5. ROBOTICS AS AN INNOVATION DRIVER

Historically, technological innovation has proven to be the most transformative and economically beneficial.

For advanced economies, innovation is the most critical determinant of long-term competitiveness, and is responsible for the majority of productivity and *per capita* income growth in regions, states, and nations. Innovation can take many forms, both technological and non-technological. But it has been technological innovation that has proven to be the most transformative, creating entirely new products, services, and industries, and as a result, generating increasing levels of economic activity for extended periods of time.

Technology is a key innovation driver, but some technologies are more impactful than others. The invention of the steam engine, widespread electrification, and the development of computer systems and digital networks have had wide-ranging and long-term beneficial economic effects, while impacting all aspects of society.

It has been demonstrated that the use of robots for manufacturing increases a country's GDP growth.

Robotics, too, is transformative in this way, particularly as systems become more interconnected to each other and the world around them, using and sharing a broad spectrum of intelligence, and becoming increasingly more capable and autonomous in the process. But even earlier generations of robotics technologies, largely limited to systems in a manufacturing automation role, have had an impact that goes beyond simple productivity increases and quality improvements. For example, in one recent study, researchers examining 17 countries estimated that between 1993 and 2007, the use of robots for manufacturing increased a country's gross domestic product (GDP) growth by 0.37 percentage points and labor productivity by 0.36 points (Graetz and Michaels, 2015).

5.1. UNIQUENESS OF ROBOTICS

Robotics technologies bridge the physical and virtual worlds.

The development of robots and robotics technology requires the mastery of multiple disciplines, including software development, along with mechanical and electrical engineering. The consequences of these dependencies produce unique technologies that function as a bridge between the physical and the virtual. Robotics technologies bridge the physical and virtual worlds.

It is the physicality inherent in robotic systems that differentiates the technology from software, although it is software that provides the "intelligence" that allows robots to physically interact with, move through, and modify their environments. These capabilities set robots apart from most other computerized or automated systems, allowing them to take on a wide range of functional roles in the workplace, public places, the home, and more, with an operational sphere that includes air, sea, and land, and even deep space.

5.2. MULTIPLIER EFFECT X2

It is somewhat misleading to describe robotics as an "industry" or "sector," which is often done for the sake of convenience. Some define robotics as the technologies and techniques used for the construction of robots, which are themselves robotic systems, another useful construct. As an innovation driver, it might better serve to think of robotics as a foundational, technology-based capability that can be applied widely. As such, the sectoral multiplier effect of robotics can be difficult to quantify, but is real nonetheless, and should include both the production of robotics technologies, as well as their contribution during use in industry and elsewhere.

Robotics should be considered a foundational, technological capability that has wide applicability.