
Transport	1.8	2.5	3.1	3.9	4.6	5.2	4	5.6	5.9	10
Gross final C	9	9.5	10.4	11	12.4	12.9	13.2	14.4	15.2	20

Source: Eurostat (2017)

Namely, it can be observed that the share of renewables in electricity goes up markedly after the crisis which decreases emissions. This helps explain the discrepancy in findings as the studies which do not find a decrease in emissions (no EKC relation) are studies which include shorter samples. Furthermore, it provides a positive outlook for renewables as a threshold level in renewables may help alleviate the concerns that faster economic growth will lead to pollution.

An additional remark might be made that these studies include the share of renewables in the energy mix and thus distinguish between renewables and non-renewables. A further step might be taken to account for sectoral differences. Additional aspects of the environmental impact of renewables include the effect on land use and ecosystems. Whereas renewables have lower carbon emissions, their effect on land-use makes their environmental impact questionable. Wind farms require up to 360 times the area to produce the same energy as a nuclear plant, whereas solar energy requires up to 75 times the land area as nuclear plants (Mackay, 2009; NEI, 2015).

Most of the EKC studies listed above defined the environmental impact in terms of carbon emissions. Al-mulali, Solarin, Sheau-Ting, and Ozturk (2016) define the environmental impact in terms of land and water footprints and find no evidence for the existence of the EKC on a sample of 58 developed and developing countries from 1980-2009. Other negative environmental impacts arise from the effects on ecosystems (habitat) and noise (Abbasi & Abbasi, 2000).

In general, there is a case to be made about the environmental dividend of renewable energy consumption, although it may be crowded out due to higher overall energy consumption. This is the environmental dividend in relation to emissions. Other environmental effects include the effect on land-use and ecosystems which require case-by-case studies which is beyond the scope of this section. Limiting ourselves to the issue of emissions, there is a case to be made about renewables. Indeed, this can be seen in the trends in major countries around the world, most notably the EU and China, which have been supporting investments in renewable energy (REN21, 2017).

Evaluating the policy potential by reviewing recent trends is imperative to deliver an environmental dividend. Namely, even if renewables have a positive environmental dividend, it may not be achieved entirely. This can occur if renewable energy is: i) crowded out due to economic growth which may increase overall energy consumption, despite the growth in renewable energy consumption and investments or ii) crowded out due to fossil fuel subsidies which may offset progress achieved with greater renewable energy use.

The increased use of renewable energy in the energy mix is one of the key goals in the EU2020 agenda. Namely, at least 20% of the EU's energy consumption has to come from renewable energy sources by 2020. At the sectoral level, at least 10% of the energy used in transportation should come from renewable energy sources. Although there is cross-country variation in the EU as regards the proximity to the 2020 target, the EU as a whole is on a fast track to meeting this commitment. The past years have been crucial for the use of renewable energy in the EU and the EU is close to achieving its targets. New investment in renewables is a worldwide trend as well, in both developing and developed countries (GSR, 2017).

This accelerating trend is due to two factors: i) countries have been subsidizing the use of renewable energy and ii) renewable energy has become cost-competitive (Stark, Pless, Logan, Zhou, & Arent, 2015). Although seemingly positive, this trend has some positive and negative ramifications. The general decrease in renewable energy cost is a positive development. There are notable between-country differences, as well as within-country differences (which explain the range of estimates for countries due to different resource endowments). In general, renewable energy has become cost-competitive as far as new grids go. This has major positive implications for regions which are urbanizing, as it may help

alleviate energy poverty (Sagar, 2005). In addition, the sector is producing new sustainable jobs (GSR, 2017).

Furthermore, although countries have been subsidizing the use of renewable energy, they have also been subsidizing the use of fossil fuels as well as noted in Chapter 2. The difference in estimates is astounding. The value of consumer subsidies for fossil fuels amounted to 548 billion $ worldwide, whereas the value of renewable energy subsidies amounted to 121 billion $ in 2014 (IEA, 2014)). The striking gap has narrowed in 2016, with fossil fuel subsidies amounting to 260 billion $ worldwide and renewable energy subsidies amounting to 140 billion $ (IEA, 2017b). Although this is generally a positive trend, it hides a caveat. Namely, these estimates reveal only the budgetary estimates of subsidies. However, public finances have to cover the cost of externalities such as environmental damages from pollution. Accounting for these externalities leads to substantially higher estimates of the overall cost of externalities, which stood at 4.9 trillion $ worldwide in 2013 and 5.3 trillion $ worldwide in 2015, or 6% of GDP in both years. The biggest subsidizers are China and the United States, with 1.8 trillion $ and 0.6 trillion $ respectively (Coady, Parry, Sears, & Shang, 2017).

Although countries have been subsidizing the use of renewables, they remain subsidizers of fossil fuels as well. Fossil fuels will likely remain a part of the energy mix, as it is technically impossible to exclude them completely. A study on the German electricity market concludes that the energy mix cannot consist of renewable energy technologies only, as the investment needs are significant and fossil fuels are needed to power shortages in the case of a slow battery/ power storage development (Sinn, 2017). An additional reason is that 100% use will create a strain on land-use (Capellan-Perez, De Castro, & Arto, 2017). This reflects the various aspects which have to be considered when analyzing the environmental dividend, i.e. emissions and other indicators of environmental quality. Thus, it is likely that fossil fuel subsidies will continue, although further technological progress will contribute to the potential for subsidy and taxation reforms. This is due to the substitutability of energy inputs which will encourage more through reforms for environmentally harmful subsidies and tax reforms based on carbon taxes. Both will contribute to lower emissions and thus an environmental dividend.

Regarding renewable energy subsidies, cost-competitiveness of renewables implies that where resource endowment is good enough, new installments do not need generation-based subsidies (IEA, 2014). This could alleviate the strain on public finances. Indeed, countries such as Germany which has been among the most ambitious in its renewable energy agenda have already started abolishing renewable energy subsidies. A further encouraging factor is that the use of renewables does not rely on public finance stimulus only, as there is ever larger private sector investment in renewables. However, it does incentivize continued use of fossil fuels, as it creates an artificial cost advantage (IISD, 2014). This discussion reveals

that tax reform in the future will have to consider renewable energy aspects in relation to fossil fuels as the two will be complements instead of substitutes as it is typically thought. The IEA projects a share of 30% for renewable energy in renewable electricity in 2022, compared to an actual share of 23% in 2015 (IEA, 2017a)

Thus, overall this discussion reveals several key points about the private finance aspects of renewable energy and its potential to have a double dividend. Renewable energy has an environmental dividend per se, since it has lower life-cycle emissions. However, economic growth which necessitates greater energy consumption may crowd this environmental dividend out, unless renewables form a substantial share in the energy mix. There are other aspects to the environmental dividend as well, such as the effect on land use. Renewable energy and fossil fuels will have to coexist in the energy mix of the 21st century if a significant strain on land use is to be avoided.

Regarding the economic dividend, the cost competitiveness of renewable energy implies a smaller need for public subsidies. Furthermore, environmentally harmful subsidies reforms reveal another source for an economic dividend, by redirecting public funds to other uses, for ex. technology deployment. Another source of an economic dividend is employment-new jobs in the renewable energy sector. Finally, since the sector is attracting ever greater private investment, it offers another source for an economic/financial dividend, by providing higher stock returns. The economic/financial dividend is analyzed in the next section empirically[1].

3.2 Risk and performance of sustainable and renewable energy stock indices

Renewable energy is becoming ever more important in terms of policy as the previous section showed. This is due to its potential to provide an environmental dividend (provided a sufficient amount of investment). This section aims to explore the economic dividend of renewable energy and more generally socially responsible investing empirically. Thus, it relates to the third empirical research question which entails the risk-return profile of sustainable indices and renewable energy indices, i.e. indices which include the stock prices of sustainable firms and firms in the renewable energy sector. The environmental dividend is assumed implicitly and stems from lower emissions associated with renewable energy and sustainability. The economic dividend itself is not a classic dividend although it refers to the private sector (firms) and the stock market. The economic dividend is a higher stock return in this case. The dividend is included in the index, as the stock prices used for the analysis are total return indices, which include the dividend paid out as well.

[1] The analysis presented in this chapter has been accepted for publication in the academic journal "Economic Research", Volume 32, 2019, pp.423-439.

The existence of a double dividend is imperative for future sustainability prospects. Namely, the renewable energy investment topic is becoming ever more relevant for investors as well due to announced policy measures for greening the economy, even though sustainable investment principles are not binding for investors. It is relevant for policy as well, as renewable energy investments and socially responsible investing (as part of the broader CSR trend) constitute private finance aspects of the double dividend, as discussed in Chapter 2. The section is divided as follows: the first subsection reviews the literature, the second subsection describes the data and methodology, whereas the third presents a discussion of the results before concluding.

3.2.1 Literature review

Research importance of the link between environmental and financial performance has been increasing throughout the past decade. As there is no one uniform description of environmental performance, there are several approaches to the research problem. The general research approach differs as well, as it depends on which aspect of financial performance one is interested in. In general, the results have not been conclusive, which can be explained with the varying approaches.

The inconclusiveness in results on whether environmental performance matters for financial performance is to be expected. Namely, both underperformance and an overperformance hypothesis can be expected (P. T. Chan & Walter, 2014). Underperformance stems from mathematical optimization. Namely, an investor cannot achieve better returns if he is faced with constrained optimization. A Socially-Responsible Investment (hereinafter: SRI) screening will therefore reduce returns, since it restricts an investor's choice set (Markowitz, 1959). Furthermore, investments into environmentally friendly technology are believed to raise operating costs for companies and they may put a significant strain on a company's financial resources, which is difficult to justify as the benefits appear in the longer-term (Guenster, Bauer, Derwall, & Koedijk, 2011).

On the other hand, overperformance is to be expected as well. This stems from cost savings from investment in pollution-reducing and more energy-efficient technologies (Porter & Van Der Linde, 1995; Spicer, 1978). Furthermore, being an environmentally responsible firm might increase performance due to better strategic alignment with stakeholders and reputational advantages (Fombrun, Gardberg, & Barnett, 2000). Finally, corporate social responsibility might also serve as a proxy for management skills (Bowman & Haire, 1975). In addition, environmentally friendly firms are exposed to less risk with fewer lawsuits expected in the long run.

Chava (2014) finds that loan syndicates of borrowers with environmental concerns comprise fewer banks. Moreover, environmentally irresponsible firms tend to have higher financing costs. This finding is corroborated by El Ghoul, Guedhami, Kim, and Park (2016). Indeed,

it is to be expected since such firms are exposed to higher risk and a narrower investor base (El Ghoul et al., 2016). Attig, El Ghoul, Guedhami, and Suh (2013) also find that high-CSR firms exhibit higher credit ratings, which reflects lower risk.

Thus, there are two key perspectives in the proposition of superior financial performance of environmentally friendly companies. The first is that they are superior in terms of financial ratios or financial variables such as stock returns for reasons listed above, for example cost-cutting or superior brand value and stakeholder engagement. The second is that they are less risky. We aim to add to the literature from both perspectives, by using the multifactor Fama-French models. In the Fama-French Capital Asset Pricing Model (CAPM), the first proposition of superior return shows as a positive alpha, whereas the second of lower risk shows as a positive beta lower than 1 (See Equation 8 below).

Most studies on the link between environmental performance and financial performance focus on their returns. Some authors choose to analyze the basic three -factor CAPM model that posits that excess return is a function of risk, size and value. The CAPM can be applied to both stocks and indices. The basic three-factor CAPM model can be extended to a five-factor CAPM that includes profitability and investment, as in Fama and French (2015). Carhart (1997) extends the basic three-factor CAPM to a four-factor CAPM that also includes momentum.

An alternative is to compile a portfolio of environmentally friendly companies and compare its performance to the performance of the broader market or a similar portfolio, which requires matching. Another alternative is to apply event studies and long-term studies. However, event studies are plagued by the drawback that an environmental disaster might take time in showing its negative effects, especially if it is related to lawsuits. In addition, when it comes to long-term studies it is challenging to pin down long-term causality (Ruggiero & Lehkonen, 2017).

Derwall, Guenster, Bauer, and Koedijk (2005) employ the Carhart four-factor model based on eco-efficiency scores and find that a portfolio of firms with high relative environmental scores outperformed a portfolio of companies with low scores by 6% p.a. over 1997–2003. The strategy of buying high SRI scores and selling low SRI scores has been shown to produce an abnormal return of 8.7% p.a. (Kempf & Osthoff, 2007).

Cai and He (2013) use the Carhart model as well on several 7 year intervals from 1992 to 2011 and find that an equal-weighted environmentally responsible portfolio outperforms in the 4th to 7th year after the first screening year. P. T. Chan and Walter (2014) study 748 environmentally-friendly firms listed on U.S. stock exchanges for the period from 1990 to 2012, and find that there is a green premium. Positive abnormal stock returns have also been found by Dixon-Fowler, Slater, Johnson, Ellstrand, and Romi (2012).

Others have compared portfolios including sin stocks (stocks belonging to the tobacco or nuclear industry for example) and conventional portfolios. Humphrey and Tan (2013) find no outperformance for portfolios that include sin stocks, whereas Hong and Kacperczyk (2009) find that a portfolio composed of sin stocks outperforms similar stocks. Geczy, Stambaugh, and Levin (2005) compare portfolios based on Socially Responsible Investing (hereinafter: SRI) to conventional portfolios and find that there is a cost to imposing an SRI constraint, which is consistent with the Markowitz portfolio theory. This finding is corroborated by Renneboog, Horst, and Zhang (2008) who document that SRI funds in the US, UK and several European and Asian-Pacific nations underperform their domestic benchmarks substantially. Xiao, Faff, Gharghori, and Min (2015) find that a portfolio of SRI funds in the US has no significant financial impact. Another study by Lean, Ang, and Smyth (2015) finds outperformance for North American and European SRI funds.

The literature is thus inconclusive as regards the financial impact of socially responsible investing. A caveat in these studies is that differences in performance may arise due to other factors such as fund size, age, investment universe etc. Some authors (Schroder, 2007; Statman, 2006) circumvent this problem by directly using SRI indices that should be immune to biases associated with specific funds such as management quality, operating costs, size, age etc. Statman (2000) finds that the Domini Social Index performed as well as or better than the Standard &Poor's 500 (S&P 500) in the period 1990–1998. In a later study, Statman (2006) compared the performance of four popular SRI such as the Domini Social Index, Calvert's Social Index, Citizen's Index and DJSI with the S&P 500 Index and found some evidence of overperformance, which varied with the period studied. Another study by Statman and Glushkov (2009) applies the four-factor Fama-French model and finds no statistically significant results of overperformance.

We extend this analysis by also estimating the five-factor Fama-French model for a range of sustainable and renewable energy indices. A limitation of previous studies is that they were focused on the U.S. Schroder (2007) extended the same approach to funds outside the United States and found no significant effect of overperformance or underperformance. Other authors have also reported no statistical significance in the SRI performance and conventional funds (Ameenc & Sourd, 2008; Munoz, Vargas, & Marco, 2013).

One aspect in which studies differ is the variable chosen for financial performance, such as returns or accounting variables, for example ROA or Tobin's Q. Some authors prefer returns, as they will reflect changes to the overall financial performance of a company in a more timely manner than traditional financial ratios (Cai & He, 2013). We use stock returns as the main financial variable as we analyze a range of indices. However, Tobin's Q is also suitable in case of a firm-level analysis, as it is a forward-looking variable that reflects intangible value (Guenster et al., 2011).

Another key aspect in which studies differ is the actual environmental variable chosen. Several authors use environmental scores or rankings from various institutions such as the KLD Research and Analytics rankings (Cai & He, 2013; Guenster et al., 2011). Others use environmental cost data such as the Trucost database (El Ghoul et al., 2016). Miroshnychenko, Barontini, and Testa (2017) use environmental, social and governance scores from the Asset4 database from Thomson & Reuters. P. T. Chan and Walter (2014) construct a portfolio from companies appearing in some of the green indices from established financial institutions. The lack of clear criteria for environmental performance implies that there is a trade-off between the transparency of the set of environmental indicators and its breadth.

In addition, portfolio analysis has typically dealt with the broader sustainability aspect. Although useful for the broader sustainability discourse, these studies are informative for the effect of environmental responsibility as long as we assume that environmental responsibility is a prerequisite for listing in socially responsible funds. However, we extend the analysis to make the environmental dimension more comprehensive by focusing on the renewable energy sector.

In terms of the double dividend discussion, it shows whether there is an economic dividend associated with private sector finance and if so where it emanates from. Namely, the economic dividend might differ among sustainable firms from various sectors and firms that are in the renewable energy sector as the latter is exposed to more volatility. Thus, public funds might be redirected to the specific segment which cannot offer a double dividend to investors. Thus, this is one relevant research niche for policy that is yet to be filled. We extend the analysis in this respect by analyzing the risk-return profile of sustainable and renewable energy stock indices.

Although there is substantial research on the link between oil prices and the general economy (Arouri, 2011; Basher & Sadorsky, 2006; Elyasiani, Mansur, & Odusami, 2011; Hammoudeh, Yuan, Chiang, & Nandha, 2010), there is comparatively less research on the renewable energy sector. Of this research, the majority analyses the relationship between renewable energy stocks and oil prices. Managi and Okimoto (2013) study the WilderHill clean energy index and its relationship to the oil price, and find a significant relationship between renewable energy stocks and the oil price. Others find that fossil fuel and renewables are viewed as competing assets (Wen, Guo, Wei, & Huang, 2014). Another finding from the literature is that technology stocks correlate with renewable energy stocks. Henriques and Sadorsky (2008) find that technology shocks and oil price shocks cause alternative energy stock prices. Other studies corroborate this finding (Inchauspe, Ripple, & Trück, 2015; Sadorsky, 2012).

Other studies analyze renewables through the CAPM model. Bohl et al. (2013) analyze a sample of German renewable energy stocks between 2004 and 2011. They find that the four-factor alpha turned negative after the 2008 crisis and document a bubble in renewable energy stocks in the mid-2000s. Other studies have also applied the CAPM model to renewable energy stocks. For example, Sadorsky (2012) finds that U.S. listed renewable energy stocks have substantial market risk as they have a high beta, typically higher than 1, in the period between 2001 and 2007. A high-beta is corroborated by Henriques and Sadorsky (2008).

Most of the existing literature has analyzed the performance of the broader sustainability aspect by analyzing the financial performance of socially responsible firms, funds or indices. The methodological approach can include portfolio construction (Cai & He, 2013; P. T. Chan & Walter, 2014; Humphrey & Tan, 2013), mutual fund comparison that requires matching (Belghitar, Clark, & Deshmukh, 2014; Lean et al., 2015; Renneboog et al., 2008; Xiao et al., 2015) or event studies. Typically, the financial variable is return, but there are approaches which also analyze the link between environmental and financial performance at the firm-level by analyzing Tobin's Q or ROA (Cai & He, 2013; Guenster et al., 2011; Miroshnychenko et al., 2017). This approach assumes a homogeneous risk and return profile for sustainable investing and clean energy investing. The latter is inherently exposed to more risk, which is why it should arguably be analyzed separately. Reboredo, Quintela, and Otero (2017) compare both types of funds, but the sample starts in 2010 and does not distinguish between regions.

We extend the CAPM model to a multi-factor model and apply it to the Dow Jones Sustainability Indices (hereinafter: DJSI) by regions (Europe, Asia, United States and the global index), as well as the indices on renewable energy. Extending the analysis towards renewables is important for policy and for information on the link between environmental and financial performance, as the renewable energy sector is exposed to more risk. The analysis is an application of the CAPM to both sustainability and clean energy (renewables) indices, which enables us to gauge the riskiness and return of both overall sustainability aspect and the specific environmental one by focusing on renewables. Riskiness follows from the relationship with the market, or the beta coefficient, and return follows from the alpha coefficient in the basic CAPM model.

The analysis provides estimates of the economic dividend within the private sector, although it should be noted that the dividend itself is not a classic dividend in its typical connotation. Rather, it refers to a higher or less risky stock return. Thus, there are two aspects to the economic dividend within this context: risk and return. The following section describes the data and the methodology for the analysis.

3.2.2 Data and methodology

Following the literature review, we use the approach by Schroder (2007) and Statman (2006). We apply the Fama and French (1992) models to data on returns of the Dow Jones Sustainable Indices (available regionally as well). The basic model is the initial Capital Asset Pricing model that specifies that the excess return (hereinafter: ER), i.e. the stock return minus the risk-free rate, depends on the idiosyncratic risk (alpha) and the systematic risk. The systematic risk is captured through the market risk premium term (hereinafter: MRP) that stands for the difference between the market index return and the risk-free rate.

Thus, in the simplest specification, alpha (α) is the excess return of the stock/index beyond the market, whereas the beta (β) reflects the relationship between the stock or index's return beyond the risk-free rate and the market return over the risk-free rate. A positive alpha indicates positive excess return that cannot be attributed to general movements in the market, as this is controlled for with the inclusion of the MRP term. Thus, the alpha term reflects idiosyncratic risk that gives a positive return in case of a positive alpha. The beta term reflects systematic risk. A risky stock or index would have a beta higher than 1, since it indicates that it moves more than the market.

Risk and return are two aspects which can be related to the economic dividend within the private finance discussion. Namely, a positive excess return or positive alpha in this case is an economic dividend. High risk is not an economic dividend per se, but it is informative about the conditions for an economic dividend in relation to private finance. Namely, high risk might be a reason to refrain from investment, thus leaving no room for an economic and thus double dividend associated with private sector finance. The implication for the general double dividend discussion is that the green economy transition will still have to rely substantially on public support.

The basic CAPM model, although useful, has been extended to incorporate other factors such as value or quality, size or momentum. Namely, in addition to stocks' or indices' excess returns being driven by broader movements in the market, there are other variables which could explain the presence of a positive alpha. The idea behind the inclusion of the three factors above exploits several empirical relationships.

The first is that small firms tend to have a premium over big firms. Thus, the alpha might be driven by the size of the premium that arises from the difference in size, small minus big (SMB). This is the size factor, or the difference between the returns of portfolios composed of small and big firms, respectively – small minus big (SMB). The second is that high-value firms will have higher stock returns. Thus, the difference in return between high- and low-value firms (or growth firms) could be what is driving the alpha. This is the value factor, or the difference between the returns of high and low value portfolios – high minus low (HML).

It should be noted that the stocks included in the portfolios are selected stocks from the broader regional market and thus do not overlap with the stocks in the sustainability indices. This implies that endogeneity issues are not a concern and even if a certain stock were to be included in both indices it would be too small to cause endogeneity issues. More specifically, the size factor is the difference in return between a portfolio composed of small and large firms in the regional market. The small firms are the firms in the bottom 10% of the total market capitalization for the region, whereas the big firms are the firms in the top 10% of the total market capitalization. The value factor is constructed as the difference in returns between a value and a growth portfolio. A value portfolio is a portfolio which has a high book to market value, whereas a growth portfolio is a portfolio with a low book to market value. These are standardized factors used in empirical research for returns.

In addition to the three factors for market risk premium, size and value (MRP, SMB, HML), Carhart (1997) proposes to extend the model to account for trend. Namely, the alpha if present, might be a consequence of the momentum on the market. Thus, he proposes to extend the model by including the return of a portfolio composed of the best performing stocks over the past 12 months, i.e. the stocks with the best trend or momentum (MOM). The factor is constructed as the difference in returns for a portfolio with high returns (top 30% of the region) and a portfolio with low returns (bottom 30%).

$$ER_t = \alpha + \beta_1 MRP_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 MOM_t + \varepsilon_t \quad (8)$$

Recently, Fama & French have extended their analysis to five factors as well (Fama & French, 2015), thus specifying the following equation:

$$ER_t = \alpha + \beta_1 MRP_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 CMA_t + \beta_5 RMW_t + \varepsilon_t \quad (9)$$

Equation 8 states that returns should be analyzed not only in relation to the market risk premium, size or value, but also in relation to investment and profitability. Namely, firms with slow growth in total assets (conservative) should have higher returns. The fourth factor captures the difference in returns between a portfolio composed of conservative investment firms and aggressive investment firms – conservative minus aggressive (CMA).

The fifth factor captures the profitability of firms, as the more profitable a firm is, the higher its returns should be. This is the profitability factor which reflects the difference between a portfolio composed of robust firms (profitable) and weak firms (less profitable) – robust minus weak (RMW). Thus, the construction of the factors follows a similar logic where firms are sorted according to their book to market value, returns, operating profitability and investment for the value, momentum, profitability and investment factors.

The inclusion of factors is useful because it allows controlling for market-wide influences. Factor investing preferences change over time. For example, a recession would lead to value

investing as opposed to growth investing, as the firms which would be expected to do well during a recession are high-value firms and not high-growth firms. The latter can be explained with deteriorated economic conditions. Thus, the performance of a stock may reflect the performance of the overall market factor which describes the stock and not its idiosyncratic factors.

Including factors controls for this as the excess return alpha reflects the part of the return which is not attributable to the performance of the general market or specific market factors which may be overperforming at a given point in time. Thus, there are no specific assumptions on the signs for the beta coefficients of the factors. They serve to describe the company set as well as to control for market-wide influences, thus isolating idiosyncratic risk through the alpha term.

We estimate the four and five-factor models by Ordinary Least Squares (hereinafter: OLS) for the Dow Jones Sustainability regional indices (DJSI) and a range of renewable indices. We use daily returns over the period October 25th 2006–June 30th 2016, amounting to 2436 observations. We follow the literature and use total return indexes (thus including dividends). All returns are in USD dollars. The DJSI indices include the top-ranked companies according to the ESG criteria in the RobecoSam rankings. The clean energy indices used are the WilderHill indices: WilderHill clean energy index (hereinafter: ECO), WilderHill New Energy Global Innovation Index (hereinafter: NEX) and the WilderHill Progressive Energy index (hereinafter: WHPRO).

The difference between the WilderHill ECO and the WilderHill NEX is that the ECO covers only firms listed in the U.S., whereas the NEX also covers firms listed outside the U.S. The criteria for both, however, is that they are companies focusing on the generation and use of cleaner energy, conservation, efficiency and advancing renewable energy. The difference between the ECO, NEX and the WHPRO is that WHPRO focuses on transitional technologies, while the former two are focused on clean technologies. The WHPRO includes companies that provide an energy bridge, “improving near term-use of fossil fuel resources by progressively reducing carbon and other pollution reflecting transitional technologies”. Thus, both belong to the renewable energy sector, albeit at a different pace to reflect the variety of firms operating in the sector, where not all are 100% renewable as it is an on-going transition.

In addition to the WilderHill indices, we also use indices from other providers, for comparability and robustness of results. The other indices are from the S-Network Global Indexes that include the Ardour Global Alternative Energy index (hereinafter: AGIGL) that includes only companies that are principally engaged in the field of alternative energy. Thus, it is closer in construction to the ECO and the NEX, but the latter have the advantage of differentiating between regions.

Thus, we analyze the broader sustainability dimension and then move to the environmental dimension through renewable indices. Within renewable indices, where possible, we estimate the same models for specific types of renewable energy. The indices used are the Bloomberg Global Solar and Wind (BGSOLAR and BGWIND) and the Ardour Solar index (SOLRX) from the renewable indices. For comparison, we also estimate the models for the S&P Global Energy index (SGES). Table 27 shows the summary statistics for each of the indices.

Table 27 Summary statistics

Variable/Statistic	Mean	Std.dev.	Min	Max
WilderHill ECO	-0.036	2.256	-13.469	15.627
WilderHill NEX	-0.002	1.628	-9.954	12.829
WilderHill PRO	0.016	1.912	-19.231	18.088
Ardour Global Alternative Energy (AGIGL)	0.001	1.890	-11.673	15.259
Ardour Solar (SOLRX)	0.046	4.612	-16.357	175.798
Bloomberg Solar (BGSOLAR)	-0.005	2.144	-11.864	16.407
Bloomberg Wind (BGWIND)	0.006	1.612	-13.018	12.960
S&P Global Energy (SGES)	0.022	1.667	-12.955	14.528
DJSI EU	0.014	1.597	-9.283	11.300
DJSI Asia	0.012	1.420	-9.810	11.449
DJSI U.S.	0.029	1.262	-8.441	10.770
DJSI GLOBAL	0.016	1.276	-7.474	9.240

Source: Bloomberg (2017), Own work

3.2.3 Sustainable indices (DJSI) results

The results indicate substantial risk that differs across regions. We obtain a relative ranking of Asia-Pacific (AP), Europe (EU), U.S. and Global in terms of risk (from the least exposed to systemic risk to the most). Whereas the DJSI Global is the only index with a beta higher than 1, other estimated beta coefficients are close to 1, which implies a relatively high systemic risk. In terms of excess returns, they are negative but not significant. The lowest return is observed for the DJSI Asia, with an annual alpha of -2.14% as shown in Table 30. The European DJSI has a positive 4-factor alpha, but it is not statistically significant.

What these results show is that sustainability remains a risky business, and a positive risk-reward relationship is generally not observed. Namely, the DJSI US has a relatively high systemic risk, as well as a negative return. Similarly, low exposure to risk, as evident in the Asian case, is suboptimal, as the estimated returns are negative. In the context of the double dividend discussion, this implies that although there is likely an environmental dividend since these are companies which rank high on sustainability, the economic dividend in terms of risk and return is uncertain and pending on the region.

In terms of the other two factors, the results show a negative and significant loading on size across regions, which implies that these stocks belong to the large-cap stocks. The Asian DJSI has a negative coefficient on the size factor, but it is not significant. The overall result for a positive relationship between market capitalization and sustainable firms is expected, as larger companies are more able to afford sustainability strategies. The value factor coefficient is positive but not statistically significant across all regions. The result implies a value effect, as the sustainable firms which do well are high value firms and not high growth firms.

The findings for the fourth factor indicate that sustainable portfolio is typically composed of contrarian stocks, i.e. stocks that have not performed well over the past year as the returns load negatively on the momentum factor. The estimated coefficient is negative and statistically significant across all regions. Thus, these stocks tend to be contrarian stocks. In general, these results imply that the factor models are able to explain a large share of the variation across most regions, as the R^2 is high, excluding Asia.

Table 28 Four-factor (Carhart) estimates for the DJSI regional indices

	(1) EU	(2) AP	(3) US	(4) Global
MRP	**0.941*** **	**0.819*** **	**0.945*** **	**1.018*** **
	(0.0126)	(0.0297)	(0.00504)	(0.0171)
SMB	**-0.302*** **	**-0.107**	**-0.181*** **	**-0.184*** **
	(0.0355)	(0.0715)	(0.00917)	(0.0456)
HML	**0.0324**	**0.0315**	**0.00600**	**0.0768**
	(0.0382)	(0.0511)	(0.0104)	(0.0490)
MOM	**-0.0829*** **	**-0.133*** **	**-0.0138** **	**-0.0460***
	(0.0243)	(0.0359)	(0.00610)	(0.0237)
α	**0.00170**	**-0.00859**	**-0.00349**	**-0.00648**
	(0.00890)	(0.0186)	(0.00373)	(0.00900)
R^2	**0.926**	**0.592**	**0.979**	**0.880**

Source: Bloomberg (2017), Own work

The five-factor model results are shown in Table 29. The estimated market risk premium loadings are stable across both regions, and we obtain a similar ranking for exposure to risk as in the four-factor model. All size loadings are negative and statistically significant which implies that the firms included in the indices are large firms. The results are comparable for the five-factor excess return as well. The five-factor model gives an annualized alpha of 1.36% p.a. (Table *30*) for DJSI EU, but it is not statistically significant. The magnitude of the alpha is substantially smaller than the magnitude reported by Derwall et al. (2005) who apply the four-factor model, which is likely due to the inclusion of the crisis.

Table 29 Fama-French five-factor model estimates for the DJSI indices

	(1) EU	(2) AP	(3) US	(4) Global
MRP	**0.931*** **	**0.757*** **	**0.963*** **	**1.025*** **
	(0.0156)	(0.0291)	(0.00518)	(0.0202)
SMB	**-0.339*** **	**-0.184*** **	**-0.169*** **	**-0.182*** **
	(0.0345)	(0.0708)	(0.00925)	(0.0459)
HML	**0.0350**	**0.00225**	**0.0111**	**0.211*** **
	(0.0546)	(0.0684)	(0.00941)	(0.0571)
RMW	**-0.200** **	**-0.0778**	**0.0910*** **	**0.253*** **
	(0.0939)	(0.0740)	(0.0142)	(0.0813)
CMA	**-0.187*** **	**-0.227*** **	**0.154*** **	**-0.112***
	(0.0595)	(0.0780)	(0.0183)	(0.0609)
α	**0.00537**	**-0.00625**	**-0.00588***	**-0.00991**
	(0.00904)	(0.0186)	(0.00355)	(0.00901)
R^2	0.926	0.593	0.981	0.882

Source: Bloomberg (2017), Own work

The annualized excess return (252 trading days) is negative and statistically significant for the DJSI US, amounting to -1.47% p.a. The other coefficients are not significant and vary in sign. The US and global DJSI excess return decrease in magnitude in the five-factor model, which implies that other factors included account for the excess return obtained in the initial estimation of the four-factor model. The annualized excess returns (alphas) and betas are shown in Table 30 below.

Table 30 Annualized alphas and estimated betas for the four-factor and five-factor portfolios

Index	**4-factor alpha p.a. (in %)**	**4-factor beta**	**5-factor alpha p.a. (in %)**	**5-factor beta**
DJSI EU	0.43	0.941***	1.36	0.931***
DJSI Asia	-2.14	0.819***	-1.56	0.757***
DJSI U.S.	-0.88	0.945***	-1.47*	0.963***
DJSI Global	-1.62	1.018***	-2.47	1.025***

Source: Bloomberg (2017), Own work

The results from both models indicate that high risk in the DJSI is not necessarily conducive to excess high returns, as the traditional portfolio theory would suggest. The varying signs in turn indicate that there is room to speak of an economic dividend associated with private finance. However, the lack of significance does not support this conclusion. At best the results imply that there is no significant advantage or disadvantage in investing in

sustainable portfolios. Thus, in the context of the double dividend discussion, there is room for private sector involvement, as it does not affect their financial results significantly.

The value and size factor coefficients are consistent with the 4-factor model. In terms of other factors, apart from the global and the U.S. portfolios, both Asia and Europe have negative coefficients on the profitability factor in both the original and the DJSI specification. This in turn implies that sustainable stocks encompassed within these indices belong to the less profitable companies. The opposite is true for the U.S. and the global portfolio, which could be a sign of institutional differences. Namely, the U.S. is characterized by higher competition in general and thus, sustainable companies are more likely to be more profitable as well.

A similar relationship emerges for the investment factor. The coefficient on CMA is positive and significant for the U.S., whereas it is negative and significant for Europe and Asia. The differences in signs between the regions implies that U.S. sustainable companies undertake a more conservative strategy. Although indicative of certain patterns, these are results for the overall sustainability indices. However, the relationship between environmentalism and financial performance could be gauged even better by focusing on renewables stocks, as these are exclusively environmental. The next section shows the results for the renewables stocks.

3.2.4 Renewable energy indices results

The renewable energy indices results are consistent with the literature, as they all have market risk premiums higher than one. This corroborates the finding by earlier studies (Henriques & Sadorsky, 2008; Sadorsky, 2012) that renewables are more sensitive to systemic risk. The geographic and sectoral dimension are informative and can be observed in Table 31. The results show that the ECO index, which includes companies at the technological forefront for renewable energy, and one of the solar indices have the highest betas among all renewable energy indices. This implies that even if there is an economic dividend in terms of excess returns, it comes with high risk. Thus, although there is an implicit environmental dividend due to the nature of the sector, the results on the economic dividend do not corroborate a bright outlook for the double dividend due to the high exposure to risk.

Focusing on the sectoral dimension, it can be observed that wind has a lower beta coefficient than solar energy. The beta coefficient for solar seems sensitive to the index used, as the specification using the Ardour Solar Index shows a substantially higher beta coefficient than the Bloomberg Solar or Bloomberg Wind Indices. However, the R^2 is low in this regression. Finally, if we take the sector as a whole, we observe that the energy sector is still sensitive to systemic risk although comparably less than the other indices.

Table 31 Four-factor (Carhart) model estimates for renewable energy stock indices

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Index	WHPRO	ECO	NEX	SOLRX	BGSOLAR	AGIGL	BGWIND	SGES
MRP	**1.492*** **	**1.733*** **	**1.404*** **	**1.966*** **	**1.483*** **	**1.553*** **	**1.134*** **	**1.229*** **
	(0.0375)	(0.0417)	(0.0263)	(0.0742)	(0.0479)	(0.0332)	(0.0436)	(0.0240)
SMB	**0.221** **	**0.655*** **	**0.635*** **	**0.416**	**0.524*** **	**0.430*** **	**0.464*** **	**-0.452*** **
	(0.0901)	(0.116)	(0.0751)	(0.282)	(0.138)	(0.103)	(0.112)	(0.0665)
HML	**-0.207***	**-0.637*** **	**-0.326*** **	**-0.907*** **	**-0.636*** **	**-0.516*** **	**-0.107**	**-0.0957**
	(0.109)	(0.126)	(0.0646)	(0.243)	(0.125)	(0.0858)	(0.101)	(0.0798)
MOM	**-0.214*** **	**-0.247*** **	**-0.142*** **	**0.224**	**-0.131***	**-0.114** **	**-0.00930**	**0.0165**
	(0.0433)	(0.0591)	(0.0378)	(0.455)	(0.0695)	(0.0530)	(0.0542)	(0.0389)
α	**-0.0119**	**-0.0687** **	**-0.0292***	**-0.00193**	**-0.0351**	**-0.0313**	**-0.0183**	**-0.00640**
	(0.0197)	(0.0277)	(0.0156)	(0.0772)	(0.0309)	(0.0200)	(0.0230)	(0.0163)
R^2	0.746	0.639	0.781	0.183	0.502	0.733	0.512	0.772

Source: Bloomberg (2017), Own work

The results are gloomier for the returns. In all cases, the alpha is negative and in the case of the ECO and the NEX Index, it is significantly negative. This amounts to substantial negative returns on an annualized level, as evident from Table 33. This differs from the previous findings for the sustainability indices, where the annualized losses (in the case of DJSI Asia for example) amounted to -2.14%. The underperformance is not statistically significant in most indices. This is a similar finding to Schroder (2007) and Statman and Glushkov (2009). However, a key difference is that they use general sustainability indices, for which we do find some statistical evidence depending on the region analyzed. A possible explanation for the contrasting results could be that utilizing environmentally friendly technologies and thus qualifying for a sustainable index is different from producing environmentally friendly technologies.

Another observation in relation to the excess returns is that the transition technology index (WilderHill) has a less negative alpha in relation to the ECO and NEX indices. This suggests that clean technologies themselves have indeed been a risky business over the past decade. The immediate implication for the private sector involvement is that transitional technologies might be better than the actual clean technologies (absent substantial public support).

Regarding the other factors, the renewable energy stock returns have a positive relationship with the size factor, unlike the DJSI indices. This implies that positive returns can be attained for small companies. The contrast with the sustainable indices results is somewhat encouraging for a green economy transition. While qualifying for overall sustainability is more likely for large-cap companies, renewables companies can be small-cap firms as well.

The value factor has a negative coefficient and is significant for half of the specifications. This implies that the stocks in the renewables sector tend to be growth stocks rather than value stocks. This result is to be expected, as the industry is still developing. Finally, the negative and statistically significant factor loadings on the momentum factor indicate that these are contrarian stocks. This implies that stock market momentum is not favorable to investors' perception about renewable energy stocks, a result that is explicable with their volatility and potential sensitivity to oil prices.

Table 32 Fama-French five-factor model estimates for renewable energy stock indices

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Index	WHPRO	ECO	NEX	SOLRX	BGSOLAR	AGIGL	BGWIND	SGES
MRP	**1.404*** **	**1.525*** **	**1.280*** **	**1.754*** **	**1.234*** **	**1.391*** **	**1.042*** **	**1.208*** **
	(0.0428)	(0.0524)	(0.0290)	(0.0780)	(0.0496)	(0.0346)	(0.0470)	(0.0278)
SMB	**0.119**	**0.459*** **	**0.556*** **	**0.353***	**0.407*** **	**0.337*** **	**0.457*** **	**-0.414*** **
	(0.0880)	(0.110)	(0.0728)	(0.187)	(0.125)	(0.0938)	(0.108)	(0.0656)
HML	**-0.0587**	**-0.682*** **	**-0.0246**	**-1.178**	**-0.148**	**-0.263*** **	**0.280** **	**0.294*** **
	(0.103)	(0.143)	(0.0663)	(0.857)	(0.130)	(0.0862)	(0.110)	(0.0845)
RMW	**-0.597*** **	**-1.761*** **	**-0.223** **	**-1.184*** **	**-0.352***	**-0.458*** **	**0.484*** **	**0.907*** **
	(0.142)	(0.188)	(0.102)	(0.259)	(0.187)	(0.140)	(0.174)	(0.104)
CMA	**-0.640*** **	**-1.066*** **	**-0.984*** **	**-0.798**	**-1.829*** **	**-1.125*** **	**-0.888*** **	**-0.518*** **
	(0.137)	(0.184)	(0.0956)	(1.233)	(0.174)	(0.129)	(0.151)	(0.112)
α	**0.000121**	**-0.0350**	**-0.0174**	**0.0296**	**-0.0113**	**-0.0137**	**-0.0154**	**-0.0136**
	(0.0197)	(0.0268)	(0.0153)	(0.0742)	(0.0299)	(0.0194)	(0.0229)	(0.0154)
R^2	0.750	0.667	0.795	0.186	0.533	0.749	0.530	0.790

Source: Bloomberg (2017), Own work

The coefficients on the size and value factor indicate that renewable stocks are small-cap and growth stocks, as in the four-factor model. The profitability and investment factor loadings imply that the stocks that have done well are not all among the most profitable, as we would expect that a decrease in profitability would be associated with a decrease in returns. In addition, the renewable energy stocks that have done well are not among the conservative ones. Namely, the negative coefficients on the investment factor imply that the renewables in this sample, which have done well, are the ones that have higher total assets. We obtain similar findings with the five-factor model estimates. The results for the annualized returns and beta coefficients are shown in Table 33.

Table 33 Annualized alphas and estimated betas for the four-factor and five-factor portfolios

Index	4-factor alpha p.a. (in %)	4-factor beta	5-factor alpha p.a. (in %)	5-factor beta
ECO	-15.902**	1.733***	-8.444	1.525***
NEX	-7.095*	1.404***	-4.290	1.280***
WHPRO	-2.954	1.492***	0.030	1.404***
AGIGL	-7.586	1.553***	-3.394	1.391***
SOLRX	-0.485	1.966***	7.743	1.754***
BGSOLAR	-8.467	1.483***	-2.808	1.234***
BGWIND	-4.507	1.134***	-3.807	1.042***
SGES	-1.600	1.229***	-3.369	1.208***

Source: Bloomberg (2017), Own work

Namely, all indices have betas higher than 1. The estimated excess returns are negative in this case as well, although statistically insignificant. Moreover, the magnitude of the negative return is smaller, as evident from Table 32. For example, the negative alpha in the five-factor model is twice smaller than in the four-factor model. Almost all indices have alphas smaller than -5% p.a. when using the five-factor model as evident from Table 33. This implies that the loss can be explained by accounting for relevant factors such as investment and profitability.

3.2.5 Discussion and conclusion

The results indicate that sustainability is a risky business as implied by the high beta globally. Our results indicate that these are likely to be large-cap, value and contrarian stocks. The results on the excess return indicate underperformance which corroborates the findings in the recent literature (Belghitar et al., 2014; El Ghoul & Karoui, 2017), but it is not statistically significant. Statman and Glushkov (2009) report a positive alpha, but the period does not include the crisis. The inclusion of the other two factors that are relatively new theoretically indicate that institutional differences transmit to sustainable firms. Namely, being sustainable does not guarantee profitability per se, as implied by the different signs for the U.S. and the European indices. Moreover, a conservative or aggressive investment strategy does not guarantee a positive alpha per se either.

Previous studies have been done on a range of socially responsible indices. Our results on the renewable energy indices indicate that these are high-beta, small-cap, growth, and contrarian stocks. These findings corroborate the results in Bohl et al. (2015) who study a range of renewable indices as well. The coefficients on the two additional factors reveal that renewables need aggressive investment to generate positive returns. In contrast, Reboredo et al. (2017) apply separate time-series regressions to a range of renewable energy indices and report an average beta lower than 1.

Regarding the other factors, the authors find that these stocks are likely to be small-cap, value and momentum stocks. Finally, perhaps the most relevant result from investors' point of view is the under/overperformance. Both Reboredo et al. (2017) and Bohl et al. (2015) report negative alphas. The significance for the negative alpha differs in the latter study, whereas the former only reports average alphas. The lack of significance can be interpreted as no financial effect as in Xiao et al. (2015). This cannot be claimed for all indices, as is evident in the case of the WilderHill Eco Index.

These results imply that there is a negative effect from sustainability, although it is not significant. This effect is the most pronounced for renewable energy indices, which indicates that in practice renewable energy is not a suitable investment for the risk-averse investor. The results on the general sustainability indices are less gloomy, thus indicating that there is a green premium for renewable energy (Reboredo et al., 2017).

In the context of the double dividend discussion, it is too early to speak of an economic/financial dividend with renewables, as the nascent sector is still exposed to substantial volatility. Thus, financing green growth cannot rely on a proposition of a double dividend in the private sector, as there is no evidence for a positive dividend or substantial statistical evidence for a negative dividend in the case of sustainable and renewable indices respectively. Thus, public support is necessary to carry out the green economy transition.

Although our study is one of the first to provide estimates on the performance of both socially responsible and renewable energy indices from the Fama-French multi-factor models, the analysis can be extended in several ways. First of all, the over/underperformance can be related to various firm-level characteristics, including specific environmental characteristics. Second, we have used the general market as the benchmark, as this is the classic approach, but it can be extended to other indices. Third, the Fama-French framework is revealing for the first two moments of the distribution of returns, average return (mean) and risk (standard deviation). Future studies could assess their performance by accounting for other characteristics of the return distribution as in Belghitar et al. (2014). Finally, although renewable energy has had negative performance in the past decade, technological innovation and climate change agreements may change the outlook over the next decade.

This analysis applied the multi-factor models using the Fama-French factors to various sustainability indices in different regions, and various renewable energy indices, as this is an unfilled research niche, particularly in the case of renewables. The results show that sustainability is risky in general. This is evident from the magnitude of the beta coefficient. The implications are gloomier when focusing on the environmental dimension within sustainability by analyzing renewables. One of the contributions of this analysis is the use of a wide range of indices which allow an insight into the heterogeneity of the beta coefficients. We find high market risk betas for renewables in general. Furthermore, our

results indicate that wind is less risky than solar and that the U.S. clean energy portfolio is indeed riskier than the global one.

In addition to the systemic risk dimension, these results provide an insight into the excess return that was positive in the European DJSI and negative but statistically insignificant in other DJSI specifications. The renewables' excess returns were negative and significant, which implies that sustainability is a risky business on the one hand, which is not justified by rewarding returns on the other. This gives investors a motive to refrain from clean energy. However, this could be a result of an improper benchmark, as this analysis relied on the market risk premium for the general markets as calculated by Fama and French (2015). Future research could use specific, relatable benchmarks.

The results obtained are informative for the double dividend discussion and by extension policymakers as high betas and low/negative alphas point out there is room for an increasing role of public policy in driving the clean energy transition. Namely, the results show that the economic dividend is not consistent across broad or narrow sustainability (sustainable indices or renewable energy indices). At best, there is no disadvantage of investment in sustainable indices, which leaves room for an economic dividend. At worst, investing in narrow sustainability comes at a premium (negative excess returns) and high risk. Thus, there is a cost associated with narrow sustainability and no consistent evidence for broad sustainability. As stated earlier, the implication is that there is still a large role for the public sector in supporting renewable energy investment and the green economy transition.

Arguably, in a policy setting where support for renewables is waning, the other option is the private sector. However, a seemingly valid reason for a lack of interest in renewables could be their poor financial performance from an investor's perspective. Thus, public policy, timely development and adoption of transitional technologies become ever more important. Technological development is crucial for this sector and it may change the outlook for renewables in the next decade. Thus, besides methodological improvements such as disaggregated analysis (firm-level), future research should aim to take technological development into account as well.

The preceding analysis thus served to provide insight into the private finance aspects of the double dividend discussion. The findings are broadly similar to the findings in the public finance aspects at the sectoral level. Namely, there are some negative effects but they are small in magnitude and generally not statistically significant. The exception are sectors which are strongly exposed to energy taxation such as the industrial sector or high volatility such as the renewable energy sector. This indicates that regardless of the private or the public aspect associated with the double dividend, public policy support is still needed. The next chapter concludes the thesis.

CONCLUSION

The preceding work aimed to contribute to the double dividend discussion. Its objective was to analyze the public finance aspects of the double dividend in a novel way, as well as to extend the double dividend discussion in other directions such as its private finance aspects. Thus, this thesis has dealt with the public and private finance aspects of the double dividend discussion. The double dividend entails simultaneous economic and environmental benefits (dividends) from environmental policy, thus it is not a dividend per se in the strict sense of the word. Namely, the economic dividend in relation to the public sector refers to the effects on GDP, employment, value added and the trade balance as one of the main goals of economic policy. Within the private sector, the economic dividend analyzed within this thesis entails the effects on risk and return for sustainable and renewable energy firms. Both the public and private finance aspects of the economic dividend are analyzed empirically, whereas the environmental dividend is analyzed implicitly.

The following section concludes this dissertation effort. It is divided in three sections. The first section describes the augmented concept of the double dividend as the main theoretical contribution, its relation to the research questions and the structure of the thesis. The second summarizes the main empirical contributions, whereas the third describes the limitations and directions for future research. The last section concludes with an outline of the way forward.

The augmented concept of the double dividend

The double dividend is a concept which stems from public policy, since it appears in relation to environmental policy, specifically environmental taxation. It states that there are economic and environmental benefits (dividends) associated with environmental taxation. Thus, it is a concept which relates to the economy-environment nexus within the overarching theme of sustainable development. The double dividend is associated with environmental taxation at least in its initial form. Furthermore, the double dividend is a concept which posits that there are simultaneous economic and environmental effects.

The former description is the traditional conceptualization of the double dividend. It entails an analysis of the effects of policies which emanate from the public sector which typically target key policy variables such as GDP or employment. Indeed, these are the main target variables for an ETR. Nevertheless, it is sensible to extend the concept of the double dividend towards its private finance aspects. This implies an analysis of the economic and environmental benefits associated with policies which emanate from the private sector and thus target private sector variables as well.

There are various reasons for a reconceptualization or augmentation of the double dividend. First of all, the green economy transition will require large funds so it is sensible to start

exploring the double dividend in the private sector so as to enable a timely positioning for firms in the green economy. Moreover, there is a theoretical basis for a double dividend in the private sector as corporate social responsibility or sustainable investing may be associated with greater value of the firm or higher stock returns. These are mechanisms to channel private investments and achieve economic dividends in the private sector whilst ensuring an environmental dividend as well. Indeed, the existence of simultaneous economic and environmental dividends is the incentive for the private sector, as these measures are voluntary and would not be initiated otherwise. The environmental dividend is public by default, as the environment is a public good.

Thus, the augmented concept of the double dividend remains within the economy-environment nexus and analyzes simultaneous economic and environmental benefits. The underlying policies though emanate from the private sector and provide economic dividends associated with variables which the private sector typically seeks to maximize (value of the firm, stock return). The latter is necessary so as to involve the private sector (voluntarily) in the green economy transition. Consequently, this will enable a smoother and quicker transition than otherwise. In relation to the augmented conceptualization of the double dividend, we formulate the following three research questions:.

1) Can energy taxation deliver a double dividend through its effect on energy dependence and the balance of payments?
2) Has energy taxation delivered a double dividend through its effect on employment or value added?
3) Is there a double dividend in private sustainable (renewable) finance in terms of the financial attractiveness of sustainable or renewable energy stocks?

The empirical contributions from the three research questions can be related to the public and private finance aspects of the double dividend and aim to fill research niches in the literature. The first two research questions provide insights for the public finance aspects of the double dividend, whereas the third research question provides insights for the private finance aspect of the double dividend policy discussion. The findings provide the basis for a systemic discussion from the results of all three empirical analyses (at the national, sectoral, firm level), thus entailing both the public and the private finance aspects. The following section describes the main empirical contributions and policy implications. The limitations and the way forward are covered in the last two sections within this chapter.

Empirical contributions and policy implications of the thesis

The previous section has outlined the research questions and described the first main contribution of the thesis. The first contribution is theoretical and consists of a reconceptualization of the double dividend. The remaining three contributions are empirical and stem from the research questions.

The first research question, or the second main contribution of the thesis, accounts for energy taxation as a current account determinant. Thus, it is a national level analysis for the EU-28 countries over the period 1990-2012. The idea itself has existed for a while and has even served as the motivation for some of the environmental tax reforms. Some of the Scandinavian countries introduced environmental tax reforms so as to decrease the dependency on oil and thus sensitivity to oil price shocks. Thus, the relation between energy taxation and energy imports and therefore the current account has existed in policy making but has not been explored empirically. Typically, current account determinants include variables such as the real effective exchange rate, fiscal policy, GDP growth etc. As Chapter 3 shows, energy taxation has a positive effect on the current account.

This result holds true regardless of the model used or the variable used for energy taxation. Thus, there is a positive effect in both dynamic models, using both energy tax revenues and the implicit energy tax variables. The estimated effects are also substantial quantitatively, up to 3 p.p. for the current account balance. This is due to the scale of the variables, thus it is realistic to expect positive and smaller effects. As reviewed in Chapter 3, there are also social effects associated with energy taxation due to regressiveness.

Although the results show a positive effect on the current account balance, thus providing support for the double dividend, the results from the energy dependency equation are somewhat mixed. Namely, the dynamic model shows very high persistence for energy dependence, which implies that the positive effect on the current account could be a result of other channels. Nevertheless, energy taxation levels should be high consistently so as to achieve the desired reduction in energy dependency due to strong habit formation. Nevertheless, the positive effect of energy taxation on the current account balance implies that it can be used as a substitute for harsher macroeconomic policies intended to adjust the trade balance. The presence of long-run effects corroborates the importance of the result for policy. The crisis does not change the results qualitatively but it changes the persistence parameter, which could have an effect on the persistence of the effects indirectly.

The second research question, or the third main contribution of the thesis, has to do with sectoral level effects of energy taxation on value added and employment. Sectoral level effects have been studied earlier but not on a wider sample at a disaggregated level. The effect is most pronounced for the industrial sector, but changes signs across the variable used. This indicates that there is some evidence to claim a negative effect, albeit not a strong one pertaining to the value added channel at least. The effects for the remaining sectors are in turn small, positive in some specifications and generally not statistically significant. Thus, the concerns for the effects of energy taxation at the sectoral level are valid to an extent.

Having conducted an ETR does not alter the results in the opposite direction. On the contrary, the effect on value added in the industrial sector is even more pronounced. This

could indicate an inconsistent ETR or deeper structural problems which do not go away solely with an ETR. The effects on the other sectors are mixed, with a positive effect in the service sectors. The results for the value added equation are thus more pronounced for the industrial sector, but they are mixed in sign across different tax specifications. Thus, there is room for concern for the effects of energy taxation but the outlook for energy taxation does not deteriorate substantially.

The outlook deteriorates when considering the estimated effects for the employment equation. One of the main premises of environmental taxation and the introduction of ETRs has been greater employment. The results show that this effect is not achieved with higher energy taxes and thus imply that energy taxation stimulates the substitution of labor for capital. Arguably, environmental tax reforms which decrease labor taxes as well could offset this effect. However, the findings for the employment equation were negative even when controlling for an ETR in the industrial sector. This could imply that the changes in labor taxation associated with the ETRs were themselves not substantial or persistent. The negative effect on employment is most pronounced and significant in the industrial sector. Moreover, the crisis exacerbates the negative effect. The results on the other sectors are mixed. There is a positive effect for the service sectors and no effect on the remaining sectors.

Thus, the concern about the effect of energy taxation on manufacturing is valid. This is discouraging for the double dividend discussion. However, the outlook for energy taxation is not completely gloomy as it does not affect other large sectors significantly. Moreover, the effects are not concentrated in a particular period. Nevertheless, it is an issue which requires greater attention for both the effects on value added, employment, as well as the greater implications for other related reforms such as energy subsidy reforms. Arguably, the scale of the economic effect on value added and employment depends on the size of the change in energy taxation which may hurt energy-intensive industries. Policymakers will have to evaluate this on a country-specific basis, relative to the size of energy-intensive industries. Nevertheless, it is clear that the effects on value added and employment call for further public support, so as to achieve a double dividend.

Unlike the first two research questions (second and third contributions) which analyze the public finance aspect of the double dividend discussion, the third research question has to do with the private finance aspect at the firm level. The empirical analysis of the private finance aspect is thus the fourth main contribution of the thesis. The green economy transition requires substantial financing needs which may not be satisfied by the public sector alone, as it is subject to public finance constraints. Thus, the question of interest is whether there are sufficient financial incentives for private sector involvement. The results show that there is no advantage or disadvantage in investing in sustainable indices per se. This result holds true generally across regional sustainability indices. Therefore, investments

in sustainability are not subject to lower returns due to a smaller (and therefore constrained) investment set which is necessarily sustainable. Thus, there is no cost related to investing in green assets.

However, there is a distinction between sustainable indices and renewable energy indices. Broad sustainability as explained in Chapter 2 entails all three dimensions, i.e. the economic, environmental and social one. The broader sustainable indices include firms which do well on either one of these dimensions. A more accurate gauge of the financial incentives necessitates differentiating between sustainable and renewable energy indices, as the latter represent narrow sustainability. The latter is also underdeveloped, but crucial as it is the sector at the green technology forefront, i.e. the carrier of the potential solutions. The results show that there are significant negative effects from investing in renewable energy. This suggests that there is a green premium associated with green energy investments. The result itself is not surprising as the sector is nascent and has been exposed to high volatility.

The results are imperative for the green economy transition, as they imply that whereas broad sustainability is accepted, narrow sustainability does not yet offer sufficient financial incentives. Thus, these results do not provide evidence for the double dividend in the private sector. On the contrary, the renewable energy sector specifically needs further support from the public sector. Moreover, although investments in broader sustainability are not subject to green premiums as the renewable energy sector, this is insufficient. Thus, new innovative mechanisms are needed to intertwine both the public and private finance aspects. Green bonds could be a promising avenue among the new green financial instruments. Crucially, the result shows that both aspects are equally relevant. This concludes the review of the main contributions of the thesis. The next section summarizes the main limitations and future research directions, before concluding with the general outlook on the way forward.

Limitations and future research directions

The analyses have provided relevant policy implications, but there are several caveats and avenues for future research as explained further on. Some limitations of the environmental tax data analysis at the national level include the choice of variables which could be extended to account for other relevant variables in the main macroeconomic identity and the current account by extension, such as financial openness or terms of trade. Methodologically, the study used a static and dynamic model. Additional avenues include estimating a hierarchical model to connect the sectoral and national level data, or a system of equations to account for the potential endogeneity of the tax variables. Furthermore, the relationship between energy taxes and energy dependence should be explored in other blocks of countries to evaluate whether this effect is only due to the price effect or could be behavioral as well due to the European Union’s global leadership in environmental policy.

Thus, future research should focus on discerning the sources for the effect on the current account through the inclusion of additional policy and current account variables and interaction effects among them, the use of hierarchical models, systems of equations and segmentation across multiple blocks of countries. Additional avenues are macro models which would enable multiple scenarios incorporating environmental tax reforms and/or green (sovereign) bonds to finance these reforms.

Additional research directions for the sectoral level analysis, beyond the estimation of a hierarchical model include accounting for the effects of various environmental policies beyond energy taxes. Studying the interaction effects among various environmental policies and the overall environmental policy stance would add to the comprehensiveness of the analysis. Modelling the interactions between the target and the policy variables would account for the endogeneity of the policy variables. Finally, another research avenue is further disaggregation at the sectoral level for energy taxes (beyond the main groups analyzed here).

Moreover, this study has analyzed the effect on value added and employment. Future research could evaluate the effects of energy taxation on other variables such as innovation. Thus, future research directions in this analysis include expanding the variable set for energy taxation or environmental policy, or extending the analysis to account for other effects such as innovation. Discerning the effects on various types of innovation is another avenue to be pursued.

Further, the renewable energy study could be repeated at the firm level as well, so as to evaluate the financial performance for both broad and narrow sustainability. Namely, this study used a small number of widely known indices for sustainability and renewable energy. This could be a limitation and future research could extend the scope of the study to include firm-level data as well. Higher data granularity will serve to inform the policy discussion further. Additionally, this study has applied the classical return factor methodology. It is based on the first two moments of the returns distribution, i.e. mean and variance. Other extensions include accounting for other moments of the distribution of returns, beyond mean and variance.

Perhaps the major limitation from the renewable energy data analysis is the time period analyzed as it refers to a period after/during which cost-effectiveness of renewable energy technologies improved drastically. Arguably, these developments take time to show up in the data. Furthermore, technological innovation and climate change agreements may alter the outlook for renewable energy in the next decades, thus improving its financial performance. Thus, extrapolating the relationship to the future is questionable as there are cost benefits to be exploited.

Future research should also analyze the sensitivity of the renewable energy sector through event studies for the period elapsed, as well as track the sensitivity in the upcoming period due to the rapid pace of technological development and the changing policy outlook. Another avenue to be explored are the effects of the new green financial instruments as well as qualitative research on the adoption of these instruments in the first place across financial institutions and firms. This concludes the overview of the results and main empirical contributions of the dissertation. The following section outlines the way forward for the double dividend outlook.

The way forward

The results from the three empirical analyses within this dissertation show mixed effects over various channels. Environmental taxation has a positive effect on the current account, but there are mixed effects at the sectoral level. The industrial and the renewable energy sectors would need continued public policy support. The latter is necessary so as to mobilize private environmental finance as well. This would enable a faster transition to a green economy. Thus, overall, the results show that the private sector can assist in the green economy transition, but there are insufficient incentives for a leading role of the private sector at this stage.

Thus, integrating both the public and private finance aspects in the analysis of the way forward for the green economy transition is even more imperative. The justified concerns about the industrial sector and the volatility of the renewable energy sector point to a greater role for the public sector, or at least a preservation of the existing one. Nevertheless, the outlook on renewables is subject to rapid change as it is pendant on technological developments. Furthermore, although this thesis has analyzed the public and the private finance aspects separately, the green bond instrument is an example of both aspects intertwined.

Green sovereign bonds are another avenue to finance the green economy transition and indeed might be a transitional instrument themselves. Namely, green sovereign bonds are an approach to mobilize private environmental finance for continued public policy support to the aforementioned sectors. Moreover, the public sector could help by providing a pipeline of environmental projects so as to assist the private sector in channeling the funds optimally. This could refer to both green sovereign and green corporate bonds. Additionally, providing a green financial infrastructure through regulation is another step which can help steer the financial sector towards embracing green projects. Ultimately, this could contribute to achieving a double dividend as well by setting the necessary mechanisms in place, thus facilitating a greater role for the private sector.

To sum up, this thesis has explored the public and private finance aspects of the double dividend discussion. The concept has been augmented and extended towards its private

finance aspects, due to various reasons related to the need for investment in the green economy transition as well as the tentative dividends associated with corporate social responsibility and sustainable investing. The results from the empirical analyses indicate that both the public and private finance aspects should be integrated within the double dividend policy discussion.

The national and the sectoral level analyses enabled an insight into the simultaneous effects of taxes on various indicators. The analysis provides compelling evidence for a double dividend at the national level due to balance of payments effects on the current account. The evidence regarding the other key variables such as value-added and employment is inconclusive. Thus it neither supports nor negates the case for a double dividend. The negative effects on value added and employment in the industrial sector are an exception to this, which calls for continuous public support. Similar policy implications ensue from the risk and return analysis for sustainable and renewable energy firms. Namely, the renewable energy sector is highly volatile and subject to negative returns which calls for further and consistent public support through subsidies for example. It is imperative that the public sector delivers this public support consistently through the average investment horizon for firms in these sectors. Ultimately, as suggested in this thesis policymakers would have to sooner or later phase out or decrease public support.

The issue at hand is the timing and magnitude, thus there has to be continuous public support which will be phased-out gradually with the development of technology. Fostering the right institutional environment so as to entice a greater involvement of the private sector is key as well. This implies that both the public and private finance aspects of the double dividend have to be intertwined accordingly. Indeed, integrating both aspects will be crucial for the policy potential of the double dividend, as well as the overall pace of a successful transition to a green economy.

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APPENDIX

Appendix 1: Summary in Slovenian language/Daljši povzetek disertacije v slovenskem jeziku

Uvod

Dvojna dividenda pomeni sočasno doseganje ekonomskih in okoljskih koristi (dividende) ob uvedbi okoljskih davkov. Okoljski davki zmanjšujejo potrošnjo energije in posledično izboljšujejo kakovost zraka, s čimer lahko dosežemo t. i. okoljsko dividendo. Če ob dvigu okoljskih davkov sočasno znižamo tudi stroške dela skozi nižje socialne prispevke ali davčne obremenitve, lahko ustvarimo tudi t. i. ekonomsko dividendo. Dvojno dividendo zato povezujemo predvsem z državo in njeno vlogo pri oblikovanju ustrezne okoljske in davčne politike (javno-finančni vidik dvojne dividende).

Danes je jasno, da za učinkovitejšo in hitrejšo zeleno tranzicijo potrebujemo mnogo več sredstev, kot so jih vlade sposobne zagotoviti. Obenem sodobni menedžerski pristopi in poslovne strategije vse bolj temeljijo na družbeno odgovornem vedenju in delovanju podjetij, ki povečuje njihovo vrednost in izboljšuje kazalnike njihovega poslovanja. Zaradi slednjih razlogov postaja zasebni sektor vse bolj nepogrešljiv in pomemben pri razumevanju samega koncepta dvojne dividende. Prvi cilj doktorske naloge je celoviteje opredeliti dvojno dividendo, saj je potrebno poleg javno-finančnega vidika mnogo bolj izpostaviti tudi njen zasebno-finančni vidik. Drugi cilj naloge je empirično proučiti ex-post učinke okoljske obdavčitve na nacionalni, sektorski in podjetniški ravni. Večina dosedanjih študij je bila namreč opravljenih na podlagi ex-ante analiz, kar kaže na določeno raziskovalno nišo, ki jo želimo zapolniti.

Na nacionalni ravni empirično proučujemo v nalogi vpliv okoljske obdavčitve na energetsko odvisnost in trgovinsko bilanco (raziskovalno vprašanje št. 1). Na sektorski ravni analiziramo vpliv okoljske obdavčitve na dodano vrednost in zaposlenost (raziskovalno vprašanje št. 2). V obeh primerih gre za proučevanje vpliva okoljskih davkov na pomembne cilje pri vodenju ekonomske politike (npr. zaposlenost, BDP, tekoči račun), zato govorimo o javno-finančnem vidiku dvojne dividende. V obeh primerih gre za oceno ekonomske dividende, medtem ko je okoljska dividenda analizirana skozi analize primerov ter poglobljen pregled literature. Na podjetniški ravni izvedemo finančno analizo donosov skozi faktorsko analizo trajnostnih indeksov in indeksov obnovljivih virov energije (raziskovalno vprašanje št. 3), zato gre v tem primeru za zasebno-finančni vidik dvojne dividende. Skozi finančno analizo donosov ocenimo ekonomsko dividendo, okoljska dividenda pa je implicitno vključena skozi izbiro samih indeksov.

Doktorska naloga ima štiri glavne znanstvene prispevke. Prvi prispevek je teoretske narave in izhaja iz prvega cilja naloge ter potrebe po celovitejši opredelitvi in drugačnem razumevanju dvojne dividende. Poleg javno-finančnega vidika je namreč potrebno močneje poudariti in izpostaviti tudi njen zasebno-finančni vidik. Preostali trije prispevki so

empirične narave in izhajajo iz drugega cilja doktorske naloge. Drugi znanstveni prispevek se nanaša na empirično oceno ekonomske dividende na nacionalni ravni skozi analizo vpliva okoljskih davkov na energetsko odvisnost in trgovinsko bilanco na ravni EU v obdobju 1990-2012. Na sektorski ravni proučujemo dvojno dividendo z vidika vpliva okoljskih davkov na dodano vrednost in zaposlenost na ravni EU v obdobju 1995-2015. Četrti znanstveni prispevek predstavlja faktorsko analizo na podjetniški ravni, katere namen je analizirati donose in tveganosti na primeru Dow Jones trajnostnih indeksov ter različnih indeksov obnovljivih virov energije v obdobju 2006-2016.

V uvodnem delu doktorske naloge so opredeljena glavna raziskovalna vprašanja: (1) Ali okoljska obdavčitev ustvarja dvojno dividendo z vidika vpliva na energetsko odvisnost in plačilno bilanco? (2) Ali okoljska obdavčitev ustvarja dvojno dividendo skozi vpliv na zaposlenost in dodano vrednost? (3) Ali obstaja dvojna dividenda z vidika finančne privlačnosti trajnostnih in obnovljivih naložb? Doktorska disertacija je razdeljena na tri glavna poglavja. Uvodno poglavje predstavlja glavna raziskovalna vprašanja in cilje doktorske naloge. V prvem poglavju obravnavamo koncept dvojne dividende ter potrebo po njenem drugačnem razumevanju. V drugem in tretjem podpoglavju sledi empirična analiza dvojne dividende iz njenega javno-finančnega in zasebno-finančnega vidika. Sledi zaključek in pregled uporabljene literature.

Poglavje 1: Koncept dvojne dividende

Dvojna dividenda posega na področje razumevanja odnosa med okoljem in ekonomijo. V prvem podpoglavju kronološko predstavimo razumevanje slednjega odnosa z vidika različnih konceptov. Razumevanje odnosa med okoljem in ekonomijo ima dolgo zgodovino, toda prvotne ideje težko povezujemo s samim konceptom dvojne dividende. Slednje so praviloma namreč namenjale pozornost bodisi ekonomskemu bodisi okoljskemu vidiku dvojne dividende.

Pregled literature pokaže, da se je problematika okolja pojavljala že v delih nekaterih klasičnih ekonomistov, kot sta David Ricardo in Adam Smith. Splošno znana je Maltusova teorija o mejah rasti zaradi omejenosti samih virov. V zgodnjih dvajsetih letih preteklega stoletja se pojavijo prvi poskusi oblikovanja ekonomskih ukrepov z namenom doseganja okoljskih koristi. Gre za t. i. Pigoujev davek, ki temelji na obdavčitvi onesnaževalca. Komplementarni pristop, ki je bil prvotno oblikovan za dosego ekonomskih koristi je t. i. Ramsejev davek. Njegov glavni cilj je maksimiranje davčnih prihodkov skozi obdavčitev dobrin z nizko cenovno elastičnostjo. Oba pristopa se osredotočata na ekonomsko ali na okoljsko dimenzijo dvojne dividende.

V šestdesetih letih preteklega stoletja se pojavi okoljevarstveno gibanje, ki sledi Maltusovi teoriji o mejah rasti s t. i. Rimskim klubom. Gibanje sledi ideji, da bo gospodarska rast dosegla meje rasti zaradi omejenosti samih virov. Naftni šoki v sedemdesetih letih preteklega stoletja dodatno potencirajo njihovo okoljevarstveno skrb. V enakem obdobju se pojavi tudi prvi poskus sočasne obravnave okoljske in ekonomske dividende (Sandmo,

Tullock, 1975), toda konceptualno se ideja dvojne dividende dokončno (iz)oblikuje šele v začetku devetdesetih let preteklega stoletja. V sedemdesetih in osemdesetih letih preteklega stoletja se pojavijo holistične teorije družbene blaginje, ki postavljajo v ospredje trajnostni razvoj, ki združuje ekonomske, družbene ter okoljske vidike razvoja. Glavno načelo trajnostnega razvoja je zadovoljitev potreb sedanje generacije na način, ki ne ogroža potreb prihodnjih generacij. Načelo trajnostnega razvoja je nadvse pomembno, saj postavlja v ospredje okolje kot enega izmed glavnih ciljev pri oblikovanju ter vodenju ekonomske in razvojne politike. V skladu s tem se je začela vse bolj odpirati tudi razprava o različnih okoljskih ukrepih.

Dvojna dividenda se konceptualno celovito prvič pojavi šele v začetku devetdesetih let preteklega stoletja v okviru okoljske davčne reforme v Evropi. Njen namen je bil skozi okoljsko obdavčitev ustvariti določene ekonomske koristi in obenem učinkoviteje odgovoriti na naraščajoče okoljske izzive. Devetdeseta leta preteklega stoletja so bila nadvse pomembna z vidika implementacije zelene davčne reforme v različnih evropskih državah, saj je slednja reforma praviloma temeljila na obdavčitvi onesnaževanja ter sočasni razbremenitvi stroškov dela. Dvojna dividenda tako obsega sočasne ekonomske in okoljske koristi (dividende), ki nastanejo zaradi uvedbe okoljskih davkov. Različni pristopi pred uveljavitvijo koncepta dvojne dividende v devetdesetih letih preteklega stoletja so praviloma namenjali pozornost bodisi ekonomskemu bodisi okoljskemu vidiku. Sočasnost je pomembna značilnost dvojne dividende, ki slednjo razlikuje od podobnih konceptov, kot je na primer Kuznetsova okoljska krivulja.

Dvojno dividendo povezujemo predvsem z državo in njeno vlogo pri oblikovanju ustrezne okoljske in davčne politike, zato govorimo tudi o javno-finančnem vidiku dvojne dividende. V okviru proučevanja odnosa med okoljem in ekonomijo je v literaturi poznana tudi t. i. Porterjeva hipoteza, ki analizira širši spekter ukrepov kot v okviru tradicionalnega razumevanja dvojne dividende. Porterjeva hipoteza namreč poudarja, da lahko tudi okoljska regulacija poveča produktivnost, inovativnost in zaposlenost v podjetjih. Gre torej za širši nabor ukrepov (regulacija, davki) in učinkov predvsem na podjetniški ravni.

Novejši pristopi posegajo na področje razumevanja družbene odgovornosti podjetij ter zelene rasti. Oboje lahko povežemo z idejo sonaravnega oziroma trajnostnega razvoja. Na podjetniški ravni je družbena odgovornost podjetij način razumevanja in implementacije ideje trajnostnega razvoja. Koncept družbene odgovornosti podjetij namreč postavlja v središče poslovnih strategij in poslovnih modelov upoštevanje okoljskih, ekonomskih in družbenih učinkov poslovanja. Na drugi strani predstavlja teorija zelene rasti način operacionalizacije ideje trajnostnega razvoja z vidika vodenja ekonomske politike. Trajnostni razvoj je namreč holistični pojem, ki nosilcem ekonomske politike ne ponuja praktičnih nasvetov. V praksi zato pogosto prihaja do zožitve treh dimenzij na dve, pri čemer sta v ospredju okolje in ekonomija. V ozadju odnosa se pojavlja potreba po oblikovanju ustrezne okoljevarstvene politike za doseganje dvojne dividende.

Kratek kronološki pregled razumevanja odnosa med okoljem in ekonomijo pokaže, da danes vse bolj v ospredje vstopa zasebni sektor. Dvojno dividendo je zato mogoče razumeti ne samo z njenega javno-finančnega vidika, ampak tudi z njenega zasebno-finančnega vidika. Poleg tega bomo za učinkovitejšo zeleno tranzicijo potrebovali predvsem zasebna sredstva, saj so javno-finančna vedno omejena. Obenem sodobni menedžerski pristopi vse bolj temeljijo na družbeno odgovornem vedenju in poslovanju podjetij, zato je zasebni sektor ključen za polno razumevanje dvojne dividende in njeno drugačno opredelitev.

V drugem podpoglavju prikazujemo pregled prispevkov različnih avtorjev z vidika njihovega razumevanja koncepta dvojne dividende, načina uporabljenega pristopa in rezultatov analiz. Pregled pokaže, da se večina avtorjev osredotoča na analizo ekonomske dividende, medtem ko okoljska dividenda ni jasno definirana ter praviloma implicitno predpostavljena. Okoljsko dividendo v literaturi povezujemo z zmanjševanjem onesnaževanja, vsesplošnim izboljšanjem stanje okolja in manjšo potrošnjo energije.

Ekonomsko dividendo avtorji praviloma razumejo skozi večjo blaginjo ali koristnost, oziroma skozi večjo učinkovitost zaradi nižjih davčnih distorzij davčnega sistema. Slednje so lahko povezane z izhodiščno neučinkovitostjo davčnega sistema. S temi vidiki sta praviloma močno povezana učinek reciklaže in skupni negativni davčni učinek. Na primer ob uvedbi zelenih davkov in sočasnem znižanju relativno visokih davkov na dohodek v enakem obsegu zaradi zagotavljanja fiskalne nevtralnosti lahko govorimo o učinku reciklaže zaradi izboljšanja izhodiščne neučinkovitosti samega davčnega sistema.

Na drugi strani veliko avtorjev povezuje razumevanje dvojne dividende tudi z glavnimi cilji na področju vodenja določenih politik v državi, kot so gospodarska rast, zaposlenost in emisije. Zaradi okoljske politike (okoljski davki) kot ključnega inštrumenta in težnje po doseganju ključnih ciljev na področju vodenja ekonomske in okoljske politike govorimo o javno-finančnem vidiku dvojne dividende. Dvojna dividenda predstavlja sočasne ekonomske in okoljske koristi (dividende), ki nastanejo zaradi uvedbe okoljskih davkov.

Obstoječe opredelitve dvojne dividende so v določeni meri pomanjkljive. Prva pomanjkljivost se kaže v nejasni izbiri ciljev, ki jih želimo skozi uvedbo okoljskih davkov doseči. Obenem študije ne dajejo nedvomnih odgovorov glede samega obstoja dvojne dividende. V doktorski disertaciji zato analiziramo ex-post učinke uvedbe okoljskih davkov z vidika vseh pomembnejših ciljev pri vodenju ekonomske politike. V okviru prvega raziskovalnega vprašanja proučujemo morebitni vpliv okoljskih davkov na tekoči račun plačilne bilance in energetsko odvisnost v državah EU, ter v okviru drugega raziskovalnega vprašanja njihov vpliv na dodano vrednost in zaposlenost.

Druga pomanjkljivost leži v dejstvu, da obstoječe študije analizirajo vplive na rast in zaposlenost predvsem na agregatni ravni oziroma se osredotočajo na posamezne sektorje. Tudi slednje študije ne dajejo nedvomnih odgovorov glede obstoja dvojne dividende. V okviru drugega raziskovalnega vprašanja disagregiramo podatke na raven različnih sektorjev. Ob tem velja opozoriti, da pri proučevanju dvojne dividende prevladujejo »ex-

ante« pristopi, kar odpira možnosti za drugačen pristop. Tretja pomanjkljivost je, da v študijah praviloma poudarjajo ekonomsko dividendo in le majhno pozornost namenjajo okoljski dividendi, tako na konceptualni ravni kot z vidika merjenja slednje.

Največja konceptualna pomanjkljivost obstoječih opredelitev in razumevanja dvojne dividende je, da slednjo povezujejo izključno z vlogo države in njeno vlogo pri oblikovanju okoljske in davčne politike, zato lahko govorimo o javno-finančnem vidiku dvojne dividende. Na drugi strani podnebne spremembe, izzivi trajnostnega razvoja in omejeni proračunski viri kažejo, da za učinkovito zeleno tranzicijo potrebujemo mnogo več sredstev, kot so jih vlade sposobne in pripravljene zagotoviti.

Privatni nosilci zelenega razvoja so predvsem v finančnem in realnem sektorju. Finančni sektor lahko uvaja različne produkte (npr. zelene obveznice) ter tako vpliva na hitrost zelene tranzicije. Obenem danes vse več finančnih institucij sledi načelom trajnostnega razvoja. Tudi sodobni menedžerski pristopi in poslovne strategije podjetij vse bolj temeljijo na družbeno odgovornem vedenju in poslovanju podjetij, ki povečuje njihovo tržno vrednost. Gre za zasebno-finančni vidik dvojne dividende in za pozitivne finančne učinke, ki nastanejo na podjetniški ravni (npr. donos, tržna vrednost) ter so rezultat trajnostne usmeritve v celotni dejavnosti podjetja kot ene izmed njegovih temeljnih strateških usmeritev. Slednji vidik proučujemo v okviru tretjega raziskovalnega vprašanja.

Zaradi zgornjih razlogov je potrebno razširiti dosedanje razumevanje dvojne dividende skozi večjo vlogo zasebnega sektorja oz. njen zasebno-finančni vidik. Ne nazadnje tudi pojem »dividenda« izvira iz zasebnega sektorja. Gre za vsebinsko nadgradnjo v primerjavi z dosedanjim izključno javnofinančnim razumevanjem dvojne dividende, tako z vidika možnih ukrepov kot z vidika ciljnih spremenljivk. Dvojna dividenda je z javnofinančnega vidika povezana z okoljskimi davki, medtem ko je z zasebno-finančnega vidika povezana s prostovoljnimi okoljevarstvenimi ukrepi v smeri večje družbene odgovornosti podjetij. V okviru javno-finančnega vidika so v ospredju glavni cilji pri vodenju ekonomske in okoljske politike kot so višja gospodarska rast, višja zaposlenost, nižje emisije in trgovinska bilanca. Z zasebno-finančnega vidika so v ospredju prostovoljni okoljevarstveni ukrepi za doseganje višjega donosa in nižjega tveganja. Prepričani smo, da je poglobljeno razumevanje dvojne dividende tako z njenega javno-finančnega kot z njenega zasebno-finančnega vidika ključno za doseganje ciljev trajnostnega razvoja in zelenega preboja.

Poglavje 2: Javno-finančni vidik dvojne dividende

Drugo poglavje je namenjeno javno-finančnemu vidiku dvojne dividende. Prvi sklop vsebuje analizo in pregled ekonomskih in okoljskih koristi (dvojna dividenda) v državah, ki so uvedle celovito zeleno davčno reformo. V celoti je bila zelena davčna reforma izvedena v šestih državah EU: Finska, Danska, Švedska, Velika Britanija, Nizozemska in Nemčija. Primerjalna analiza pokaže, da so bili motivi za okoljsko obdavčitev tako ekonomski kot okoljski, pri čemer so v večini državah zasledovali predvsem ekonomske motive, kot so vpliv na gospodarsko rast, zaposlenost in plačilno bilanco. Skandinavske države so na

primer uvedle okoljsko obdavčitev za boljše obvladovanje prevelike energetske odvisnosti in naftnih šokov. Višji okoljski davki zmanjšujejo potrošnjo energentov in posledično energetsko odvisnost države, s čimer se zmanjša tudi občutljivost države na naftne šoke. V drugih državah so bili ob uvedbi zelene davčne reforme osredotočeni na nekatere druge pomembne cilje pri vodenju ekonomske politike, kot sta zaposlenost in dodana vrednost (BDP). Doktorska naloga se omenjenim trem ciljem (energetska odvisnost in tekoči račun plačilne bilance, dodana vrednost, zaposlenost) z vidika okoljskih davkov bolj podrobno posveča v drugem in tretjem podpoglavju drugega poglavja.

Primerjalna analiza držav je pokazala, da so pozitivni okoljski učinki (okoljska dividenda) zaradi okoljske obdavčitve vidni v vseh izbranih državah. Države so znižale emisije in obdržale pozitivno rast BDP v zadnjih dveh desetletjih. Zniževanje emisij je danes prisotno tudi v energetsko intenzivnih industrijah, vendar ne v vseh državah. Tukaj izstopata predvsem Finska in Nizozemska kot državi, ki sta med letoma 1990 in 2012 povečali emisije energetsko intenzivnih industrij. Nemčija, Velika Britanija in Danska so na drugi strani znižale emisije energetsko intenzivnih industrij glede na leto 1990. Podobne trende izboljšanja vidimo tudi pri energetski učinkovitosti, saj so vse države znižale energetsko intenzivnost.

Končni učinek zelenih davčnih sprememb je odvisen od mnogih dejavnikov. Eden od slednjih je nedvomno (ne)prisotnost okolju škodljivih subvencij. Podatki in študije tudi kažejo, da so v mnogih državah prisotna velika nihanja pri energetskih davkih, kar kaže na določeno nekonsistentnost pri vodenju okoljske politike. Podjetja namreč težje načrtujejo, če so izpostavljena nekonsistentnim in nepredvidljivim vladnim ukrepom. Številne študije opozarjajo tudi na problem regresivnosti, saj okoljska obdavčitev pogosto najbolj prizadene tiste v dohodkovno najšibkejšem položaju.

Z javnofinančnega vidika je ekonomska dividenda proučevana na dveh nivojih (sektorski, nacionalni). Na nacionalni ravni je bila preverjena hipoteza o pozitivnem vplivu okoljske obdavčitve na energetsko odvisnost in tekoči račun plačilne bilance (raziskovalno vprašanje št. 1). Na sektorski ravni gre za hipotezo o vplivu okoljskih davkov na zaposlenost in dodano vrednost (raziskovalno vprašanje št. 2). Ekonomska dividenda je analizirana na nacionalni in sektorski ravni, medtem ko je okoljska dividenda obravnavana implicitno. Prvo raziskovalno vprašanje odpira vprašanje energetskega uvoza in posledično izboljšanega stanja v trgovinski bilanci.

V empirični analizi sta bili ocenjeni enačbi za energetsko odvisnost in trgovinsko bilanco s pomočjo metode panelnih podatkov ter statičnih in dinamičnih modelov. Analiza je pokazala, da energetski davki negativno vplivajo na energetsko odvisnost predvsem dolgoročno. Obenem je energetska odvisnost izrazito persistentna spremenljivka, saj je koeficient vztrajnosti večji od 0,8. Slednje poudarja pomembnost konsistentne okoljske politike, ki zahteva zmerno in postopno poviševanje okoljskih davkov oziroma poskus njihove ohranitve na približno enaki ravni skozi daljše časovno obdobje.

Empirična analiza je pokazala, da okoljski davki pozitivno vplivajo tudi na trgovinsko bilanco. Ocenjeni učinek je približno 3-odstoten, če se delež energetskih davkov v BDP-ju poveča za 1 odstotek. Gre za relativno zmeren učinek, saj znaša delež energetskih davkov v BDP-ju praviloma med 1 in 3 odstotki. Obstaja pozitiven učinek na trgovinsko bilanco, vendar učinek slednjega ne zadostuje za odpravo visokih primanjkljajev v trgovinski bilanci. Rezultati tudi kažejo, da je mogoče v luči varčevalne politike skozi uvedbo okoljskih davkov hkrati izboljšati stanje okolja in stanje v trgovinski bilanci ter obenem sprejeti manj stroge varčevalne ukrepe. Z okoljskimi davki je mogoče doseči izboljšanje stanja v trgovinski in proračunski bilanci, s čimer se deloma odpravlja problem t. i. dvojnega deficita.

Empirični rezultati dokazujejo obstoj ekonomske dividende na nacionalni ravni skozi pozitivne učinke okoljskih davkov na energetsko odvisnost in tekoči račun plačilne bilance. Na sektorski ravni proučujemo ekonomsko dividendo z vidika vpliva okoljskih davkov na druge pomembne cilje ekonomske politike, kot sta zaposlenost in dodana vrednost (BDP). Rezultati kažejo, da obstajajo določeni dokazi o negativnem vplivu energetskih davkov na dodano vrednost in zaposlenost. To še posebej velja za industrijski sektor ne glede na uporabljeno spremenljivko za energetski davek. Implicitni energetski davek ima negativni učinek na zaposlenost v vseh sektorjih, medtem ko je učinek okoljske davčne reforme odvisen od vrste sektorja. Učinek je v industrijskem sektorju negativen in pozitiven v storitvenem.

Z vidika dvojne dividende ni dokaza o njenem obstoju v industrijskem sektorju. Obenem ni dokazov o znatnih negativnih učinkih v drugih sektorjih. Industrijski sektor kot izrazito energetsko intenziven sektor zaradi slednjega potrebuje ustrezno javnofinančno podporo, še posebej v času gospodarske krize in naraščajoče negotovosti, ko negativni učinki na zaposlenost in dodano vrednost pridejo še bolj do izraza. Empirični rezultati ne kažejo doslednih dolgoročnih učinkov okoljske davčne reforme na katerikoli sektor. Podjetja se mnogo lažje prilagodijo majhnim in nenehnim spremembam, zato mora biti okoljska politika konsistentna in dolgoročno usmerjena. Analiza dvojne dividende z javno-finančnega vidika ob uvedbi okoljskih davkov torej kaže na pozitivni ekonomski učinek v primeru trgovinske bilance in negativni učinek v primeru dodane vrednosti ter zaposlenosti predvsem v industriji.

Poglavje 3: Zasebno-finančni vidik dvojne dividende

Doktorska naloga obravnava poleg javnofinančnega tudi zasebno-finančni vidik dvojne dividende. Pri slednjem gre za finančne učinke, ki so posledica trajnostne usmeritve kot ene izmed temeljnih strateških usmeritev določenih podjetij. Učinki na podjetniški ravni se kažejo skozi povečano tržno vrednost in izboljšanje določenih finančnih kazalnikov (npr. ROA, ROE). Zasebno-finančni vidik dvojne dividende je pomembno proučiti predvsem z vidika ugotavljanja njegovega potenciala za prevzemanje večje vloge pri spodbujanju zelene rasti. Zaradi slednjega je dvojno dividendo smiselno proučevati predvsem v okoljskih sektorjih, kot je na primer sektor obnovljivih virov energije. Okoljska dividenda je namreč

implicitno prisotna v sektorju obnovljivih virov energije, saj se emisije ob njihovi uporabi relativno ustrezno znižujejo.

Tretje poglavje vključuje empirično analizo ekonomske dividende na ravni podjetij skozi finančno analizo donosov trajnostnih indeksov in indeksov obnovljivih virov energije (raziskovalno vprašanje št. 3). Razlikovanje med obema sektorjema je pomembno in smiselno, saj je sektor obnovljivih virov energije izpostavljen večjemu tveganju kot sektor t. i. trajnostnih podjetij. V prvi skupini gre za skupek podjetij iz različnih področij, ki imajo vidik trajnosti močno vključen v svoje poslovne strategije. V drugi skupini imamo opravka s skupkom podjetji, ki se ukvarjajo izključno z obnovljivimi viri energije.

Rezultati kažejo, da je tveganost izražena skozi beto v faktorskih modelih CAPM večja kot 1, kar pomeni, da je sektor obnovljivih virov energije bolj volatilen kot trg. Donosi so negativni, četudi statistično neznačilni. V splošnem rezultati empirične analize kažejo, da presežne pozitivne alfe oziroma presežne donosnosti, nepojasnjene s splošnimi gibanji na finančnih trgih ni oziroma je slednja v nekaterih primerih tudi negativna. Rezultati kažejo, da bi povprečni vlagatelj posloval z izgubo, kar ni spodbudno z vidika ustvarjanja zasebne finančne pobude. Empirične analize kažejo, da trajnostna usmeritev pomembno ne vpliva na donose. Slednje tudi pomeni, da vlagatelji ne utrpijo finančne škode zaradi omejenega naložbenega izbora trajnostnih indeksov.

Ob tem velja opomniti, da gre za hitro razvijajoči se sektor, v katerem lahko tehnološki napredek izredno hitro in močno vpliva na padec določenih stroškov. Zaradi slednjega lahko postanejo finančne naložbe tudi v obnovljive vire donosne. Empirični rezultati nakazujejo, da zasebni sektor samostojno (še) ne more biti vodilni nosilec zelenega preboja. V splošnem so rezultati empirične analize spodbudni za agendo zelene rasti, vendar je potrebno ob tem posebej poudariti in izpostaviti vlogo javnega sektorja kot dodatnega motorja želenih sprememb. Zaradi slednjega je razumevanje sinergije med zasebnim in javnim sektorjem še toliko pomembnejše.

Zaključek

Doktorska naloga obravnava javno-finančni in zasebno-finančni vidik dvojne dividende. V prvem poglavju smo celoviteje opredelili koncept dvojne dividende. Drugo in tretje poglavje sta namenjeni analizi javno-finančnih ter zasebno-finančnih vidikov dvojne dividende. Omenjeni strukturi sledijo tudi štirje glavni prispevki v doktorski nalogi.

Prvi znanstveni prispevek je teoretičen in temeljni na celovitejšem razumevanju koncepta dvojne dividende. Dvojna dividenda je relativno nov koncept, ki se pojavi v začetku devetdesetih let prejšnjega stoletja. Razumevanje samega odnosa med okoljem in ekonomijo ima dolgo zgodovino, a zgodnje ideje težko povezujemo s samim konceptom dvojne dividende. Različni pristopi so namreč namenjali pozornost bodisi ekonomskemu bodisi okoljskemu vidiku dvojne dividende. Prva poglobljena analiza obeh vidikov se je pojavila

šele proti koncu sedemdesetih let prejšnjega stoletja, konceptualno pa se ideja dvojne dividende dokončno izoblikuje šele v začetku devetdesetih let ter operacionalizira na ravni politik v okviru zelenih davčnih reform v Evropi. Dvojna dividenda konceptualno predstavlja sočasne ekonomske in okoljske koristi (dividende), ki nastanejo zaradi uvedbe okoljskih davkov.

Takšno razumevanje dvojne dividende postavlja v ospredje vpliv okoljskih davkov na glavne cilje ekonomske politike, kot so zaposlenost, plačilna bilanca in gospodarska rast, zato govorimo tudi o javno-finančnem vidiku dvojne dividende. Obenem zelena tranzicija zahteva visoka finančna sredstva in sodobni menedžerski pristopi vse bolj poudarjajo pomen družbeno odgovornega poslovanja in delovanja podjetij, zato je potrebno obstoječi t. i. javnofinančni vidik dvojne dividende nadgraditi skozi večjo vlogo zasebnega sektorja. Zasebno-finančni vidik dvojne dividende poudarja finančno privlačnost zelenih zasebnih naložb ter temelji na prostovoljni vključitvi zasebnega sektorja.

Drugi znanstveni prispevek dokazuje obstoj ekonomske dividende na nacionalni ravni skozi analizo vpliva okoljskih davkov na energetsko odvisnost in trgovinsko bilanco v EU v obdobju 1990-2012. Empirična analiza je pokazala, da energetski davki negativno vplivajo na energetsko odvisnost in pozitivno na trgovinsko bilanco. Učinki so značilni tudi dolgoročno, kar je pomembno tudi z vidika vodenja ekonomske politike v času fiskalne konsolidacije. Zaključki so pomembni tudi z vidika geopolitičnega položaja Evrope v zvezi z njeno energetsko odvisnostjo in z vidika fiskalne vzdržnosti v večjem delu Evrope. Analizo je mogoče nadgraditi skozi proučevanje povezave med energetsko odvisnostjo in energetskimi davki v različnih skupinah držav, za katere ni značilna tako močna zavezanost okolju in okoljski politiki. Bodoči raziskovalni napori bi morali biti usmerjeni tudi v vključitev dodatnih spremenljivk pri proučevanju tekočega računa plačilne bilance in njihovega medsebojnega vpliva. V nadaljnjih raziskavah bi lahko skozi sistemske enačbe gospodarstva analizirali tudi vpliv odvisne spremenljivke na neodvisne (raven ali uvedba) zaradi problema potencialne endogenosti pojasnjevalnih spremenljivk, ki so tretirane kot eksogene.

Tretji znanstveni prispevek predstavlja sektorsko analizo vpliva okoljskih davkov na dodano vrednost in zaposlenost na ravni EU v obdobju 1995-2015. Rezultati na sektorski ravni so manj spodbudni, predvsem za industrijo. Analiza vpliva okoljskih davkov na dodano vrednost in zaposlenost je namreč pokazala na izrazito negativne učinke v industrijskem sektorju. Rezultati narekujejo nadaljnjo javnofinančno podporo omenjenim sektorjem. Analizo bi bilo mogoče nadgraditi skozi ocene učinkov vpliva različnih okoljskih (energetskih) davkov ter skozi vpliv na druge pomembne spremenljivke, kot so na primer inovacije. Lahko bi nadgradili analizo tudi skozi hierarhičen model, ki povezuje obe ravni analize, saj trenutna temelji bodisi na nacionalni bodisi na sektorski ravni. Sektorsko analizo bi lahko dodatno poglobili tudi z analizo na ravni podjetij. V analizo bi bilo mogoče vključiti tudi preostale okoljske ukrepe, ki odražajo celotno okoljevarstveno stališče določene države

in njihove medsebojne sinergije. Pri tem bi lahko na primer upoštevali tudi obremenitve podjetij z vsemi okoljskimi ukrepi oziroma njihovo razbremenitev s podeljevanjem okolju škodljivih subvencij. Ker so predmet preučevanja okoljski ukrepi bi lahko v nadaljnjih raziskavah proučili tudi potencialno endogenost neodvisnih spremenljivk skozi modeliranje ustreznega sistema enačb.

Četrti znanstveni prispevek predstavlja faktorsko analizo donosov in tveganosti na primeru trajnostnih indeksov ter različnih indeksov obnovljivih virov energije v obdobju 2006-2016. Razlikovanje med različnimi indeksi je pomembno, saj sta sektorja izpostavljena različnim profilom tveganosti, pri čemer so trajnostna podjetja bistveno manj tvegana kot podjetja v sektorju obnovljivih virov energije. Pri analizi donosov in tveganosti v daljšem časovnem obdobju se je pokazalo, da trajnostna usmeritev pomembno ne vpliva na donose. Slednje pomeni, da vlagatelji ne utrpijo finančne škode zaradi omejenega naložbenega izbora trajnostnih indeksov. Indeksi obnovljivih virov so imeli negativno donosnost, kar je bilo še posebej izraženo v sektorjih, ki so v ospredju tehnološkega razvoja.

Zaradi slednjega in dejstva, da gre za relativno nov sektor, je potrebno zagotoviti zadostno javno-finančno podporo. Analiza v tretjem poglavju temelji na različnih indeksih, zato jo je mogoče nadgraditi skozi disagregirano analizo na podjetniški ravni. Obenem bi bilo smiselno v analizo vključiti različne scenarije okoljskih reform in zelene finančne inštrumente za financiranje zelene reforme ter opredelitev sektorjev in podjetij glede na intenziteto njihove okoljske usmeritve. Nadaljnje raziskave bi morale vključevati tudi tehnološki razvoj, saj bo slednji v veliki meri vplival na večjo cenovno dostopnost novih tehnologij in na potencialno doseganje dvojne dividende tudi pri obnovljivih virih energije.

Doktorska disertacija obravnava javno-finančni in zasebno-finančni vidik dvojne dividende. Dvojna dividenda je tradicionalno pojem, ki ga zaradi uporabljenih inštrumentov (okoljski davki) povezujemo predvsem z javnim sektorjem. Obenem obseg potrebnih finančnih sredstev in potreba po družbeno odgovornejšem poslovanju podjetij kažeta na potrebo po drugačnem in celovitejšem razumevanju dvojne dividende in sicer predvsem skozi njen zasebno-finančni vidik. Rezultati analiz obenem kažejo na obstoj dvojne dividende na nacionalni ravni skozi vpliv energetskih davkov na tekoči račun plačilne bilance. Na sektorski ravni težko govorimo o obstoju dvojne dividende, saj so prisotni negativni učinki energetskih davkov na dodano vrednost ter zaposlenost predvsem v industrijskem sektorju. Na ravni podjetij analiza njihovih donosov in tveganosti pokaže, da trajnostna usmeritev pomembno ne vpliva na donose.

Zaradi slednjih ugotovitev je potrebno industrijskemu sektorju in sektorju obnovljivih virov energije vsaj na začetku investicijskega ciklusa zagotoviti ustrezno visoko javno-finančno podporo. Zasebni sektor sicer lahko pripomore k hitrejši zeleni tranziciji, toda trenutne finančne spodbude so nezadostne. Javno-finančna podpora se lahko ustrezno zmanjšuje ob razvoju ustreznega institucionalnega okolja za privatne investitorje in ob hitrejšemu razvoju tehnologije. Potencial dvojne dividende je zato v veliki meri odvisen predvsem od

razumevanja in optimalnega izkoristka sinergij med javnim in zasebnim sektorjem. Slednje bo odločilnega pomena pri realizaciji dvojne dividende v polnem pomenu te besede oziroma pri hitrejšem prehodu v trajnostno naravnano družbo.