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## **Impact of innovation on employment: A review of literature**

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### **Abstract**

The primary objective of this study is to assess the significance of the knowledge diffusion process in relation to the employment outcomes resulting from sustainable development investments made by major multinational corporations. To gauge the degree of technological interconnectedness among these companies, we employ a measure derived from the distribution of environmentally friendly patents. Within this analytical framework, we aim to decipher the multifaceted factors influencing labor innovation outcomes, which encompass both the displacement of jobs and the compensation effects stemming from innovation.

This study delves into two primary research inquiries. Firstly, we examine whether investments in the green economy stimulate job creation at the firm level, specifically within three distinct environmental domains: water, waste, and energy. Secondly, we seek to understand the extent to which the diffusion of knowledge plays a pivotal role in supporting labor within an environmental context. This is achieved by scrutinizing the impact of intra-industry externalities.

The research emphasizes the need not only for economic incentives to facilitate the transition to cleaner technologies but also for more robust measures aimed at promoting job generation within the environmental sector. This dual approach is essential for realizing a fully sustainable paradigm within these corporations.

**Keywords:** labor demand, employment, international trade

## 1. Introduction

There is a burgeoning interest in research regarding the sustainable utilization of economic resources, with an expanding array of scholarly works (Arbolino et al., 2017; Arbolino et al., 2018; Aggarwal et al., 2023e). Numerous studies have explored the connection between innovation aimed at enhancing firm-level output or productivity and its impact on job creation (Van Zandweghe, 2010), revealing a relatively limited correlation. These findings lend support to the notion of technological unemployment due to the introduction of new machinery (Brynjolfsson and McAfee, 2011; Aggarwal and Chakraborty, 2020b). Consequently, the influence of automation on changes in employment has assumed a pivotal role in contemporary discussions.

The employment outcomes resulting from innovation represent an intricate interplay between job displacement and the compensatory dynamics of innovation (Harrison et al., 2014; Piva and Vivarelli, 2018a, 2018b; Aggarwal and Chakraborty, 2020a). The assessment of innovation's impact on employment is intricate due to the diverse array of effects it encompasses. On one hand, product innovations or the introduction of new products that foster the emergence of fresh markets (Piva and Vivarelli, 2018a) can yield positive job-creation effects. On the other hand, process innovations or the adoption of new and markedly improved production methods (Piva and Vivarelli, 2018b; Aggarwal, 2020; Aggarwal et al., 2021) may lead to technological unemployment due to heightened labor productivity. Nevertheless, there are also indirect effects that serve as compensation for reductions in employment resulting from process innovations.

Regarding product innovations, we can observe a favorable impact on employment (Say, 1964), often referred to as the 'welfare effect.' However, this outcome may be attenuated by a 'substitution effect' (Freeman and Soete, 1994; Edquist et al., 2001; Bogliacino and Pianta, 2010) which arises due to the displacement of established products (Katsoulacos et al., 1986; Hall et al., 2008; Harrison et al., 2014).

When examining process innovations, we can observe a direct impact on job reduction, as the introduction of new process methods often allows for achieving the same output with fewer employees. Nevertheless, there exist several compensatory mechanisms (Marx et al., 1954; Say, 1964; Edquist et al., 2001; Hall et al., 2008; Aggarwal and Chakraborty, 2020c, 2021, 2022) that counterbalance the labor-saving effects of process innovation. Primarily, the cost savings resulting from process innovation could lead to lower prices, potentially stimulating market demand and consequently increasing employment (Neary, 1981; Stoneman, 1983; Hall and Heffernan, 1985; Dobbs et al., 1987; Aggarwal et al., 2022). However, the extent of this effect depends on assumptions related to perfect competition (Sylos Labini, 1969) and demand elasticity, which might attenuate the initial positive impact.

Given the recognition of various potential effects, as previously described, the ultimate influence of innovation on employment remains uncertain. Consequently, interpreting empirical analyses becomes crucial in discerning a net employment outcome, with due consideration of the economic and social context in which the investigation is conducted.

The number of studies examining the impact of green innovations on employment is on the rise (Crespi et al., 2015; Gagliardi et al., 2016). This growing interest is driven by the pursuit of achieving more sustainable development goals in many countries. Nonetheless, green economy investments have a unique nature, as the requirement for government intervention to create new market opportunities may yield a comparatively lower return when compared to other types of innovations (Marin and Lotti, 2017; Aggarwal, 2016, 2017a, 2017b).

Nevertheless, the empirical support regarding the influence of environmental innovations in facilitating the diffusion of knowledge to promote employment is rather limited. This paper aims to address this gap by examining the ramifications of knowledge transfer between firms operating within the same technological sector, commonly known as intra-industry knowledge spillovers. Specifically, we explore two primary research questions: firstly, we assess the impact of environmental innovations on employment across three distinct domains, namely water, waste, and energy; secondly, we gauge the influence of knowledge externalities resulting from innovations on employment within the same technology sector.

## **2. Literature Review**

The growing interest in research revolves around the impact of green economy innovations on employment. This heightened focus is driven by the shift towards cleaner production as a crucial element for achieving sustainable growth in industrialized nations. Additionally, these regions have experienced elevated unemployment rates due to economic and financial crises that have persisted since 2006. There is a pressing need for more empirical studies to comprehensively assess the advantages and drawbacks associated with the transition process.

We can categorize research into two broad categories: one that explores the overall relationship between technology and employment and another that specifically delves into the realm of green technologies.

- **Empirical Evidence based on Technology and Employment**

From a macroeconomic standpoint, Sinclair (1981) observes that high demand elasticity and elasticity of factor substitution have a positive impact on employment. Additionally, Layard and Nickell (1985) emphasized the crucial role of labor demand elasticity in response to changes in the ratio between real wages and labor productivity. Specifically, this parameter should exhibit sufficient responsiveness to offset initial job destruction. Feldmann (2013) also noted that technological progress leads to short-term unemployment. On the contrary, Matuzeviciute et al. (2017) argued that technological innovations do not significantly affect unemployment.

Looking at microeconomic perspectives, Van Reenen (1997) discovered a favorable effect of innovation on employment through an analysis of UK manufacturing firms. Piva and Vivarelli (2005) also found a modest positive impact of gross innovative investment on employment. In the research by Hall et al. (2008), a positive relationship between product innovation and employment was established, although no significant impact was observed for process innovation.

Bogliacino and Pianta (2010) uncovered a positive link between product innovation and employment, focusing particularly on high-tech manufacturing sectors in eight European countries. Lachenmaier and Rottmann (2011) delved into German manufacturing firms and identified a positive effect of various innovation measures on employment. Meanwhile, Bogliacino and Vivarelli (2012) presented evidence of job creation resulting from Research and Development (R&D) expenditures in high-tech industries across 15 European countries.

Harrison et al. (2014) confirmed that process innovation tends to displace employment, whereas product innovations exhibit a more job-friendly character. Ciriaci et al. (2016), based on the Spanish Community Innovation Survey (CIS) covering 3304 Spanish firms, demonstrated that innovative, smaller, and younger firms are more likely to consistently create jobs compared to non-innovative firms. Barbieri et al. (2019) conducted research on 265 innovative firms and identified a job-creation effect, particularly in high-tech and large firms.

Cirillo et al. (2018) examined 36 manufacturing and service industries across five major European countries (Germany, France, Spain, Italy, and the UK) and noted varying impacts of product innovations across different managerial categories. Piva and Vivarelli (2018a and 2018b) confirmed a labor-friendly impact of R&D expenditures in medium-high sectors but did not find a significant impact in low-tech sectors. Lastly, Van Roy et al. (2018) analyzed approximately 20,000 European firms and concluded that technological change, as indicated by forward-citation weighted patents, tends to be beneficial for labor.

- **Empirical Evidence based on Green Technology and Employment**

Studies have yielded varying perspectives on the relationship between environmental regulations and their impact on the economy. Some research, as indicated by (Bartik, 2015; Dechezleprêtre and Sato, 2017; Aggarwal, 2023b, 2023d) suggests that environmental regulations can lead to higher production costs and subsequently result in increased output prices. This, in turn, can reduce consumer demand and ultimately lead to a slower rate of employment growth. Conversely, other studies, represented by (Ambec, 2013; Antonioli, 2013; Aggarwal, 2023a, 2023c), argue that environmental innovations lead to a shift in the workforce from regulated, polluting industries to less environmentally harmful ones.

Pfeiffer and Rennings (2001) provide evidence supporting the positive influence of product innovation on employment, but they also note negative effects of environmental innovations, particularly in industries with a lower demand for skilled labor. Rennings and Zwick (2002) conducted an analysis of environmental innovations across five European countries, considering both manufacturing and service firms, but found no significant impact on employment.

Horbach (2010) discovered a positive impact of environmental innovations on employment in Germany. In contrast, Cainelli et al. (2011) identified a negative effect of environmental innovations on employment in Italy. Gagliardi et al. (2016) measured the impact of environmental innovations using patent data and highlighted their strong positive effect on job creation processes.

Costantini et al. (2018) found that energy efficiency gains in energy-intensive industries could reduce the rate of employment growth. However, they also observed that energy efficiency improvements in the public sector had a positive impact on employment growth. Furthermore, a more comprehensive policy mix was seen to reinforce positive employment growth impacts.

Nonetheless, there is a notable scarcity of empirical data regarding the impact of environmentally friendly innovations on employment, with a specific dearth of information regarding the role of knowledge diffusion processes in the employment outcomes of green innovation. This paper endeavors to address this void in the existing body of literature.

**Table 1.** Literature for employment effect of innovation

<b>Authors</b>	<b>Data</b>	<b>Methodology</b>	<b>Results</b>
Aldieri and Vinci (2018)	Firms from USA, Europe and Japan over the period 2002-2010	Ordinary least squares (OLS)	Negative effect of own innovation on employment
Costantini et al. (2018)	15 European countries over the time span 1995-2009	Ordinary least squares (OLS) in First Differences	Negative effect of investments for energy efficiency on employment growth
Matuzeviciute et al. (2017)	25 European countries over the period 2000-2012	Generalized Method of Moments (GMM)	No significant effect of innovation on employment
Aggarwal and Chakraborty (2019)	Seven major product groups in 25 countries over the period 2001-2015	Feasible general least squares (FGLS) method with time specific random effects	Higher innovation leads to greater potential for participation in global value chains (GVCs)
Aggarwal et al. (2023a)	Developed and developing economies are selected over the period 2001-2019	Generalized method of moments (GMM)	Positive impact of green innovation on the employment outcomes of the country
Aggarwal et al. (2023b)	Trade in value data for the group of countries from 2000-2018	Generalized least square (GLS) method	Positive impact on innovation and higher efficiency on the high-skilled labor force

### 3. Discussion and Concluding Remarks

Ensuring the sustainability of economic systems holds paramount importance for optimizing the utilization of goods and services in contemporary industrialized nations. This study delves into two pivotal inquiries. Firstly, it enhances our understanding of how investments in the green economy affect employment at the firm level, thereby contributing to the empirical evidence in this domain. Secondly, it sheds light on the dissemination of knowledge within environmental contexts by scrutinizing the impact of Marshallian externalities. While numerous studies investigate the connection between innovation aimed at boosting firm-level output or productivity and its job-creating implications (Aggarwal and Chakraborty, 2017), they frequently overlook the indirect consequences of these investments on the employment of other firms. This paper seeks to bridge this gap in existing literature by emphasizing the substantial role played by knowledge processes in the green economy sector.

The intricate interplay between the displacement and compensatory forces of innovation appears to be influenced by knowledge spillovers. Indeed, the empirical findings reveal that Marshallian spillovers in the green economy sector have a detrimental effect, confirming the prevalence of displacement effects. This discovery carries significant policy implications. It underscores the necessity not only for economic incentives to facilitate the transition toward cleaner technologies but also for robust measures that promote job creation within the realm of environmental activities. Such multifaceted actions are imperative for the complete and sustainable advancement of firms in this context.

However, it is important to acknowledge certain limitations in the methodological approach employed in our research. Specifically, our approach focused on assessing the technological proximity between different technology classes of environmental patents. Nevertheless, it's worth noting that Jaffe's measure has its own set of shortcomings. Jaffe's proximity concept primarily addresses knowledge flows occurring within the same technology class, which is defined as Marshallian or intra-industry, while it does not account for spillovers between distinct classes, known as Jacobian or inter-industry, or diversified externalities. In such cases, alternative and potentially more suitable approaches may be considered.

Therefore, further analysis is warranted. Expanding our analysis to include Jacobian or inter-industry spillovers could provide valuable insights. Additionally, it would be intriguing to investigate the extent to which other avenues of knowledge diffusion, such as the mobility of skilled workers or inventors, play a significant role in shaping the impact of green economy investments on firms' employment.

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