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Modeling Tomorrow: Innovation for Sustainable Development Innovation Systems, Technological Capabilities, and Sustainability Transitions in Latin America and the Caribbean



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Modeling Tomorrow: Innovation for Sustainable Development

Innovation Systems, Technological Capabilities, and Sustainability Transitions in Latin America and the Caribbean

CHAPTER 1

I. Rethinking Innovation Systems and Ecosystems

Revisiting National Systems of Innovation in the UN SDGs Era (2016–2026)

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1. Introduction:

The Sustainable Development Goals (SDGs) Report 2025 declared a "global development emergency": only 35% of SDG targets are on track or making moderate progress, and 18% have regressed below the 2015 baseline (United Nations, 2025, p. 2). The challenges include: (a) extreme poverty affecting more than 800 million people; (b) climate crisis marked by record-breaking high temperatures; (c) 120 million people forcibly removed from their homes amid deteriorating peace and security; (d) mounting economic and financial crises; and (e) accelerating environmental degradation.

The SDGs themselves call for integrated, multi-stakeholder strategies that address the complex interdependencies between social, economic, and environmental goals, in other words systematic and holistic approaches. The innovation systems (IS) framework offers a particularly appropriate analytical and policy toolkit for this purpose. By examining the interactions among actors, institutions, and knowledge flows that drive transformative change, the IS framework provides insights into how countries can accelerate progress toward achieving the SDGs through coordinated interventions that enhance innovation capacity, strengthen institutional arrangements, and mobilize resources effectively. All in all, the SDGs challenges require complex systemic change and cannot be solved by technological fixes alone. The SDGs/Agenda 2030 formally began on January 1, 2016 (United Nations, 2015). Ten years on, this is a timely moment to assess progress. Although the SDGs initially received broad support, political discourse has since shifted, with growing resistance driven in part by misinformation and disinformation (Sa'ad Abdullahi & Pindiga, 2023).

In this situation, the National System of Innovation (NSI) framework can be useful for three reasons: first, because nation-states remain central actors in shaping innovation outcomes; second, because national governments bear primary responsibility for implementing the SDGs; and third because addressing complex challenges requires participation of multiple actors driving systemic change.

The paper reviews the evolution of the NSI framework, recent renewed interest in national innovation coordination, and its application to Canada's sustainability, resilience, and sovereignty challenges. It concludes with implications for research and policy, emphasizing NSI relationships and lessons from the first decade of SDG implementation (2016–2026).

2. Literature Review

The literature shows NSI approaches can advance SDGs via interconnected mechanisms. Across 130 countries, knowledge-based capabilities positively affect SDG outcomes (Li et al., 2023); data from 143 countries (2011–2023) estimate a 1-point Global Innovation Index rise correlates with a 0.486-point SDG Index increase, confirming innovation's role (Le et al., 2025). Pathways include technology, collaboration, and systemic change (Ramirez et al., 2019).

Key NSI components include R&D, university-industry-government linkages, policy frameworks, and capacity-building (Weerasinghe & Gunawardena, 2024); however, their effectiveness is context-dependent, moderated by development, institutions, and sector interactions. Gains are strongest in lower-middle-income countries (Le et al., 2025); while high-income countries need deeper transformation (Christensen et al., 2021; Novillo-Villegas et al., 2025). Nevertheless, success requires strong institutions, government support for networks, and aligned capacity-building (Chaparro-Banegas et al., 2024).

2.1 Key contributions and evolution of the NSI

As early as the mid-1990s, Metcalfe[1] (1994, 1995) was publishing papers on innovation policy from an evolutionary/system perspective; Nelson had even earlier offered a view on how and why the direction and prioritization of technological change matter to addressing societal challenges. His book *The Moon and the Ghetto* (1977) addresses a central paradox of modern economies: societies capable of extraordinary technological achievements often struggle to address persistent social problems such as poverty and inequality. Nelson argues that this paradox arises due to how societies pursue technological endeavors and how they approach social challenges. Large technological projects succeed because they mobilize coordinated funding, clear objectives, performance metrics, and aligned incentives across organizations. Social problems, by contrast, are addressed through fragmented responsibilities, weak incentives, and poor feedback mechanisms. In "The Moon and the Ghetto Revisited" (2011), Nelson emphasizes that these institutional failures remain largely unresolved, limiting the scalability and effectiveness of social innovations. In related work (e.g. Mowery et al., 2010), he proposed new types of policy models for addressing problems like climate action. Eventually, he formulated a pertinent question: "can we reorient our innovation systems so that the advances we get are better directed to meeting society's most pressing needs?" (Nelson, 2011, p.682)[2].

While many science, and technology scholars in the decades following the Second World War emphasized the contributions of military technologies to civilian technological advances (Gummett & Reppy, 1988), other scholars of the same period argued that technological progress also originated from civilian domains. For instance, Lundvall (1988) proposed: a "welfare-industrial complex oriented towards the fulfillment of social needs in relation to energy, housing, environment, transport, and the health service [which could] be as effective as warfare-industrial complexes in provoking new technology" (p. 366).

[1] 2025 saw the loss of some of the greatest scholars within the field of economic and technical change, including F. Scherer, S. Metcalfe, and R. Nelson.

[2] Nelson joined the GlobeLics initiative, started by Lundvall, which is aimed at enhancing higher (PhD) education in developing countries, much in line with the thoughts behind The Moon and the Ghetto.

Christopher Freeman was another key scholar in the development of innovation system thinking relevant to the SDGs. His book The Economics of Hope (Freeman, 1992) emphasizes the importance of directionality in technological change, opposing dysfunctional predictions based on modelling from Meadows and colleagues at MIT in the early 1970s, and arguing that innovation holds potential for solving societal challenges if promoted wisely. He emphasizes the role of public investment, regulation, and long-term strategy in steering innovation toward socially beneficial outcomes.

2.2 Calls for NSI to increase focus on issues related to UN SDGs

Many innovation scholars increasingly stress the need to respond to urgent calls for action on sustainability transition policies (Chaminade, 2020; Christensen et al., 2021; Andersen et al., 2023; Lema & Perez, 2024). The IS framework speaks directly to this agenda: it has been applied to sustainability transformation (Schlaile et al., 2017), the engagement of excluded communities and civil society (Earl et al., 2023), capacity to achieve the UN SDGs in low and middle-income countries (Adenle et al., 2023) and high-income countries (Cavalli & McGahan, 2024), and the SDGs concerning economic inequality and climate action (Lundvall, 2024).

Innovation system approaches to policy gained attention in the early 2000s (Christensen & Fagerberg, 2021) but have since waned in popularity. Perhaps the field's most popular contribution to advancing innovation policy and addressing the UN SDGs is Mazzucato's (2018) concept of mission-oriented policy. In articulating this idea, Mariana Mazzucato builds on the NSI literature but brings it back to its more active political roots.

In her analysis of the contributions of the NSI framework, Mazzucato (2011) pointed to its ability to improve understanding of national innovation policy, noting that NSI showed that "it is not the quantity of R&D that matters but how it is distributed throughout an economy, and often the crucial role of the state in achieving this" (p. 65). In other words, while the NSI framework describes how innovation is developed, Mazzucato goes further, asking what innovation should be designed to do, and who should benefit. Her main argument is "that the state can be far more proactive in spurring industrial innovation at the forefront of knowledge than is currently understood by policy makers" (p.70).

Mazzucato (2025, 2026) has also called for reimagining SDG financing by moving beyond gap-filling exercises toward actively shaping financial systems to support transformative change. These contributions collectively establish mission-oriented policies as viable mechanisms for accelerating SDG progress through purposeful direction of innovation and investment.

This approach emphasizes the active role of the state in shaping markets through coordinated public investment and strategic policy direction (Mazzucato, 2018). Traditional innovation system approaches, rooted in the NSI framework, typically focus on horizontal policies that address structural weaknesses, such as limited absorptive capacity, weak linkages between actors, or insufficient knowledge flows. In contrast, mission-oriented policies begin with explicit, societally relevant goals and mobilize multiple policy instruments to steer innovation toward desired outcomes (Larrue, 2021). Rather than merely fixing systemic failures, mission-oriented approaches seek to actively create and shape markets in alignment with public priorities.

One potential issue for the effectiveness of this approach is the increasing power of corporations and the decreasing role of national governments (Mazzucato, 2025). In fact, the role of national

governments in achieving the UN SDGs has experienced competition of various types from the private sector. Genuine contributions are observed in specific contexts, such as private firms, hybrid organizations like B Corps, and companies with robust stakeholder governance mechanisms, where accountability structures align incentives with long-term sustainability outcomes rather than short-term reputational gains (Diez Busto et al., 2021) , cooperatives or employees ownership trusts (MacLeod & Johnson, 2026). However, in other cases, corporations, under the disguise of Corporate Social Responsibility (CSR) or Environment, Social, and Governance (ESG) initiatives, have been accused of superficially co-opting the UN SDGs rather than substantively advancing them (Spry & France, 2025). Empirical evidence largely supports this critique, revealing widespread "SDG-washing" characterized by symbolic actions, selective disclosure, and a decoupling of communications from real performance (Heras-Saizarbitoria et al., 2021). Studies indicate that most large corporations, particularly publicly traded firms, engage in performative use of SDG iconography and cherry-picked goals to manage impressions without implementing meaningful changes (Heras-Saizarbitoria et al., 2021).

The following section introduces the idea of the potential return of a NSI framework in the context of current geopolitical challenges.

2.3 A return of National System of Innovation (NSI)?

One of the reasons watered-down SDG efforts and SDG-related greenwashing have occurred has been the declining role of the national governments and their lack of innovation potential, along with multinational corporations seeing financial benefit in suggesting that they are taking action towards critical issues. However, if we return to the NSI concept as originally articulated, the role of the nation-state was very clear (Lundvall, 1992).

Historically, national governments have been essential to innovation development (Freeman, 1987, 1995). The nation-state remains the dominant level at which innovation policy is designed, resourced, and legitimated. The early concept of the NSI related to:

> *"... a new spirit of what might be called "technonationalism" in the air, combining a strong belief that the technological capabilities of a nation's firms are a key source of their competitive prowess, with a belief that these capabilities are in a sense national, and can be built by national action."* (Nelson & Rosenberg, 1993, p. 12)

However, subsequent global trends contributed to shifting the focus of innovation system research away from the "national." Following the end of the Cold War, accelerated globalization and market liberalization led to growing skepticism about the role of national governments, per se, in economic coordination (Fukuyama, 1989).

Various innovation scholars agreed that "the *'national'* system of innovation concept has run its course and now provides only decreasing returns" (Sharif, 2006).

Globalization challenged the NSI framework by weakening nationally rooted innovation structures and creating a risk that firm-level gains from participation in the global value chain would not translate into sustained national knowledge development or upgrading (Lundvall, 2016). During the late 1990s and early 2000s, research on innovation fragmented into complementary and sometimes competing perspectives, including Regional Innovation Systems (Cooke et al., 1998), Sectoral Systems of Innovation (Malerba, 2002), and Socio-Technical

Transitions (Geels, 2004). Later, the more firm-centric concept of "entrepreneurial ecosystems" nearly eclipsed the broader "innovation system" framework in both academia and public policy (Spigel & Stam, 2018). This diversity of IS approaches resulted in confusion and blurred boundaries (Rakas & Hain, 2019). Perhaps more importantly, while these approaches generated valuable insights, they may have weakened attention to the role of national-level coordination and governance in innovation (e.g. Holbrook & Salazar, 2004; Wolfe & Lucas, 2004).

The Covid-19 pandemic contributed to mark a turning point that reversed decades of declining attention to national-level innovation governance. Recent evidence confirms a "structural break around 2020, characterized by accelerated policy activity and the emergence of 'new industrial policies' motivated by supply chain resilience, national security, and geopolitical concerns" (Evenett et al., 2025, p. 2).

This shift has restored the nation-state to analytical prominence and reopened questions about how national industrial and innovation policy operate under conditions of globalized production and strategic risk (Juhász et al., 2024; Breznitz & Gingrich, 2025).

3. Methodology

This paper adopts a conceptual, narrative literature-synthesis approach, drawing on the National Systems of Innovation (NSI) tradition and the broader innovation-systems and mission-oriented policy literatures to reassess their relevance for the UN SDGs a decade into implementation of the 2030 Agenda. This synthesis is complemented by a short bibliometric-style trend analysis intended to track shifts in scholarly and public discourse around national-level innovation coordination. We also analyze Google Ngram Viewer data for the term "industrial policy" in English-language publications (data downloaded early 2026) alongside Google Trends search-interest data for the terms "industrial policy," "innovation systems," and "innovation policy." These discourse-trend data are used descriptively, alongside secondary sources, to contextualize the discussion of Canada's National System of Innovation presented below.

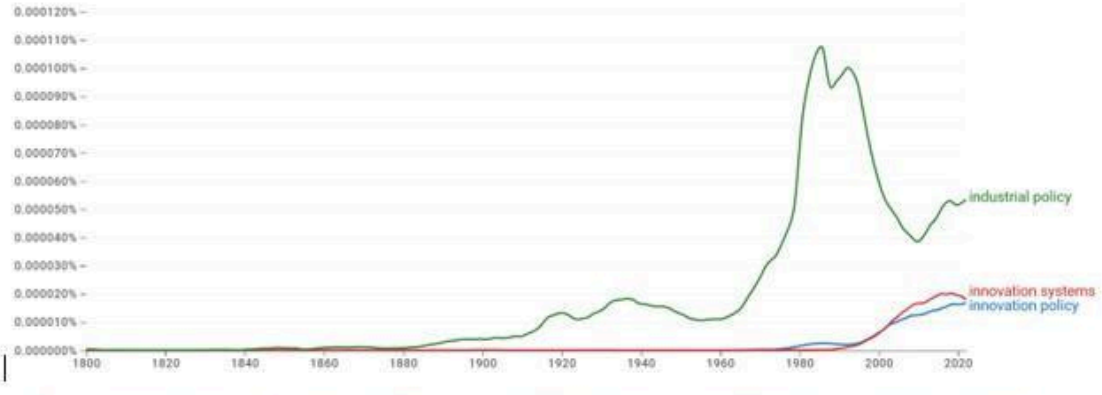
4. Analysis

4.1 Discourse trends: industrial policy, innovation systems, and innovation policy

As illustrated by long-term trends in search interest, concepts such as "innovation system" and "innovation policy" have gained visibility since the late 1990s and early 2000s (Christensen & Fagerberg, 2021), reflecting their growing use in academic and policy debates. This pattern suggests a gradual shift away from narrow, firm-level or R&D-focused perspectives toward more systemic views that emphasize institutions, coordination, and multi-level interactions across national, regional, and sectoral innovation systems.

An analysis of Google Ngram Viewer data downloaded January 2026 reveals a significant decline in the usage of the term "industrial policy" in English-language publications from the mid-1990s until approximately 2010. Since then, however, the term has experienced some resurgence. This resurgence is notably more pronounced and abrupt than the more gradual trends observed for related concepts like "innovation systems" or "innovation policy," suggesting a broader scholarly and policy re-engagement with state-led economic coordination.

Figure 1. Revisiting National Systems of Innovation in the UN SDGs Era (2016–2026)



Notably, while Google Trends data for the search terms "industrial policy," "innovation systems," and "innovation policy" shows no sustained increase in search interest in recent years, it also shows that a distinct spike occurred in mid-July 2025. This peak, likely catalyzed by significant policy announcements from the Trump administration, including unprecedented tariffs, trade policies, and hostile geopolitical posturing toward many nations, prompted explosive growth for all three terms, with "industrial policy" leading.

Figure 2. Revisiting National Systems of Innovation in the UN SDGs Era (2016–2026)



Collectively, these trends indicate that contemporary economic policy debates are increasingly characterized by a fusion of systemic innovation perspectives with more direct attention to "new" industrial policy instruments. This convergence raises critical questions for governance and coordination, particularly regarding the integration of innovation policy frameworks, traditional industrial policy tools, and mission-oriented approaches for national economic development and resilience. Perhaps, given these conditions, a "new" NSI will arise.

4.2 The case of Canada

Canada's innovation system is characterized by strong inputs but weak outputs, the innovation paradox which remains at the core of its economic and societal challenges (Gellatly & Gu, 2024;

Hewitt, 2024). This may partially result from the pronounced dependency on the United States which has long impacted Canada's economic and innovation systems. This structural reliance has historically afforded US entities substantial influence over both R&D and commercialization in Canada (Atkinson & Zhang, 2024; Gold, 2025). This dependence was manageable when trade relations were stable (Stanley, 2006); however, recent aggressive trade policies adopted by the US have exposed serious vulnerabilities in the Canadian economy, negatively impacting investment, the job market, and overall economic growth (Tombe, 2025). President Trump's expression of an intent to take Canada "by economic force" (Louis, 2025) and trade disputes will influence business decisions.

The 2025 Federal Budget highlights the need to respond to this shift: "A new era of disruption demands (…) a new economic foundation built on resilience, sovereignty, and innovation" (Department of Finance Canada, 2025, p. 2). Canada may have the components of the strong innovation system needed to support such a transformation, including an ample knowledge base and strong organizations and institutions, but improved systemic orchestration is needed among these components. Some innovation policy experts even claim Canada does not have a proper functioning NSI (Zhang, 2025).

Canada's federal government currently prioritizes SDG 3 (Good Health and Well-Being), SDG 5 (Gender Equality), SDG 8 (Decent Work and Economic Growth), SDG 14 (Life Below Water), and SDG 17 (Partnerships for the Goals) (Government of Canada, 2025). In light of the major economic, social, and national security challenges Canada is facing, however, Tombe (2025) argues that "In this environment, policies that strengthen the economic foundation must take priority. Other goals, however worthy, may need to wait." While Canada has so far avoided some of the worst-case outcomes associated with rising geopolitical and economic tensions, it remains possible that these pressures may require a reassessment and more policy attention to other SDGs.

There is a need for further research to address the relative weakness of Canada's innovation system and advance the country's progress toward the SDGs. Research in this direction would benefit from incorporating the NSI framework (Lundvall, 1992; Niosi, 2000; Chaminade et al., 2018), which provides a systemic view of innovation at the national level. This framework could help to generate urgently needed knowledge to support the strengthening of Canada's national innovation capacity by providing a system-wide analysis of Canada's NSI in a broad sense[3], going beyond examining R&D, high-tech sectors, and patents to examine the relationships among key actors within Canada's NSI.

As articulated by Canada's Prime Minister Carney (2026), strengthening national innovation capacity in these turbulent times should not be understood as a move to create "isolated fortresses". Recent geopolitical developments suggest that the advancement of a NSI does not

[3]Niosi (2000), working with other innovation scholars, published the volume “Canada’s National System of Innovation”. Quoting the innovation literature, he distinguished between “the narrow definition [of NSI] (encompassing only the institutions active in R&D and the public regulatory agencies) and the broad sense (also including supporting private institutions, such as banks, and public ones, such as government infrastructure and education systems)” (p. 5). Niosi acknowledged that his work focused on the narrow sense.

imply withdrawal from global networks, but rather a reconfiguration of international engagement through diversification of partnerships and more balanced interdependencies. From this perspective, analyzing the relational structure of Canada's NSI is particularly important, as it helps identify coordination failures, institutional bottlenecks, and areas where domestic capacity could be strengthened through more resilient and diversified forms of collaboration (Freire-Gibb et al., 2026).

5. Concluding Remarks

The persistent lack of progress toward the UN Sustainable Development Goals demonstrates that fragmented policy responses are no longer sufficient. The SDGs demand coordinated, system-wide action that aligns technological change with clearly defined social priorities. This paper has argued that revisiting the National Systems of Innovation (NSI) framework provides a timely and necessary foundation for meeting this challenge.

Historically, NSI scholarship emphasized that innovation outcomes are shaped by institutions, public policy, and coordination, not by markets and firms alone. These insights remain directly relevant to the SDGs, which require directionality, collective action, and long-term commitment to achieve. Empirical evidence shows that innovation systems can accelerate progress toward certain SDGs, but also that poorly governed innovation can undermine others. This underscores the need for innovation policy that goes beyond R&D intensity and commercialization to address systemic governance and societal purpose.

Recent developments, including geopolitical tensions and supply-chain disruptions, have generated renewed interest in industrial policy and led national governments to embark on innovation policy agendas. In this context, mission-oriented approaches can be understood not as a break from NSI thinking, but as a reinforcement of its original political and societal foundations, providing practical tools to steer innovation toward sustainability goals.

The Canadian case illustrates both the risks of weak system coordination and the opportunities offered by a broader NSI perspective. While Canada possesses strong innovation inputs, persistent coordination failures limit its ability to translate these strengths into sustainable outcomes, leading to what has been termed Canada's innovation paradox. Addressing this gap requires renewed attention to the structure and quality of relationships across the NSI, including horizontal and vertical approaches within public institutions, finance, education, industry, national security and civil society.

Revisiting the NSI framework is therefore not only an academic exercise, but a policy imperative. Empowering innovation systems to advance the SDGs requires restoring the role of the state as a coordinating and directional actor, strengthening institutional linkages, and aligning innovation with societal missions. In an era of overlapping sustainability and geopolitical challenges, a renewed NSI framework offers a coherent and actionable pathway for advancing the UN SDGs.

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