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The effects of environmental investments on employment in the Greek economy: An input-output approach (2010-2020)*

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Abstract: The purpose of this paper is to evaluate the contribution of the environmental investments ("green" investments) in terms of employment in the Greek economy. The "green" investments include investments in electricity generation from renewable energy technologies, reducing domestic energy consumption, reducing air emissions from automobiles and alternative waste management, etc. The "green" investment vector is estimated for the Greek economy by sector of economic activity for the time period 2010-2020. The Input Output (IO) approach is applied to our research question given that it calculates direct, indirect and induced effects on employment, by sector of economic activity. Concerning employment, the main finding of the paper is that each 1M€ of investments is expected to create employment equal to 24.75 full-time equivalent employees, of which 56.49 % is direct, 23.29% indirect and 20.22% induced employment. Meanwhile, every year the "green" investments create employment equal to 74300 full-time equivalent employees, on average.

Keywords: green investments, Greece, input – output analysis, employment effects.

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1. Introduction

During the last years an extended debate has been taking place that focuses on environmental policies as a key area of investments (IPCC, 2007a; IPCC, 2007b; Stern, 2006). The so-called "green" investments are expected to increase employment (among other economic benefits) and improve environmental quality through the reduction of greenhouse emissions and other pollutants. (See Algoso, 2004; EREC, 2007; ILO, 2009; Kammen et al., 2009; Pollin et al., 2008a)

The purpose of this research is to evaluate the economic significance of the "green" investments associated with a range of activities that make use of, or contribute to, environmental resources in terms of employment created. More specifically, the aim of the research is to estimate the jobs created by a specific "green" investment plan which will take place in the period 2010-2020 and the location of economic activities new jobs are related to. Input –output analysis is used to assess the macroeconomic impact (direct – indirect – induced) of the investment expenditures by sector of economic activity.

The paper is structured as follows: section 2 presents the nature of the planned "green" investment in the Greek economy (2010-2020); section 3 sets out the methodological framework; section 4 describes the data and the variables; section 5 analyzes the empirical results; finally, section 6 concludes.

2. "Green" Investments in Greece: A brief overview

The "green" investment plan for the Greek economy was developed within a framework described as "20-20-20 by 2020" policy targets, adopted by the European Commission (EU) in 2008. The purpose of "20-20-20 by 2020" is to set European countries in a track towards low-carbon, energy-efficient economy, by (i) a reduction in EU greenhouse gas emissions of at least 20% below 1990 levels, (ii) a 20% increase of EU energy consumption for renewable resources and (iii) a 20% reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency (European Renewable Energy, 2007; European Commission, 2008).

This target requires large scale investments across EU[1], and the specialization of the targets for Greece covers a wide area of activities such as: *electricity generation from renewable energy technologies and improvement of power grid efficiency* (wind, photovoltaic, hydro, geothermic, biomass, smart grid electrical transmission system between

[1] See European Commission (2009), EWEA (2008), UNEP et *al.* (2007).

the islands*), improvement of building efficiency* (heating & cooling systems, boilers, solar systems, lighting systems, insulation,), *improvement of vehicles and sustainable bio-fuels* (low carbon private and public vehicle, bio-diesel, ethanol), *alternative waste management* (recycling, energy from waste, composting). Meanwhile, disinvestment is an expected outcome for conventional electricity generation[2] because of the reduction of electricity demand and the reduction of fossil fuel power installed (Lalas et *al.,* 2010).

These activities are connected with specific sectors of economic activity[3] and the estimation of the investments distribution among sectors[4] led to an estimated vector of investments for each year in the period 2010-2020 (Table 2, Appendix). The "green" investments plan requires on average 3000 M€ per year (in 2009 prices), equal to 1.26% of the country's Gross Domestic Product (GDP).

The allocation of the necessary investments to cover the targets of "20-20-20 by 2020" by sector of economic activity shows that the industries that are affected most are: 14 (Manufacture of machinery and equipment n.e.c.) accounting for 27.36% of total investment, 19 (Constructions) accounting for 23.88%, 15 (Manufacture of electrical and optical equipment) accounting for 12,46%, 25 (Real estate, renting and business activities) accounting for 9.86%, 20 (Trade, maintenance and repair services of motor vehicles and motorcycles; retail sale of automotive fuel) accounting for 7.44% and 10 (Manufacture of chemicals, chemical products) accounting for 6.04% of total investments.

3. Methodology

For the estimation of the "green" investments' impact on employment there are two basic approaches : (1) macroeconomic models and, more specifically, the input–output Leontief model that seeks to capture the direct, indirect and induced effects (''top-down model'') and (2) analytic models based on the generation of employment coefficients, such as jobs per unit of production or production capacity installed, or jobs per unit of investment spending (''bottom-up''). Apparently, both models have advantages and disadvantages[5].

[2] In Greece, the main fuel is lignite, which is a very polluting material.
[3] The economy is divided in 29 sectors of economic activity, following the taxonomy of NACE rev.1. Industry classification is available in Table 1, Appendix.
[4] For the distribution of investments by sector see Lalas et *al.* (2010).
[5] The most promising route forward then appears to be with the various possibilities for 'hybrid' input-output modelling, whereby top-down and bottom-up methods and/or physical and economic components are combined (Sangwon, 2009).

According to the literature, the "bottom-up" model is mostly used for micro-level studies where, for instance, a local investment takes place or a new enterprise is about to be built. Either way, for the secure estimation of the employment coefficients a collection of large scale data is necessary, making the analytical approach laborious and time-consuming. On the other hand, "bottom-up" models are difficult to use in order to calculate indirect or induced employment and cannot be used for the calculation of job losses.

On the other hand, the input output model (IO model) contains information on inter-industry relationships and is best suited for measuring the impact of an investment plan with influence on a variety of industries because it provides a more complete picture of the economy, as a whole. It is designed to encompass direct and indirect effect of changes in the final demand of an industry caused by a new investment, as well as the induced effect due to changes of income and consumption spending of households. At the same time, the IO model is able to estimate job losses caused, for example, by disinvestment in the fossil fuel sector. (DWEA, 2008; Kammen et *al.*, 2004; Pollin, 2009; Wei et *al.*, 2009; Sangwon, 2009).

For the estimation of the "green" investments' impact on the creation of employment at the sectoral level, we use the input-output model. The IO model will be used to calculate the changes in employment and occupations for the entire economy. We chose the widely used IO model because its implementation is straightforward, the derived results directly interpretable and the data easy to access. In this context, the analysis is based on the typical assumption that production technology for the Greek economy remains constant. The direct effect refers to the impact on the sectors that receive the investments, the indirect effect refers to the impact on the sectors that have linkages to the sectors that have received the direct results, and the induced effect refers to the impact on the sectors where the extra income due the investments is spent (Kammen et *al.* 2009; Pollin et *al.* 2008b, Renner et *al.* 2008).

To calculate the direct macroeconomic impacts, the technological coefficients were derived from the original input-output table by dividing each element of the intermediate demand sub-table by the total sector specific production. Whenever the final demand of the *j*th product changes by one unit and the demand of all other products remains constant, the *j*th sector will change its production level by one unit to satisfy this new demand. This change in production level will affect the level of primary inputs which is measured by the direct coefficients.

Varying the final demand of a sector also causes indirect changes to all other sectors because production in one sector is, usually, an input for other sectors (Miller and Blair, 1985).

Estimation of these indirect results is one of the main goals of input-output analysis and is done by using the Leontief matrix:

$$X = (I-A)^{-1} F \quad (1)$$

where

X is the vector of total production,

I the unit matrix,

A the technology matrix,

$(I-A)^{-1}$ is the Leontief inverse matrix

F the vector of final demand.

Furthermore, output also changes and the direct and indirect impacts are measured by using the Leontief inverse:

$$X_{GREEN}=(I-A)^{-1}F_{Green} \quad (2)$$

where:

X_{GREEN} expresses both the direct and indirect impacts on the output

F_{GREEN} is the vector of "green" investments (final demand).

The direct and indirect increase in output creates extra income and consequently an increase in consumption expenditures by households which, in turn, creates a new extra final demand and a new increase in output and employment. This effect is called induced effect, and for its estimation we expand the matrix A to include the private expenditure (by household) vector as a new column and the wages of employees row vector as a new row.

In this case, we calculate the direct, indirect and "green" investments induced "green" investments effect by means of the following equation:

$$X'_{GREEN}=(I-A')^{-1} F'_{GREEN} \quad (3)$$

where

X'_{GREEN} expresses the direct and indirect and inducted impacts on the output

$(I-A')^{-1}$ is the Leontief inverse matrix which includes the household consumption and the wages of employees.

F'_{GREEN} is the vector of "green" investments.

It should be noted that in the case we calculate the induced effect we add in F_{GREEN} vector an extra cell which is equal to zero, so that the calculations are plausible. For the estimated changes, e.g. in employment, similar coefficients have been calculated:

$$L_{GREEN} = \lambda(I-A)^{-1} F_{GREEN} \quad (4)$$

where

λ is the direct coefficient vector of employment, expressing the employment per unit of sectoral output

L_{GREEN} is the vector of the direct and indirect employment required for the completion of "green investments".

The induced impacts on employment are calculated as follows:

$$L_{GREEN}' = \lambda'(I-A')^{-1} F'_{GREEN} \quad (5)$$

where:

L'_{GREEN} is the vector of direct, indirect and induced employment caused by the "green" investments.

We also estimate direct and indirect multipliers by occupation, using a transformation of equation (4). We replace the vector of direct employment with a matrix containing the required employment by occupation, per unit of output (direct coefficient).

$$M_{GREEN} = m(I-A)^{-1} F_{GREEN} \quad (6)$$

where:

m is the matrix of direct employment coefficient by sector and occupation.

M_{GREEN} is a matrix of the required employment by sector and occupation for the completion of "green investments".

4. Data and Variables

The data that are used for the estimation of the effect of "green" investments are:

- The domestic Input-Output table[6] for the Greek economy for 2005 (source: Eurostat).
- Output by sector of economic activity (M€) for 2008 (source: Eurostat)
- Employment by sector of economic activity in thousand full time-equivalent employees for 2008 (source: Eurostat)

[6] Using the domestic input-output table we calculate only the effects taking place because of domestic production, and not because of the intermediate goods and services which are imported from abroad. The use of a total input-output table, where all intermediate consumption is included, would overestimate the effects.

- Employment by sector of economic activity and occupation[7] for 2008 (source: Greek Labour Force Survey).
- Investment vectors (Table 2, Appendix) for time period 2010-2020 (source: Lalas et *al.,* 2010).

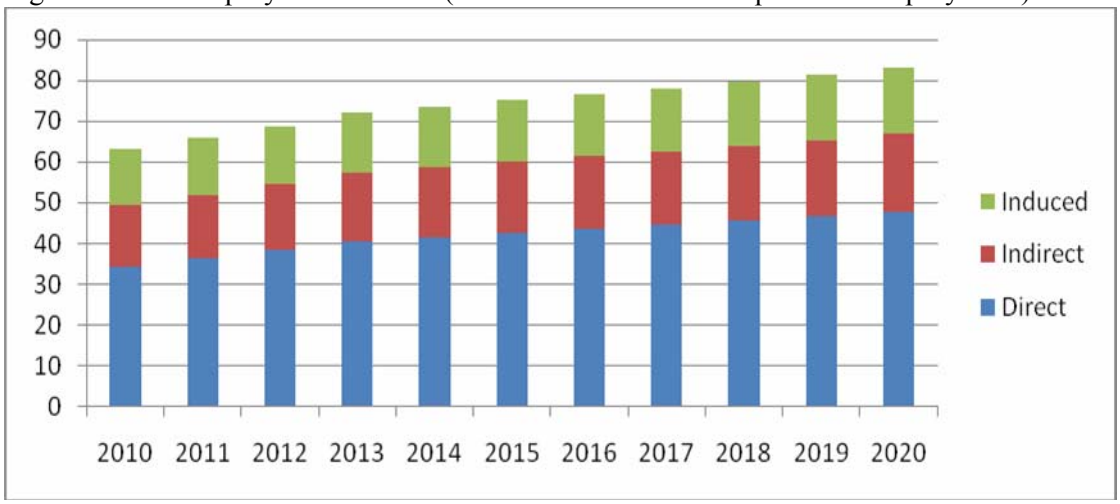
Our level of analysis refers to 29 sectors of economic activity (using NACE rev.1.1 categories) meaning that all our data are available or calculated in these dimensions.

5. Empirical Analysis

A crucial matter when calculating the effects of "green" investments is the expected changes in employment, especially if we consider the high unemployment levels in the Greek economy. The detection of the industries where changes in employment are more significant is a criterion for the investments' dynamic to create more employment. Moreover, the employment effect depends on the sectoral distribution of the investments, the sectoral productivity and the inter-sectoral relations of the economy.

The results from the application of the input–output model to the investment schedule are presented in figure 1. It is important to note here that a part of this new employment is expected to be temporary (for example infrastructure, construction and design related jobs) and another part is expected to be permanent (manufacturing and maintenance jobs).

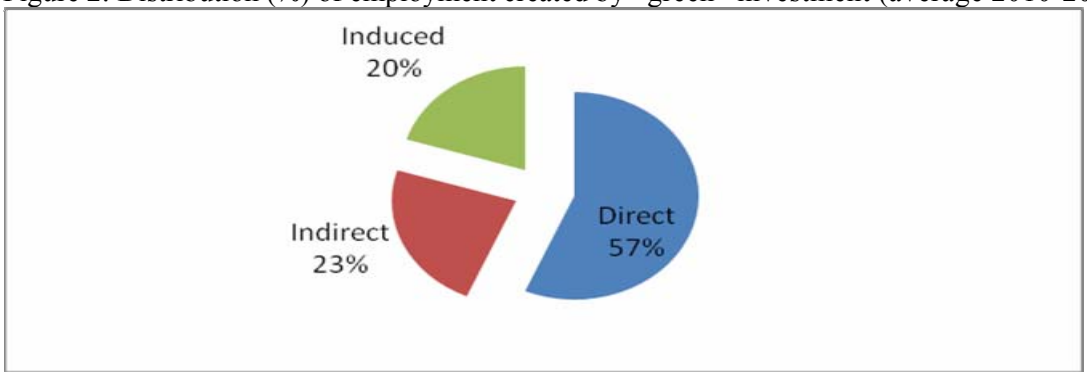
Figure1: Total employment created (thousands of full-time equivalent employment)



[7] For the classification of occupations that follow ISCO88, see Table 3 (Appendix).

In figure 2, the average annual employment caused by the "green" investment is illustrated. The average new employment over the whole time span is equal to about 74,300 full time-equivalents, of which 57% is direct, 23% indirect and 20% induced. This additional employment represents 1.5% of the total labour force in Greece.

Figure 2: Distribution (%) of employment created by "green" investment (average 2010-20)



In figure 3, new employment by primary, secondary and tertiary sector for the years 2010 and 2020 is illustrated. As shown in figure 3, direct results are concentrated in the secondary sector, where most investments take place. Considering indirect employment it should be noted that for the primary sector it is equal to 15.9% of total investment, for the the secondary sector equal to 14% and for the tertiary equal to 37.1%.

It seems that the service sector in Greece has higher linkages. Some differentiation is, also observed in induced employment, (39.1% in the primary sector, 5.2% in the secondary sector and 35.65 in the tertiary sector). This picture is the result of the fact that the households consume their income mostly in services and have very limited direct economic transaction with manufacturing.

Figure 3: Employment created by "green" investments (thousands of full-time equivalent employment)

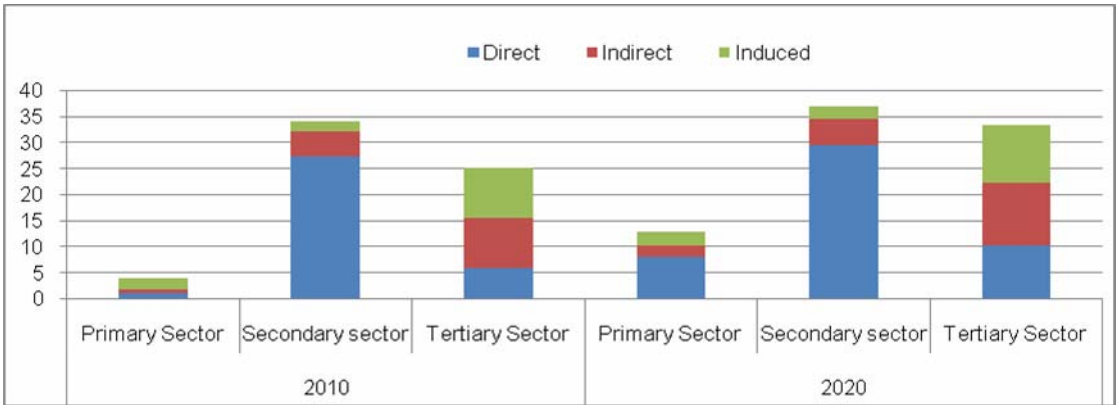


Figure 4 illustrates the effects caused by "green" investments (average annual employment) for all the sectors. At the sectoral level, the sectors experiencing the highest direct results are the sectors which satisfy the demand for investment. However, from figure 4 it is evident that the indirect and induced effects are transmitted, to a certain extent, to all the sectors of the economy.

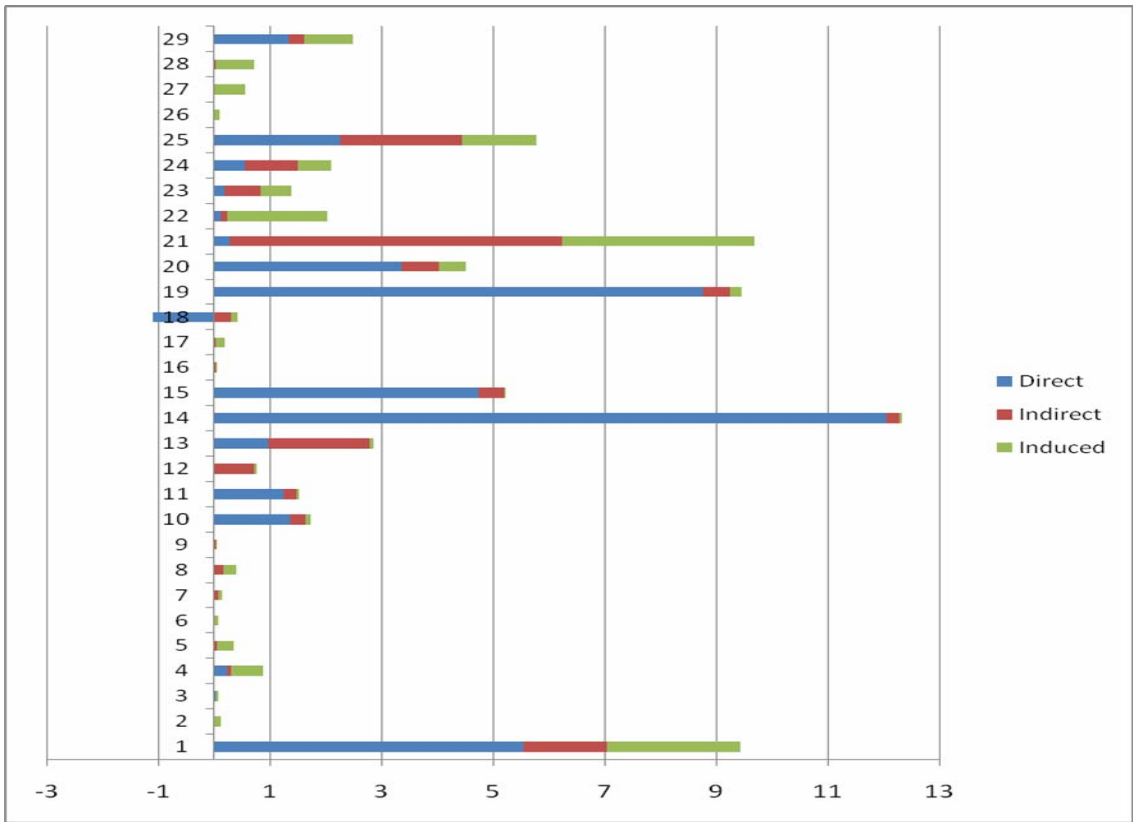
More precisely, sectors: 14 (Manufacture of machinery and equipment n.e.c.), 21 (Wholesale trade and Retail trade; except of motor vehicles), 19 (Construction), 1 (Agriculture, hunting and forestry), 25 (Real estate, renting and business activities) και 15 (Manufacture of electrical and optical equipment) contribute relatively more to the creation of employment. The same sectors have also, the higher direct employment effects.

What is also important is the ratio of indirect results to the total. This ratio is an expression of the internal dynamics of the economy and its capability to expand the economy's production capacity (and income), related to this specific investment. The sectors with the higher indirect results: 25 (Real estate, renting and business activities), 13 (Manufacture of basic metals and fabricated metal products), 21 (Wholesale trade and Retail trade; except of motor vehicles), 1 (Agriculture, hunting and forestry), 24 (Financial intermediation) and 12 (Manufacture of other non-metallic mineral products).

The induced effects are concentrated mostly in the tertiary sector – with the exception of agriculture, hunting and forestry – and, more specifically, in sectors: 21 (Wholesale trade and Retail trade; except of motor vehicles and motorcycles), 22 (Hotels and restaurants), 25 (Real estate, renting and business activities), 29 (Other community, social, personal service activities) and 28 (Health and social work).

As shown in figure 4, sector 18 (Electricity, gas and water supply) has a negative direct effect on employment (a reduction in sectoral employment is expected), as a result of the disinvestment in fossil fuel. But, as a result of the sector's high interstectoral relations, indirect and induced effects are positive.

Figure 4: Average annual employment created by "green investments" (Thousands full-time equivalent employment)



Furthermore, the allocation of employment by occupation provides us with the crucial professions that are needed for the realization of this particular investment. From figure 5 it is evident that 7 occupations are indispensable for the completion of the investment plan, covering more than 50% of total employment. These occupations are: 72 (Building trade workers) with 10.39% of average annual employment, 74 (Machinery and related trades workers) with 9.19%, 13 (Managers of small enterprises) with 8.48%, 41 (Office clerks) with 7.42%, 53 (Models, salespersons and demonstrators) with 7.42%, 63 (Agricultural workers - multiple growers) with 4.69% και 73 (Metal and related trades workers) with 4.25%.

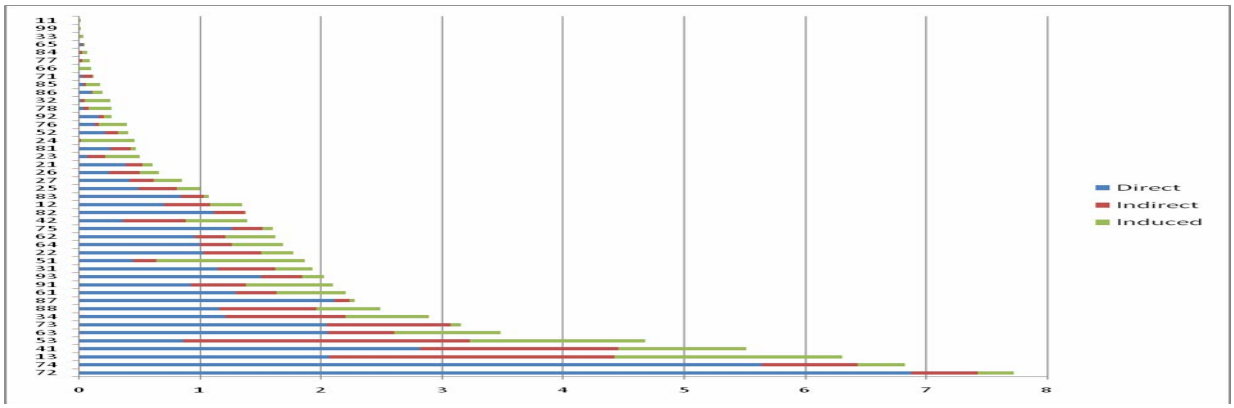
Higher direct effect on employment is more important in: 72 (Building trade workers), 74 (Machinery and related trades workers), 41 (Office clerks), 87 (Assemblers), 13 (Managers of small enterprises), 63 (Agricultural workers - multiple growers) and 73 (Metal and related trades workers)

Indirect effect is more important in: 53 (Models, salespersons and demonstrators), 13 (Managers of small enterprises), 41 (Office clerks), 73 (Metal and related trades workers), 34 (Finance and sales associate professionals etc), 74 (Machinery and related trades workers) and 88 (Drivers and mobile plant operators).

Finally, induced effects appear in the following sectors: 13 (Managers of small enterprises), 53 (Models, salespersons and demonstrators), 51 (Personal services workers), 41 (Office clerks), 63 (Agricultural workers - multiple growers) and 34 (Finance and sales associate professionals etc).

It is important to note that, according to the taxonomy of the occupational skills (OECD, 1998), the new employment is distributed as follows: 25.07% white-collar high-skilled occupations, 18.63% white-collar low-skilled, 39.46% blue-collar high-skilled and 16.84% blue-collar low-skilled occupations.

Figure 5: Average annual employment created by "green investments" by occupation (Thousands full-time equivalent employment)



6. Conclusions

This paper applied input-output analysis to calculate the macroeconomic impacts of "green" investments in the Greek economy by sector of economic activity for the years 2010-2020. The input-output model was used to calculate changes in employment for the entire economy and occupations. We chose the popular IO model because its implementation is straightforward, the derived results directly interpretable and the data easy to access. We showed that the current plan is expected to created, on average, 74,300 full time equivalent employees every year, which is equal to about 1.5% of the labour force of the country. The distribution of the results by occupation shows that a wider increase in the demand for high skilled employment relatively to the expected demand for low skilled workers.

In this context, a comparative study of the employment effects of "green" investments for several countries or local economies, taking into account technological differences, is a fine example for future investigation.

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Appendix

	Table 1: Industry Classification
1	Agriculture, hunting and forestry
2	Fishing
3	Mining and quarrying
4	Manufacture of food products; beverages and tobacco
5	Manufacture of textiles and textile products
6	Manufacture of leather and leather products
7	Manufacture of wood and wood products
8	Manufacture of pulp, paper and paper products; publishing and printing
9	Manufacture of coke, refined petroleum products and nuclear fuel
10	Manufacture of chemicals, chemical products and man-made fibres
11	Manufacture of rubber and plastic products
12	Manufacture of other non-metallic mineral products
13	Manufacture of basic metals and fabricated metal products
14	Manufacture of machinery and equipment n.e.c.
15	Manufacture of electrical and optical equipment
16	Manufacture of transport equipment
17	Manufacturing n.e.c.
18	Electricity, gas and water supply
19	Construction
20	Trade, maintenance and repair services of motor vehicles and motorcycles; retail sale of automotive fuel
21	Wholesale trade and Retail trade; except of motor vehicles and motorcycles
22	Hotels and restaurants
23	Transport, storage and communication
24	Financial intermediation
25	Real estate, renting and business activities
26	Public administration and defence; compulsory social security
27	Education
28	Health and social work
29	Other community, social, personal service activities

Table 2: "Green" Investments by sector of economic activity (M€)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	30	65	105	150	160	170	179	189	199	210	221
2	0	0	0	0	0	0	0	0	0	0	0
3	4	4	4	4	4	4	4	4	4	4	4
4	21	23	25	27	29	31	34	36	39	42	45
5	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0
10	129	139	148	158	169	180	191	202	214	227	240
11	132	134	136	137	139	140	142	144	145	147	149
12	0	0	0	0	0	0	0	0	0	0	0
13	149	149	149	149	149	149	149	149	149	149	149
14	767	778	789	799	810	821	832	843	854	865	875
15	346	352	357	363	369	374	380	385	391	396	402
16	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0
18	-44	-89	-134	-179	-225	-270	-315	-360	-405	-450	-495
19	693	697	702	706	711	716	721	726	732	737	744
20	223	223	223	223	223	223	223	223	223	223	223
21	7	8	9	10	11	12	13	14	15	17	18
22	6	6	7	8	8	9	10	10	11	12	12
23	16	18	20	21	23	25	27	28	30	32	34
24	15	22	29	36	43	51	58	65	72	79	87
25	242	253	264	275	285	296	307	318	329	339	350
26	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0
29	14	28	41	55	69	83	96	110	124	138	151

Source: Lalas et *al.* (2010)

Table 3: Classification of Occupations (ISCO88)

11	Legislators and senior officials
12	Corporate managers
13	Managers of small enterprises
21	Physical, mathematical and engineering science professionals
22	Architects, engineers and related professionals
23	Life science and health professionals
24	Teaching professionals
25	Accountants
26	Legal professionals
27	Archivists, librarians, social science, writers and creative or performing artists and related
31	Physical and engineering science technicians
32	Life science and health associate technicians
33	Teaching associate professionals
34	Finance and sales associate professionals etc
41	Office clerks
42	Customer services clerks
51	Personal services workers
52	Protective services workers
53	Models, salespersons and demonstrators
61	Market gardeners and crop growers
62	Field crop and vegetable growers
63	Agricultural workers - multiple growers
64	Animal producers and related workers
65	Forestry and related workers
66	Fishery workers and related workers,
71	Extraction trade workers
72	Bulding trade workers
73	Metal and related trades workers
74	Machinery and related trades workers
75	Craft printing and related trades workers
76	Food processing and related trades workers
77	Wood treaters, cabinet-makers and related trades workers
78	Textile, garment and related trades workers
81	Stationary plant and related operators
82	Mining and mineral-processing-plant operators
83	Rubber- and plastic-products machine operators
84	Wood-products machine operators
85	Textile-, fur- and leather-products machine operators
86	Food and related products machine operators
87	Assemblers
88	Drivers and mobile plant operators
91	Sales and services elementary occupations
92	Agricultural, fishery and related labourers
93	Labourers in mining, construction, manufacturing and transport
99	Not classified