# When green fingers are not enough to create green jobs: An analysis of green job development in Brazil

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**Abstract:** Rising temperatures and sea levels as well as the depletion of natural resource stocks place sustainable development more than ever at the center of our political and economic policies. Yet how does one 'go green'? Transforming current economic structures into a 'green' economy is a complicated process. The type of jobs that are present in an economy largely determine the structure of that economy. It is therefore no surprise that the creation of green jobs is a key component of the 'going green' process. But what determines how many green jobs are present in a region? Using occupational data for 27 Brazilian states between 2003 and 2013 this paper examines whether the economic complexity of a state explains why one state has a greener occupational space than another. After constructing a green jobs index we show that economic complexity does indeed have positive explanatory power when it comes to the green jobs index. We also show that transitioning through this occupational space is a slow and difficult process. Despite this we see positive signs that the significant regional differences in greenness that we observe are declining. States which were initially not very green became relatively a lot greener than states which were initially already relatively green, which indicates convergence.

**Keywords** ● Green Jobs ● Green Economy ● Sustainable Development ● Economic Complexity ● Brazil

**JEL Classification:** O13, Q55, R58

## 1. Introduction

Over the past decades it has become widely accepted that our current way of living poses a serious threat to the quality of life of future generations (e.g. Sample, 2003; Hopwood et al., 2005). Policies focused on sustainable development have ignited the transformation of economies into so called 'green economies' (Pearce et al., 1989; Grazi et al., 2007). This rise of the green economy is accompanied by the rise of 'green jobs'. In fact, the emergence of green jobs is one of the driving forces behind the transition towards green economies (Renner et al., 2008).

The transition towards a green economy is however not desired by all policymakers. The challenge of how to simultaneously promote economic growth and environmental protection remains. Policies that benefit the environment often have the stigma of being expensive and inefficient, which is why policymakers often expect such policies to hurt economic growth (Bezdek et al., 2008). The United Nations Environment Programme (UNEP) reports claims that this belief is not based on facts, this claim is supported by the abundant literature that finds a positive link between sustainable development (and green job creation in particular) and economic growth (e.g. Bezdek et al. (2008); Cai et al., 2011; Kammen and Engel, 2009; Lehr et al., 2001; Martinez-Fernandez, 2010). This literature shows that environmental protection, economic development, and jobs creation can be complementary and compatible.

Despite what policymakers often believe, environmental protection has become a large profitmaking and job-creating industry since the late 1960s. Environmental protection represented a $300 billion industry in the US in 2003 and accounted for five million jobs (Bezdek et al., 2008). Most of these five million people do not even realize that their occupation helps to protect the environment. Only a few of them have classic environmental jobs, such as environmental engineers and ecologists, most of them have standard jobs such as accountants, computer analysts and factory workers. Since significantly more jobs are linked to environmental jobs than perhaps initially thought it is not surprising that Bezdek et al. (2008) find a positive relationship between economic growth, job creation, and environmental protection. The transition towards a green economy should thus not only be desired by policymakers due to its ability to mitigate the effects of climate change, but also as a way to generate wealth (Shutters et al., 2015).

How can this desire be transformed into a concrete transition towards a green economy? Modern economies are immensely complex systems consisting of many dimensions, several of these dimensions play a role in the transformation towards a green economy. A joint paper by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and Local Governments for Sustainability (ICLEI) (GIZ and ICLEI, 2012) analyzes urban economies and identifies several dimensions and goals which are relevant for a country that desires to transition to a green economy.

This paper focuses on one of the dimensions identified by GIZ and ICLEI (2012), namely the important role of the creation of green jobs in the transition process. The creation of green jobs is closely related to the occupational structure of a country and is a logical consequence of a transition towards a green economy. The occupational structure of a country is the mix of different types of jobs found in an economy, this occupational structure of a country is therefore one of the defining characteristics of an economy (Renner et al., 2008). The structure of this occupational space is altered in a significant way when new green jobs enter the economy. However, the movement or transition through the 'occupation space' toward a green economy is a slow and difficult process (Shutters et al., 2015). Some countries struggle to become green whilst others transition relatively easy, this raises the question: what explains the differences in this transition process of various countries? This paper applies the analytical perspective that argues that the set of knowledge, skills, and technologies that are present in an economy crucially determine an economy's ability to transition towards a green economy (Shutters et al., 2015). The jobs that are present in a country represent the available skills and knowledge in a country. Some skills and technologies, by their nature, are easily transitioned into other economic activities (such as managers and politicians) whilst some are not (such as truck drivers), and may even hinder the transitional process. This observation is not particularly new, as it was first proposed by Arrow (1962) and later by Robert and Lucas (1993) and Stokey (1988). However, Hausmann and Hidalgo (2011) and Hidalgo et al. (2007) have recently revived this insight when they proposed the concept of the 'Product Space'. The Product Space is a network representation of the relatedness or proximity between products traded in the global market (Hausmann et al., 2014). The Product Space is closely related to the concept of 'economic complexity', which seeks to explain the knowledge accumulated in a country's population (the networks that people form) and that is expressed in the country's industrial composition (Hausmann and Hidalgo, 2007).

The purpose of this paper is twofold: We first apply the methodology by Muneepeerakul et al. (2013) and Shutters et al. (2015) to measure the greenness of the Brazilian states. Second, we examine whether it is indeed the level of economic complexity of an economy that plays an important explanatory role in the transition towards a green economy through the channel of green job creation. In order to do that we empirically analyze the Brazilian economy based on panel data for the 27 Brazilian states over the period 2003-2013.

The paper is structured as follows: the section 2 defines what green jobs and the green economy exactly are. Then it considers the theoretical framework and reviews both the literature and the empirical literature. This includes literature on sustainable development, development economics, and the link between green jobs and economic complexity. Section 3 describes the data and the variables of interest and takes a closer look at the methodology that is applied in this paper. Section 4 discusses the results and then, we provide concluding remarks and policy recommendations.

## 2. Theoretical framework

### 2.1 Defining the green economy and green jobs

The simplest definition of a 'green job' states that green jobs are the ones that contribute to the improvement of environmental quality (Peters et al., 2011). This definition of a green job is extremely broad and includes occupations which most people would not link directly to green jobs, such as construction workers, factory workers, and accountants who work for a greentech company for example. Their daily activities do not contribute directly to improved environmental quality (Mass et al., 2010). Some scholars argue that this broad definition is popular amongst policymakers because it results in larger counts of green jobs than a more narrow definition, this makes it easier for them to tap into federal and state funding streams for green projects (Mass et al., 2010). That is why others (e.g. Morriss et al., 2009; Michaels and Murphy, 2009) assume a stricter definition and argue that only jobs that directly have an impact on improved environmental conditions are green, such as environmental engineers and ecologists. The argument that some jobs that fall under the broad definition of green jobs do not directly contribute to environmental protection is valid, but also overlooks an important aspect. A company that produces and installs solar panels clearly directly benefits the environment, however a company cannot be ran only by solar panel engineers. The administration and transport department are crucial for the survival of the company. The people who work on these departments do not directly protect the environment, but they are clearly employed in the green sector and should therefore be counted as green jobs. As a result it would be too shortsighted to apply a very narrow definition of green jobs.

This paper therefore adopts the definitions of a green economy and job that are proposed by The Occupational Information Network Resource Center (O*NET, a program of the US Department of Labor/Employment and Training Administration). They define the green economy as "economic activity related to reducing the use of fossil fuels, decreasing pollution and greenhouse gas emissions, increasing the efficiency of energy usage, recycling materials, and developing and adopting renewable sources of energy". Based on this, they use the following definition of green jobs: "The "greening" of occupations refers to the extent to which green economy activities and technologies increase the demand for existing occupations, shape the work and worker requirements needed for occupational performance, or generate unique work and worker requirements". The O*NET definition of green jobs differentiates between three types of green occupations:

1. The first set of green occupations are the so called 'green increased demand occupations'. These types of jobs experience an increase in demand due to the green economy, but the tasks of the jobs do not change. Examples of such jobs are chemists and welders. These kinds of occupations are also part of the broad definition of green jobs.
2. The second group of green jobs are the so-called 'green enhanced skills occupations'. The workers in these occupations may or may not experience an increase in demand, but the green economy will change the work and worker requirements significantly. Examples of such occupations are agricultural engineers and construction managers. The essence of their occupation has not changed, but the increased focus of the green economy forced them to take environmental quality into consideration and this alters their daily activities.
3. The final set of occupations are the 'green new and emerging occupations'. The impact of green economy activities and technologies is sufficient to create the need for unique work and worker requirements. These jobs are very closely related to the core principles of the green economy and form the basis of the narrow definition of green jobs. Examples of such jobs are climate change analysts, environmental economists, and solar plant engineers.

These definitions show that green jobs can have very different characteristics and that there is a varying level of greenness attached to each of the three categories. Despite these facts, this paper considers all three categories as green jobs, since all of the occupations included contribute to the green economy, albeit some more directly than others.

### 2.2 The importance of a green economy

Some scholars separate the economy, the environment, and society from each other (e.g. Hardi and Zdan, 1997; West Midlands Round Table, 2000; ICLEI, 1996; du Plessis, 2000; Barton, 2000). This suggests that each sector is, at least in part, independent of the others and this creates a potentially troublesome lack of linkage. This view allows for trade-offs between environmental and social issues, some pollution is deemed acceptable to increase growth, for example. Such trade-offs suggest that a conceptual division exists between humanity and the environment. Hopwood et al. (2005) argue that such a division is incorrect, they believe that in reality humanity depends on the environment, and that society both exists in, and depends on the environment. The economy exists within society, according to them. Humanity is at the center of the environment, thus we depend on the environment for our survival and our wellbeing. Unfortunately, not all economists and policymakers seem to realize how urgent the need for green development truly is.

This urgency becomes clear when we consider the rate at which the world population is growing. But it is not only the population of countries that is growing, incomes are also rising. It will change consumption patterns, the growing incomes and population will increase the demand of goods, which have to be produced with a limited amount of natural resources. This idea was formalized when Grossman and Krueger (1994) transformed the traditional Kuznets curve into an environmental Kuznets curve. The environmental Kuznets curve argues that environmental degradation increases in the earlier stages of economic development and then later again decreases, as the economy develops past a certain threshold (Grossman and Krueger, 1994). This illustrates the challenges emerging economies have to deal with.

The severity of these challenges become even clearer when we also consider the effects of climate change. The scientific and anecdotal evidence of human caused climate change is overwhelming (Sample, 2003). Present production methods cause the loss of biodiversity and the salinization of the soil (Hopwood et al., 2005). Would the world be able to cope with the situation if living standards in the rest of the world were to increase to western levels? Is there enough oil to fuel all these vehicles and would we be able to deal with the carbon emissions? Brazil, as an emerging economy, experiences rapidly rising incomes and population numbers, and the increased demands that this puts on the environment should be incorporated in a proper definition of sustainable development.

### 2.3 Green jobs and sustainable development

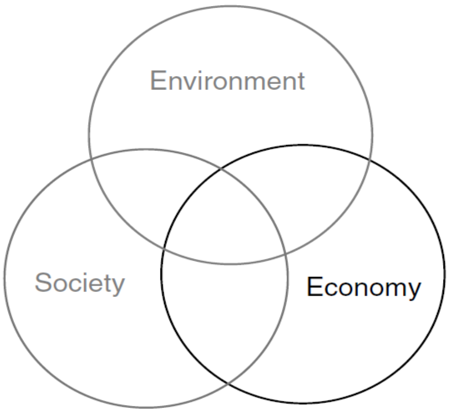
Williams et al. (2004, p. 1) call sustainable development a “notoriously difficult, slippery and elusive concept to pin down”. This notion is supported by Fowke and Prasad (1996), who have identified eighty definitions of sustainable development which are different, competing, and sometimes contradictory.

The modern discussion that involves the term ‘sustainable development’ stems from the 1980s. It was introduced by the Brundtland Commission’s report on the global environment and development in 1987, which was the first overview of the world which considered the environmental aspects of development from an economic, social and political perspective (Redclift, 2005). The report launched the term ‘sustainable development’ into policy discourse, but also into everyday language. The Brundtland Commission defined sustainable development as “... development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland Commission, 1987, p. 16).

This definition, however, did not remain uncontested throughout time. The answer to the question ‘what is to be sustained’ is not agreed upon by all academics. Sustainable development can be approached from various perspectives, one of these perspectives argues that it is the current levels of production (or consumption) that need to be sustained (e.g. Pearce et al., 1989; Mitlin, 1992; Bueno Montaldo, 2013). At first glance this might appear to be a rather unambitious goal, but when we consider the growing population as well as the rising incomes it becomes clear that it is no simple task to achieve this goal. Other scholars argue that sustainable development should be focused on preserving the environment rather than on economic indicators (e.g. Goldsmith et al., 1995; McBurney, 1990; Trainer, 1996). These different perceptions are ultimately linked to the structural division that exists between those who support ‘strong’ sustainable development and those who support the ‘weaker’ variant. The strong version argues that we must live within the environmental and ecological limits of our planet, whereas the weaker variant is more optimistic and assumes that human-made capital will be able to replace the declining stock of natural capital (e.g. Scottish Executive Social Research, 2006; Willams et al., 2004). This paper focuses on the later approach, as the creation of green jobs ultimately helps to replace natural capital with human-made capital.

The division of sustainable development into different aspects is also discussed extensively in the literature. Giddings et al. (2002) argue that sustainable development is often split up into three individual areas: the economy, society, and environment. This separation often leads to narrow techno-scientific approach, this view is represented in figure 1. Elkington (1998) tries to avoid this pitfall as he formalizes this division with the Triple Bottom Line (TBL) concept. The TBL approach represents sustainable development in a comprehensive way in which the economic dimension (profit), the social dimension (people), and the ecological dimension (planet) are represented. Willard (2012) generalizes the TBL concept in a way that can be applied to companies as well as societies as a whole by using the three-legged stool metaphor. In this metaphor the economy, society, and economy form the legs of a three-legged stool. If one of these legs is absent, the stool falls over.

Figure 1: Common three-ring sector view of sustainable development




Source: Giddings et al. (2002), p. 189.

Indeed, the debate on the question whether we should focus on environmental preservation or levels of production potentially creates outcomes which hurt the environment. A perhaps concerning issue with the concept of sustainable development that it is increasingly linked with poverty alleviation. Paul (2008, p. 579) argues that it appears that "...what began as a call to protect the environment in the service of human development has become a more specific call to prioritize improvements in the well-being of the very worst-off now and in the future". A study conducted by the Scottish Executive (2006) underlines the need for research that directly benefits green policy making. Their review concludes that there is "insufficient knowledge about whether or how a policy or action could contribute to more sustainable forms of development". Robinson (2004) draws a similar conclusion, he argues that there is a need for "an approach to sustainability that is integrative, is action-oriented, goes beyond technical fixes, incorporates a recognition of the social construction of sustainable development, and engages local communities in new ways" (Robinson, 2004, p. 369). An understanding of what promotes the creation of green jobs helps policymakers to construct such integrative policies.

This paper uses a definition of sustainable development which is in line with the three-legged stool approach (Willard, 2012). This means that economic growth should not be promoted at the expense of the environment, but it should also not be left out of the sustainable development equation. Even though the main purpose of the present paper is not to analyze poverty alleviation, it does address an issue that lies at the intersection between the economy, environment, and society. Green jobs do not only contribute to environmental protection, but they also have an impact on economic growth and the way society is structured.

The idea that a green job contributes to a more sustainable world is agreed upon by practically all authors, even by those who criticize the definition of green jobs (e.g. Leoni and Lavecchia, 2010; Morris et al., 2009; Michaels and Murphy, 2009). This contribution can mean that a company or organization operates in a 'green' sector (e.g. solar energy), but it can also mean that the organization is part of a conventional sector, but it makes genuine and substantial efforts to green its operations.

## 2.4 Sustainable development and Economic Complexity

The concept of economic complexity is a relatively new idea and forms its own branch under the ‘development economics’ movement.

Hidalgo and Hausmann (2009) propose that economic complexity is a driving force behind economic growth. They argue that as people and firms specialize in different activities, economic efficiency increases, suggesting that development is associated with an increase in the number of individual activities and with the complexity that emerges from the interactions between them. They have developed a view of economic growth and development that gives a central role to the complexity of a country's economy.

Ultimately, the complexity of an economy is related to the multiplicity of useful knowledge embedded in it. When we allocate productive knowledge to individuals it is important that the bits of information each person gets is internally coherent so that a person can perform a certain task. Hidalgo and Hausmann refer to these “modularized chunks of embedded knowledge” as capabilities (Hidalgo and Hausmann, 2011). Some capabilities are active at the individual level, others at the level of organizations or even networks. Countries do not simply make the products and services they need, they make the ones they can. To do so, they need people and organizations that possess relevant knowledge. Economic complexity, therefore, is expressed in the composition of a country’s productive output and reflects the structures that emerge to hold and combine knowledge.

To understand how the complexity of a country can be measured it is important to consider two other aspects of economic complexity: ubiquity and diversity. First of all, the amount of embedded knowledge that a country has is expressed in its productive diversity, or the number of distinct products that it makes. Second, products that demand large volumes of knowledge are feasible only in the few places where all the necessary knowledge is available. They define ubiquity as the number of countries that make a product. In this sense it is assumed that production factors are randomly spread across the world, and not highly concentrated. Using this terminology, we can observe that complex products – those that require a lot of knowledge and different capabilities – are less ubiquitous. The ubiquity of a product, therefore, reveals information about the amount of knowledge that is required for its production. Hence, the amount of knowledge that a country has is expressed in the diversity and ubiquity of the products that it makes (Hidalgo and Hausmann, 2011).

This quote helps to make the link between green job creation and economic complexity clear. The creation of green jobs is a development strategy that seeks to promote certain green products and services. Knowing what the best way to achieve this goal is would assist policymakers. This paper hypothesizes that it is the level of economic complexity of a region that explains the differences in the greenness of region’s occupational space. Ultimately economic complexity is driven by the amount of embedded knowledge in a region, which is closely related to the human capital that is present (Hausmann et al., 2014). The creation of green jobs is aimed at substituting natural capital with human-made capital. Investing in human capital is one of the channels through which both green job creation and raising the level of economic complexity of a region can be achieved.

## 3. Methodology

The methodology that is used in this paper in order to determine why some states are greener than others consists of two stages. The occupational greenness of the Brazilian states is calculated in the first stage. The green jobs index variable, which is the result of this first stage, is then the main dependent variable in the second stage of the methodology. The second stage consists of an empirical analysis of the impact of the economic complexity of the states and various control variables on the capability of an economy creates green jobs.

### 3.1 Green jobs index

The previously mentioned Product Space concept (which is part of the economic complexity framework) is relevant for this paper because the characteristics of occupations and the interconnectivity between them can be placed in a similar framework. Shutters et al. (2015) propose the so called 'green jobs index' in order to quantitatively measure the occupational greenness of a region. This index provides a quantitative measure of how close an economy is to the idealized structure of a green economy. They apply their methodology to urban areas (Metropolitan Statistical Areas) in the United States. We use this index to determine to what extent differences in economic complexity explain variation in terms of occupational greenness. For our calculations we use the definition of green jobs as defined by O*NET as previously discussed.

Even though the index by Shutters et al. (2015) appears to be very similar to existing indices at first glance, it provides several important advantages[1]. Most of the existing indices are qualitative, rather than quantitative. Secondly, Shutters et al. (2015) method can easily be used to determine the occupational greenness of regions, and even cities. Their approach also defines an economy based on its mix of worker skills instead of its prevalent industries, which is more common. And finally, their measure allows for the assessment of specific regions across a country for which sufficiently detailed employment data is available (Shutters et al., 2015). Furthermore, this index provides an original way of measuring an economy's progress towards a green economy. Even though it can be classified as an economic index, it is not based on GDP, economic growth, or consumption. This adds value as such factors are increasingly seen as incomplete indicators of well-being (Costanza et al., 2014).

[1] Such as the STAR communities (http://www.starcommunities.org/) rating and the UN prosperity index (http://unhabitat.org/urban-initiatives/initiatives-programmes/city-prosperity-initiative/).

The green jobs index that Shutters *et al*. (2015) construct finds it roots in the work by Muneepeerakul *et al*. (2013). Here, we follow the methods from Muneepeerakul *et al*. (2013) and Shutters *et al*. (2015). However, instead of applying the methodology to urban areas, this paper uses it to measure the occupational greenness of the Brazilian states. This is a three-step process, the first step determines whether a state is specialized in an occupation by constructing the location quotient (Azis *et al.,* 1997). This is considered to be the case when the fraction of the states' employment in that occupation exceeds the mean fraction across all states. Similarly, we may use the location quotient of occupation *i* in state *m* which is defined as:

$$LQ_i^{(m)} = \frac{\left(X_i^{(m)}/\sum_i X_i^{(m)}\right)}{\sum_m X_i^{(m)}/\sum_m \sum_i X_i^{(m)}} \qquad (1)$$

where *xi* (*m*) is the number of workers employed in occupation *i* in state *m*. Thus, state *m* is specialized in occupation *i* if its location quotient *LQi* (*m*) > 1. The economic structure that is constructed here is based on occupational data. This data covers the skills and human capital in the labor force that characterize an economy (Florida, 2012; Florida *et al.,* 2008; Jones and Romer, 2010; Moretti, 2012). The specialization of an occupation is taken as a proxy for the aggregate comparative advantage that a given state economy has for that occupation. Location-specific conditions presumably account for this relative specialization. Examples of such conditions are geographical conditions, natural endowments, infrastructures and labor force skills (Muneepeerakul *et al*., 2013). We also follow Muneepeerakul *et al*. (2013) in their approach to take the economy's set of occupational specializations (SOS) as representative of its economic structure. So after the first of the three steps we know for each individual Brazilian state in which occupations they are specialized, in which they are not specialized, and in which they are almost specialized.

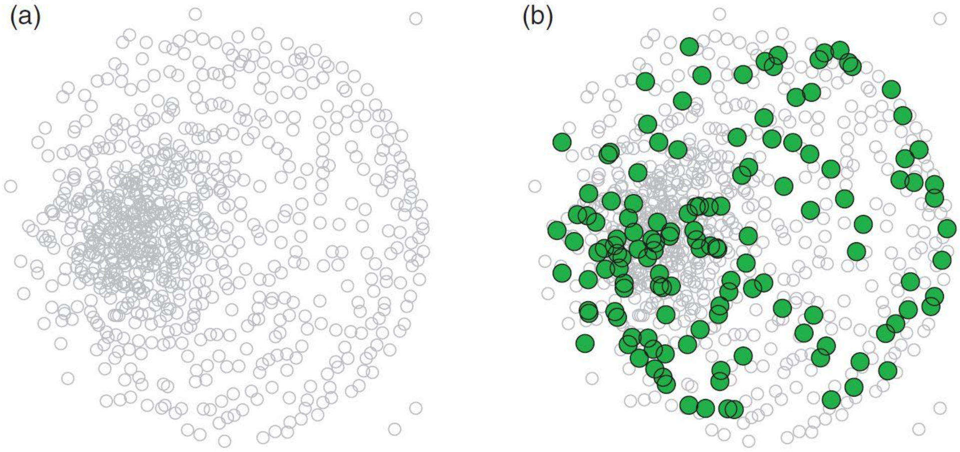
The next step includes calculating the colocation pattern of these occupational specializations. The goal this step is to learn more about the interdependence between occupations. Muneepeerakul *et al*. (2013) employ conditional probability: do conditional probabilities differ from marginal ones, if the presence of a specialized occupation in a state is partly determined by the presence of another specialized occupation? We define the interdependence between occupations *i* and *j*, *ζij*, as:

$$\xi_{ij} = \frac{P\left[LQ_i^{(M)}>1, LQ_j^{(M)}>1\right]}{P\left[LQ_i^{(M')}>1\right] P\left[LQ_j^{(M'')}\right]} - 1 \qquad (2)$$

where *M*, *M'*, and *M''* denote a randomly selected state (Muneepeerakul *et al.,* 2013). How a state's specialization in one occupation may enhance or hinder its specialization in another occupation is represented in this metric. Positive $\xi_{ij}$ means that occupations *i* and *j* are more likely to be specialized in the same states than if they are independently distributed across states. This implies that the two occupations may share some common requirements or contribute to common economic outputs (Shutters *et al*., 2015). The opposite is true for $\xi_{ij}$<0, while $\xi_{ij}$=-1 means that occupations *i* and *j* are never specialized in the same state (Muneepeerakul *et al.,* 2013). These interdependencies can be used to develop the so-called 'occupation space', a structural perspective that views an urban economy as a web of interdependencies, both positive and negative, among its labor occupations (Muneepeerakul *et al.*, 2013). This is closely related to the Product Space that is proposed by Hidalgo and Hausmann (2007).[2]

Shutters *et al*. (2015) use the occupational space to make the green jobs index less abstract, their occupational space is represented in figure 2 (a). What is remarkable is that the occupations are not uniformly distributed in the occupational space. The occupations with a high interdependence form a dense core, the occupations with weak or negative interdependencies form the periphery of the occupational space. It is now also possible to construct the idealized green occupational space (figure 2(b)). In this stylized occupational space all the green occupations (as defined by O*NET) are specialized. The green nodes are spread out over the entire occupational space. Figure 3.2 (b) shows that the occupations closest to a green occupation, that is, those with greatest positive $\xi'$s with the green occupation, do not have to be green themselves. This already suggests that transitioning to a green economy is no straightforward process. The current SOS of a state determines the difficulty of different paths towards the green economy. Just like a country is the most likely to specialize in a product that is the closest to products that a country is already producing, a state is also most likely to specialize in an occupation that is the closest to a states' current specializations (Hausmann and Hidalgo, 2007; Shutters *et al*., 2015).

Figure 2: The occupational space and the idealized green occupational space




Source: Shutters et al. (2015)

This concept is then quantified by Shutters *et al*. (2015) in the third step. This third step also builds on the work done by Muneepeerakul *et al*. (2013). Shutters *et al*. (2015) define the green jobs index of a state $m$, $G(m)$, as follows:

$$G^{(m)} = \frac{1}{N_G} \sum_{g \in SOS_G} V_g \left( SOS_c^{(m)} \right)^{1-\delta_g} \tag{3}$$

where SOSG represents the SOS of the green economy (figure 2(b)), SOSC$^{(m)}$ the current SOS of state *m*, and *N*G the total number of green occupations in SOSG. The potential of a state to become specialized in occupation *i* is represented by *Vi*, which is based on the

[2] Note that the purpose of this paper is not to construct an occupation space, however the concept does play a central role in this paper.

interdependencies between occupation $i$ and all occupations currently specialized. $\delta g$ is an indicator function: it is 1 if state $m$ already specializes in occupation $g$ and 0 if it does not. Thus, a green occupation $g$ has the value of 1 if the state already specializes in that occupation and has the value of $Vg$ if it does not. $G^{(m)} = 1$ if the economy specializes in all $N$G green occupations. Thus, $G^{(m)}$ measures the degree to which state $m$ penetrates the green economy. On the other hand, $1 - G^{(m)}$ measures how far a state $m$ must move through the occupation space to become a completely green economy.

### 3.2 Empirical methodology: dynamic panel data

The newly constructed green jobs index variable allows us to empirically investigate the relationship between greening the occupational space and economic complexity. This paper uses dynamic panel data to examine this relationship because the model includes a lagged dependent variable ($GJI_{i,t-1}$) as a control variable. We expect that the current level of the green jobs index of a state is heavily determined by its past level. A state that was very green in the previous period is very unlikely to be suddenly completely not-green in the following period. Only an external shock could cause such a sudden shift. We therefore deem it necessary to include the lag of the green jobs index in our model, not including this control variable would lead to omitted variable bias.

Doing this will increase the consistency of our results, but also leads to various difficulties with the estimation of the model. Adding a lagged dependent variable causes the strict exogeneity of the regressors assumption to no longer hold. Dynamic panel data also leads to inconsistent results when many of the usual Ordinary Least Squares (OLS) estimators are applied such as Least Square Dummy Variables, fixed effects and random effects (Nickell, 1981). Various authors have proposed solutions that allow us to obtain a consistent estimator of $\gamma$. This paper applies the popular generalized method of moments (GMM) approach that was designed by Eakin *et al*. (1988), Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998) in order to solve this problem. We pay attention to two general estimators that are designed for situations with "small T, large N" panels. This means that there are few time periods and many individuals; with independent variables that are not strictly exogenous, with fixed effects; and with heteroskedasticity and autocorrelation within individuals (Roodman, 2006). The dataset that is used for this paper is small with data for just 10 years and 27 states. We therefore need an estimator that is suited for a small sample.

The usual first-differenced GMM estimator eliminates the individual effects $\alpha i$ and the time invariant variables $Zi$. This usual GMM estimator experiences several issues, which are increasingly present in case of small samples like in this paper. Windmeijer (2005) shows that there commonly is a small sample downward bias of the estimated asymptotic standard errors of the efficient two-step GGM estimator. This is explained by the fact that the asymptotic standard errors do not take the extra variation in small samples due to the estimated parameters in the weight matrix into account. Blundell and Bond (2000) also argue that it is important to exploit initial condition information in generating efficient estimators for dynamic panel data models where the time-series observations is small. Asymptotic variance comparisons suggest that the system GMM estimator is significantly more efficient than non-linear GMM in this case (Blundell and Bond, 2000).

Since the system GMM estimator will give us the most consistent and efficient estimates it will be used as the main estimator in this paper. For completeness we will also show the results of various other estimators: pooled OLS, fixed effects, and the differences GMM. Here it is important to note that the pooled OLS estimator overestimates the coefficient for the lagged dependent variable, whereas the fixed effects estimator underestimates the coefficient. The coefficient of the lagged dependent variable should be between the estimated coefficients of pooled OLS and fixed effects when estimated with the differences GMM estimator. If that is the case, the estimator is stable.

The last issue that warrants discussion is the difference between one-step and two-step GMM results. Both one-step and two-step are consistent, but the latter is more asymptotically efficient. However the two-step GMM estimator also experiences a small sample downward bias of the estimated asymptotic standard errors in linear models. This is explained by the fact that the asymptotic standard errors do not take the extra variation in small samples due to the estimated parameters in the weight matrix into account (Windmeijer, 2005). A solution for the problem is presented by Windmeijer (2005) The existing bias is corrected with Windmeijer's procedure and researchers therefore prefer the two-step GMM estimation method. This paper follows the same approach. Finally the standard test of over-identifying restrictions associated with Sargan (1958) and Hansen (1982) (the Sargan or J-test) will be performed to ensure the model is correctly specified, as well as the Arellano-Bond autocorrelation test for dynamic panel data.

### 3.2.1 The model

As stated in our theoretical framework, based on the literature we expect the level of economic complexity of an economy to have an effect on the occupational greenness of a state. Based on the existing literature we expect to find a positive relationship between economic complexity and the greenness of the occupational space. The econometric model includes an indicator of the level of economic complexity of an economy (ECI), and all the several control variables. The greens job index is the main dependent variable and the following model is estimated:

$$GJI_{i,t} = \beta_0 + \beta_1 GJI_{i,t-1} + \beta_2 ECI_{i,t} + Z_{i,t} + \alpha_i + \varepsilon_{i,t} \tag{4}$$

We test the null hypothesis that $\beta_1$ *and* $\beta_2$ will be zero. In other words, under our null hypothesis we expect that $ECI_{i,t}$ and the lagged green jobs index $GJI_{i,t-1}$ to have no effect on the green jobs index. Our alternative hypothesis is that these parameters will be larger than zero, which means that $ECI_{i,t}$ and $GJI_{i,t-1}$ will have a positive effect on the level of occupational greenness of a state. $Z_{i,t}$ represents all the control variables that were used. For a full list of all the control variables used see table 3.1. $\alpha_i$ is the unobserved time-invariant individual effect and $\varepsilon_{i,t}$ is the error term.

### 3.3 Data

This section briefly discusses the data, describes the variables that are used in this research and shows the sources of the data. This paper uses panel data for the 27 Brazilian states over the period 2003-2013.[3] We cannot extract variables that have an impact on the greenness of the occupational space of a region from the literature. We therefore have used intuition and economic reasoning to determine which other variables could have an impact on the green jobs index. The name of the all the variables, their hypothesized signs, as well as their descriptions and sources are provided in the table 3.1 below.

Table 3.1: Description of the variables used in the model.

| Variable | Description | Hypothesized sign | Source |
|---|---|---|---|
| Green Jobs Index | Calculated based on the concept and methodology of Muneepeerakul et al. (2013) | Positive | Author's calculations (based on occupational data from RAIS) |
| Economic Complexity Index | ECI is a scale that uses the theory and calculations for economic complexity to rank countries according to their level of complexity, following Hidalgo and Hausmann (2009) | Positive | Fapemig |
| LN GDP per capita | This variable represents the Gross Domestic Product per capita, 1 000 000 R$ (current - 2010) | Positive | IPEADATA |
| Rate of Urbanization | Describes the projected average rate of change of the size of the urban population over the given period of time | Positive | Author's calculations (Based on population data from IBGE) |
| Fiscal government result | This variable describes the fiscal government result as a share of GDP | Positive | Controladoria Geral da União |
| Credit supply | This variable describes the credit supply (public and private) as a share of GDP | Positive | Banco Central do Brasil |
| Southeast | Dummy variable, 1 if the state is part of the South-East region, 0 otherwise | Positive | Authors |
| Northeast | Dummy variable, 1 if the state is part of the North-East region, 0 otherwise | Negative | Authors |

[3] The list of the 27 states including their abbreviations: Acre (AC), Alagoas (AL), Amapá (AP), Amazonas (AM), Bahia (BA), Ceará (CE), Distrito Federal (DF), Goiás (GO), Espírito Santo (ES), Maranhão (MA), Mato Grosso (MT), Mato Grosso do Sul (MS), Minas Gerais (MG), Pará (PA), Paraíba (PB), Paraná (PR), Pernambuco (PE), Piauí (PI), Rio de Janeiro (RJ), Rio Grande do Norte (RN), Rio Grande do Sul (RS), Rondônia (RO), Roraima (RR), São Paulo (SP), Santa Catarina (SC), Sergipe (SE), Tocantins (TO).

| | | | |
|---|---|---|---|
| South | Dummy variable, 1 if the state is part of the South region, 0 otherwise | Positive | Authors |
| North | Dummy variable, 1 if the state is part of the North region, 0 otherwise | Negative | Authors |

Source: Created by the authors.

## 4. Results and discussion

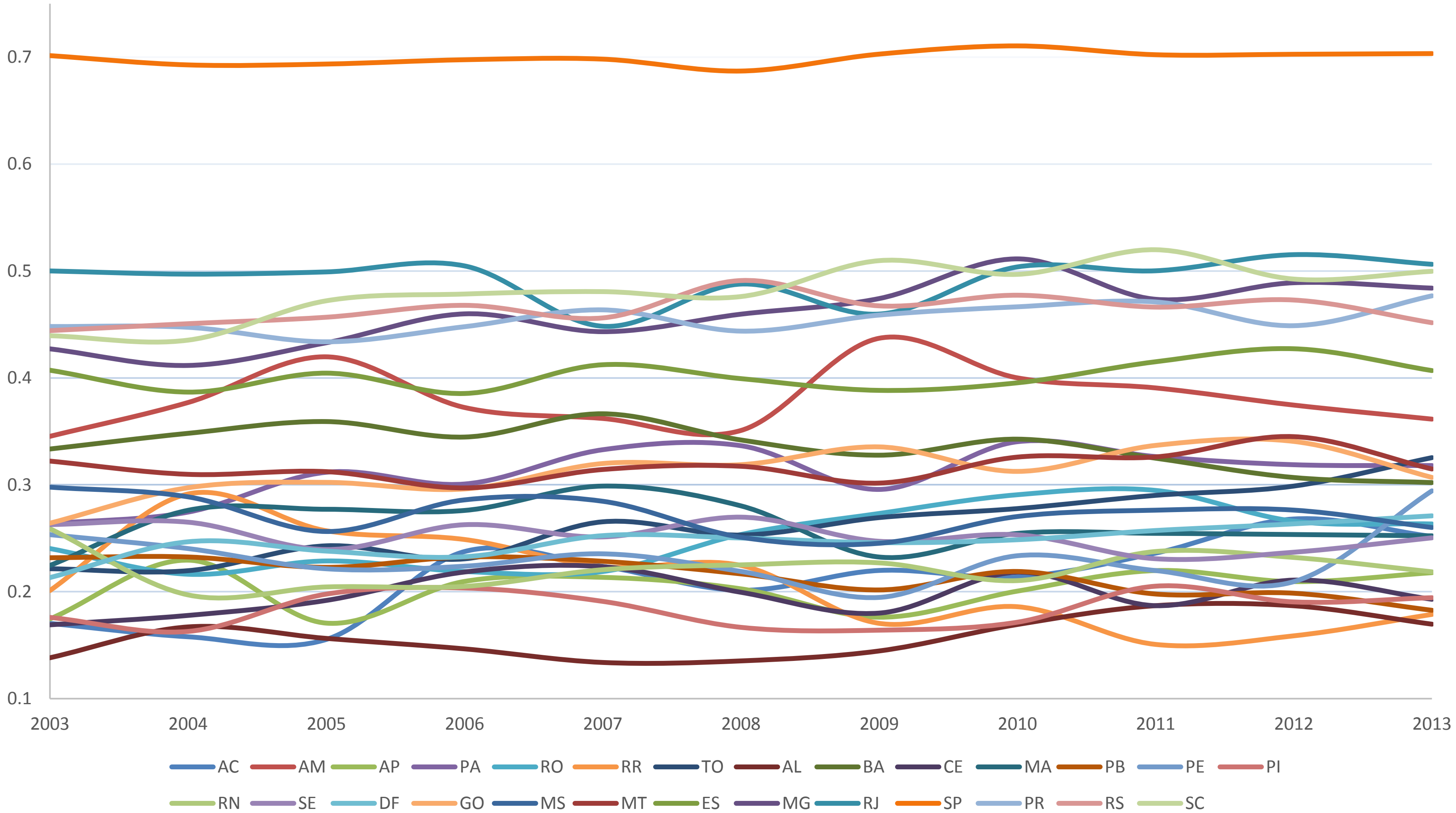
### 4.1 Green jobs index results

The green jobs index shows how the greenness of the occupational spaces of the 27 Brazilian states has developed between 2003 and 2013.[4] Figure 3 shows that São Paulo has a much greener occupational space than all of the other Brazilian states. São Paulo is the most populous state in Brazil and it is also the major industrial and economic powerhouse of the Brazilian economy. It is not a surprise that the richest and most developed state has the greenest occupational space. A lot of green jobs are quite developed and therefore require solid investment and developed financial institutions. In the ten year period of our dataset no big changes occur in the occupational greenness of a state in Brazil. This is in line with Shutters *et al.* (2015) and their finding that to become green is very difficult.

With the exception of São Paulo nearly all states have a green jobs index between 0.20 and 0,50, with most states being between 0.20 and 0.30. For the interpretation of these figures it is important to remember that the green jobs index is a scale that ranges from zero to one. If the green jobs index for a state is one, that state has a perfect green occupational space which means that that state is specialized in all green occupations. On the other hand, if a state has a green jobs index of zero it is as far away as possible from the idealized green economy and is not specialized in any of the green occupations. The average green jobs index throughout Brazil is a little above 0.30 for all years. This shows that Brazil is nowhere near the idealized green economy. This is not very surprising since it is not common for emerging economies to pay much attention to the environment, as is observed by the environmental Kuznets curve (Grossman and Kruger, 1994).

[4] The full green jobs index results can be found in the appendix.

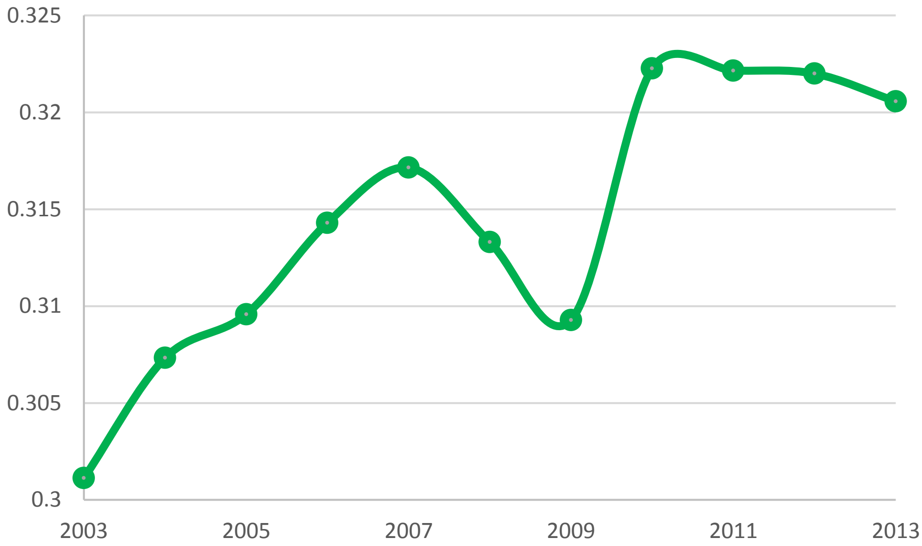
Figure 3: Dynamic of the Green Jobs Index for the Brazilian states 2003-2013




Source: Created by the authors.

Throughout the period analyzed there are both rising and falling states in terms of the green jobs index, but there is not a single state that experienced huge changes in its index. This shows that the occupational greenness of a region is rather stable in the short term. When we analyze the development of the average green jobs index (figure 4) we see that the average occupational greenness of Brazil moves very slowly, but is increasing (from 0.30 in 2003 to 0.32 in 2013). What also stands out in figure 4.2 is that the occupational greenness seems to react to the current state of the economy. There was a clear decline in the green jobs index in 2008-2009 which coincides with the global financial crisis. A decreasing trend also becomes visible around 2012, which is when it became apparent that Brazil was having serious economic struggles.

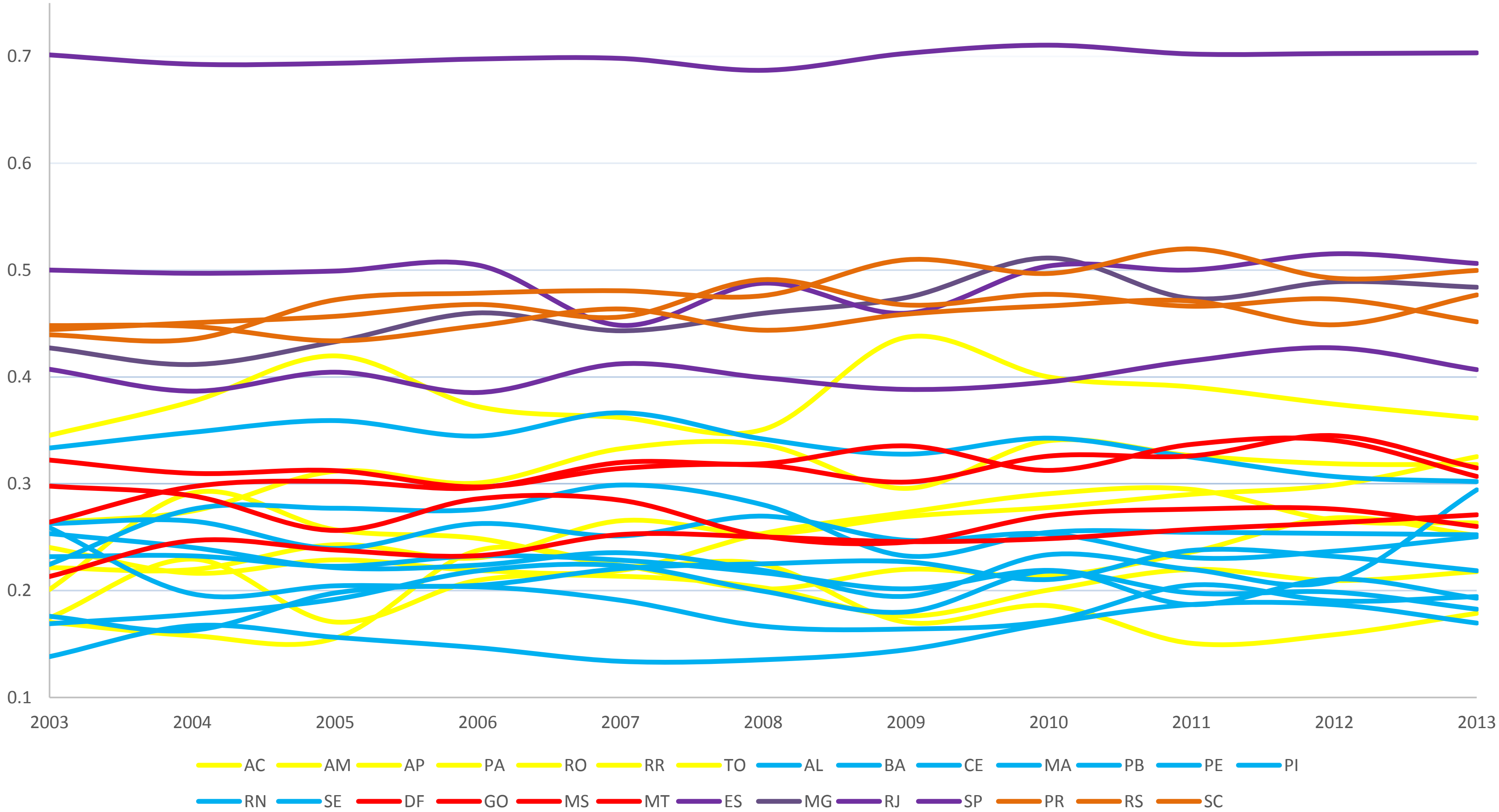
Figure 4: The average green jobs index over all states 2003-2013




Source: Created by the authors.

These initial results also enable us to say something about the regional differences that exist in Brazil. Figure 5 shows the green jobs index based on the five Brazilian regions and shows clear regional differences in Brazil.

Figure 5: Dynamic of the green jobs index per Brazilian region 2003-2013

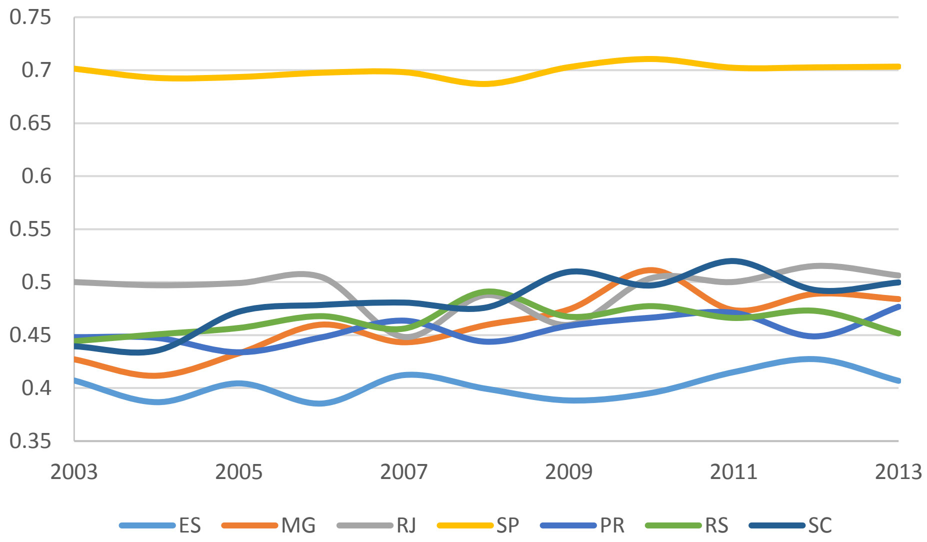



Source: Created by the authors. Legend: Yellow = North, blue = Northeast, red = West-Center, purple = Southeast, orange = South.

The South and the South-East are the most green in terms of their occupational space. This was to be expected since these regions are the richest and most economically developed. In fact, the only state (that is not from the South or South-East) that is greener than a state from the South or the South-East is Amazonas, which is, in a few years greener, than the South-East's state of Espírito Santo. A possible explanation for this is that it's capital Manaus is known for its Free Trade Zone which attracts a lot of diverse economic activity. The non-governmental organizations that present in that area to protect the rainforests could also be a possible explanation for the relatively high amount of green jobs that are present in Amazonas. The North and the North-East are the least green. This was also expected since these regions are also the poorest and not very well developed.

Finally figure 6 shows the development of the states with the highest initial green jobs index. These states experienced very little to no change in their green jobs index between 2003 and 2013. A possible explanation for this could be that their economies were already well developed and experienced little change. This is particularly interesting because the states with the lowest initial green jobs index all experienced growth.

Figure 6: The states with the highest initial green jobs index




Source: Created by the authors.

### 4.2 Empirical results and discussion

This section will show and discuss the empirical results of this paper based on the estimation of a model to evaluate which variables have a relationship to greenness of an economy. In order to make sure our model was correctly specified we run several tests which showed the model is correctly specified and there is no serial autocorrelation. The main results are presented in table 4.1 below.

Table 4.1: Regression results of the applied estimation methods

| Variable | Pooled OLS | Fixed Effects | FD-GMM | SYS-GMM |
|---|---|---|---|---|
| Initial Green Jobs Index (t-1) | 0,6766*** | 0,1096*** | 0,3008 | 0,3443*** |
| | (0,03707) | (0,03615) | (0,25053) | (0,10621) |
| Economic Complexity Index | 0,0006*** | 0,0004 | 0,00002 | 0,0007*** |
| | (0,0001) | (0,00048) | (0,00033) | (0,00019) |
| LN GDP per capita | 0,0053** | 0,0071 | 0,0099 | 0,0011 |
| | (0,00169) | (0,00441) | (0,00619) | (0,004) |
| Rate of urbanization | -0,04554 | 0,1718** | -0,3503*** | -0,2298*** |
| | (0,03817) | (0,07986) | (0,09811) | (0,06303) |
| Fiscal government result | 0,0005 | -0,00007 | 0,0007* | 0,0015*** |
| | (0,00094) | (0,00063) | (0,0004) | (0,00025) |
| Credit supply | -0,0076 | 0,04789*** | 0,0195 | 0,0463*** |
| | (0,00928) | (0,01631) | (0,01259) | (0,01000) |
| South-East | 0,0473*** | | | 0,0582* |
| | (0,01017) | | | (0,03323) |
| North-East | -0,0309*** | | | -0,1090** |
| | (0,00885) | | | (0,05506) |
| South | 0,0486*** | | | 0,1871** |
| | (0,01054) | | | (0,07774) |
| North | -0,0145* | | | -0,0297 |
| | (0,007948) | | | (0,02829) |
| _cons | 0,19049*** | 0,07083 | 0,3891*** | 0,3856*** |
| | (0,03904) | (0,06211) | (0,09232) | (0,10292) |
| | | | | |
| Observations | 296 | 296 | 243 | 270 |
| R-squared | 0,9305 | 0,6186 | -- | -- |
| Standard errors in parenthesis | | | | |
| *** p<0,01, ** p<0,05, *p<0,1 | | | | |

Source: Created by the authors of this paper.

The variable initial green jobs index has a positive and significant coefficient. This means that a high green jobs index in the previous period has a strong positive effect on the index in the following period. It means that countries that are well developed and have a lot of green jobs are likely to have a lot of green jobs in the next period as well.

As for our main dependent variable, our hypothesis is that we expect the level of economic complexity of a state to have a positive effect on the greenness of the occupational space of a state. We find that our main independent variable, the economic complexity of a state, has a positive coefficient and it is statistically significant. This impact is a very minor increase, but this was to be expected considering the fact that it is an established fact that 'greening' the occupational space of a region is a very time consuming process. But there exists a positive and significant relationship between the level of economic complexity of a state and how green its occupational space is. These results are reinforced by the finding that the GDP per capita variable is insignificant, even though it has the expected positive sign. This indicates that green job growth is not driven by income but really by how economically complex the economy is.

Another variable that is significant statistically is the urbanization rate and it has a negative coefficient of –0.23.This variable is added as a control variable to check whether the urbanization rate of a state has an impact on the green jobs index. We expected that states where more people live in the cities to have more green jobs because cities are usually more developed than rural areas, which means more (green) jobs are present there. This negative coefficient is therefore not in line with our hypothesis. A possible explanation for this is that highly urbanized areas always attract a lot of different economic activity. Almost all businesses are attracted to urbanized areas due to the huge benefits that accompany these areas. This could lead to relatively less people working in the green sector, which has a negative impact on the green jobs index. To illustrate: if a (large) green company or non-governmental organization (NGO) is located in a rural area it is very likely that a relatively large share of the labor force is working for that company, and thus that that region is specialized in the accompanying occupations. The same company or NGO in a highly urbanized area is less likely to attract a relatively large share of the labor force (due to the relative abundance of other economic activity) and is thus less likely to be specialized in the related occupations.

We also added a variable which represents the fiscal responsibility of a government. This fiscal government result variable is the fiscal result of a state divided by its GDP. This variable is added as a proxy for institutions and controls for the effect of institutional quality on green job development. A stable government which is financially responsible is more likely to pay attention to sustainable development and to be able to promote growth of the green sector. This variable is significant at the one percent level and positive, albeit with an economically small coefficient. We also controlled for financial development with the credit supply variable. This proxy variable consists of both the public and private credit supply. This is a proxy for financial development since economies that are more financially developed have better institutions which provide credit. This credit is important for investment and other economic activities. Both investment and economic activity are directly related to green job creation. This variable has the expected positive sign, and it is statistically significant. Financial development therefore positively affects the creation of green jobs, which makes sense because especially innovative new green ventures require capital.

Finally we also add regional dummy variables. We do this to check whether the location of a state has an effect on the occupational greenness of that state. We expect that being in the less developed North to have a negative effect on the GJI of a state. Similarly we expect states in the richer and more developed South to have more green jobs. We added dummies for the North, North-East, South, and South-East. The omitted dummy represents the West-Center region. All dummies have the expected sign, being in the North or the North-East has a negative impact on the green jobs index of a state, whilst being in the South or the South-East has a positive impact, relative to being in the West-Center region. All dummies, except for the North dummy, are significant and thus we find clear evidence that the geographical location of the state has an impact on the green jobs index.

These results allows us to conclude that we accept the hypothesis that economic complexity has a positive effect on green job development in the Brazilian states. We also find that financial development and institutional quality play an important role when it comes to the creation of green jobs. Finally we also see that being located in the South has a positive effect on the green jobs index. This again underlines that there are significant regional differences in Brazil.

**Conclusion**

This empirical paper set out with two goals in mind. The first was to measure the occupational greenness of the 27 Brazilian states. The second was to examine the assumption that higher levels of economic complexity contribute to the greenness of the occupational space of a state.

First, it was constructed the green jobs index for the Brazilian states and the results show that São Paulo is not only the economic capital of Brazil, but also its green capital, as no other state even comes close to the green jobs index of São Paulo. The second thing that is clear is that the green jobs index of states changes very slowly in a regional level, not a single state experienced considerable changes between 2003 and 2013. This supports similar evidence that is found by Shutters *et al*. (2015). We also find the expected significant regional differences, the more developed South and South-East are much greener in terms of their occupational spaces than the less developed North and North-East. However, the states with the lowest initial green jobs index show promising growth, whereas the states with the highest initial green jobs index remained practically at the same level between 2003 and 2013. This could be a sign of regional convergence. Finally we see that the average green jobs index throughout Brazil is slowly increasing between 2003 and 2013. The global financial crisis led to a slump in 2008-2009, but the increase picked up again after those years. Brazil seems to become greener, however the green jobs index growth seems to respond to the state of the economy. It is no secret that recent years have shown that Brazil's rapid growth and an emerging economy has come to a stop. The last few years of our green jobs index numbers appear to reflect this stagnation.

We also find that states that were previously relatively green are more likely to be greener in the future as well, as the initial green jobs index variable has a strong positive and significant coefficient. The results also show that financial development and institutional quality have a positive impact on green job growth. Finally our regional dummies empirically prove what our green jobs index results already indicated. States that are located in the more developed South do indeed have a greener occupational space than states that are located in the North, North-East, and West-Center.

These results are relevant for policymaking on various levels. First of all, the greenness of the 27 Brazilian states is now measured. This enables the federal government to quickly get an overview of not only which state is green and which is not, but also of what the regional differences are in regards to what jobs certain states are specialized in. We know from the theory on economic complexity that the existing knowledge and skills in an economy determine for a large part in which directions a country can grow. Some non-green jobs are, by their nature, very close to green jobs. Knowing in which of these jobs, that are close to being green, a state has a relative comparative advantage is useful for policymakers who want to make their economy greener, as it shows which sectors have potential for that state. This knowledge shows the best channels through which a state can go green. If a state is specialized in high-tech engineering it should focus on green jobs that are close to this sector, as that state already possesses the required knowledge for such green jobs. This way the index that we created allows policymakers to make full use of the existing potential in a state when 'going green'. Regional policies can be based on this index as it shows what region is specialized in what kind of jobs.

Various policy implications can be derived from the positive relationship that we have found between economic complexity and the green jobs index. The policy message for states that seek to green its occupational space is clear: create an environment where a greater diversity of productive activities can thrive and, in particular, activities that are relatively more complex. The ability to successfully export new products is a reflection of the fact that the state has acquired new productive knowledge that will then open up further opportunities for progress. What a state needs to do to achieve this will be highly specific to the context of the state and the product. States are more likely to succeed in this agenda if they focus on products that are close to their current set of productive capabilities, as this would facilitate the identification and provision of the missing capabilities. However, economic complexity clearly focuses on differences between states. A state should not seek to find a "golden" set of policies that is right for every state to implement. A state should start with evaluating what it produces now, and then look for options that are in the same realm.

It is clear that increasing the complexity of an economy is not an easy task, especially since most knowledge is difficult to transfer. Our results also indicate other policy measures that a country can focus on, which are perhaps easier to implement. Establishing good institutions and stimulating financial development within a country have positive effects on green job development. Such matters can be achieved by reforming banking regulations and reforming the legal system, for example. Surely no simple tasks, but perhaps more achievable than increasing the complexity of the economy in the short run. For achieving the latter, it would be wise of countries to map their own product space, in order to get a clear view of in which directions they should focus their economic growth.

When it comes to the limitations of this research, the small sample is the most problematic one. We only have data for 27 states over a ten year period. Especially when researching the green jobs index, which changes very slowly, a large sample would be very useful. It would be interesting to see whether further research would find more pronounced results with data for a larger period. Repeating the same research on a municipality level would also add value, as this would greatly expand the dataset. Furthermore it would be interesting and useful for future research to redo this analysis for green products, rather than green jobs. This would directly show what products a state is specialized in and which of these products are close to a green product. This provides relevant knowledge for both policymakers and industries. Finally it would also be useful to test whether there are regional spillover effects. Does the greenness of neighboring states have a positive impact on the greenness of a state? It would be valuable to know whether such a relationship exists because convergence is more likely to occur when there are strong regional spillover effects since this would allow states to catch up quicker.

**References**


Arrow, K. (1962). Economic welfare and the allocation of resources for invention. In *The rate and direction of inventive activity: Economic and social factors* (pp. 609-626). Princeton University Press.

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The review of economic studies*, *58*(2), 277-297.

Azis, I. J., Drennan, M. P., Miller, R. E., Saltzman, S., & Thorbecke, E. (1998). *Methods of interregional and regional analysis* (Vol. 490). Aldershot: Ashgate.

Bahar, D., Hausmann, R., & Hidalgo, C. A. (2014). Neighbors and the evolution of the comparative advantage of nations: Evidence of international knowledge diffusion?. *Journal of International Economics*, *92*(1), 111-123.

Barton, H. (2000). Conflicting perceptions of neighbourhood. *Sustainable Communities: The Potential for Eco-neighbourhoods, Earthscan, London*, 3-18.

Bezdek, R. H., Wendling, R. M., & DiPerna, P. (2008). Environmental protection, the economy, and jobs: National and regional analyses. *Journal of Environmental Management*, *86*(1), 63-79.

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of econometrics*, *87*(1), 115-143.

Blundell, R., & Bond, S. (2000). GMM estimation with persistent panel data: an application to production functions. *Econometric reviews*, *19*(3), 321-340.

Bond, S. R., Hoeffler, A., & Temple, J. R. (2001). GMM estimation of empirical growth models.

Brundtland, G., Khalid, M., Agnelli, S., Al-Athel, S., Chidzero, B., Fadika, L. & Singh, M. (1987). Our Common Future (\'Brundtland report\').

Bun, M. J., & Windmeijer, F. (2010). The weak instrument problem of the system GMM estimator in dynamic panel data models. *The Econometrics Journal*, *13*(1), 95-126.

Can, M., & Gozgor, G. (2016). Dynamic Relationships among CO2 Emissions, Energy Consumption, Economic Growth, and Economic Complexity in France. *(March 30, 2016)*.

Cahill, M. (2001). Social policy and the environment. *The Gildredge Press, Brighton*.

Cahill, M., & Fitzpatrick, T. (2002). *Environmental issues and social welfare*. Blackwell Publishing.

Cai, W., Wang, C., Chen, J., & Wang, S. (2011). Green economy and green jobs: Myth or reality? The case of China's power generation sector. *Energy*, *36*(10), 5994-6003.

Cleary, J., & Kopicki, A. (2009). Preparing the Workforce for a "Green Jobs" Economy. *Rutgers, NJ: John J. Heldrich Center for Workforce Development*.

Du Plessis, C. (2000). Cities and sustainability: sustaining our cultural heritage. *Cities and Sustainability: Sustaining Our Cultural Heritage*.

Elkington, J. (1998). Partnerships from cannibals with forks: The triple bottom line of 21st-century business. *Environmental Quality Management*, *8*(1), 37-51.

Engel, D., & Kammen, D. M. (2009). *Green jobs and the clean energy economy*. Copenhagen: Copenhagen Climate Council.

Florida, R. (2014). *The Rise of the Creative Class--Revisited: Revised and Expanded*. Basic books.

Florida, R., Mellander, C., & Stolarick, K. (2008). Inside the black box of regional development—human capital, the creative class and tolerance. *Journal of economic geography*, *8*(5), 615-649.

Fowke, R., & Prasad, D. K. (1996). Sustainable development, cities and local government: Dilemmas and definitions. *Australian Planner*, *33*(2), 61-66.

Giddings, B., Hopwood, B., & O'brien, G. (2002). Environment, economy and society: fitting them together into sustainable development. *Sustainable development*, *10*(4), 187-196.

GIZ and ICLEI. (2012). Green urban economy—conceptual basis and courses for action. *Deutche Gesellschaft fuer Internationale Zusammenarbeit (GIZ) and Local Governments for Sustainability(ICLEI), Bonn, Germany*.

Goldsmith, E., & Norberg-Hodge, H. (1995). *The future of progress: Reflections on environment and development*. Green Books.

Gülen, G. (2011). Defining, measuring and predicting green jobs. *Copenhagen Consensus Center*.

Grazi, F., van den Bergh, J. C., & Rietveld, P. (2007). Spatial welfare economics versus ecological footprint: modeling agglomeration, externalities and trade. *Environmental and Resource Economics*, *38*(1), 135-153.

Griggs, D., Stafford-Smith, M., Gaffney, O., Rockström, J., Öhman, M. C., Shyamsundar, P., ... & Noble, I. (2013). Sustainable development goals for people and planet. *Nature: international weekly journal of science*, *495*.

Grossman, G. M., & Krueger, A. B. (1994). *Economic growth and the environment* (No. w4634). National Bureau of Economic Research.

Hansen, L. P. (1982). Large sample properties of generalized method of moments estimators. *Econometrica: Journal of the Econometric Society*, 1029-1054.

Hardi, P., & Zdan T. (1997). *Assessing sustainable development* (No. C024. 003). International Institute for Sustainable Development: Winnipeg.

Hausmann, R., & Hidalgo, C. A. (2011). The network structure of economic output. *Journal of Economic Growth*, *16*(4), 309-342.

Hidalgo, C. A., & Hausmann, R. (2009). The building blocks of economic complexity. *proceedings of the national academy of sciences*, *106*(26), 10570-10575.

Hidalgo, C. A., Klinger, B., Barabási, A. L., & Hausmann, R. (2007). The product space conditions the development of nations. *Science*, *317*(5837), 482-487.

Hopwood, B., Mellor, M., & O'Brien, G. (2005). Sustainable development: mapping different approaches. *Sustainable development*, *13*(1), 38-52.

International Council for Local Environmental Initiatives (ICLEI). (2000). *The Local Agenda 21 Planning Guide: An Introduction to Sustainable Development Planning*. International Development Research Centre.

Kuznets, S. (1955). Economic growth and income inequality. *The American economic review*, *45*(1), 1-28.

Lavecchia, L., & Stagnaro, C. (2010). Are Green Jobs Real Jobs?. *Istituto Bruno Leoni, Milano*.

Lehr, U., Lutz, C., & Edler, D. (2012). Green jobs? Economic impacts of renewable energy in Germany. *Energy Policy*, *47*, 358-364.

Nickell, S. (1981). Biases in dynamic models with fixed effects. *Econometrica: Journal of the Econometric Society*, 1417-1426.

Norton, J. J., Drewes, D. W., Kroustalis, C. M., Rivkin, D., & Lewis, P. (2009). *Greening of the World of Work: Implications for O* NET-SOC and new and emerging occupations*. National Center for O* NET Development.

Martinez-Fernandez, C., Hinojosa, C., & Miranda, G. (2010). Green jobs and skills: the local labour market implications of addressing climate change. *Working document, OECD. Available from: www. oecd. org/cfe/leed/44683169. pdf*.

Mass, W., Moss, P., Hopkins, M., & Ross, M. (2010). Skills for green jobs in the United States. *ILO Skills and Employability Department*.

McBurney, S. (1990). *Ecology into Economics Won't Go, or, Life is not a Concept*. Hartland: Green Books.

Michaels, R., & Murphy, R. P. (2009). Green jobs: fact or fiction. *Institute for Energy Research, Houston, Texas, January*, 1-15.

Mitlin, D. (1992). Sustainable development: A guide to the literature. *Environment and Urbanization*, *4*(1), 111-124.

Montaldo, C. R. B. Sustainable Development Approaches for Rural Development and Poverty Alleviation & Community Capacity Building for Rural Development and Poverty Alleviation.

Moretti, E. (2012). *The new geography of jobs*. Houghton Mifflin Harcourt.

Morriss, A. P., Bogart, W. T., Dorchak, A., & Meiners, R. E. (2009). 7 Myths About Green Jobs. *U Illinois Law & Economics Research Paper No. LE09-007*, 09-14.

Muneepeerakul, R., Lobo, J., Shutters, S. T., Goméz-Liévano, A., & Qubbaj, M. R. (2013). Urban Economies and Occupation Space: Can They Get “There” from “Here”?. *PloS one*, *8*(9), e73676.

Paul, Bâc Dorin. "A history of the concept of sustainable development: Literature review." *The Annals of the University of Oradea, Economic Sciences Series* 17.2 (2008): 576-580.

Peters, D. J., Eathington, L., & Swenson, D. (2011). An exploration of green job policies, theoretical underpinnings, measurement approaches, and job growth expectations. *Iowa State University*.

Pearce, D. W., Markandya, A., & Barbier, E. (1989). *Blueprint for a green economy* (Vol. 1). Earthscan.

Redclift, M. (2002). *Sustainable development: Exploring the contradictions*. Routledge.

Redclift, M. (2005). Sustainable development (1987–2005): an oxymoron comes of age. *Sustainable development*, *13*(4), 212-227.

Renner, M., Seeney, S., Kubit, J., & Mastny, L. (2008). Green jobs.

Robert E., Lucas J. (1993). Making a miracle. *Econometrica*, 61, 251–272.

Robinson, J. (2004). Squaring the circle? Some thoughts on the idea of sustainable development. *Ecological economics*, *48*(4), 369-384.

Roodman, D. (2006). How to do xtabond2: An introduction to difference and system GMM in Stata. *Center for Global Development working paper*, (103).

Safarzyńska, K., Frenken, K., & van den Bergh, J. C. (2012). Evolutionary theorizing and modeling of sustainability transitions. *Research Policy*, *41*(6), 1011-1024.

Sample, I. (2003). Not just warmer: it's the hottest for 2000 years. *The Guardian*, *1*.

Scottish Executive. (2006). Sustainable Development: A Review of International Literature. *Social Research. doi*, *10*.

Shutters, S. T., Muneepeerakul, R., & Lobo, J. (2015). How hard is it for urban economies to become 'green'?. *Environment and Planning B: Planning and Design*, 0265813515600108.

Stokey, N. L. (1988). Learning by doing and the introduction of new goods. *The Journal of Political Economy*, 701-717.

Trainer, F. E., & Trainer, T. (1996). *Towards a sustainable economy: the need for fundamental change*. Jon Carpenter Publishing.

United Nations Environment Programme (UNEP) (2008). Green jobs: towards decent work in a sustainable, low-carbon world. *Joint report by the UNEP, ILO, IOE, ITUC Green Jobs Initiative*.

West Midlands Round Table (2000). Quality of Life: the Future Starts Here. *West Midlands Round Table for Sustainable Development: Solihull*.

Willard, B. (2012). *The new sustainability advantage: seven business case benefits of a triple bottom line*. New Society Publishers.

Williams, C. C., & Millington, A. C. (2004). The diverse and contested meanings of sustainable development. *The Geographical Journal*, *170*(2), 99-104.

Windmeijer, F. (2005). A finite sample correction for the variance of linear efficient two-step GMM estimators. *Journal of econometrics*, *126*(1), 25-51.

Van den Bergh, J. C. (2010). Externality or sustainability economics?. *Ecological Economics*, *69*(11), 2047-2052.