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Environmental fiscal reform and the possibility of triple dividend in European and non-European countries: evidence from a meta-regression analysis

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Environmental fiscal reform and the possibility of triple dividend in European and non-European countries: evidence from a meta-regression analysis

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Abstract

We present a synthesis of simulation studies concerning green tax reform (GTR) in European and non-European countries. The GTR performance is analysed in a triple dividend (TD) context including the reduction of carbon dioxide (CO_2) emissions (first dividend), increased GDP (second dividend), and higher employment (third dividend). Our findings are fourfold: (i) there is high TD potential, with stronger evidence for second and third dividends in European countries; (ii) a reduction in labour tax is the most potent GTR policy measure to entail TD; (iii) TD evidence is stronger when mixed tax and tax recycle policies are employed; (iv) taxes based on CO_2 emissions exhibit the highest TD potential.

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JEL classifications: H23, O44, Q58

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1. Introduction

The double dividend (DD) prospect of environmental tax reform (ETR), also known as green tax reform (GTR), is a well-researched topic (see Patuelli et al., 2005, Anger et al., 2010, Maxim et al., 2019). GTR is referred to as a tax reform that proposes a reduction in the tax burden on factors of production, at the cost of new or higher taxes on environmental polluters. The DD hypothesis stems from the notion that a GTR can not only deliver environmental dividends but can also include economic benefits. The environmental dividend is achieved through a reduction in the emission of greenhouse gases (GHGs), as is widely accepted in contemporary literature (Aldy and Stavins, 2012). Albeit, an initial concern related to GTR was that lower energy consumption may lead to lower production, and that the environmental benefit may come at the cost of economic growth. However, we now know that GTR can spur innovation in energy efficiency and in the sector of renewable energy (RE), which can address economic concerns and deter loss of economic growth (Stern and Stern, 2007). In addition, recycling of tax revenue raised through GTR can entail further economic benefits, depending on the particular revenue recycle policy. This has been the mainstay of the DD hypothesis (Tullock, 1967), and numerous types of revenue recycle schemes, and various forms of economic dividends of GTR have been studied over the past few decades in this regard (see Pearce, 1991, Morris et al., 1999, Garbaccio et al., 1999, Jorgenson and Wilcoxen, 1993).

Further evolution of the DD prospect of GTR includes the potential for generating triple dividend (TD). The commonly used parametric definition of DD has been linked to the environmental benefits arising from lower emissions and further welfare benefits, driven by revenue recycle schemes (Giménez and Rodríguez, 2010). However, there is no structured definition for TD; to date, it has been measured in numerous ways by different researchers. Pereira and Pereira (2014) measured TD as an improvement in employment and GDP, along with a reduction in GHGs emissions. Van Heerden et al. (2006) defined the third dividend as poverty reduction, alongside increased GDP and reduced emissions. Bovenberg and Van der Ploeg (1998) took a similar approach, where employment and an increase in income were considered as the second and third dividends, respectively.

The literature on GTR-driven DD is relatively rich, but existing research on TD is scarce. In this meta-regression paper, we attempted to address this gap by presenting a holistic overview of the existing research findings, in order to measure the possibility of yielding a GTR-led TD. In our paper, we used the definition of TD provided by Bovenberg and van der Ploeg (1996), where a cleaner environment (reduction in emissions), a rise in overall consumption (increased GDP), and growth in private (employment growth) are defined as the three possible dividends of GTR. In this paper, we label these as the first (reduction of CO_2), second (GDP), and third (employment) dividends of GTR, respectively. Furthermore, we also categorise our database between European and non-European countries. The purpose of doing so was to observe whether there was any noticeable difference between the two regions in terms of responding to policy measures.

Our findings can aid policy makers in optimizing the GTR policies by making them suitable for the country in question based on its location. A number of noticeable differences between European and non-European studies have already been reported in a double dividend context (see Maxim and Zander, 2019, Maxim et al., 2019), and the present study was conducted with the aim of discovering whether such differences also exist for TDs. In addition, the existing literature of meta-analyses on GTR (see Patuelli et al., 2005, Maxim et al., 2019) is primarily focused on the third dividend (employment). The dataset of Patuelli et al. (2005) includes studies prior to the year 2000. Most of the non-European studies are published after the year 2000 and follow in the footsteps of European studies. Our updated dataset includes all those relevant simulations. On the other hand, both the works of Maxim et al. (2019) and Maxim and Zander (2019) primarily focus on employment, and only in a very limited way on CO_2 emissions. The novelties in our study are the inclusion of a third dividend (GDP) and a statistical analysis that includes all three dividends (employment, GDP and CO_2 reductions). In our study, we used a multivariate analysis to include all three dividends

[2] A rise in employment level generates a first-order effect on private welfare because change in employment is a short run phenomenon and real wage is rigid in the short run. Real wage stringencies cause a gap between the actual wage and the reservation wage which yields the private welfare and it increases when employment level goes up.

as separate dependent variables. Hence, this is the first meta-regression paper of its kind to quantify the impact of GTR in a TD context. Additionally, in this paper, we critically analyse the performance of the second dividend (GDP) across European and non-European countries. Our initial hypothesis was that there would be differences across regional groups, as the economy and environmental policies in European countries are more coherent, this due to the strong presence of both the European Union (EU) and the European Environment Agency (EEA).

The paper is organised as follows. Section 2 presents the database summary and an overall survey of the dataset applied in this study. Section 3 exhibits all the statistical analyses we conducted to perform the meta-analysis and reports the results. Section 4 provides concluding remarks and summarises the key findings.

2. Database summary and exploration

2.1 The available data

Our database comprised 152 economic simulation results taken from 34 different studies. We used the same database as in Maxim et al. (2019), with the inclusion of six additional simulation results from Pereira et al. (2016)[3]. All simulation results were categorised between European and non-European countries, based on the region of study. This is referred to as the 'country variable' throughout this paper. Furthermore, simulation results are also categorised between simulation characteristics such as tax type, model type, recycling method, and time period of the study. Tax type is categorised as: (i) CO_2: tax based on the emissions of CO_2 gases; (ii) EC tax: tax proposed by the European community; (iii) energy tax: tax based on the use of energy products; (iv) other taxes, which predominantly include mixed taxes. Model types are segregated as: (i) GE: general equilibrium model; (ii) M: macroeconomic model; (iii) I/O: input-output model. Under time period, simulations of 10 years or less are considered short-term, while the rest are classified as long-term studies. Finally, recycling tax revenue methods are categorised as: (i) SSC: a reduction in employer's social security contribution, payroll taxes, or any other form of labour tax; (ii) LSTH:

[3] Full database in Appendix A1.

lump-sum transfer to household/industry; (iii) PIT: personal income tax; (iv) CT: capital tax; (v) VAT: value added tax; (vi) other recycles. To ensure the authenticity of our data, we only used simulation results published in peer- reviewed journal articles, indexed in the SCOPUS database.

2.2 Descriptive statistics and subgroup comparisons

Table 1 presents the average of GDP, employment, and CO_2 emissions data, divided between European and non-European countries compared to the baseline scenario. The data shows triple dividend potential for both European and non-European countries, as the simulation results exhibit an average increase in GDP and employment, along with CO_2 emissions reduction. However, the overall increase of GDP and employment in European countries are noticeably larger than for non-European countries. The opposite is true for the environmental dividend of GTR, where non-European countries outperformed their European counterparts.

Table 1: Average of GDP, employment, and CO_2 emissions data across European and non-European countries compared to the baseline scenario.

Dividends of GTR	N	European countries (Mean ± SD)	N	Non-European countries (Mean ± SD)	N	All regions combined (Mean ± SD)

[4] GDP refers to the real GDP.
[5] Exchange rate or consumer price index is used as numerarie in most CGE models.

GDP	77	0.1395 ± 1.1545	49	0.0940 ± 0.6526	126	0.1218 ± 0.9871
Employment	103	0.6036 ± 1.3887	49	0.1752 ± 0.8293	152	0.4655 ± 1.2496
CO_2 emissions	81	-4.8156 ± 4.9705	20	-6.2720 ± 7.0937	101	-5.10 ± 5.4466

SD: Standard deviation

Among 126 simulation results that reported percentage change of GDP, 63.49% show positive change. The results suggest that GTR in European countries give rise to greater consumption. The breakdown of GDP performance is further elaborated in Figure 1, which shows that 70.12% of the simulation results indicate an increment of GDP in European countries, compared to only 53.06% in non-European countries.

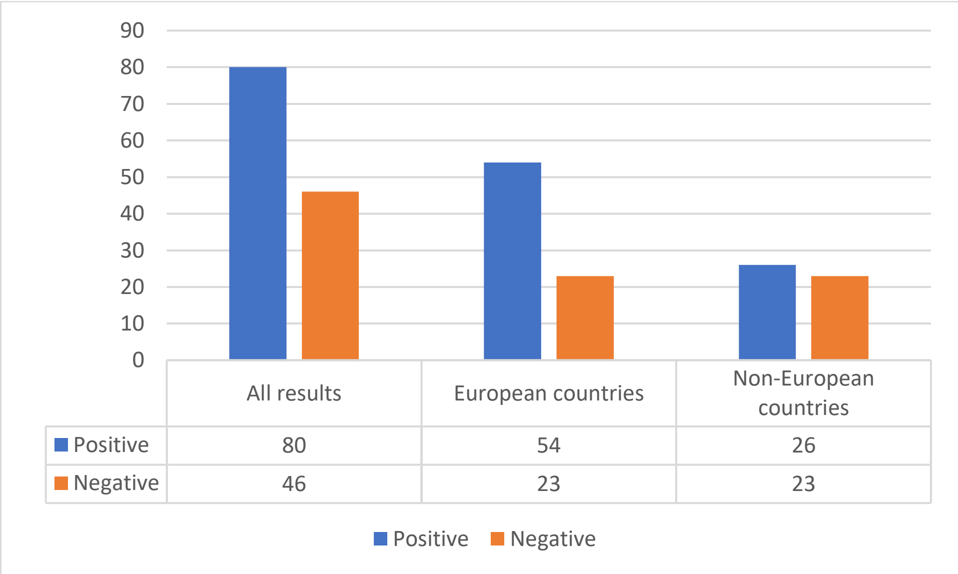

Figure 1: The impact of GTR on GDP.

When it comes to employment, we see a similar pattern. 73.73% of the simulation results for European countries show positive employment changes, which is only 55.10% for non-European countries (see Figure 2). The employment and GDP data both show similar performance across the two country groups, with European countries being the dominant performers. GTR entailing higher consumption and inducing greater employment demonstrates the nexus between real GDP and employment, which has been presented in the literature in a variety of ways (see Sawtelle, 2007, Shin, 1999).

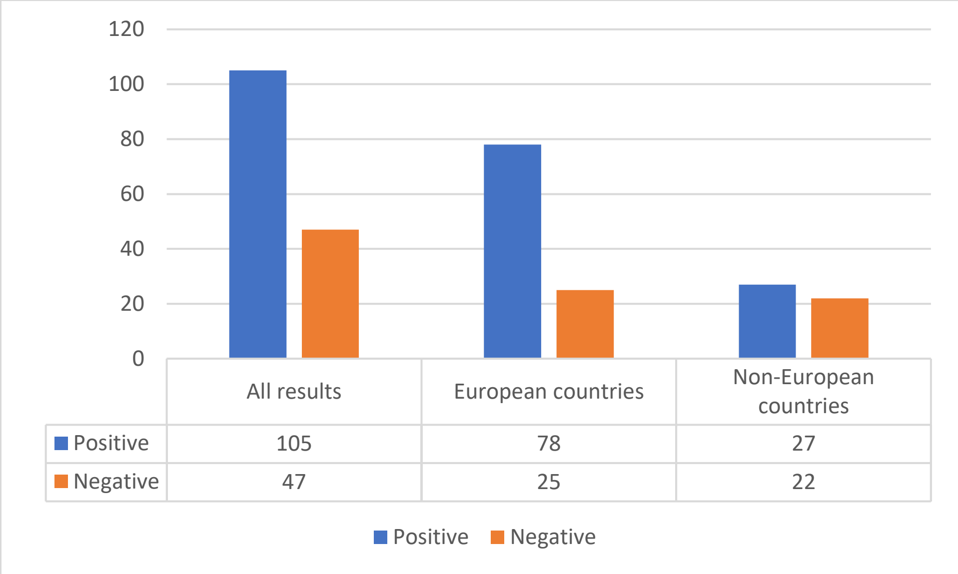

Figure 2: The impact of GTR on employment.

Regarding the environmental dividend of GTR that arises in the form of lower CO_2 emissions (see Fig.3), however, non-European countries outperformed their European counterparts in terms of emissions reduction. The average emissions reduction in non-European countries was 1.46% higher than in European countries. This negative relationship between the environmental dividend and other non-environmental economic dividends supports results presented in Anger et al. (2010).

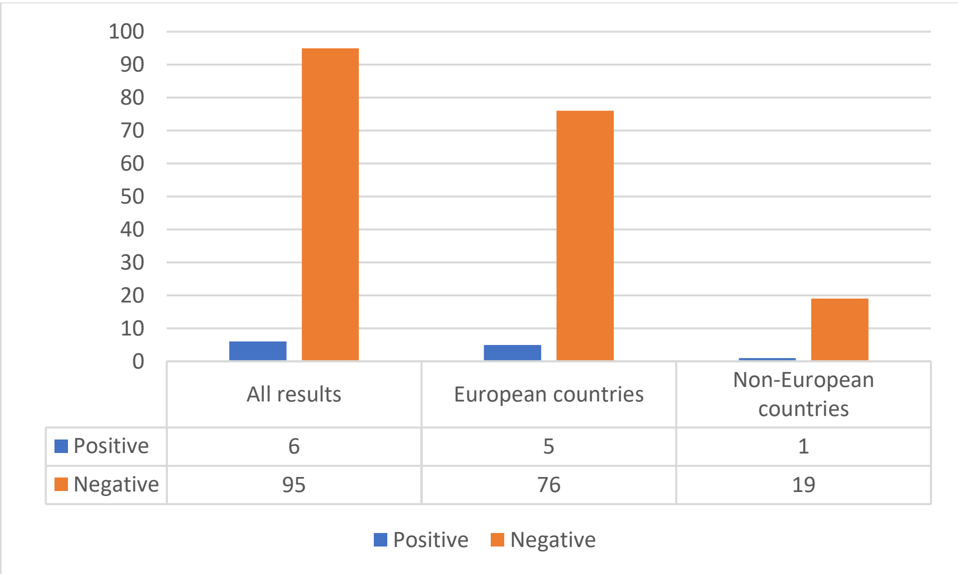

Figure 3: The impact of GTR on CO_2 emissions.

We further decompose the simulation results according to the economic models that were used to generate them. This allow us to understand the role of the economic models and whether they had caused any bias in the results.

Table 2: Simulation results of second and third dividends according to different economic models

Model type	Second dividend (GDP)			Third dividend (Employment)		
	Highest	Lowest	Mean±SD	Highest	Lowest	Mean±SD
GE	7.65	-1.71	0.08±1.13	5.97	-2.44	0.41±1.30
M	1.40	-2.87	0.21±0.69	3.19	-3.39	0.63±1.15
I/O	0.18	0.07	0.12±0.055	0.08	0.02	0.053±0.03

SD: Standard deviation

Table 2 shows that macroeconomic models generated higher means for both second and third dividends. However, the volatility of GE models was the highest; particularly, the higher estimates of some of the results generated from GE models standout uniquely in the dataset. The results driven from I/O models were the least volatile.

3. Statistical analysis

In this section, we conducted three separate statistical analyses to test the following:

1. An ordinary least square (OLS) regression with GDP as the only dependent variable to observe the impact of various simulation characteristics, including the country variable, on simulation results.
2. A multiple analysis of variance (MANOVA) with employment and GDP as the dependent variables, to test the impact of various simulation characteristics, including the country variable, on simulation results.
3. MANOVA test with employment, GDP, and CO_2 reductions as dependent variables, to test the impact of various simulation characteristics, excluding the country variable, on simulation results. Country variable was excluded due to a lack of non-European simulation results on CO_2 emissions.

3.1 GDP as the second dividend

The purpose of this analysis was to break down the second dividend of GTR and analyse its overall performance across country groups. The impact of the country variable and other simulation characteristics on the third dividend (employment) has already been tested by Maxim et al. (2019); however, no such analysis is present in the literature concerning GDP. According to Patuelli et al. (2005), the performance of GDP as a second dividend is vague and inconclusive. A survey paper by Bosquet (2000) reports the positive relationship between a reduction in employers' social security contributions (SSC) and an increment of overall consumption caused by GTR. However, there is no statistical analysis for observing the impact of country group on simulation results, or a meta-regression analysis that quantifies the impact of various simulation characteristics on deviation of GDP from the baseline.

We found equal variances when assessing GDP across two country groups (Levene's test significance 0.436), suggesting GDP, which was the dependent variable in this analysis, to be homoscedastic. Since all our moderator variables (simulation characteristics), along with the country variable were binary, we employed OLS to construct our initial model. The basic meta-regression model is as follows:

$$Y_j = \varphi + \sum_{k=1}^{N} \beta_k Z_{jk} + \sum_{k=1}^{N} \sum_{l=1}^{N} \beta_{kl} Z_{jk} Z_{jl} + \varepsilon_j$$

Here, Y is the vector of effect-size (second dividend), φ denotes the average GDP variation for average study characteristics, β_k is the meta-regression coefficient incorporating the main effect of kth study characteristic Z_k, β_{kl} is the meta-regression coefficient for interaction terms between the generic variables Z_k and Z_l, and ε_j reflects the disturbance term.

Our results show that country group had no effect on simulation results concerning GDP, and as such, there were no significant differences between European and non-European studies. The results also suggest that, with the exception of the tax recycling method, none of the moderator variables had any significant effect on GDP (see Table 3).

Table 3: Parameter estimates of OLS.

Variable	β	T	P-value
Constant	-.071	-0.630	0.530
Recycling type: SSC	0.230	2.635	0.009
Number of observations		126	
Goodness of fit		R^2= 0.053	

3.2 Testing for triple dividend with country variable as a moderator

In this part, we analyse the triple dividend potential of GTR. Due to a very limited number of simulation results concerning the first (environmental) dividend from non-European countries, we excluded CO_2 emissions data from this analysis. Nevertheless, the assumption here is that the first dividend of GTR is a stylised fact, as this association has been proven numerous times in the literature (see Bosquet, 2000, Patuelli et al., 2005, Anger et al., 2010).

With two continuous dependent variables and multiple categorical independent variables, we adopted MANOVA to test whether mean differences among simulation characteristics were significant for GDP and employment. In our database, 152 simulation results showed a percentage change in GDP or employment, or both, compared to the baseline scenario. Based on the size of this sample, we excluded all independent variables with less than 20 observations to maintain robustness[6] (Mertler and Reinhart, 2016). We also included the interaction terms between country variable and all tax type and tax recycle type variables. We then tested the dependent variables for normality. Table 4 shows the results of a Shapiro-Wiki test, while Figure 4 and Figure 5 present the histogram for both GDP and employment, respectively. The results show that both employment and GDP were non-parametric. This was expected for our meta-regression analysis, as all these simulation results were derived from different studies, with different model parameters and assumptions. This violated one of the assumptions of MANOVA, and as a result, we used Pillai's trace to interpret the multivariate results (Mertler and Reinhart, 2016).

Table 4: Test for normality, employment, and GDP.

Shapiro-Wilk			Shapiro-Wilk		
Statistic	df	Sig.	Statistic	Df	Sig.
.835	152	.000	.725	126	.000

[6] See Appendix A2.

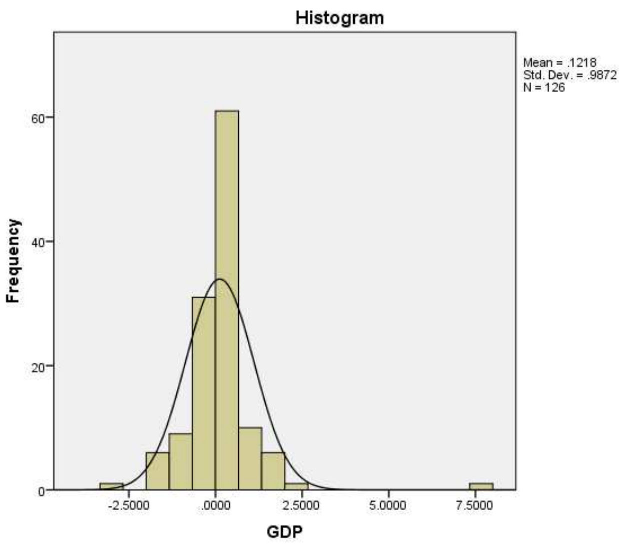

Figure 4: Frequency distribution of GDP.

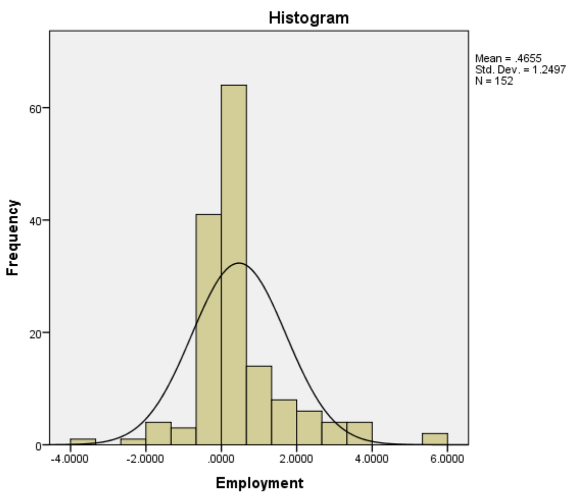

Figure 5: Frequency distribution of employment.

Next, we tested the correlation for multicollinearity, and found no multicollinearity between GDP and employment (see Table 5), as the correlation between our two dependent variables was reasonably low, and the variation inflation factor (VIF) was only 1.00.

Table 5: Correlation coefficient matrix for GDP and employment.

		Employment	GDP
Employment	Pearson correlation	1	.563
	Sig. (2-tailed)		.000
	N	152	126
GDP	Pearson correlation	.563	1
	Sig. (2-tailed)	.000	
	N	126	126

The MANOVA results show that model type: GE model (Pillai's trace = 0.068, F (2, 109) = 3.965, p = 0.02, partial η^2 = 0.068), model type: M model (Pillai's trace = 0.104, F (2, 109) = 6.357, p = 0.002, partial η^2 = 0.104), recycle type: SSC (Pillai's trace = 0.143, F (2, 109) = 9.078, p = 0.000, partial η^2 =0.143), and tax type: other taxes (Pillai's trace = 0.138, F (2, 109) = 8.747, p = 0.000, partial η^2 = 0.138), had a significant impact on the combined dependent variable of GDP and employment. Country variable, or any of the interactions between country with tax type or tax recycle type, was non-significant.

3.3 Test for triple dividend excluding country variable

In the third analysis, we tested for the triple dividend, and included all three dividends in our model as dependent variables. However, we excluded the country variable as a moderator, as well as all its interaction terms from this analysis, due to insufficient data on CO_2 emissions across the two country groups. The test of normality showed that CO_2 emissions data was non-parametric (Shapiro-Wilk df = 101, p = 0.000), as was the case for the other two dependent variables, which was expected. The correlation coefficient matrix is presented in Table 6. The correlations between the variables show no risk of multicollinearity. We also tested the VIF, which was 1.00, between CO_2 and the other two dependent variables.

Table 6: Correlation coefficient matrix for GDP and employment and CO_2 emissions.

		GDP	Employment	CO_2 emissions
GDP	Pearson correlation	1	.563	-.172
	Sig. (2-tailed)		.000	.134
	N	126	126	77
Employment	Pearson correlation	.563	1	-.137
	Sig. (two-tailed)	.000		.171
	N	126	152	101
CO_2emissions	Pearson correlation	-.172	-.137	1
	Sig. (two-tailed)	.134	.171	
	N	77	101	101

According to our results, recycle: other recycles (Pillai's trace = 0.160, F (3, 67) = 4.266, p = 0.008, partial η^2 = 0.160), recycle: SSC (Pillai's trace = 0.428, F (3, 67) =16.687, p = 0.000, partial η^2 = 0.428), tax type: CO_2 (Pillai's trace = 0.210, F (3, 67) = 5.94, p = 0.001, partial η^2 = 0.210), and tax type: other taxes (Pillai's trace = 0.218, F (3, 67) = 6.232, p = 0.001, partial η^2 = 0.218), had significant impacts on the composite variable of GDP, employment, and CO_2 emissions.

4. Conclusions

Our findings reveal that region of study is not a significant factor when it comes to the performance of GTR in a triple dividend context. We also found no significance for the country variable when testing solely for the impact of various simulation characteristics on GDP.

According to the three different analyses we conducted, SSC as a tax recycling method is indicated as being the most effective tool for generating favourable outcomes from a GTR. Our results suggest that a reduction in employers' social security contributions, or any form of labour tax cut, will not only positively induce GDP, but will also have a profound impact on the triple dividend context, irrespective of the region of study. Therefore, this policy can be equally effective in both European and non-European countries. We also found other recycling methods to have a significant impact on the combined effect of GDP and employment. Other recycles primarily comprised a reduction in food tax and a combination of various tax recycle policies. A blend of several recycling policies will therefore be more effective, compared to a single tax recycle policy for the second and third dividends.

The results also suggest that the use of a macroeconomic model along with a GE model can significantly influence the outcome of simulation results when measuring the effect on GDP and employment simultaneously. Our results conform to those of Patuelli et al. (2005) in this regard. We also observed significantly higher volatility in simulation results coming from GE models in our initial survey. The reason for this is the fact that GE models are exceptionally sensitive to the assumptions made by the modeller. Assumptions about variables, such as elasticity, time period and the relationship between different economic agents, vastly influence the results generated by the models. Future modellers should be aware of this fact and may wish to consider designing further tests to improve the robustness of simulation results.

When it comes to tax policy, other taxes, which represents predominantly mixed taxes, had a significant effect on the composite variable of GDP and employment. We also found other taxes to be significant in the third scenario, where CO_2 emissions was included in the multivariate analysis as a dependent variable. Our findings suggest that, similar to a mixed recycle policy approach, employing mixed taxes will be more conducive to giving rise to triple dividends. Additionally, we also found CO_2-based taxes to be more effective in the case of energy taxes for triple dividends when CO_2 emissions data was included in the multivariate analysis.

The initial survey we conducted of our database containing all simulation results indicates the high triple dividend potential of GTR, as all three dividends were present in the mean of our dataset. This is also supported by the findings of Barker et al. (2016). Our statistical analyses also suggest that the use of CO_2-based taxes along with a tax reform based on the reduction of labour taxes could be an effective policy measure for TD. The underlying economic reasoning for such a nexus is quite powerful. CO_2 taxes are essentially a tax on energy and increasing them results in a higher cost for running capital goods. Simultaneously, a reduction in labour taxes causes labour to become relatively cheaper than capital. Given that there will thus be a certain degree of substitution between labour and capital, there will be a proportionally higher usage of labour compared to capital for production. The substitution between labour and capital is debatable, as certain studies suggest that labour and capital are complements (see Knoblach et al., 2019, Mućk, 2017), while some studies suggest that sectoral substitution elasticity differs and that it is therefore in certain sectors that labour and capital can substitute each other (Alvarez-Cuadrado et al., 2017). This implies that the majority of the simulation results in our dataset come from models which employed production functions that allowed a certain degree of substitution between labour and capital.

Despite not finding the region of study to be a significant moderator in our statistical analyses, we observed a noticeable difference in the GTR performance of European and non-European countries in the triple dividend context in our initial survey. Future research should consider a further breakdown of the simulation characteristics to statistically identify the cause of differences in GTR performance between European and non-European countries.

References

ALDY, J. E. & STAVINS, R. N. 2012. The promise and problems of pricing carbon: Theory and experience. *The Journal of Environment & Development,* 21**,** 152-180.

ALVAREZ-CUADRADO, F., VAN LONG, N. & POSCHKE, M. 2017. Capital–labor substitution, structural change, and growth. *Theoretical Economics,* 12**,** 1229-1266.

ANDRÉ, F. J., CARDENETE, M. A. & VELÁZQUEZ, E. 2005. Performing an environmental tax reform in a regional economy. A computable general equilibrium approach. *The Annals of Regional Science,* 39**,** 375-392.

ANGER, N., BÖHRINGER, C. & LÖSCHEL, A. 2010. Paying the piper and calling the tune?: A meta-regression analysis of the double-dividend hypothesis. *Ecological Economics,* 69**,** 1495-1502.

BACH, S., KOHLHAAS, M., MEYER, B., PRAETORIUS, B. & WELSCH, H. 2002. The effects of environmental fiscal reform in Germany: a simulation study. *Energy policy,* 30**,** 803-811.

BACH, S., KOHLHAAS, M. & PRAETORIUS, B. 1994. Ecological tax reform even if Germany has to go it alone. *Economic Bulletin,* 31**,** 3-10.

BARDAZZI, R. 1996. A Reduction in Social Security Contributions: which Alternatives for Financing Coverage? *Economic Systems Research,* 8**,** 247-270.

BARKER, T., ALEXANDRI, E., MERCURE, J.-F., OGAWA, Y. & POLLITT, H. 2016. GDP and employment effects of policies to close the 2020 emissions gap. *Climate Policy,* 16**,** 393-414.

BARKER, T., BAYLIS, S. & MADSEN, P. 1993. A UK carbon/energy tax: The macroeconomics effects. *Energy Policy,* 21**,** 296-308.

BARKER, T. & KÖHLER, J. 1998. Equity and ecotax reform in the EU: achieving a 10 per cent reduction in CO2 emissions using excise duties. *Fiscal Studies,* 19**,** 375-402.

BOR, Y. J. & HUANG, Y. 2010. Energy taxation and the double dividend effect in Taiwan's energy conservation policy—an empirical study using a computable general equilibrium model. *Energy Policy,* 38**,** 2086-2100.

BOSELLO, F. & CARRARO, C. 2001. Recycling energy taxes: impacts on a disaggregated labour market. *Energy Economics,* 23**,** 569-594.

BOSQUET, B. 2000. Environmental tax reform: does it work? A survey of the empirical evidence. *Ecological Economics,* 34**,** 19-32.

BOSSIER, F. & BRÉCHET, T. 1995. A fiscal reform for increasing employment and mitigating CO2 emissions in Europe. *Energy Policy,* 23**,** 789-798.

BOVENBERG, A. L. & VAN DER PLOEG, F. 1996. Optimal taxation, public goods and environmental policy with involuntary unemployment. *Journal of Public Economics,* 62**,** 59-83.

BOVENBERG, A. L. & VAN DER PLOEG, F. 1998. Consequences of environmental tax reform for unemployment and welfare. *Environmental and Resource Economics,* 12**,** 137-150.

CARRARO, C., GALEOTTI, M. & GALLO, M. 1996. Environmental taxation and unemployment: some evidence on the 'double dividend hypothesis' in Europe. *Journal of Public Economics,* 62**,** 141-181.

CIASCHINI, M., PRETAROLI, R., SEVERINI, F. & SOCCI, C. 2012. Regional double dividend from environmental tax reform: An application for the Italian economy. *Research in Economics,* 66**,** 273-283.

CONRAD, K. & LÖSCHEL, A. 2005. RECYCLING OF ECO-TAXES, LABOR MARKET EFFECTS AND THE TRUE COST OF LABOR--A CGE ANALYSIS. *Journal of Applied Economics,* 8**,** 259-278.

DE MOOIJ, R. A. & BOVENBERG, A. L. 1998. Environmental taxes, international capital mobility and inefficient tax systems: Tax burden vs. tax shifting. *International Tax and Public Finance,* 5**,** 7-39.
FELDER, S. & VAN NIEUWKOOP, R. 1996. Revenue recycling of a CO2 tax: Results from a general equilibrium model for Switzerland. *Annals of Operations Research,* 68**,** 233-265.
GARBACCIO, R. F., HO, M. S. & JORGENSON, D. W. 1999. Controlling carbon emissions in China. *Environment and development economics,* 4**,** 493-518.
GIMÉNEZ, E. L. & RODRÍGUEZ, M. 2010. Reevaluating the first and the second dividends of environmental tax reforms. *Energy Policy,* 38**,** 6654-6661.
HOLMLUND, B. & KOLM, A.-S. 2000. Environmental tax reform in a small open economy with structural unemployment. *International Tax and Public Finance,* 7**,** 315-333.
JANSEN, H. & KLAASSEN, G. 2000. Economic impacts of the 1997 EU energy tax: simulations with three EU-wide models. *Environmental and Resource Economics,* 15**,** 179-197.
JORGENSON, D. W. & WILCOXEN, P. J. 1993. Reducing US carbon emissions: an econometric general equilibrium assessment. *Resource and Energy Economics,* 15**,** 7-25.
KEMFERT, C. & WELSCH, H. 2000. Energy-Capital-Labor Substitution and the Economic Effects of CO2 Abatement: Evidence for Germany. *Journal of Policy Modeling,* 22**,** 641-660.
KILIMANI, N. 2014. Water Taxation and the Double Dividend Hypothesis. University of Pretoria, Department of Economics.
KNOBLACH, M., ROESSLER, M. & ZWERSCHKE, P. 2019. The Elasticity of Substitution Between Capital and Labour in the US Economy: A Meta-Regression Analysis. *Oxford Bulletin of Economics and Statistics*.
LEE, S., POLLITT, H. & UETA, K. 2012. An assessment of Japanese carbon tax reform using the E3MG econometric model. *The Scientific World Journal,* 2012.
LIU, Y. & LU, Y. 2015. The Economic impact of different carbon tax revenue recycling schemes in China: A model-based scenario analysis. *Applied Energy,* 141**,** 96-105.
MABEY, N. & NIXON, J. 1997. Are Environmental Taxes a Free Lunch? Issues in Modelling the Macroeconomic Effects of Carbon Taxes. *Energy Economics,* 19**,** 29-56.
MANRESA, A. & SANCHO, F. 2005. Implementing a double dividend: recycling ecotaxes towards lower labour taxes. *Energy Policy,* 33**,** 1577-1585.
MARKANDYA, A., GONZÁLEZ-EGUINO, M. & ESCAPA, M. 2013. From shadow to green: Linking environmental fiscal reforms and the informal economy. *Energy Economics,* 40**,** S108-S118.
MAXIM, M. R. & ZANDER, K. 2019. Can a Green Tax Reform Entail Employment Double Dividend in European and non-European Countries? A Survey of the Empirical Evidence. *International Journal of Energy Economics and Policy,* 9**,** 218-228.
MAXIM, M. R., ZANDER, K. K. & PATUELLI, R. 2019. Green Tax Reform and Employment Double Dividend in European and Non-European Countries: A Meta-Regression Assessment. *International Journal of Energy Economics and Policy,* 9**,** 342-355.
MERTLER, C. A. & REINHART, R. V. 2016. *Advanced and multivariate statistical methods: Practical application and interpretation*, Taylor & Francis.
MIRHOSSEINI, S. S., MAHMOUDI, N. & VALOKOLAIE, S. N. P. 2017. Investigating the relationship between green tax reforms and shadow economy using a CGE model - A case study in Iran. *Iranian Economic Review,* 21**,** 153-167.
MORRIS, G. E., REVESZ, T., ZALAI, E. & FUCSKO, J. 1999. Integrating environmental taxes on local air pollutants with fiscal reform in Hungary: Simulations with a computable general equilibrium model. *Environment and Development Economics,* 4**,** 537-564.
MUĆK, J. 2017. *Elasticity of substitution between labor and capital: robust evidence from developed economies*, Narodowy Bank Polski. Education & Publishing Department.

O'RYAN, R., DE MIGUEL, C. J., MILLER, S. & MUNASINGHE, M. 2005. Computable general equilibrium model analysis of economywide cross effects of social and environmental policies in Chile. *Ecological Economics,* 54**,** 447-472.

PATUELLI, R., NIJKAMP, P. & PELS, E. 2005. Environmental tax reform and the double dividend: A meta-analytical performance assessment. *Ecological Economics,* 55**,** 564-583.

PEARCE, D. 1991. The Role of Carbon Taxes in Adjusting to Global Warming. *Economic Journal,* 101**,** 938-48.

PEREIRA, A. M. & PEREIRA, R. M. 2014. Environmental fiscal reform and fiscal consolidation: the quest for the third dividend in Portugal. *Public Finance Review,* 42**,** 222-253.

PEREIRA, A. M., PEREIRA, R. M. & RODRIGUES, P. G. 2016. A new carbon tax in Portugal: A missed opportunity to achieve the triple dividend? *Energy Policy,* 93**,** 110-118.

POLLITT, H., PARK, S.-J., LEE, S. & UETA, K. 2014. An economic and environmental assessment of future electricity generation mixes in Japan–an assessment using the E3MG macro-econometric model. *Energy Policy,* 67**,** 243-254.

ROSON, R. 2003. Climate change policies and tax recycling schemes: simulations with a dynamic general equilibrium model of the Italian economy. *Review of Urban & Regional Development Studies,* 15**,** 26-44.

SAHLÉN, L. & STAGE, J. 2012. Environmental Fiscal Reform in Namibia:A Potential Approach to Reduce Poverty? *The Journal of Environment & Development,* 21**,** 219-243.

SAVEYN, B., VAN REGEMORTER, D. & CISCAR, J. C. 2011. Economic analysis of the climate pledges of the Copenhagen Accord for the EU and other major countries. *Energy Economics,* 33, Supplement 1**,** S34-S40.

SAWTELLE, B. 2007. Analyzing the Link Between Real GDP and Employment: An Industry Sector Approach. *Business Economics,* 42**,** 46-54.

SHIN, D. 1999. An equilibrium theory of wage and employment cyclicality by gender and by industry. *Southern Economic Journal***,** 451-471.

STERN, N. & STERN, N. H. 2007. *The economics of climate change: the Stern review*, cambridge University press.

TULLOCK, G. 1967. Excess benefit. *Water Resources Research,* 3**,** 643-644.

VAN HEERDEN, J., GERLAGH, R., BLIGNAUT, J., HORRIDGE, M., HESS, S., MABUGU, R. & MABUGU, M. 2006. Searching for Triple Dividends in South Africa: Fighting CO_2 pollution and poverty while promoting growth. *The Energy Journal***,** 113-141.

VANDYCK, T. & VAN REGEMORTER, D. 2014. Distributional and regional economic impact of energy taxes in Belgium. *Energy Policy,* 72**,** 190-203.

WELSCH, H. & EHRENHEIM, V. 2004. Environmental fiscal reform in Germany: a computable general equilibrium analysis. *Environmental economics and policy studies,* 6**,** 197-219.

Appendices

Appendix A1

Table A.1.: Database summary.

Source	Model	Region of study	Model type	Tax type	Tax Recycle type	Time period	Number of simulations
Bach et al. (1994)	DIW	European	M	Energy tax	SSC	Short term	1
Bardazzi (1996)	INTIMO	European	IO	Other taxes	SSC	Short term	3
	INTIMO	European	IO	Other taxes	SSC	Short term	
	INTIMO	European	IO	Energy tax	SSC	Short term	
Barker et al. (1993)	HERMES/MIDAS/DRI	European	M	EC tax	PIT	Short term	12
	HERMES/MIDAS/DRI	European	M	EC tax	PIT	Short term	
	HERMES/MIDAS/DRI	European	M	EC tax	VAT	Short term	
	HERMES/MIDAS/DRI	European	M	EC tax	VAT	Short term	
	HERMES/MIDAS/DRI	European	M	EC tax	PIT	Long term	
	HERMES/MIDAS/DRI	European	M	EC tax	VAT	Long term	
	HERMES/MIDAS/DRI	European	M	Other taxes	VAT	Short term	
	HERMES/MIDAS/DRI	European	M	Other taxes	VAT	Short term	
	HERMES/MIDAS/DRI	European	M	Other taxes	PIT	Short term	

	HERMES/MIDAS/DRI	European	M	Other taxes	PIT	Short term	
	HERMES/MIDAS/DRI	European	M	Other taxes	VAT	Long term	
	HERMES/MIDAS/DRI	European	M	Other taxes	PIT	Long term	
Barker and Köhler (1998)	E3ME	European	M	Energy tax	SSC	Long term	1
Carraro et al. (1996)	WARM	European	GE	EC tax	SSC	Long term	6
	WARM	European	GE	EC tax	SSC	Long term	
	WARM	European	GE	EC tax	SSC	Long term	
	WARM	European	GE	EC tax	SSC	Long term	
	WARM	European	GE	EC tax	SSC	Long term	
	WARM	European	GE	EC tax	SSC	Long term	
Holmlund and Kolm (2000)	None	Non-European	GE	Energy tax	SSC	Short term	8
	None	Non-European	GE	Energy tax	SSC	Short term	
	None	Non-European	GE	Energy tax	SSC	Short term	
	None	Non-European	GE	Energy tax	SSC	Short term	
	None	Non-European	GE	Energy tax	SSC	Short term	
	None	Non-European	GE	Energy tax	SSC	Short term	
	None	Non-European	GE	Energy tax	SSC	Short term	
	None	Non-European	GE	Energy tax	SSC	Short term	
Jansen and Klaassen (2000)	HERMES	European	M	EC tax	SSC	Short term	3
	E3ME	European	M	EC tax	SSC	Short term	
	GEM-E3	European	GE	EC tax	SSC	Short term	

Kemfert and Welsch (2000)	LEAN-TMC	European	GE	CO_2	LSTH	Long term	4
	LEAN-TMC	European	GE	CO_2	LSTH	Long term	
	LEAN-TMC	European	GE	CO_2	SSC	Long term	
	LEAN-TMC	European	GE	CO_2	SSC	Long term	
Mabey and Nixon (1997)	EGEM;SLE EC; EGEME; EGEMX	European	M	CO_2	PIT	Long term	6
	EGEM;SLE EC; EGEME; EGEMX	European	M	CO_2	PIT	Long term	
	EGEM;SLE EC; EGEME; EGEMX	European	M	CO_2	PIT	Long term	
	EGEM;SLE EC; EGEME; EGEMX	European	M	CO_2	SSC	Long term	
	EGEM;SLE EC; EGEME; EGEMX	European	M	CO_2	SSC	Long term	
	EGEM;SLE EC; EGEME; EGEMX	European	M	CO_2	SSC	Long term	
De Mooij and Bovenberg (1998)	Mobile capital; Fixed capital	European	GE	Energy tax	SSC	Long term	12
	Mobile capital; Fixed capital	European	GE	Energy tax	SSC	Long term	
	Mobile capital; Fixed capital	European	GE	Energy tax	SSC	Long term	
	Mobile capital; Fixed capital	European	GE	Energy tax	CT	Long term	
	Mobile capital; Fixed capital	European	GE	Energy tax	CT	Long term	

	Mobile capital; Fixed capital	European	GE	Energy tax	CT	Long term	
	Mobile capital; Fixed capital	European	GE	Energy tax	Other recycles	Short term	
	Mobile capital; Fixed capital	European	GE	Energy tax	Other recycles	Short term	
	Mobile capital; Fixed capital	European	GE	Energy tax	Other recycles	Short term	
	Mobile capital; Fixed capital	European	GE	Energy tax	SSC	Short term	
	Mobile capital; Fixed capital	European	GE	Energy tax	SSC	Short term	
	Mobile capital; Fixed capital	European	GE	Energy tax	SSC	Short term	
Roson (2003)	Dynamic general equilibrium model of Italy	European	GE	CO_2	SSC	Short term	2
	Dynamic general equilibrium model of Italy	European	GE	CO_2	CT	Short term	
Pereira and Pereira (2014)	DGEP	European	GE	CO_2	LSTH	Long term	4
	DGEP	European	GE	CO_2	VAT	Long term	
	DGEP	European	GE	CO_2	PIT	Long term	
	DGEP	European	GE	CO_2	SSC	Long term	
Kilimani (2014)	UgAGE	Non-European	GE	Other taxes	Other recycles	Short term	6
	UgAGE	Non-European	GE	Other taxes	Other recycles	Short term	
	UgAGE	Non-European	GE	Other taxes	Other recycles	Short term	

	UgAGE	Non-European	GE	Other taxes	Other recycles	Long term	
	UgAGE	Non-European	GE	Other taxes	Other recycles	Long term	
	UgAGE	Non-European	GE	Other taxes	Other recycles	Long term	
Conrad and Löschel (2005)	GEM-E3	European	GE	CO_2	SSC	Short term	4
	GEM-E4	European	GE	CO_2	SSC	Short term	
	GEM-E5	European	GE	CO_2	LSTH	Short term	
	GEM-E6	European	GE	CO_2	LSTH	Short term	
Bach et al. (2002)	LEAN	European	GE	Energy tax	SSC	Long term	2
	PENTA-RHEI	European	M	Energy tax	SSC	Long term	
Pollitt et al. (2014)	E3MG	Non-European	M	CO_2	PIT	Long term	9
	E3MG	Non-European	M	CO_2	PIT	Long term	
	E3MG	Non-European	M	CO_2	PIT	Long term	
	E3MG	Non-European	M	CO_2	PIT	Long term	
	E3MG	Non-European	M	CO_2	PIT	Long term	
	E3MG	Non-European	M	CO_2	PIT	Long term	
	E3MG	Non-European	M	CO_2	PIT	Long term	
	E3MG	Non-European	M	CO_2	PIT	Long term	
	E3MG	Non-European	M	CO_2	PIT	Long term	
Bosello and Carraro (2001)	WARM	European	M	Energy tax	SSC	Short term	8
	WARM	European	M	Energy tax	SSC	Short term	
	WARM	European	M	Energy tax	SSC	Short term	

	WARM	European	M	Energy tax	SSC	Short term	
	WARM	European	M	Energy tax	SSC	Long term	
	WARM	European	M	Energy tax	SSC	Long term	
	WARM	European	M	Energy tax	SSC	Long term	
	WARM	European	M	Energy tax	SSC	Long term	
Manresa and Sancho (2005)	Static general equilibrium model of Spain	European	GE	EC tax	SSC	Short term	6
	Static general equilibrium model of Spain	European	GE	EC tax	SSC	Short term	
	Static general equilibrium model of Spain	European	GE	EC tax	SSC	Short term	
	Static general equilibrium model of Spain	European	GE	EC tax	SSC	Short term	
	Static general equilibrium model of Spain	European	GE	EC tax	SSC	Short term	
	Static general equilibrium model of Spain	European	GE	EC tax	SSC	Short term	
André et al. (2005)	Static general equilibrium model of Spain	European	GE	CO_2	SSC	Short term	3
	Static general equilibrium model of Spain	European	GE	CO_2	PIT	Short term	
	Static general equilibrium model of Spain	European	GE	Other taxes	SSC	Short term	

Saveyn et al. (2011)	GEM-E3	European	GE	CO_2	SSC	Long term	3
	GEM-E4	European	GE	CO_2	SSC	Long term	
	GEM-E5	European	GE	CO_2	SSC	Long term	
Welsch and Ehrenheim (2004)	LEAN_2000	European	GE	Energy tax	SSC	Long term	1
Bossier and Bréchet (1995)	HERMES	European	M	EC tax	SSC	Short term	1
Felder and Van Nieuwkoop (1996)	Static general equilibrium model of Switzerland	European	GE	CO_2	LSTH	Short term	6
	Static general equilibrium model of Switzerland	European	GE	CO_2	LSTH	Short term	
	Static general equilibrium model of Switzerland	European	GE	CO_2	SSC	Short term	
	Static general equilibrium model of Switzerland	European	GE	CO_2	SSC	Short term	
	Static general equilibrium model of Switzerland	European	GE	CO_2	SSC	Short term	
	Static general equilibrium model of Switzerland	European	GE	CO_2	SSC	Short term	
Vandyck and Van Regemorter (2014)	Dynamic regional CGE model of Belgium, based on GEM-E3	European	GE	Energy tax	SSC	Long term	2
	Dynamic regional CGE model of Belgium,	European	GE	Energy tax	LSTH	Long term	

	based on GEM-E4						
Markandya et al. (2013)	Static general equilibrium model of Spain	European	GE	CO_2	LSTH	Short term	3
	Static general equilibrium model of Spain	European	GE	CO_2	CT	Short term	
	Static general equilibrium model of Spain	European	GE	CO_2	SSC	Short term	
Ciaschini et al. (2012)	Static bi-regional CGE model of Italy	European	GE	Other taxes	PIT	Short term	4
	Static bi-regional CGE model of Italy	European	GE	Other taxes	PIT	Short term	
	Static bi-regional CGE model of Italy	European	GE	Other taxes	Other recycles	Short term	
	Static bi-regional CGE model of Italy	European	GE	Other taxes	Other recycles	Short term	
Sahlén and Stage (2012)	Static CGE model of Namibia	Non-European	GE	Other taxes	VAT	Short term	5
	Static CGE model of Namibia	Non-European	GE	Other taxes	VAT	Short term	
	Static CGE model of Namibia	Non-European	GE	Other taxes	SSC	Short term	
	Static CGE model of Namibia	Non-European	GE	Other taxes	LSTH	Short term	
	Static CGE model of Namibia	Non-European	GE	Other taxes	LSTH	Short term	
Lee et al. (2012)	E3MG	Non-European	M	CO_2	PIT	Long term	2

	E3MG	Non-European	M	CO_2	Other recycles	Long term	
O'Ryan et al. (2005)7	ECOGEM-Chile	Non-European	GE	Other taxes	LSTH	Short term	1
Mirhosseini et al. (2017)	Static CGE model of Iran	Non-European	GE	Energy tax	LSTH	Short term	3
	Static CGE model of Iran	Non-European	GE	Energy tax	CT	Short term	
	Static CGE model of Iran	Non-European	GE	Energy tax	SSC	Short term	
Bor and Huang (2010)	EnFore-CGE-Taiwan	Non-European	GE	Energy tax	LSTH	Short term	5
	EnFore-CGE-Taiwan	Non-European	GE	Energy tax	Other recycles	Short term	
	EnFore-CGE-Taiwan	Non-European	GE	Energy tax	Other recycles	Short term	
	EnFore-CGE-Taiwan	Non-European	GE	Energy tax	Other recycles	Short term	
	EnFore-CGE-Taiwan	Non-European	GE	Energy tax	Other recycles	Short term	
Van Heerden et al. (2006)	Static CGE model of South Africa	Non-European	GE	CO_2	VAT	Short term	8
	Static CGE model of South Africa	Non-European	GE	CO_2	Other recycles	Short term	
	Static CGE model of South Africa	Non-European	GE	CO_2	Other recycles	Short term	
	Static CGE model of South Africa	Non-European	GE	Energy tax	VAT	Short term	
	Static CGE model of South Africa	Non-European	GE	Energy tax	Other recycles	Short term	
	Static CGE model of South Africa	Non-European	GE	Energy tax	Other recycles	Short term	
	Static CGE model of South Africa	Non-European	GE	Other taxes	VAT	Short term	

[7] Used change of utility as a proxy for employment.

	Static CGE model of South Africa	Non-European	GE	Other taxes	Other recycles	Short term	
Liu and Lu (2015)	CASIPM-GE	Non-European	GE	CO_2	Other recycles	Short term	2
	CASIPM-GE	Non-European	GE	CO_2	Other recycles	Short term	
(Pereira et al., 2016)	DGEP	European	GE	CO_2	Other recycles	Long term	6
	DGEP	European	GE	CO_2	Other recycles	Long term	
	DGEP	European	GE	CO_2	Other recycles	Long term	
	DGEP	European	GE	CO_2	Other recycles	Long term	
	DGEP	European	GE	CO_2	Other recycles	Long term	
	DGEP	European	GE	CO_2	Other recycles	Long term	

Appendix A2

Table 7: Independent variables used in MANOVA.

Country
Time period
GE model
Macro model
Recycle: LSTH
Recycle: PIT
Recycle: others
Tax type: energy tax
Recycle: SSC
Tax type: CO_2
Tax type: other tax