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General sources of general purpose technologies in complex societies: Theory of global leadership-driven innovation, warfare and human development

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ABSTRACT

A fundamental problem in the field of the economics of innovation is how to explain the sources of path-breaking innovations that support the human development and socio-economic progress in complex societies. The study here confronts this problem by developing the theoretical framework of *global leadership-driven innovation*, which endeavors to explain the general sources of General-Purpose Technologies (GPTs). Evidence, based on an inductive study of some leading societies, shows that the sources of strategic GPTs are, *de facto*, associated to the goal of global leadership of a purposeful system in the presence of effective and/or potential environmental threats. In particular, a purposeful system (e.g. a complex society), with high economic potential and purposeful institutions having the purpose of achieving/sustaining a global leadership, tends to engender GPTs that are spread in the long run. The conceptual framework is applied to analyze the current determinant of a vital case study: the U.S. Navy's Mobile User Objective System (MUOS), a possible next GPT. Over the centuries, the General Purpose Technologies – that support technological, social and economic change – have significantly changed, but their driving force, based on the goal of global leadership, is an invariant feature of the human development. The vital linkages between observed facts provide a general framework to explain the sources of General Purpose Technologies, which induce human development and progress in society.

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Causarum Cognitio²

1. A main problem in technology studies

In the field of the economics of technical change is important to understanding the sources of path-breaking innovations that support economic growth and wealth of nations.³ A fundamental problem is how economic subjects, and in which circumstances, cause and sustain General Purpose Technologies (GPTs), the core of technological and economic change (cf. [52]).

Some social scientists have described several approaches to explain the drivers of technological change (cf. [38,44,45,51,58,106,105,190,193,239]). Porter and Stern [175] show a positive relationship between Gross Domestic Product (GDP) per capita and innovative capacity of countries.⁴ Hayami and Ruttan [110] discuss the process by which societies develop technologies that facilitate the substitution of relatively abundant (hence, cheap) factors of production for relatively scarce (hence, expensive) factors in the economy system: the induced innovation approach (cf. also [189,193]). General Purpose Technologies (GPTs),⁵ as path-breaking innovations, are driven by several concomitant forces [111].⁶ However, the most important driving force of changes in the techno-economic paradigm (e.g. GPTs) is a fundamental problem for the economics of technical change, which is not well understood.

The study here confronts this scientific issue by developing the global leadership-driven innovation approach, a conceptual framework that endeavors to explain the sources of General Purpose Technologies by the goal of global leadership of purposeful systems.

The theory of global leadership-driven innovation can be schematically summarized by the diagram:



This study is part of a large research program that has the goal to explain the different determinants of innovations in order to establish a comprehensive theoretical

framework concerning the long-term development of technological change and human development. The philosophy of science of this study is based on the epistemological stance that: “the cause of a phenomenon is whatever adequately explains it, the whole ground, reason, or source of it” (G. Vico as quoted by Flint [87, p. 105ff]). The evidence of this theory is performed by an inductive study of scientific realism concerning some critical GPTs driven by leading societies (Thagard [213,p. 145]; cf. [129]).

2. Theoretical grounding

General-Purpose Technologies (GPTs) are revolutionary changes from current technological trajectories (Bresnahan [20, pp. 763–791]). GPTs are characterized by pervasiveness, inherent potential for technical improvements, and ‘innovational complementarities’, giving rise to increasing returns-to-scale such as the steam engine, the electric motor, and the semiconductors (Bresnahan and Trajtenberg [21, p. 83], original emphasis).⁷ Lipsey *et al.* [145, p. 43] define the General Purpose Technology: “a technology that initially has much scope for improvement and eventually comes to be widely used, to have many users, and to have many Hicksian and technological complementarities”. These enabling technologies exert a pervasive impact across firms, industries and countries/economies. Main features of GPTs are a long-run period between their emergence and impact on socio-economic systems [61,145,186]. According to Lundvall [149], these technological innovations are generated by a profitable interaction of elements within the National System of Innovation⁸ (cf. also [165]). Soete *et al.* [205, p. 1176] also argue the crucial role of innovation systems in contemporary economies for the innovation performance of nations. However, a fruitful “National System of Innovation” is a necessary but *not sufficient* determinant for supporting new General Purpose

Technologies. In fact, Roland [184, p. 84] states that “not all technologies will thrive in all environment”.

Constant [53, p. 15] advanced the concept of presumptive anomaly to explain the radical advances in technology: “presumptive anomaly occurs in technology ... when assumptions derived from science indicate either under some future conditions the conventional system will fail (or

² From Latin to English: *Seek knowledge of causes* (Aristotle, 384–322 BC).

³ See also [10,32,72,74,89,90,104,177,189,194,197].

⁴ Cf. [33,34].

⁵ See Refs. [20,21,119]. This paper analyzes the origins of GPTs that generate long-run structural and social change. These path-breaking innovations are mainly of transformative nature: a “destructive creation” [24] that makes prior products and knowledge obsolete (cf. [52]). This study uses interchangeably the terms GPTs, enabling technologies, revolutionary innovations, new techno-economic paradigms and changes in the techno-economic paradigm to indicate path-breaking innovations with a very strong impact on geo-economic systems [30,31,37].

⁶ Cf. [35,37,38,42–46,50,51,106].

⁷ cf. also [20,63,97,146,181,186].

⁸ Lundvall [149] states that the national system of innovation (NSI) refers to the complex network of agents, policies, and institutions supporting the process of technical advancement in an economy. The narrow definition of NSI includes the sub-system of research sector represented by universities and research laboratories, while the broad NSI includes many sub-systems such as finance, firms, government, research sector, and so on.

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