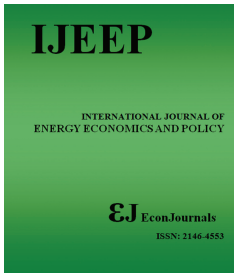

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Can a Green Tax Reform Entail Employment Double Dividend in European and non-European Countries? A Survey of the Empirical Evidence

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ABSTRACT

This paper synthesises the simulation studies concerning green tax reform (GTR) and employment double dividend (EDD) in European and non-European countries. The studies included investigate the effect of GTR on employment. We compared the simulation results between European and non-European countries to understand the impact of study region and our findings are fivefold. First, the simulation results suggest that GTR-driven EDD is observed in both European and non-European countries, but the average effect on employment in European countries (0.67%) is significantly greater than in non-European countries (0.18%). Second, optimal tax and tax revenue recycling policies in European and non-European countries for EDD are not identical. Reducing employers' social security contributions (SSC) has the potential to generate EDD in both countries. However, a reduction in value added tax has the highest average effect on employment in European countries (1.62%), which negatively affects employment in non-European countries (−0.02%). Third, a reduction in personal income tax as a tax recycling method creates a marginally average employment dividend in non-European countries (0.16%) but is counterproductive in European countries (−0.15%). Fourth, other taxes, which predominantly represent mixed taxes, exhibit the highest EDD potential in both European (1.01%) and non-European (0.46%) countries. Finally, employment dividend diminishes over time, but a weak quadratic pattern has been observed that reveals an accelerating effect on employment in the long term. These reflections should be considered before employing GTR in non-European countries in order to yield EDD.

Keywords: Green Tax Reform, Double Dividend, Employment
JEL Classifications: H23, H21, E24

1. INTRODUCTION

Green tax reform (GTR) has been a buzzword for several decades and has spread worldwide as a policy measure to address environmental concerns (OECD, 2015). The reform component of green tax strives to shift the tax burden from production (e.g., payroll tax) to environmental pollution. Nevertheless, the policy has often faced political backlash due to lack of transparency (Dresner et al., 2006). This called for the policy to offer additional economic benefits in order to gain wider public acceptance.

The double dividend (DD) hypothesis of GTR is an extensively researched topic that considers the possibility of producing additional economic benefits using environmentally beneficial tax measures (Terkla, 1984, Lee and Misiolek, 1986, Pearce, 1991, Tullock, 1967). Both GTR and the DD postulate that the existing tax regime and environmental policies are not optimal and there is room for improvement. The government's tax revenue recycling is at the heart of any policy aimed to achieve DDs through GTR. Anger et al. (2010) and Patuelli et al. (2005) provide comprehensive overviews of the literature concerning GTR and the DD. However, there is a caveat when employing policy instruments to entail

GTR-driven DDs because the emergence of economic dividends is highly sensitive to policy design (Bosquet, 2000).

The tax neutrality component of GTR that originates from revenue recycling creates the possibility of a second non-environmental dividend. This second dividend can manifest in the form of growth in gross domestic product (GDP), a reduction in unemployment, fiscal benefits, and an overall improvement in economic welfare (Pearce, 1991, Jorgenson and Wilcoxen, 1993, Morris et al., 1999). Despite extensive evidence favouring GTR-driven DDs, it is undeniable that the path towards a greener tax regime is challenging. Major hurdles such as inflation driven by an increase in production costs, deteriorating international competitiveness, impact on low income groups (especially factory workers), and vested interest by lobby groups and voters should be addressed (Bassi et al., 2009). A drastic GTR is not feasible due to the rise in such short-term costs, which can only be partially prevented by introducing the reform gradually (De Miguel and Manzano, 2011).

This paper aims to extend the understanding of GTR and the DD in the context of improved employment, often regarded as the employment DD (EDD). In this paper, we synthesised the results of 146 simulations from 33 studies. A greater emphasis is placed on understanding the practical implications of EDD in European and non-European countries. The paper also investigates the long-term impact of GTR on employment. The purpose of this exploration is to provide a framework for non-European countries where GTR is gaining acceptance as a policy measure to address the environmental concerns. It is organised as follows: Section 2 provides the foundation by outlining GTR, Section 3 presents the empirical results of all the studies concerning EDD and summarises the modelling evidence, and Section 4 concludes with implications for future research.

2. EVOLUTION OF GTR

European Environmental Agency (EEA) has classified green taxes into three major categories: Cost-covering charges, incentive taxes, and fiscal environmental taxes (European Environmental Agency, 1996). The principle idea behind cost-covering charges, which are at an early stage of evolution in environmental taxes, is to cover the cost of regulation and control. Under this regime, the user pays for consumption of environmental resources (e.g. water); covering the cost of regulators who are responsible for ensuring the preservation of these environmental resources. Incentive taxes were developed later based on environmental taxes and are very much in line with Pigouvian tax. Here, tax is imposed on the polluter with the intention to change the behaviour of the polluter in the long term. The amount of tax is determined by the cost of environmental damage caused by the polluter. Fiscal environmental tax is the most recent environmental tax and aims to shift the primary focus of the tax system from distortionary tax towards tax for use of resources, without causing any significant change to the budgetary balance. Fiscal environmental tax is predominantly orchestrated by financial recycling and is the main driving force behind modern GTR. When green taxes were initially proposed to place monetary value on carbon emissions, there was backlash as the proposed taxes to achieve the desired reduction in emissions were too high and were therefore rendered politically unacceptable. Introducing financial recycling and lowering existing taxes made GTR more feasible (Metcalf, 2000).

2.1. Efficiency DD

The efficiency DD of environmental taxation pivots the notion that such systems can reduce pollution by taxing the polluter and generating environmental welfare. Simultaneously, revenue generated from tax enables the government to make a more efficient tax system by reducing other distortionary taxes such as income tax, and by creating economic welfare (Tullock, 1967). Tax on factors of production is considered distortionary because it results in welfare loss.

The existence of efficiency DD was challenged by Bovenberg and Goulder (1996). According to their work, the biggest weakness in efficiency DD-driven GTR is that to gain the efficiency dividend, the revenue from contemporary tax must be completely substituted by the revenue generated from green taxes. However, the green tax base is too narrow, which makes it very difficult to substitute the revenue of income and payroll tax with a GTR. Even though green tax has the potential to generate higher revenue by utilising resource rent and expanding to other forms of industrial pollution (Gaffney, 1972, Repetto, 1996), it is unrealistic to expect such major reform anytime soon. This means a revenue-neutral GTR is unable to completely replace the existing tax system, thus these two taxes may co-exist. This could lead to a tax interaction effect (Bovenberg and Goulder, 1996) and result in greater welfare loss. This is possible due to the negative impact of the tax interaction effect compared to the positive benefit of revenue recycling (Parry, 1995).

Extensive discussion on efficiency DD in the literature led to the discovery of weak form of DD (Goulder, 1995). The weak DD argument postulates that recycling the revenue from green taxes by reducing distortionary fiscal taxes is optimal for overall welfare compared to returning it back to the economy in the form of a lump sum payment. This hypothesis is widely accepted by economists (Schöb, 2003).

2.2. EDD

Employment lead DD was pioneered by European economists as Europe was infested by involuntary unemployment during the late 1980s. After the work of Pearce (1991), EDD received increased attention from scholars. This hypothesis suggests that an EDD-driven revenue-neutral GTR can effectively solve two problems: (i) Improve the environment by putting a cost on pollution, and (ii) curtail payroll and other distortionary taxes that impact employment (Pearce, 1991, Repetto et al., 1992, Oates, 1993). To create DDs, it is important to ensure that a balance is maintained between the economic losses of GTR and the welfare created by revenue recycling (Patuelli et al., 2005).

3. MODELLING EVIDENCE

Table 1 summarises the details of all 33 studies on EDD that we have included in our database[1]. The 146 simulation results are categorised according to the model type, region of study, time

1 Interested readers can contact the author for more details of the database.

Table 1: Summary of empirical studies that investigated GTR and the employment effect

Study	Data	Method/s applied	Major finding/s
Pereira and Pereira (2014)	The data set consists of variables such as domestic spending data, primary energy demand, energy prices, foreign account data, public sector data, population and employment data, private wealth and capital stock (2008) of the Portuguese economy. The macroeconomic and energy aggregate variables are averages of data from 1990–2008.	The study used a dynamic general equilibrium model (DGEP) of the Portuguese economy.	Various recycling channels of CO_2 tax revenue were analysed. Recycling was grouped between three major policies: (i) Demand-driven policies (LSTH, VAT), (ii) employment-driven policies (SSC, PIT); and (iii) investment-driven policies (renewable energy investment tax credit). The latter two policies exhibited significant EDD potential.
Kilimani (2014)	The dataset is based on the 2009 Social Accounting Matrix (SAM) of Uganda. Thirty-nine industries and commodities were used with household data, which were classified into four regional groups.	The study employed the Uganda applied general equilibrium model to evaluate the impact of different water tax scenarios.	The plausibility of EDD was highly sensitive to tax rates. It was evident that EDD is achievable but depends on the sector in which the tax is levied, the tax rate, and the revenue recycling process. The study found plausible EDD, especially in the short term.
Kemfert and Welsch (2000)	Data were taken from 11 major economic sectors in the German economy, and three major factors of production for each of the sectors were established. Data were aggregated and disaggregated. Time series data for the period of 1970–1988 was used to construct the database. The base year for model calibration was 1985.	A dynamic multi-sector CGE model, LEAN-TCM, was used.	Financial recycling was simulated in two ways: (i) A lump sum transfer to private household, and (ii) labour cost reduction. A noticeable growth in employment was observed with negative growth in carbon emissions when recycling was carried out through labour cost reduction.
Bach et al. (2002)	This study used data from 58 industries in Germany to simulate the carbon emission and employment data in the period of 1999–2010.	The PANTA RHEI multi-sector econometric simulation and forecast model and the LEAN two-region empirical general equilibrium model were used.	Using green tax revenue to cut employers' pension contributions led to a 2% decrease in carbon emissions and an increase of 0.1-0.6% in employment, creating an additional 250,000 jobs by 2010.
Pollitt et al. (2014)	Twelve different scenarios of denuclearisation in Japan were analysed. An extensive time series database from 1970–2010 was used to calibrate the simulation.	The global E3MG macro-econometric model was used.	Denuclearisation and a shift towards renewable energy, coupled with GTR did not reduce GDP. In addition, it induced a slight increase in employment and reduced carbon emissions, therefore entailing EDD.
Bosello and Carraro (2001)	Data from 15 EU countries was used to evaluate different policy suggestions.	An econometric model titled WARM was used.	It is possible to gain EDD only in the short term, which depends on a trade-off between environmental and employment dividends. EDD is amplified when: (i) Financial recycling includes both skilled and unskilled workers compared to incorporating just unskilled ones; (ii) a cooperative policy adopted by EU countries resulted in greater benefit over a non-cooperative policy.
Manresa and Sancho (2005)	The effect of green tax on energy goods and the subsequent impact on pollution and employment was measured under a revenue neutral assumption in the Spanish economy. Simulations were conducted under a range of policy scenarios. Baseline data was calibrated from a 1990 SAM of Spain.	A static applied general equilibrium model of Spain was used.	Empirically, it is possible to attain EDD by reducing payroll taxes. However, the study found that revenue neutrality of GTR is essential but not always sufficient to create EDD.
André et al. (2005)	The model used data from 24 productive sectors in Andalusia, Spain and simulated four different policy combinations based on the 1990 input output table of Andalusia.	A static CGE model of Spain was used.	The study showed that reducing payroll taxes using the revenue generated from taxing CO_2 or SO_2 emissions creates EDD. However, the same cannot be achieved by reducing income tax.
Conrad and Löschel (2005)	The model covered seven different sectors and two primary factors of production in the German economy.	An applied general equilibrium analysis with GEM-E3 model was used.	The potential of EDD was documented when the simulation was based on the market price of labour. However, the same did not apply when the simulation was based on the user cost of labour.

(Contd...)

Table 1: ***(Continued)***

Study	Data	Method/s applied	Major finding/s
Saveyn et al. (2011)	This study analysed the economic significance of the Copenhagen Accord by simulating various climate scenarios up to 2020 for selected developed and developing countries, keeping the EU as the main focus. The model used the GTAP 7 database for the year 2004.	The general equilibrium model, GEM-E3, was used.	The study showed the futility of grandfathered cap-and-trade (C&T) scheme in yielding EDD. Different combinations of auctioned permits in C&T exhibited some EDD potential in the EU. However, the reduction in employees' social security contributions, driven by GTR performed best for employment and GDP when compared to all other alternatives.
Welsch and Ehrenheim (2004)	Input-output tables for the EU and Germany in the year 1995 formed the core database. Financial recycling was incorporated by imposing an additional excise tax on energy carriers and lowering employers' contributions to pension funds.	A dynamic general equilibrium model of the EU, LEAN_2000, was used.	Simulation results showed that moderate EDD with minimal effect on GDP can be achieved through GTR. However, if the initial growth in employment causes an increase in wage claims, employment dividend diminishes over time and GDP is negatively affected.
Bardazzi (1996)	Input-output data from Italy in the year 1993 was used as the simulation database.	An input-output model of Italy, INTIMO, was used.	A cut in SSC, financed by an increase in energy tax, VAT, and an alternative tax on a firm's value were simulated. The effect of this on the environment was not measured in this study, but marginal growth in employment in all three scenarios was observed.
Bach et al. (1994)	Input-output data from West Germany in the year 1988 was used as the base scenario.	A macroeconomic model, DIW, was used.	Simulation results depicted a significant reduction in carbon emissions coupled with employment growth.
Carraro et al. (1996)	Time series data from 1978–1989 from six EU countries (Germany, Italy, the UK, Spain, the Netherlands and France) comprised the core database.	Econometric general equilibrium model, WARM, was used.	The simulation results exhibited EDD in the short term but was disputable in the long term.
Barker and Köhler (1998)	Coordinated, uncoordinated, and unilateral strategies to decrease CO_2 emissions by 10% in all EU member states by 2010 were compared with unilateral policies in each member state using time series and cross-sectional data from the period 1968–1993.	This study used the E3ME econometric model.	With a multi-lateral EU co-ordinated excise duty, it was possible to yield EDD. The GTR must stay revenue-neutral, reducing employers' SSC through financial recycling.
Holmlund and Kolm (2000)	A hypothetical scenario with two sectors (tradeable and non-tradeable), where all firms use labour as well as an imported polluting factor (energy) for production were analysed.	A general equilibrium approach was used.	A switch from labour taxes to energy taxes had the potential to increase employment. However, the effect on overall welfare was ambiguous as simulation results showed a marginal decrease in real GDP.
Barker et al. (1993)	Estimated net use of energy in the UK in 1991, taken from the digest of UK energy statistics provided the backbone of the database was used.	The macroeconomic model, HERMES, was linked to the energy model, MIDAS, to create an operational multi-model system.	The revenue recycling approach of GTR (lowering VAT and personal income taxes) was analysed. The study exhibited an overall reduction in carbon emissions accompanied by growth of 0.2% in GDP from baseline with marginal growth in employment.
Jansen And Klaassen (2000)	The study used three different models to simulate the impact of a proposed 1997 EU energy tax. Fuel consumption data from 1997 was used as the baseline scenario and was compared with simulation results from 2005 to measure the impact of the shock.	Two econometric models, HERMES and E3ME, and one dynamic general equilibrium model, GEM-E3, were used.	The study showed that the proposed tax increase of 10–25% on mineral oils in EU countries had a positive impact on both GDP and employment with a reduction in CO_2 emissions of 0.9-1.6%.
Mabey And Nixon (1997)	The effect of environmental taxes on employment, energy consumption, and GDP were compared from two econometric models. These supply-side econometric models were constructed based on quarterly adjusted time series data from the UK in the period of 1965–1992.	Two supply-side econometric models, EGEM and SLEEC, with two of EGEMs extensions (EGEME and EGEMX).	Both supply-side models exhibited the efficacy of environmental taxes in curbing energy consumption and carbon emissions. However, EDD was found in the results driven from the EGEM model and its extensions. A marginal triple dividend (increased GDP) was documented when recycling was achieved

(Contd...)

Table 1: ***(Continued)***

Study	Data	Method/s applied	Major finding/s
			by reducing SSC compared to reducing personal income taxes.
De Mooij and Bovenberg (1998)	The study encompassed a hypothetical European economy. However, the calibration of the study included empirical information driven from various econometric studies concerning European economies.	The model was based on a small European economy that had two separate versions. The assumption for one is that capital is perfectly mobile internationally, whereas the other keeps capital fixed across boundaries.	Simulation results showed the potential of EDD, especially when capital was immobile. Capital immobility is a short-term phenomenon. Therefore, the study demonstrated the short-term EDD potential of GTR.
Roson (2003)	The 1997 Italian SAM, which was updated from the 1990 SAM through maximum likelihood estimation made up the base year data for the model.	A dynamic general equilibrium model of the Italian economy was used.	The study demonstrated that a reduction in labour taxes with the revenue generated from carbon taxes can be counterproductive and could increase unemployment, disapproving the existence of EDD in the Italian economy.
Bossier and Bréchet (1995)	The study analysed the impact of EC tax across six EU countries. The study measured the impact of a tax cut by reducing the SSC of the employer, using the revenue generated from carbon/ energy tax.	A top-down macroeconometric model, HERMES, was used.	Strong evidence for EDD was documented, simultaneously increasing employment while reducing carbon emissions.
Felder and van Nieuwkoop (1996)	Household data categorised into six different classes based on income, and 41 industrial sector data of Switzerland of 1990 comprised the core database.	A large-scale static general equilibrium model of Switzerland was used.	GTR increased welfare, even in the absence of any strong environmental dividend. The study also demonstrated that any distributional inefficiency of GTR can be repealed by lowering other distortionary taxes.
Vandyck and van Regemorter (2014)	IO tables, regional and national government accounts, household accounts and employment data from Belgium in the year 2005 were used as the base scenario.	A regional CGE model from Belgium, which is largely based on GEM-E3 was used.	Two different scenarios were analysed in the simulation: Recycling of energy tax revenue through a lump sum transfer, and a reduction in SSC. The latter proved to be EDD conducive at both a regional and a national level.
Markandya et al. (2013)	The database was composed of an IO table, environmental satellite accounts, and energy balance sheets from Spain in the year 2005. It also included the contribution of labour markets to the shadow economy.	A static multi-sector general equilibrium model from Spain was used.	Three different recycling approaches were modelled: SSC, CT, and LSTH. One of the key contributions of this study is that it considered the shadow economy as a key contributor to the double dividend hypothesis and overall found strong evidence for EDD.
Ciaschini *et al*. (2012)	A bi-regional SAM from Italy in the year 2003 provided the core data. The study was designed to analyse the impact of a progressive green tax on the regional economy.	A static bi-regional CGE model of Italy was used.	Two different tax reductions (PIT and Italian regional production tax) as a means of financial recycling of tax revenue were analysed. Regional EDD was observed. However, as an aggregate, employment growth was negative.
Sahlén and Stage (2012)	The model used SAM from Namibia in the year 2004 as the primary database.	The model was based on the generic CGE model created by the International Food Policy Research Institute (IFPRI) for developing countries.	Three types of revenue recycling mechanisms (VAT reduction, LSTH, and unskilled labour subsidy) under five scenarios were used to test the possibility of a triple dividend (lower emissions coupled with increased GDP and employment). A reduction in VAT as a means of recycling showed the highest potential to achieve a triple dividend.
Lee et al. (2012)	The core database consisted of time series data, covering the period 1970–2008. The baseline scenario was scaled to the policies of World Energy Outlook, 2010.	The E3MG global macro-econometric model was used.	The simulation was designed to observe the macroeconomic effects of carbon taxes in Japan that are intended to cut the carbon emissions by 25% by 2020, compared to the levels in 1990. The study shows if tax revenues are recycled effectively, it can yield EDD.

(Contd...)

Table 1: *(Continued)*

Study	Data	Method/s applied	Major finding/s
O'Ryan et al. (2005)	The database was created from the 1996 Chilean SAM.	A static CGE model, ECOGEM-Chile, was used.	Six types of environmental taxes and recycling policies were simulated. The study focused on taxing three air pollutants (PM10, SO_2 and NO_2) and the simulation results demonstrated that taxing PM10 results in the highest environmental dividend compared to the other two. The study also showed that LSTH as a method of tax revenue recycling is economically beneficial and enhances social utility.
Mirhosseini et al. (2017)	A 2006 SAM of the Iranian economy was used as the database.	A static CGE model of Iran was used.	Three types of revenue recycling policies (LSTH, CT, and SSC) were analysed to evaluate the DD potential of GTR in Iran. The study also incorporated the shadow economy in its modelling approach. A GTR involving labour tax reduction generated noticeable EDD.
(Bor and Huang, 2010)	For simulations, the study included data from 21 industries and 48 commodities, taken from the 2001 IO table of Taiwan.	A dynamic CGE model of Taiwan, EnFore-CGE, was used.	Six recycling scenarios of energy tax revenues were analysed. All scenarios proved to be counterproductive in yielding EDD and exhibited negative growth of employment.
Van Heerden et al. (2006)	The database was based on 1998 Sam of South Africa.	A static CGE model of South Africa, based on the ORANI-G model, was used.	Four tax policies (carbon tax, fuel tax, electricity tax, and energy tax) along with three different recycling schemes (VAT, direct tax, and food tax) were analysed to search for triple dividends. A triple dividend of economic growth, poverty alleviation and a reduction in emissions were observed when a reduction in food tax was used as a means of revenue recycling. The study also demonstrated EDD potential.
Liu and Lu (2015)	The database was based on the 2007 SAM of China which covered 137 industries.	A dynamic CGE model of China, CASIPM-GE, was used.	Carbon tax was recycled using two scenarios of production tax and consumption tax reduction in China. The study identified the effectiveness of carbon tax in China in curbing emissions, however no EDD was found. Rather, an adverse impact on employment under was observed in both scenarios.

GDP: Gross domestic product

Table 2: CO_2 emissions reduction in European and non-European countries

All results		European countries		Non-European countries	
N	95	N	75	N	20
Mean±SD	−5.46511±5.4122%	Mean±SD	−5.249936±4.9056959%	Mean±SD	−6.272025±7.0937374%

SD: Standard deviation

period of study, tax type, and tax recycling method. Results from European and non-European countries are compared for a deeper understanding of the significance of the study region. Model type is grouped between general equilibrium model (GE), macroeconomic model (M) and input output model (IO). Time period of study is categorised between short term[2] and long term[3]. Tax type includes tax based on carbon emissions (CO_2), tax proposed by the European Community (EC), tax based on use of energy products (E) and other taxes which includes various types of mixed taxes. Tax recycling method is classified into SSC, value added tax (VAT), personal income tax (PIT), lump sum transfer to household (LSTH) and other recycles.

3.1. Environmental Dividend

The environmental dividend is measured using carbon emissions data. The simulation results demonstrate a reduction of emissions compared to the baseline scenario, highlighting the possibility of the environmental dividend, often referred as the first dividend. Table 2 shows the results of 95 simulations, categorised between European and non-European countries. The average emissions reduction of -5.46511% across all regions and the frequency

2 Simulation duration is 10 years or less.
3 Simulation duration is more than 10 years.

distribution shown in Figure 1. strongly evidence the first dividend. Even though the simulations concerning GTR and EDD are from non-European countries that have measured the emissions reduction are very limited in number compared to those from European countries, the average results are very similar.

3.2. Employment Dividend

A positive change in employment compared to the baseline scenario evidences the employment (second) dividend. Table 3 presents the employment results, categorised according to the European and non-European contexts. The results show that the employment dividend is more prominent in European countries compared to non-European countries. Figure 2 groups the simulation results of the analysis of the positive and negative employment effects across the two contexts. 77.31% of the simulation results coming from European countries demonstrate a positive employment effect, while for non-European countries, the statistic is only 55.10%. The simulations, however, use a wide range of different models and model assumptions. Therefore, understanding the country-specific results on the employment effect requires further exploration.

3.3. Subgroup Comparisons

The performance of GTR is affected by the country of study, but there are several other moderator variables that can greatly influence the simulation outcomes. Table 4 presents the average employment effect, categorised according to the European and non-European contexts, which is then further categorised according to the model type, time period of study, tax type, and tax recycling method. The comparison shows some stark differences across country groups in terms of yielding the employment effect.

Figure 1: Frequency distribution of 95 different simulations that measured the reduction of carbon emissions compared to the baseline scenario

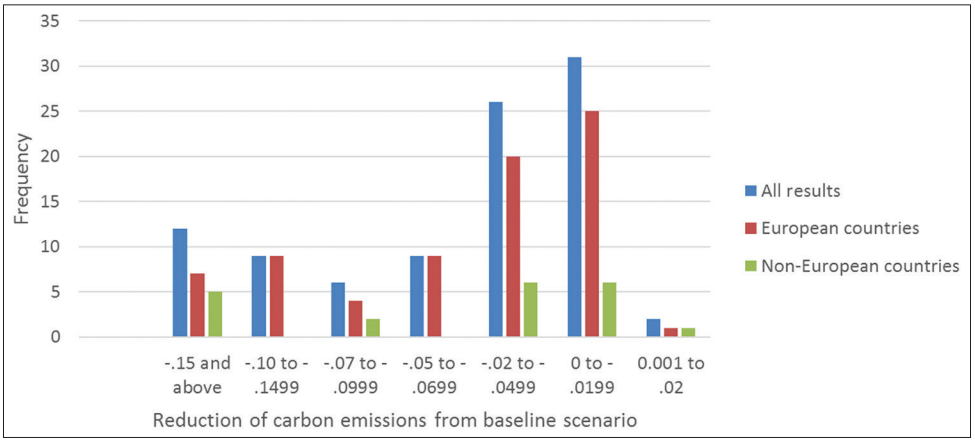


Figure 2: Impact on employment: 146 simulations results grouped based on the employment effect across the two geographic contexts

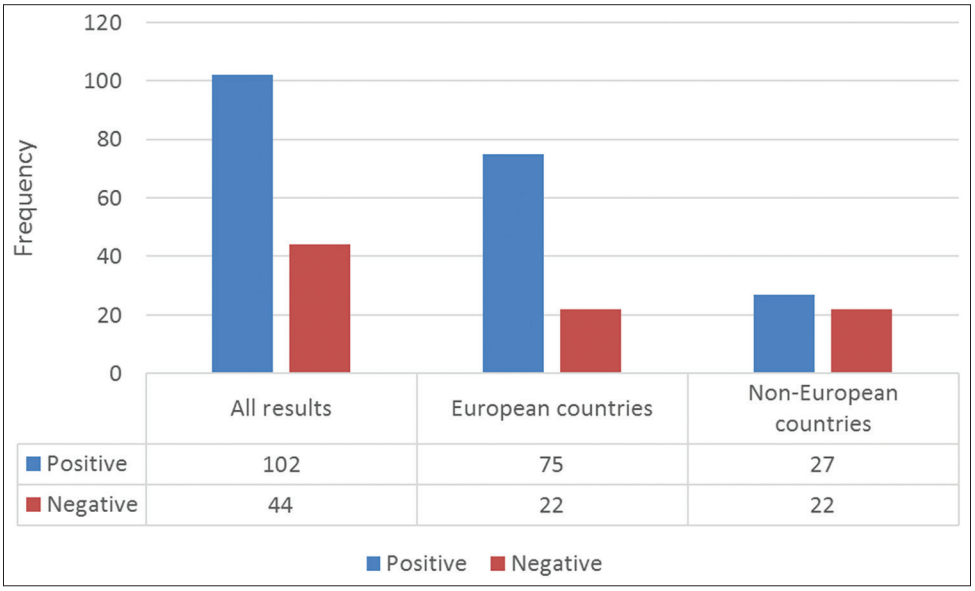


Table 3: Employment changes in European and non-European countries

All results		European countries		Non-European countries	
N	146	N	97	N	49
Mean±SD	0.5047±1.2841	Mean±SD	0.6684±1.4380	Mean±SD	0.1806±0.8269

SD: Standard deviation

Table 4: Average employment effect, categorised between different moderator variables across European an non-European countries

Moderator variables		All countries			European countries			Non-European countries		
		N	% share	Average employment effect (%)	N	% share	Average employment effect (%)	N	% share	Average employment effect (%)
Model type	M	43	29.45	0.7057	32	32.98	0.8967	11	22.44	0.15
	IO	3	2.05	0.0533	3	3.09	0.0533	-	-	-
	GE	100	68.49	0.4318	62	63.91	0.5803	38	77.55	0.1895
Time period	Short term[4]	89	60.95	0.5172	54	55.67	0.7191	35	71.42	0.2058
	Long term[5]	57	39.04	0.4851	43	44.32	0.6046	14	28.57	0.1178
Tax recycling method	SSC	68	46.57	1.0775	58	59.79	1.0805	10	20.40	1.06
	LSTH	14	9.58	−0.32473	9	9.27	−0.4584	5	10.20	−0.0840
	PIT	23	15.75	−0.0145	13	13.40	−0.1494	10	20.40	0.1610
	CT	6	4.10	−0.5589	5	5.15	−0.4707	1	2.04	−1
	VAT	12	8.21	0.9388	7	7.21	1.6231	5	10.20	−0.0191
	Other recycles	23	15.75	−0.1137	5	5.15	−0.1550	18	36.73	−0.1022
Tax type	CO_2 tax	50	34.24	0.4637	34	35.05	0.6781	16	32.65	0.0081
	EC tax	22	15.06	0.6296	22	22.68	0.6296	-	-	-
	E tax	47	32.19	0.3642	28	28.86	0.5293	19	38.77	0.1211
	Other taxes	27	18.49	0.7232	13	13.40	1.008	14	28.57	0.4587

The first comparison concerning the model type demonstrates a reasonable level of homogeneity. In European countries, the use of the M model yields a higher employment effect than the GE model. It is difficult to comment on the performance of the IO model due to an insufficient number of observations. The opposite trend is observed in non-European countries, where GE models yield simulation results, with higher employment changes than the baseline. majority of the research employed GE modelling as the primary method and used simulation to underpin the impact of GTR on carbon emissions and employment in mid to long term. Model design and model specification greatly influence the result.

The duration of the simulations also presents an analogous outcome. Both European and non-European countries demonstrate a higher employment effect in short-term simulations than in long-term simulations. It is beyond the scope of this paper to investigate the reason for this phenomenon. A time series analysis of the employment effect is presented in a separate section that further discusses the employment effect over time.

A significant portion (59.79%) of the simulations from European countries use SSC as the method of tax recycling, which generates an average employment growth of 1.08% compared with the baseline scenario. However, we find a reduction in VAT generating the highest employment effect (1.62%) among all the different tax recycling methods. The remaining tax recycling methods, such as LSTH, PIT, CT, and other tax recycling methods yield a negative employment effect; therefore, they are counterproductive for EDD. Simulations from non-European countries also exhibit similar outcomes. However, instead of VAT reduction, reduction of PIT yields a marginal positive employment effect (0.16%) along with SSC (1.06%). In both European and non-European countries, tax recycling through the reduction of SSC results in a strong employment effect, which is already noted in the literature on this topic (Bosquet, 2000, Patuelli et al., 2005). However, the notable feature of our observations is the efficacy of VAT reduction in European countries and PIT reduction in non-European countries in creating the employment dividend.

The performance of different tax types shows that other taxes, which includes various mixed taxes, taxes on fossil fuels, and electricity, has the highest potential for generating the employment effect in both European and non-European countries. Tax based on CO_2 emissions performs noticeably better in creating the employment dividend in European countries compared to non-European countries. EC tax also demonstrates its efficacy in European countries, followed by E tax. However, in non-European countries, E tax performs significantly better than CO_2-based taxes in creating the employment effect.

3.4. Time Series Analysis of Employment Effect

Our core database had 20 dynamic simulations, which report the annual employment effect over a time horizon. This allowed us to observe the annual employment change intertemporally. The simulation results for all 20 dynamic studies are presented in Table 5. We identified a weak quadratic pattern with a goodness of fit of 8% (Figure 3). The figure shows a diminishing employment effect over time. However, a second round of accelerating employment growth was observed from year nine.

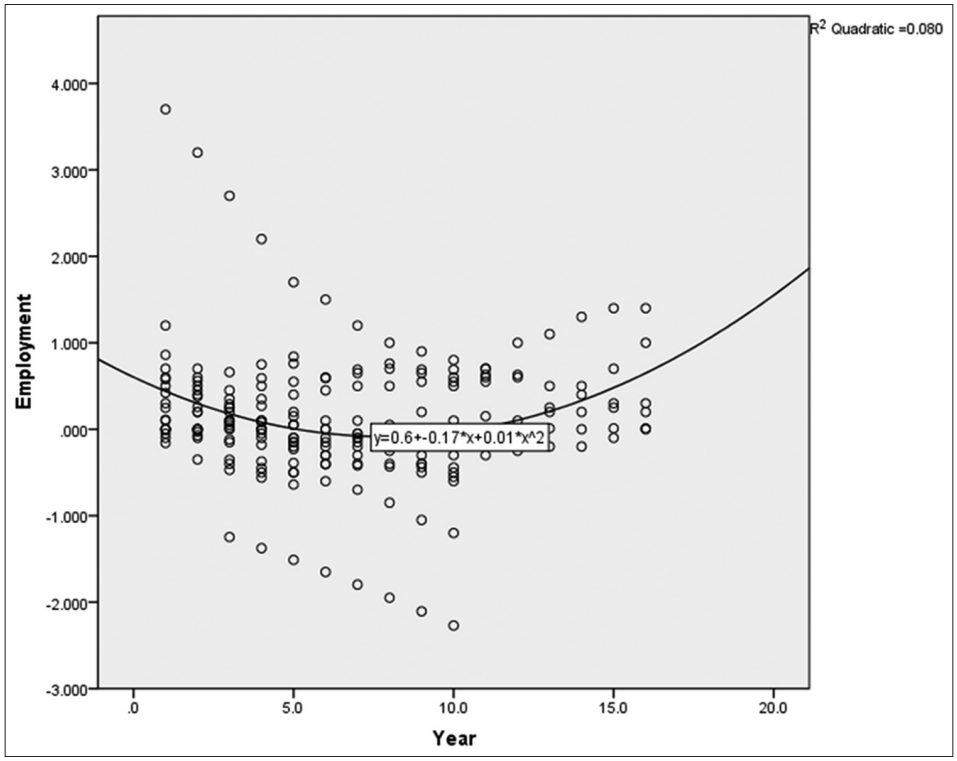
Understanding the trend of employment dividends on GTR and scaling the employment effect is considerably difficult. Any post-hoc measure of policy effectiveness is likely to be masked by a false effect of numerous exogenous macroeconomic variables. According to the post-hoc study of Lawn (2006), who measured the effectiveness of GTR-driven EDD in four European countries, neither employment nor environmental effect was noteworthy. The study also reported a marginal increase in CO_2 emissions. Such observations are inadequate to prove or disprove the effectiveness of GTR as there are numerous other factors that can be accounted for when considering the changes in employment and the emissions during the observed years. A more objective approach would be to observe the simulation results from the economic models that are

4 Simulation duration is 10 years or less.
5 Simulation duration is more than 10 years.

Table 5: Intertemporal employment effect

Study	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16
(Welsch and Ehrenheim, 2004)	0.86	0.38	0.29	0.59	0.76	0.59	0.69	0.76	0.69	0.69	0.63	0.63				
(Bor and Huang, 2010)	0	0	0.05	0.1	0.15	0.1	0.1	0.05	−0.05	−0.1						
	0	0	0.1	0.1	0.05	0	−0.05	−0.2	−0.4	−0.55						
	0	0	0.08	0.08	0.05	0	−0.05	−0.2	−0.4	−0.5						
	0	0	0.02	−0.05	−0.15	−0.1	−0.1	−0.25	−0.5	−0.6						
	0	0	−0.15	−0.45	−0.5	−0.6	−0.7	−0.85	−1.05	−1.2						
(Carraro et al., 1996)	3.7	3.2	2.7	2.2	1.7	1.5	1.2	1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2
	1.2	0.7	0.2	0	−0.2	−0.3	−0.3	−0.2	−0.1	−0.1	−0.02	0	0.25	0.5	0.7	1
	−0.1	−0.1	−0.4	−0.5	−0.5	−0.4	−0.2	0	0.2	0.5	0.7	1	1.1	1.3	1.4	1.4
	0.5	0.4	0.1	0	−0.1	−0.2	−0.15	−0.1	−0.05	0	0	0.01	0.01	0	0.01	0.01
	0.7	0.6	0.25	0	−0.1	−0.3	−0.4	−0.4	−0.3	−0.3	−0.3	−0.25	−0.2	−0.2	−0.1	0
	0.3	0.2	0	−0.1	−0.15	−0.15	−0.1	0	0	0.1	0.15	0.1	0.2	0.2	0.25	0.3
(Roson, 2003)	−0.051	−0.072	−0.352	−0.372	−0.39	−0.407	−0.42	−0.432	−0.439	−0.443						
	0.247	0.257	−1.247	−1.376	−1.511	−1.651	−1.797	−1.949	−2.106	−2.27						
(Pereira and Pereira, 2014)	−0.16	−0.35	−0.47	−0.56	−0.64											
	0.58	0.45	0.35	0.27	0.2											
	0.11	−0.03	−0.12	−0.18	−0.23											
	0.42	0.56	0.66	0.75	0.84											
(Bach et al., 2002)	0.6	0.5	0.45	0.5	0.55	0.6	0.65	0.7	0.65	0.6	0.6					
	0.1	0.2	0.25	0.35	0.4	0.45	0.5	0.5	0.55	0.55	0.55					

Figure 3: Employment effect over time



specifically designed to quantify any underlying changes resulting from policy shock, while keeping everything else constant.

The observed trend in annual changes in employment had two salient features. First, we discerned a strong downward trend and a diminishing employment effect. Anger et al. (2010) showed a negative relationship between environmental regulation stringency and the employment dividend. The stricter the environmental tax policy, the greater the reduction in emissions, but employment dividend was diminished. According to De Miguel and Manzano (2011), a sudden and rapid increase in environmental taxes can be counterproductive and should be introduced gradually. A gradual introduction of environmental taxes and a systematic surge in the stringency of the tax burden to reach closer to the Pigouvian level explains the diminished effect on employment.

The long-term effect of environmental tax on employment and on the overall economy is complicated and is subject to opposing views. According to Bosquet (2000), employment dividend diminishes in the long term. However, according to Tetsuo (2003),

environmental tax renders two competing effects on long-term economic growth. The positive effect comes from the improved environmental quality, bequeathed for the next generation, and if the optimal level of tax is maintained, it can require long-term economic growth including employment. In our observation, a diminishing pattern exists. The second round of accelerating growth in the data requires further investigation to identify the reasons behind it.

4. CONCLUSIONS

This paper reviewed the existing literature concerning GTR and EDD and found substantial empirical evidence across European and non-European countries. With a mixture of well-designed policies, it is possible to entail EDD through GTR. However, the tax rate and the revenue recycling processes are crucial. The revenue neutrality of GTR is preferred but is not guaranteed to result in EDD. An internationally coordinated and uniform GTR is required to introduce the desired effect. Otherwise, carbon leakage can prevent the potential benefits of GTR. To achieve EDD, it is imperative to partially shift the tax burden of labour to other income groups.

The simulation results support the possibility of generating EDD across European and non-European countries. However, the tax and tax recycling methods are sensitive to the country under study. A universal policy across European and non-European countries may not bring optimal results.

The employment effect of GTR diminishes in the short term but is ambiguous in the long term. It is possible for the diminishing employment effect to reverse and experience subsequent growth in the long term as the simulation results show a weak quadratic pattern. Further investigation is required to understand this phenomenon and to prescribe practical guidelines.

There are several areas where more research is needed to make the benefits of GTR and EDD more apparent. First, the positive impact of GTR on labour has been researched, but the impact of an improved environment that may result from a successful reform is yet to be addressed. Second, despite the empirical evidence in favour of EDD, GTR has struggled to gain wider public acceptance. Qualitative research is required to gain in-depth knowledge on what policies can render GTR more socially acceptable. Third, how to broaden the scope of green taxes is an important concern. Currently, the primary focus is on carbon emissions. However, a myriad of other forms of environmental pollution are overlooked and should be considered in the context of green taxes.

Simulation results aid in policy making but should not be used as a comprehensive guideline across different regions. Country-specific studies are necessary to understand the connection between GTR and different macroeconomic factors to understand the effect on employment. The long-term effect of GTR on employment is also dubious. Our observations reveal that secondary growth of diminishing employment is possible in the long term, but further exploration is needed.

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