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Green investment: Trends and determinants

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HIGHLIGHTS

- We offer a definition of green investment and review its trend since 2000.
- We analyze its determinants from both theoretical and empirical perspectives.
- Green investment is boosted by economic growth, interest rates, and fuel prices.
- Feed-in-tariffs and carbon pricing schemes impact positively green investment.

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ABSTRACT

This paper fills a gap in the macroeconomic literature on renewable sources of energy. It offers a definition of green investment and analyzes the trends and determinants of this investment over the last decade for 35 advanced and emerging countries. We use a new multi-country historical dataset and find that green investment has become a key driver of the energy sector and that its rapid growth is now mostly driven by China. Our econometric results suggest that green investment is boosted by economic growth, a sound financial system conducive to low interest rates, and high fuel prices. We also find that some policy interventions, such as the introduction of carbon pricing schemes or “feed-in-tariffs,” which require use of “green” energy, have a positive and significant impact on green investment. Other interventions, such as biofuel support, do not appear to be associated with higher green investment.

1. Introduction

There is now a wide consensus that climate change is occurring, caused by human-induced greenhouse gas emissions, mainly from fossil fuel combustion and changes in land use. Climate change could produce severe negative outcomes and has important macroeconomic consequences. Higher temperatures, rising sea levels, and extreme weather conditions may severely impair output and productivity (IMF, 2008a). Climate developments will also affect fiscal positions through their direct impact on tax bases and spending programs, and more importantly, through the policies needed to mitigate climate change and adapt behaviors and production to the new environment (IMF, 2008b; Jones and Keen, 2009; Parry, 2011). These costs and risks point to the unsustainability of current patterns of energy use. At the same time, the transition to a low-carbon emission model will require large investments in alternative energy sources, because green technologies, such as wind turbines or solar panels, are capital-intensive, especially in the early stages of development (Johnson and Lybecker, 2009).

Increasing the share of green investment (GI) is not only a medium-term climate target. Proponents of investment in low-carbon energy sources also cite the need to enhance energy security, reduce adverse health effects of air pollution, and find new sources of growth (Accenture, 2011; McKinsey, 2009; OECD, 2011; PriceWaterhouseCoopers, 2008). As of today, GI is already a significant contributor to electricity and energy generation. Renewable energies represent one-fifth of electricity generation worldwide (IEA WEO 2010). The pace of green capital accumulation has accelerated in recent years, led by technological progress, economies of scale, strong policy support, and favorable public opinion. Green programs had also proven to be important in national fiscal stimulus plans during the 2008/09 global financial crisis.

The purpose of this paper is to analyze and explain recent trends in GI based on a new multi-country dataset, with a view to better understanding what policies have been successful in promoting it. To our knowledge, no study has yet been conducted that defines the concept of GI in a macroeconomic sense, and relates it to macro determinants from a cross-country perspective.

The paper utilizes a broad definition of GI, which encompasses both traditional energy sources (e.g., hydropower) and new technologies. It shows that GI has become a key driver of the

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energy sector, as it now exists on a similar scale to investment in fossil-fuel capacity. GI is also a global phenomenon, with leadership shifting from Europe and the United States in the 1990s to China in more recent years.

Our econometric results have important implications for the design of policies to bolster GI. They suggest that macroeconomic policies that are generally effective for increasing private investment as a whole are also useful for GI, in particular, enhancing GDP growth and lowering the cost of capital. At the same time, not all public interventions are successful in boosting GI. Feed-in tariffs (a form of price support) and carbon pricing mechanisms are found to foster GI, while other policies, like biofuel support, do not appear to be associated with higher investment rates.

The paper is organized as follows: Section 2 discusses conceptual and methodological issues related to the definition and measurement of GI. Section 3 analyzes the relative importance of green and conventional energy sources. Section 4 reviews recent trends in GI, drawing from financial data and other relevant sources. Section 5 analyzes the determinants of GI from both theoretical and empirical perspectives. Finally, Section 6 concludes.

2. What is green investment and how can it be measured?

2.1. Definition and components of green investment

In this study, GI refers to the investment necessary to reduce greenhouse gas and air pollutant emissions, without significantly reducing the production and consumption of non-energy goods.[1] GI covers both public and private investment. Our approach to GI differs from that of the forward-looking economic literature on mitigation and abatement costs, which measures the *incremental* investment needed to meet a certain climate target relative to a business-as-usual scenario (Appendix A).

Core strategies for reducing emissions can be classified according to their intermediate objective. Most GI is intended either to reduce the pollution caused by energy generation, or to decrease energy consumption. In addition, GI also covers technologies that sequester carbon, as deforestation and agriculture are important sources of carbon emission. Accordingly, Table 1 identifies three main components of GI:

- *Low-emission energy supply*. GI involves shifting energy supply from fossil fuels to less polluting alternatives, either for electricity generation (wind, solar, hydropower, etc.), or as direct sources of energy (biofuel, for example). The GI concept thus extends not only to emerging environmental technologies such as wind and solar photovoltaic power, but also to more established technologies, like hydropower.[2]
- *Energy efficiency*. GI also includes technologies that reduce the amount of energy required to provide goods and services. In the electricity sector, there is scope for improving efficiency in power generation (moving from sub- to super-critical coal)[3] and transmission and distribution (by using more efficient grids and smart grid technologies).[4] There is also potential for efficiency gains in transport, including through the utilization of more fuel-efficient and hybrid cars, as well as greater use of mass transit. In industrial equipment, efficiency gains can be achieved through energy-saving appliances and improved waste management. In construction, efficiency could be enhanced through improved insulation and cooling systems.
- *Carbon sequestration*. After fossil fuel combustion, deforestation is the second-largest contributor to carbon emissions worldwide, accounting for 20% of total emissions (Report of the Intergovernmental Panel on Climate Change, 2007). Halting ongoing deforestation, reforesting, and sequestering more carbon in soils through new agricultural practices, are therefore crucial to reducing carbon emissions. Deforestation and agriculture may also offer some of the lowest-cost abatement opportunities. However, the main mitigation strategies in these areas rely on labor, rather than physical capital (for example, changes in crop and soil management practices), and available data on GI in this area is limited.

Although nuclear may also be considered as a low-emission energy supply, we do not include it in our definition of green investment for the following reasons. First, nuclear power produces radioactive waste. Second, the investment decisions in nuclear and renewable energy are likely to be very different. Renewable energy investments involve smaller-scale private investments, while nuclear spending is often larger and funded by the public sector. In addition, investment in renewable energy depends on geo-physical conditions (for instance the water supply), while the development of nuclear energy hinges more heavily on technological progress. Finally, the production costs of both types of energy might differ.

2.2. Measuring green investment

Our measure of GI covers: (i) financial investment in renewable technologies (including large hydroelectric projects), (ii) selected energy-efficient technologies,[5] and (iii) research and development (R&D) in green technologies. Investment in carbon sequestration, which is difficult to measure, is excluded from the analysis.

Excluding large hydro projects, data on renewable GI is provided by Bloomberg New Energy Finance (BNEF). BNEF has the most complete database on renewable energy projects and is widely used by public and private entities (Appendix B). BNEF records financial investment (acquisition of financial assets), which may differ from physical investment, although project financing is usually earmarked in the renewable sector. Investment covered by the database is mostly private, but BNEF separately reports the green component of fiscal stimulus programs and public R&D spending.

For large hydropower projects (not covered by the BNEF database), we use capacity data provided by the U.S. Energy Information Administration. Estimating investment flows from capacity data is particularly challenging.[6] This is because the capital costs of hydro projects are likely to be highly heterogeneous,

[1] The emission of greenhouse gases (in particular carbon dioxide) and pollutants (such as sulfur dioxide and nitrogen oxide) lead to global warming, smog, and acid rain, and have adverse effects on health. Our analysis focuses on emission reduction to restrict the scope of the GI concept in light of data availability. Other environmental objectives could have been considered, such as reducing the reliance on fossil fuels, avoiding resource depletion, preventing damages to water and soil, reducing waste, and preserving biodiversity. For instance, Eurostat (2009) adopts a broader approach by defining environmental spending as the acquisition of technologies, goods, and services whose main purpose is to limit the degradation and depletion of natural resources.

[2] Biofuels are part of GI, despite their debated impact on carbon emissions (IMF, 2008d), so that all renewable energy sources are considered "green" in our study. For simplicity's sake, our measure excludes "fossil-fuel switching," for example, the replacement of coal with natural gas, which also contributes to emission reduction.

[3] Supercritical coal-fired plants are highly efficient electricity plants that burn less coal per megawatt-hour produced.

[4] A smart grid is a form of electricity network using digital technology.

[5] The Bloomberg New Energy Finance database used in this study only covers selected energy efficient technologies, labeled under the category "Energy Smart Technologies" (for instance, smart grids or power storage).

[6] Capacity refers to the maximum output of electricity and is usually in the form of kilowatts (kW) and megawatts (MW).