Economic Modelling 61 (2017) 439–447

Contents lists available at ScienceDirect

Economic Modelling

journal homepage: www.elsevier.com/locate/econmod

Green versus brown: Comparing the employment impacts of energy efficiency, renewable energy, and fossil fuels using an input-output model

Heidi Garrett-Peltier

Political Economy Research Institute, University of Massachusetts Amherst, 418 N. Pleasant St, Amherst, MA 01002, United States

ARTICLE INFO

JEL codes:
C67
D57
J20
Q42
Q43
Q56

Keywords:
Input-output
Renewable energy
Energy efficiency
Fossil Fuels
Employment multipliers
Fiscal policy

ABSTRACT

Global carbon emissions have reached unsustainable levels, and transforming the energy sector by increasing efficiency and use of renewables is one of the primary strategies to reduce emissions. Policy makers need to understand both the environmental and economic impacts of fiscal and regulatory policies regarding the energy sector. Transitioning to lower-carbon energy will entail a contraction of the fossil fuel sector, along with a loss of jobs. An important question is whether clean energy will create more jobs than will be lost in fossil fuels. This article presents a method of using Input-Output (I-O) tables to create "synthetic" industries – namely clean energy industries that do not currently exist in I-O tables. This approach allows researchers to evaluate public and private spending in clean energy and compare it to the effects of spending on fossil fuels. Here we focus on employment impacts in the short-to-medium term, and leave aside the long-term comparison of operations and maintenance employment. We find that on average, 2.65 full-time-equivalent (FTE) jobs are created from $1 million spending in fossil fuels, while that same amount of spending would create 7.49 or 7.72 FTE jobs in renewables or energy efficiency. Thus each $1 million shifted from brown to green energy will create a net increase of 5 jobs.

1. Introduction

Employment in the clean energy sector, or so-called "Green Jobs," has become an important issue politically as an avenue to reduce unemployment while growing the economy on a sustainable path. Carbon emissions have reached an unsustainable level, and the global energy system must be transformed in order to limit global climate change to a 2 degree Celcius rise above pre-industrial levels by 2100 (Bruckner et al., 2014). Many studies have evaluated the relationship between economic growth, energy use, and emissions (Bloch et al., 2015; Chen et al., 2016; Narayan et al., 2016). There is debate both among economists and environmentalists as to whether economic growth is necessary and what level is sustainable. "Green Growth" is sometimes seen as a way for standards of living to rise while carbon emissions fall (e.g. Pollin et al., 2014).

National governments have long used both fiscal policy and regulation in the energy sector. Fiscal policy has included tax preferences, direct public spending, loan guarantees and other financing mechanisms, investments in research and development, and many other forms of financial support and incentives. In simultaneously addressing questions of job creation, emissions reduction, and energy use, it is important to understand the economic effects of energy policy and public spending within the energy sector. Particularly when the policy goal is to reduce unemployment, it is useful to compare the employment effects of clean energy as opposed to fossil fuels. For a given level of public spending, how many jobs would be supported by renewable energy (RE) and energy efficiency (EE) industries compared to fossil fuel (FF) industries? What would be the net effect on employment if spending shifts from fossil fuels to clean energy?

There is a small but growing body of literature examining the economic benefits of a clean energy transition, including those of job creation (Pollin et al., 2014; Lehr et al., 2012). While the peer-reviewed literature is still limited and the impacts on employment are sometimes noted as being disputed (Lambert and Silva, 2012), a number of researchers using input-output modeling have found positive employment impacts resulting from the growth of renewable energy industries (Malik et al., 2014; Markaki et al., 2013; Tourkolias and Mirasgedis, 2011) Input-output models are often used for these studies because they have the advantage of being transparent, having few assumptions built in, are easily replicable, and are built from current or recent data from national accounts.

One current drawback of using I-O models to study clean energy impacts is that renewable energy industries and energy efficiency industries are not explicitly identified as industrial categories in national accounts. While industries such as oil extraction, natural gas distribution, and petroleum refining exist in most national accounting

E-mail address: hpeltier@econs.umass.edu.

http://dx.doi.org/10.1016/j.econmod.2016.11.012
Received 9 March 2016; Received in revised form 15 November 2016; Accepted 18 November 2016
Available online 28 November 2016

systems, industries such as wind, solar, or home weatherization do not. Thus we cannot readily compare the employment impacts of demand for fossil fuel to demand for clean energy, making policy assessment difficult. Some researchers have overcome this obstacle by disaggregating and re-aggregating the industries in the I-O tables in order to separate green from traditional activities, or by adding a new set of industries to the existing tables (Malik et al., 2014; Garrett-Peltier, 2011).

A re-aggregation approach is useful for analyzing mature industries and has been used to study "satellite accounts" such as the Health Care Satellite Account and the Travel and Tourism Satellite Accounts of the U.S. Bureau of Economic Analysis (U.S. BEA). The main drawback to such an approach is the collection or availability of data sufficient for detailed disaggregation, a problem that is particularly concerning with nascent industries such as clean energy. This re-aggregation approach is generally time-consuming, requiring detailed survey data as well as compilation and re-balancing of the input-output tables.

This article presents an alternative approach for analyzing the employment impacts of renewable energy and energy efficiency industries. I use an input-output model, but rather than re-aggregating the tables to separate green from non-green activities, I treat clean energy spending as a demand shock. That is, I treat additional spending as investments in the industry, and simulate the effects of expanding the clean energy sector by creating vectors of demand that include the manufacturing, construction, and service industries that comprise the clean energy sector. As shorthand, I refer to this as the "synthetic industry" approach.

In essence, what the "synthetic industry" approach does is use existing data in the national accounts, in existing I-O tables. While "wind" or "solar" are not identified as industries as such, the activities and materials making up the wind and solar industries are already implicitly captured in existing I-O tables. In the synthetic industry approach, we use existing data from national accounts and create a proxy, a vector of demand for the package of goods and services making up each synthetic industry.

The advantages of the "synthetic industry" approach are twofold: First, the data requirements are fewer than those necessary for re-aggregation; and second, this method could be used as a complementary modeling technique to re-aggregation, where this "synthetic industry" approach is used to assess the initial impacts of investments in creating or expanding an industry, and then the re-aggregation technique is used to model ongoing operations and maintenance of an established industry.

In this article I perform synthetic industry analysis for renewable energy industries such as wind, solar, and bioenergy, as well as for energy efficiency industries including building weatherization, mass transit and freight rail, and electrical grid upgrades. I build from the methods first presented in Garrett-Peltier (2011) but update with the most recent data available, which are the 71-industry "Summary" tables for 2013 from the U.S. BEA. In addition, I generate new cost vectors for various renewable and efficiency industries and compare the results with those using previously-established cost structures. I then present a method of analyzing the sensitivity of the results to the choice of specification.

I present the methodology for simulating demand for RE and EE industries, then use existing literature and survey data to form vectors of demand. I estimate employment multipliers for 9 clean energy industries and 2 fossil fuel industries. I then present a simple policy example estimating the overall impact of shifting $1 billion in fossil fuel subsidies into investments in renewable energy or energy efficiency. I provide the weights used in composing all of these 11 energy industries to allow replication by other researchers.

I find that on average, renewable energy creates 7.49 full-time-equivalent (FTE) jobs per $1 million spending, energy efficiency creates 7.72 FTE jobs per $1 million spending, and fossil fuels create 2.65 FTE jobs per $1 million spending. These job numbers include both direct and indirect (supply-chain) jobs, and the multipliers are the same regardless of whether the source of demand is public or private spending. It is important to note that these employment effects are relevant for the short-to-medium term, in which an expansion of clean energy involves significant increases in manufacturing and installation of renewable and efficiency technologies. Here we leave aside the long-run comparison of operations and maintenance employment in the energy sector. Overall, I find that the expansion of clean energy creates three jobs for each job lost in the fossil fuel sector, and for each $1 million shift from fossil fuels to clean energy, an average of five additional jobs are created.

2. Data and methods

2.1. Brief background on input-output analysis

Input-output (I-O) analysis is useful in estimating the impact of changes in demand for the output of an industry or group of industries. I-O tables provide a "snapshot" of the economy. In any given year, they show the inputs used by each industry, the outputs produced by each industry, and the relationship between industry output and final demand among various users.

I-O tables are constructed from surveys of businesses as well as from administrative records and are generally available at various levels of detail ranging from sector (~12 industries) to detailed or benchmark tables (~400–500 industries). In the U.S., benchmark tables are produced by the U.S. BEA every 5 years, include approximately 500 industries, and are updated annually to produce sector and summary level tables. I-O tables provide a useful framework for policy and business analysis (Horowitz and Planting, 2009). A detailed description of the basic I-O framework is readily available in publications such as Miller and Blair (2009).

The U.S. BEA's I-O tables include a "make" table (the commodities produced by each industry), a "use" table (the use of commodities by intermediate and final users), a "direct requirements" table which is an algebraic manipulation of the make and use tables showing the amount of a commodity required by an industry to produce a dollar of the industry's output, and a "total requirements" table which is also known as the "Leontief Inverse Matrix," described below.

The I-O model allows us to estimate economy-wide impacts of investments in a range of RE and EE technologies, and thus has useful macroeconomic implications. Further, it also allows us to evaluate the effects on specific sectors and industries, which is useful for industrial policy as well as employment, training, and readjustment policies.

The input-output model I will use here to study the EERE (Energy Efficiency and Renewable Energy) industry is based on the U.S. BEA 2013 annual tables at the 71 industry ("summary") level. The BEA "Total Requirements" table shows how an increase in demand for a particular industry's product will lead to increased output in that industry and all related industries. For example, an increase in demand for farm products would increase farm output and would also increase output in other industries that provide inputs to the farm industry, such as fertilizer and farm machinery manufacturing. The total requirements table will be an $n \times n$ matrix where n is the number of industries. Once we obtain this table, we can post-multiply it by a vector of final demand (Y) to estimate the effects on output (X). Thus our basic equation to estimate a change in output resulting from a change in final demand is:

$$\Delta X = (I - A)^{-1} \Delta Y$$

Where $(I-A)^{-1}$ is the Leontief inverse matrix or "Total Requirements" table.

Using the above impact equation, we can see how changes in alternative types of final demand (personal consumption, private investment, federal government expenditures, or exports) affect output. We can also isolate a change in final demand for one industry or a