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Why Do Some Countries Innovate Better than Others? A New Perspective of Science, Technology, and Innovation Policy Regimes and National Absorptive Capacity

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Abstract: This paper looks into the determinants of national innovation performance from the perspective of policy regime and establishes a theoretical model on how a country's dual Science, Technology, and Innovation (STI) policy regimes, democratic and meritocratic, and national absorptive capacity (NAC) jointly determine its national innovation performance. A democratic STI policy regime promotes innovation through channels of freedom, social equality, and public participation. A meritocratic STI policy regime promotes innovation through channels of good governance and rational policymaking. The model further proposes that the relationships between STI policy regimes and national innovation performance are moderated by potential NAC (PNAC) and realized NAC (RNAC) in opposing directions. The fixed-effects panel regression of OECD countries confirms that both democratic and meritocratic STI policy regimes have positive effects on national innovation performance. Moreover, the democratic effect is positively moderated by PNAC but negatively moderated by RNAC. In contrast, the meritocratic effect is positively moderated by RNAC but negatively moderated by PNAC. The major contribution of this paper is to highlight the importance of a country's STI policy regimes as the bedrock and NAC as the leverage to generate more homegrown innovations.

Keywords: STI policy regimes; democracy; meritocracy; national absorptive capacity; national innovation performance

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1. Introduction

Nations' competition in technology and innovation has drawn rapt attention from the academic and business communities as the great power rivalry between the U.S. and China has intensified in recent years. Looking back at the history of technological competition among nations, stories of nations' rise and fall kept being told while lessons kept being learned. Great powers take technology and innovation as the cornerstone to gain unsurmountable leadership in the geopolitical chess game. During the Cold War, the U.S. combined huge investments in defense-related R&D [1] and government funding initiatives such as "Small Business Innovation Research" (SBIR) and "Small Business Technology Transfer" (STTR) to promote public—private partnership in technology and innovation. The primary purpose is to improve the general environment, encourage universities and public institutes to conduct basic research, and induce private enterprises to engage in applied research and commercialization [2,3].

Small countries take technology and innovation as the cornerstone to launch, catch-up, and secure their advantages in the global competition. Taiwan provides effective public R&D funding towards targeted industries like semiconductors and ICT products [4], and utilizes government policies to enliven innovative activities from SMEs in the high-tech sector [5]. Ireland strives to create an innovator-friendly environment to attract foreign direct investment (FDI) to foster science and engineering research [4,6]. South Korea

combines technology-driven policy [7], innovation-driven policy [8], and the "Green New Deal" [9] to launch an all-front advance in industrial and green innovation. Israel's "neo-developmental state" model leverages pilot agencies and policy innovations to trigger structural transformation of the "science-based industry" and eruptive growth of high-tech sectors [10,11].

With the challenges of climate change and resource depletion growing more intense and imminent, it becomes more urgent for countries not only to innovate in technology but also in sustainability. The European Union's "The European Green Deal" aims for full decarbonization and equitable development through spillover effects triggered by policy mix designs [12]. South Korea declared the ambitious "Green New Deal" to envision a national green engineering mega-project in green urbanization, green industrial development, and low-carbon renewable energy [9]. Norway skillfully adopted a policy mix of regulation, financial incentives, and consultancy services to facilitate the transition to green buildings in the construction sector [13]. Finland successfully raised energy efficiency by adopting creative policy instruments [14], and launched the Mobility as a Service (MaaS) policy experiment [15] to further move towards a low-carbon society. Clearly, sustainable innovation has been a critical part of countries' competitive advantages in the era of sustainability transition.

Why do some countries innovate better than others? Scholars in innovation research (IR) apply different approaches to unravel this puzzle. From the perspective of innovation systems [16,17], the theory of national systems of innovation (NSI) traces its intellectual roots to neo-institutional theory [18] and evolutionary economics [19], and looks into how technology and innovation are created and diffused in an input–output mechanism composed of existing institutions [20]. All these institutional arrangements facilitate interactive learning [21] and determine "the scale, direction and relative success of all innovative activities" [22].

From the perspective of collaborative networking, the theory of "The Triple Helix" model explores the overlaying communications and expectations among universities, industries and government at the network level, leading to the reconstruction of institutional arrangements for national innovation and policymaking [23]. From the perspective of competence building, the theory of "national innovative capacity" (NIC) explores how a nation's internal environment and fundamental infrastructure affect a nation's potential to produce, commercialize, and diffuse technological innovation [24].

Scholars in other fields of social science seek to employ new perspectives that might help solve the puzzle of national innovation performance. The theory of "varieties of capitalism" claims that countries with a more liberal economy tend to induce more radical technological change while countries with a more coordinated economy tend to produce more incremental technological change [25], though this claim was not fully supported by empirical evidence [26]. The influence of other factors, such as political decentralization [27], international linkages [28], and the degree of individualism [29], on national innovation performance has also been explored.

All these theoretical approaches attempt to explore the roles of environment, institutions, infrastructure, actors, and linkages on national innovation performance. They are concerned about the political structures, economic institutions, and social fabrics in which national innovative processes are embedded, as well as the constraints and costs imposed by their mutual embeddedness. They stress the division of labor, coordination, and cooperation between the public sector and the private sector in promoting innovation activities that help trigger radical and incremental innovation. However, several important aspects in the national innovation function are not fully addressed.

First, the existing theoretical approaches recognize the important role played by public policies, but mostly focus on the role of economic policies [22], R&D policies [21], or industrial policies targeting specific sectors [30]. There exists some degree of insufficiency in the literature that addresses national innovation from the perspective of generalized STI (Science, Technology, and Innovation) policies with common characteristics that tran-

scend country borders. Second, the existing approaches mainly take a neo-institutional perspective [31], and stress the overwhelming role of institutions in embedding innovative organizations [32], facilitating interactive learning between users and producers [21], and regulating how policies shape innovation processes [33]. However, institutions alone may not account for all the major driving forces behind STI policies. There exist policy values, key agents, policy paradigms, policymaking mechanisms, governance modes, and embedded culture that jointly set up the foundation of STI policies. Third, although the existing approaches stress the role of institutional learning [34], knowledge spillover [33], and knowledge transfer [35], they tend to adopt the micro-analytical level that centers on interactive learning and creative forgetting [34]. What is not fully recognized is the fact that a country as a whole constitutes the "national learning system", which features the incremental process of technical change driven by the absorption and diffusion of technological knowledge [36]. This kind of ability in knowledge absorption and diffusion may be critical in converting and translating STI policies into concrete innovation outcomes.

Hence, this study aims to address these research gaps and extend the existing approaches by adding the new perspective of country-level STI policy regimes and knowledge absorption dynamics to address two core research questions:

RQ1: How do a country's STI policy regimes affect its performance in innovation outputs?

RQ2: How does a country's capacity in knowledge absorption factor into the national innovation function?

To investigate these research questions, this study first proposes the concept of dual STI policy regimes, and hypothesizes that both a democratic policy regime and a meritocratic policy regime act as positive contributors to national innovation performance. Second, this study introduces the concept of national absorptive capacity (NAC) as a key moderating factor of the national innovation function, and hypothesizes that potential NAC (PNAC) and realized NAC (RNAC) moderate, in opposite directions, how a democratic policy regime and a meritocratic policy regime affect national innovation performance.

This study is expected to make positive contributions to the existing research on national innovation in several ways. First, this study introduces a new conceptual framework of national innovation that contains STI policy regimes and NAC. The society-centered democratic policy regime and the state-centered meritocratic policy regime differ in various dimensions, promote innovation through different channels, and may play complimentary roles to each other. Second, this study brings theories of knowledge search, technology spillover, and organizational learning into the research on national innovation, and reinterprets these theories with new theoretical and policy implications at the national level. Third, this study enriches STI policy research on what a country should do to promote innovation. This study argues that a country needs to establish an ambidextrous set of STI policy regimes in both democracy and meritocracy, and use its NAC as the leverage to construct an innovation ecosystem capable of both exploration and exploitation.

The rest of the paper will proceed through five sections. In Section 2, the relevant literature is reviewed, a conceptual model is constructed, and six major hypotheses are established. In Section 3, the collection of the panel data from OECD countries is clearly delineated, the variables are operationally defined, and the statistical models are specified. In Section 4, fixed-effects regression of panel data is conducted, the empirical results are presented, and a robustness analysis is conducted. In Section 5, theoretical and policy implications of the empirical results are discussed. In Section 6, all the major findings are summarized, research limitations are discussed, and suggestions on future directions of research are proposed.

2. Theories and Hypotheses

2.1. Theoretical Framework of STI Policy Regimes

2.1.1. Theory of Policy Regimes

What is a policy regime? May and Jochim [37] defined a policy regime as the "governing arrangements" that address policy problems while at the same time generate policy

legitimacy, coherence, and durability. The governing arrangements include institutional arrangements, interest alignments, and shared ideas. According to Wilson [38], policy regime can be constructed based on specific issue areas and mainly contains three dimensions: power arrangement, policy paradigms, and policymaking mechanisms. Power arrangement involves interactions of core interest groups that support the policy regime. Policy paradigms identify problems, provide solutions, and formulate policies. Policymaking mechanisms refer to the decision processes in which government organizations, professional associations, and interest groups jointly develop and maintain policies. Howlett [39] further argued that a policy regime contains its own logic that links policy tools and objectives, while it further entails governance modes in legislation, corporatism, markets, and networks.

How is a policy regime different from institutions? Jochim and May [40] argued that a policy regime is conceptually broader than institutions since a policy regime contains multiple dimensions in issues, ideas, interests, and institutions. Moreover, a policy regime is essentially "boundary-spanning" and contains governing arrangements that hold control over multiple subsystems. Hence, various elements from different subsystems can be integrated to function in a concerted manner so as to reduce the inertia in the original policy subsystems [40]. Moreover, a domestic policy regime echoes the concept of an "international regime" composed of "implicit or explicit principles, norms, rules, and decision-making procedures around which actors' expectations converge in a given area of international relations" [41].

Accordingly, the policy regime approach incorporates the established institutional approach, while it addresses the counterargument that institutions alone are insufficient to achieve the desired outcome unless key actors from diverse settings reach an agreement on shared principles, beliefs, and goals [42]. This approach contains political settings such as politico-administrative institutions in which policymaking is embedded [43]. This approach looks into a bigger picture painted with polity, politics, and policies [44]. Furthermore, this approach reflects fundamental concepts of structure as "rules and resources" [45] and schema as "generalizable procedures" [46]. It echoes the "structure–agency" model that integrates contexts, actions, and strategies [47]. Moreover, the policy regime approach emphasizes "state–society synergy" [48] in which government and communities engage in the process of coproduction [49,50].

Based on the above discussions, this study summarizes the key differences between a policy regime and institutions, as Table 1 illustrates.

Table 1. Main characteristics of a policy regime and institutions.

	Policy Regime	**Institutions**
Definition	Governing arrangements for addressing policy problems	Rules of the game that constrain and structure human interaction
Fundamental structure	State and society	State
Main elements	Power alignment; policy paradigms; policymaking mechanisms	Rules; norms; shared strategies
Purpose	Governing; Problem-solving; Capability-enhancing	Lowering transaction costs; Facilitating resource allocation; Monitoring and controlling; Sanctioning and rewarding; Learning and forgetting
Guiding principle	Policy values; Embedded culture	Institutional grammar; Instrumental rationality
Method of categorization	Policy areas	Regulative, normative, cognitive; Political, economic, social
Outcome	Policy instruments; Governance modes	Resource allocation; Acceptable behaviors; Interactive networks
Primary dynamics	Structure–agency	Behavior–interaction
Chief agents of change	Policy innovators	Institutional entrepreneurs

Based on the theories above, this study proposes the adoption of the policy regime approach in order to further investigate the key question of why some countries innovate better than others. Here, the STI policy regime is defined as "the set of policy values, key agents, power arrangement, policy paradigms, policymaking mechanisms, governance modes, political institutions, and embedded culture that jointly determine a country's STI policy goals, designs, instruments, as well as outcomes." Furthermore, this study proposes the conceptual framework of dual STI policy regimes, democratic and meritocratic, as the main theoretical pillar for exploring the core research questions.

2.1.2. Democratic STI Policy Regime

Essentially, a democratic STI policy regime is society-centered. It gains legitimacy through competitive elections, integrates citizens' voices through public participation, and transforms collective choices into political decisions. It is mainly composed of an "institutional arrangement for arriving at political decisions in which individuals acquire the power to decide by means of a competitive struggle for the people's vote." [51]. It contains two fundamental dimensions—contestation and participation—while at the same time it can be defined in terms of sources of authority, purposes of service, and constituting procedures [52].

A democratic STI policy regime aims to address the problem of "democratic deficit", the "incongruence between majority public preference and public policy" [53,54]. Democratic deficit in essence represents the confrontation between "We the People" and "We the Authorities" [55]. This kind of confrontation may originate from input and output sides. The input side concerns whether people with various interests and identities have proper access and due representation in policymaking processes. The output side concerns whether policies address immediate challenges, promote problem-solving, and raise general welfare [55,56].

A democratic STI policy regime incorporates various socio-economic agendas and seeks to transform STI policymaking processes by actively aligning concerns from diverse interest groups and ultimately accelerating socio-technical co-evolution within the regime [57]. A democratic policy regime tends to be born out of a pluralistic society that tolerates dissent, and cherishes values of fairness, equity, and diversity. Taking these values as the basic policy guidance, this kind of regime tends to favor a participatory policymaking mechanism, adopt governance modes in markets and networks, and build an alliance with diverse interest groups.

A democratic STI policy regime features civil groups as the key agent. Civil groups seek to leverage limited resources to maximize influence by forming "epistemic communities", which constitute "networks of professionals with recognized expertise and competence in a particular domain and an authoritative claim to policy-relevant knowledge" [58]. These epistemic communities seek to transform policymaking mechanisms by triggering knowledge production mechanisms and guiding policy decision-makers' learning processes [59]. Through epistemic communities, civil groups integrate and augment their voices, while at the same time engage in policy solution-finding, knowledge construction, and political lobbying [60]. Moreover, civil groups participate in established R&D systems by means of strengthening links, aligning objectives, consulting on research topics, carrying out field work, and serving as research centers, so that the domains of science and technology can be broadened [61].

Democratic STI policymaking features a "multi-actor arena" in which various stakeholders compete and confront with diverse interests, agendas, and perspectives on reality [62]. This multi-actor policy arena triggers the rise of various participatory bottom-up policymaking mechanisms that include the likes of civic engagement, citizen participation, and participatory technology assessments. Civic engagement leverages community-wide efforts and local institutions for collective problem-solving and policy agenda-setting [63]. Citizen participation allows policy experts to incorporate citizens' relevant information into all stages of policymaking processes, and enables citizens to obtain more information

regarding the stakes they have in different policy options [64]. A participatory technology assessment (pTA) aims to respond to structural changes in democratic society and to facilitate knowledge dissemination from experts to the public in order to raise public understanding of science, engineering, and technology [65].

What stands out as the epitome of democratic policy regime is the very kind of policy paradigm called "Transformative Innovation Policy" (TIP) [66–68]. TIP aims to transform STI policymaking by accommodating unorthodox outsider voices that have been previously ignored or slighted by policy makers. TIP engages in not only the transactional side but also the transformative side, especially the failure of the transformative system [69]. TIP takes on the grand challenge of climate change and pushes for the sustainability transition, the fundamental process of transformation towards sustainable modes in production and consumption [70]. TIP actively adopts the policy mix with both creative and destructive policy instruments in order to accelerate the transition process towards sustainability [15].

Regarding the nature of technology, a democratic policy regime takes the cautious view that technology development is tempted to favor the privileged while ignoring the concerns of the disadvantaged [71]. Hence, STI policies should incorporate fair access to and equalized participation in both the creation and diffusion of innovation. Furthermore, STI policies should make a comprehensive assessment on every aspect of interdependencies between technology and society [72] and heed the social impact of technology [73]. Additionally, STI policies ought to hasten the development of "below the radar" (BRI) innovations that harness indigenous knowledge to solve local problems [74]. Echoing this view is the "distribution sensitive innovation policy" (DSIP) that seeks to raise productivity for low-skilled workers, increase minorities' employment in technology-intensive industries, and revitalize disadvantaged regions [75].

2.1.3. Meritocratic STI Policy Regime

Essentially, a meritocratic STI policy regime is state-centered. It originated in the post-industrial society governed by a merit-based system in which "differential status and differential income are based on technical skills and higher education" [76]. This kind of merit-based principle involves job placement, conditions of opportunity, and reward schedules [77]. This kind of regime reflects the very essence of the so-called "dirigiste states" [78] in which technocrats set up policy objectives, design policy instruments, and steer policy implementation based on policy logics of causation or effectuation [79].

A meritocratic policy regime tends to be born out of a rational society that has deep-rooted respect for technical expertise and cherishes values of efficiency, growth, and security. Taking these values as the basic policy guidance, this kind of regime tends to favor policy-making mechanisms of rational choices or organizational processes [80], adopt legal and corporatist governance modes, and seek to build an alliance of academics, professionals, and technocrats.

A meritocratic STI policy regime features technocrats as the key agents. Technocrats' authority originates from what Max Weber called the "rational–legal legitimacy", which derives from laws and rules that stipulate power distribution and bureaucratic structures [81]. Technocrats with technical specialization wield legal authority embedded in a rational and impersonal bureaucratic organization charged with a fixed jurisdiction, hierarchical authority, and general rules [82]. Technocrats are expected to possess qualities of "passion, a sense of responsibility, and a sense of proportion" [83]. Required to fulfill faithful duties under the supervision of the state, technocrats' top concern and foremost goal is always to build up sustained national comparative advantages in technological advancement, industrial development, and economic growth.

The meritocratic STI policy regime found its heyday in the postwar Bretton Woods system in which IMF, the World Bank, and GATT served as key players regulating and coordinating the international economy, finance, and trade. This postwar grand system featured institutionalized government support for basic and applied R&D that sought to address market failure and promote innovative activities [84]. Government combined

"mission-oriented" policies to tackle grand challenges and maintain strategic leadership, and "diffusion-oriented" policies to build up an innovative capacity to trigger technological change and accelerate knowledge diffusion [85].

A meritocratic policy regime seeks to promote technological innovation through four major procedures: problem identification, goal setting, policy designs, and policy evaluation [86]. It features not only administrative procedures but also bureaucratic organizations such as national policy councils (NPC) [87] and innovation agencies [88]. It utilizes policy targets and tools in supply, demand, and environmental sides [86]. Additionally, it applies policy tools to promote global collaboration in science and technology, the generation of innovation in a global context, and the exploitation of innovations on a global scale [89].

What stands out as the epitome of a meritocratic policy regime is the very kind of policy paradigm called Holistic Innovation Policy (HIP) [90], which takes a systematic view and promotes policies addressing every aspect of innovation. HIP seeks to "integrate all public actions that influence or may influence innovation processes" [91]. HIP stresses the role of institutions and deals with four basic dimensions: provision of knowledge inputs, demand-side activities, provision of constituents, and support services for innovation [90,91]. HIP is essentially system-oriented and can be evaluated based on policy instruments, policy mix, and socio-economic performance with involvement from different levels of expertise [92].

2.1.4. Main Characteristics of Dual STI Policy Regimes

Based on the above discussions, this study summarizes the main characteristics of dual STI policy regimes in Table 2.

Table 2. Main characteristics of dual STI policy regimes.

	Democratic STI Policy Regime	**Meritocratic STI Policy Regime**
Core structure	Society-centered	State-centered
Intellectual roots	Schumpeterian	Weberian
Policy values	Fairness; equity; diversity; trust	Efficiency; growth; security; prosperity
Key agents	Organized citizens and civil groups with diverse concerns	Technocrats with professional expertise and technical qualifications
Power alignment	A coalition of diverse interest groups and government officials	An alliance of academics, professionals, and technocrats
Policy paradigms	Transformative Innovation Policy (TIP)	Holistic Innovation Policy (HIP)
Policymaking mechanisms	Participatory Bottom-up and top-down	Rational choice; organizational process Mainly top-down
Governance mode	Market governance Network governance	Legal governance Corporatist governance
Political institutions	With competitive elections and representative legislative bodies that enable organized citizens and civil groups to voice concerns and build coalitions to reshape policymaking	With legal frameworks and bureaucratic organizations that empower technocrats to map out and carry out policies
Embedded culture	Respect for pluralism and diversity; broad tolerance of opposing opinions	Respect for expertise and professional judgment
Problems to address	Democratic deficit Transformative failure	Market failure Governance failure
Main policy issues	Sustainable development; societal welfare; social justice	Technological capabilities; industrial productivity; economic growth

2.2. STI Policy Regimes and Innovation

2.2.1. Democratic STI Policy Regime and Innovation

A democratic policy regime, in its very essence, embodies a society's fundamental assumptions, social structures, and cultural traditions. Having witnessed the great catastrophes caused by fascism and communism in the 1930s and 1940s, Karl Popper [93] proposed the concept of "open society" in contrast to "closed society". Popper defined open society as being composed of "humanness, reasonableness, freedom, and equality". Popper ar-

gued that an open society implanted with democratic ideals and liberal practices is more receptive to unorthodox thinking and brand new ideas, thus becoming more conducive to breakthrough technological innovation. Florida [94] echoed Popper's arguments by stating that a society with high open-mindedness to novel ideas and tolerance towards eccentric lifestyles attracts talented people and give the "creative class" free rein to generate entrepreneurship and innovativeness.

The connection between democracy and innovation has in recent years attracted renewed attention from scholars across different fields in social sciences. Gao et al. [95] conducted an empirical test on the "Popper hypothesis", but concluded that there was no direct positive effect of democracy on national innovation performance. Wang et al. [96] re-tested the "Popper hypothesis" using various democratic indices and confirmed that democracy enhances innovation. Whetsell et al. [97] found solid empirical evidence to support the "democracy–science hypothesis", which states that democracy promotes scientific discoveries. Carayannis and Campbell [98] further argued that democracy serves as an "innovation enabler" that benefits creators, inventers, and innovators alike. Other researchers reached similar conclusions regarding the role of democracy in promoting innovation [99–101]. Regarding innovation in the sustainability transition, research shows that democracy can be a main driver generating climate policy outputs [102], as well as green technological innovation [103,104].

How does a democratic policy regime foster science, technology, and innovation? The first and foremost channel is freedom. Amartya Sen [105] espoused freedom as an instrument to promote individual capabilities, which ultimately generate more creative ideas and practical innovations. Sen's proposition has been confirmed by empirical research in terms of individual freedom [106], economic freedom [107], political freedom [108], and social freedom [101]. Additionally, freedom can also enhance entrepreneurial activities, which unleash new businesses, new products, and new innovations [109–111].

The second channel is social equality, which refers to the ideal status in which all people in society are endowed with the same rights and equipped with the same access to opportunities and resources [112]. Social equality ensures equal participation from all walks of life and provides motivations for talented individuals to innovate. Social equality erases traditional barriers while it accelerates the diffusion of innovation indiscriminately to members in a society [113–116]. The more rapidly and broadly the diffusion of old innovations proceeds, the more likely the production of new innovations will become.

One key aspect of social equality is gender equality, which promotes collaborative knowledge production conducive to the generation of new technology and innovation [117]. Female empowerment has been a key driver of the democratic movement [118], which in turn empowers more women to participate in basic and applied research. Various researchers have confirmed that removing gender barriers and creating a female-friendly environment largely improve both the quantity and quality of innovation production [119–122].

A democratic policy regime also encourages public deliberation and debates on the direction of STI policies, as well as the development of new technologies. The so-called "deliberative democracy" refers to "a process of open discussion leading to an agreed judgment on policy" [123]. Deliberative democracy brings in "epistemic benefits" by establishing deliberative procedures in agenda-populating and agenda-winnowing [124]. Regarding technology development, Pesch [125] argued that public debates unleash questions regarding the desirability and credibility of technology developers' worldviews and expectations, thus achieving the process of democratization in technology development.

Based on the discussions above, this study argues that a democratic policy regime enhances a nation's performance in innovation outputs through channels of freedom, social equality, and public deliberation.

Hypothesis 1. *Nations with a higher degree of democratic STI policy regime perform better in innovation outputs than nations with a lower degree of democratic STI policy regime.*

2.2.2. Meritocratic STI Policy Regime and Innovation

A meritocratic STI policy regime enhances innovation as a fixer of market failure and a problem solver to market externalities. Therefore, government steps in to provide institutional support (like intellectual property protection) and targeted funding (like R&D subsidies) in order to encourage more innovative efforts and induce more innovative production [33,42]. Prior research has shown consistent results regarding the positive role of government R&D subsidies in innovation [126–128]. Compared to industrial R&D that incurs considerable social costs, government R&D brings multiple social benefits in building trust between stakeholders through technology brokerage, generating new demand for radical R&D markets, and socializing risks by promoting stakeholder governance [129].

The new era of mobile communication and information technology saw the meritocratic STI policy regime redefined not only as a market fixer but also as a market creator. For example, the U.S. government set up the foundation for the mobile communication revolution by supporting the development of the internet, wireless communication, as well as optical screens [130]. Hence, a meritocratic STI policy regime acts as a trustful force to create necessary conditions for the introduction of new technology and lays the groundwork for the demand side of new markets [131].

However, it cannot be neglected that the quality of a meritocratic policy regime does affect the appropriateness of policy instruments, as well as the consequent policy outcomes. A meritocratic policy regime that should have aimed to correct market failures may possibly incur "governance failures" in which technocrats lack the capability to provide systematic directions or address emergent problems with specific policies [132]. Examples of governance failures include ineffective policy enforcement, inhibited public participation, underrepresentation of regulated groups, or even a lack of legitimacy [39].

Contrary to governance failure, "good governance" is defined as the process and structure that direct sociopolitical and economic relations, and thus can be reflected in indicators such as participation, rule of law, transparency, and accountability [133]. Good governance is embodied in principles of decentralization, effectiveness, and cohesion [134]. Good governance not only raises institutional quality but also generates "state capacity", which refers to the state's ability to "implement official goals, especially over the actual or potential opposition of powerful social groups" [135].

The relationship between governance quality and innovation performance has been widely studied by scholars across different fields in social sciences. Various researchers confirmed that the quality of governance has a positive effect on countries' innovation performance [136–138]. On the other side, recent research has shown that government corruption inhibits innovation across national, regional, and corporate levels [139–142], and severely hurts environment-related technological innovation [141,143]. In contrast, researchers showed that corruption control exerts a positive effect on the national innovative output [144,145].

Based on the discussions above, this study argues that a meritocratic STI policy regime promotes a nation's performance in innovation outputs through channels of market-fixing and market-creating policy instruments, as well as good governance.

Hypothesis 2. *Nations with a higher degree of meritocratic STI policy regime perform better in innovation outputs than nations with a lower degree of meritocratic STI policy regime.*

2.3. The Moderating Role of National Absorptive Capacity (NAC)

2.3.1. Theory of NAC

Cohen and Levinthal [146] first proposed and defined absorptive capacity (AC) as an organization's ability to "recognize the value of new, external information, assimilate it, and apply it to commercial ends". AC is primarily a function of an organization's prior knowledge and could be developed through the cognitive structures of learning. AC serves as the critical link between R&D investments and knowledge accumulation, and is particularly critical when an organization wishes to extend its knowledge base that is

beyond the reach of its routine activities. The process may start with individual absorptive agents, move into organizational procedures, and culminate in absorptive outcomes [147].

Essentially, AC carries two faces of "learning and innovation" [146], encompasses various nodes along the entire network of knowledge creation and diffusion, and thus can be categorized based on distinct value activities. Zahra and George [148] proposed that AC can be broken down into potential AC (PAC) and realized AC (RAC). PAC refers to an organization's ability to "acquire and assimilate" external knowledge, while RAC refers to the ability to leverage the absorbed knowledge in order to "transform and exploit". Jansen et al. [149] found that an organization's "coordination capabilities" strengthen PAC while "socialization capabilities" strengthen RAC. Furthermore, both PAC and RAC can be instrumental in organizations' imitation and innovation strategies, and thus could have indirect impacts on sustained competitive advantages [150].

Though most of the AC literature dwells on the firm level, AC can be extended to the country level, leading to the concept of "national absorptive capacity" (NAC), which refers to a country's ability to "learn and implement the technologies and associated practice of all developed countries" [151]. Compared to AC, NAC is more concerned about domestic technological capabilities and cross-national technology transfer [152,153], and thus can be determined by a country's R&D spending, the context within the innovation system, and the distance from the technological frontier [154]. Put simply, NAC reflects the "globalizing" of domestic AC [155] and helps raise less-developed countries' exposure to international technology spillovers [156].

Compositionally, NAC retains key features of technological exposure and application, but involves unique macro-dimensions in education, finance, governance, and policies [157]. These dimensions can be analyzed vertically and horizontally, and can be reassembled into industrial, scientific, institutional–administrative, and public policy NACs [158]. Moreover, NAC involves both macro-level systematic change and micro-level interactive processes, and thus may constitute a co-evolutionary relationship with the national innovative capability [159].

2.3.2. NAC as a Moderator between STI Policy Regimes and Innovation

A country's innovation capability-building rests on its ability to conduct knowledge searches, which can be observed from two major dimensions: knowledge search scope and knowledge search depth. "Knowledge search scope" refers to the breadth by which new knowledge is explored, while "knowledge search depth" refers to the frequency with which old knowledge is exploited [160]. Knowledge search modes comprise value chain search and capital search, while it may involve industry–university–research institute collaborations and inward licensing [161]. Accordingly a country's STI policy regimes and NAC constitute critical parts of its search processes in gaining access to advanced knowledge, as well as in establishing technological capabilities and technical practices of its own.

Just as AC can be categorized into PAC and RAC, NAC can also be categorized into potential NAC (PNAC) and realized NAC (RNAC). PNAC centers on a country's capacity in identifying, accessing, and learning cross-national knowledge spillovers. RNAC centers on a country's capacity in digesting, disseminating, and commercializing cross-national knowledge spillovers. From the perspective of the knowledge value chain [162,163], PNAC is more concerned with the upstream activities of the value chain while RNAC is more concerned with the downstream activities. From the perspective of knowledge creation, PNAC is more concerned with internalizing explicit knowledge into tacit knowledge, while RNAC is more concerned with combining various genres of explicit knowledge or externalizing tacit knowledge into explicit knowledge [164].

This study defines potential national absorptive capacity (PNAC) as a nation's ability to "acquire and assimilate" external technology knowledge through openness to global knowledge flows [165], learning opportunities, and knowledge transfer [166]. A democratic STI policy regime is conducive to innovation because it creates an open society in which

different views and thoughts can be exchanged freely and debated thoroughly. This kind of environment is especially critical for scientific discovery and experimental exploration. The process of discovery and exploration requires constant exposure to the newest knowledge and the ensuing intellectual activities in filtering, sorting, digesting, and learning.

A country's high PNAC brings an advantage of broadly tapping into a wide array of explorative activities and intellectual fields. As these kinds of explorative opportunities and efforts grow and multiply, a rising trend of more researchers engaging in a more diverse set of new knowledge domains occurs. This helps trigger a sharp rise in both knowledge search scope and depth in exploration, a great leap forward in scientific discoveries and breakthrough inventions, and eventually an eruptive growth in innovation. Hence, PNAC acts as a moderator in converting a democratic STI policy regime into more innovation outputs.

Hypothesis 3. *Potential NAC positively moderates the relationship between a democratic STI policy regime and a nation's performance in innovation outputs.*

This study defines realized national absorptive capacity (RNAC) as a nation's ability to "transform and exploit" external technology knowledge through internationalization and diversification [167] in the "global value chains" [168]. A meritocratic STI policy regime is conducive to innovation because it creates a well-functioning state that provides high-quality civil service, adequate regulation, intellectual property protection, and R&D subsidies for individuals, institutes, and firms to conduct exploitative activities. This kind of environment is especially critical for applied research and commercial exploitation, as a meritocratic policy regime actively fixes market failure and creates market demand for new technology and innovations. The process of application and commercialization requires constant exposure to the latest information, precise identification of business opportunities, and swift initiation of pilot projects. All these contribute to put novel ideas first into feasible application and then into profitable businesses.

A country's high RNAC brings the advantage of concentrated investments in exploitative activities and applied technology. As this concentration reaches a specific threshold, accelerated knowledge accumulation and a sharpened learning curve work together to bring about a sharp rise in both knowledge search scope and depth in exploitation. That triggers a great leap forward in product quality and process improvement, and eventually an eruptive growth in product and process innovation. Hence, RNAC acts as a moderator in a converting meritocratic policy regime into more innovation output in application and commercialization.

Hypothesis 4. *Realized NAC positively moderates the relationship between a meritocratic STI policy regime and a nation's performance in innovation outputs.*

On the other side, since PNAC serves as an important channel for knowledge acquisition and assimilation, a too high degree of PNAC indicates a too high degree of knowledge search in exploration but a too low degree of knowledge search in exploitation. This damages the possibilities of exploitative activities in turning scientific advancement into practical application. Eventually, a steep drop in the exploitative knowledge search will surpass the benefits of a more explorative knowledge search. Put in another way, a too high degree of PNAC indicates "too much science" but "too little engineering". That draws excessive resources into explorative activities, leaving exploitative activities with insufficient investment and attention. All these will lead to an inevitable decline in product and process innovation.

Hypothesis 5. *Potential NAC negatively moderates the relationship between a meritocratic STI policy regime and a nation's performance in innovation outputs.*

By the same reasoning, since RNAC serves as an important channel for knowledge transformation and exploitation, a too high degree of RNAC indicates a too high degree of

knowledge search in exploitation but a too low degree of knowledge search in exploration, thus damaging the explorative activities in searching for new intellectual horizons and creative ideas. Eventually, a steep drop in the explorative knowledge search will surpass the benefits of a more exploitative knowledge search. Put in another way, a too high degree of RNAC indicates "too much engineering" but "too little science". That draws excessive resources into exploitative activities, leaving explorative activities with insufficient investment and attention. All these will lead to a highly possible decline in scientific discoveries and technological breakthrough.

Hypothesis 6. *Realized absorptive capacity negatively moderates the relationship between a democratic STI policy regime and a nation's performance in innovation outputs.*

2.4. A Conceptual Model of STI Policy Regimes, NAC, and Innovation

Based on the above discussions, a conceptual model is constructed to align the six major hypotheses with the two core research questions. To answer the first research question regarding the impact of a country's STI policy regimes on its performance in innovation outputs, this study argues that both democratic and meritocratic STI policy regimes exert positive influences on national innovation performance. To answer the second research question regarding how a country's capacity in knowledge absorptive factors into its national innovation function, this study argues that NAC moderates STI policy regimes' impacts on their performance in innovation outputs. The direction of the moderating effect depends on the match between the type of the STI policy regime and the type of NAC. Both types of NAC may be beneficial or detrimental in different moderating routes. The interactive effect will be positive when an STI policy regime finds the proper match of NAC that fits into its essential nature. Figure 1 illustrates the conceptual model.

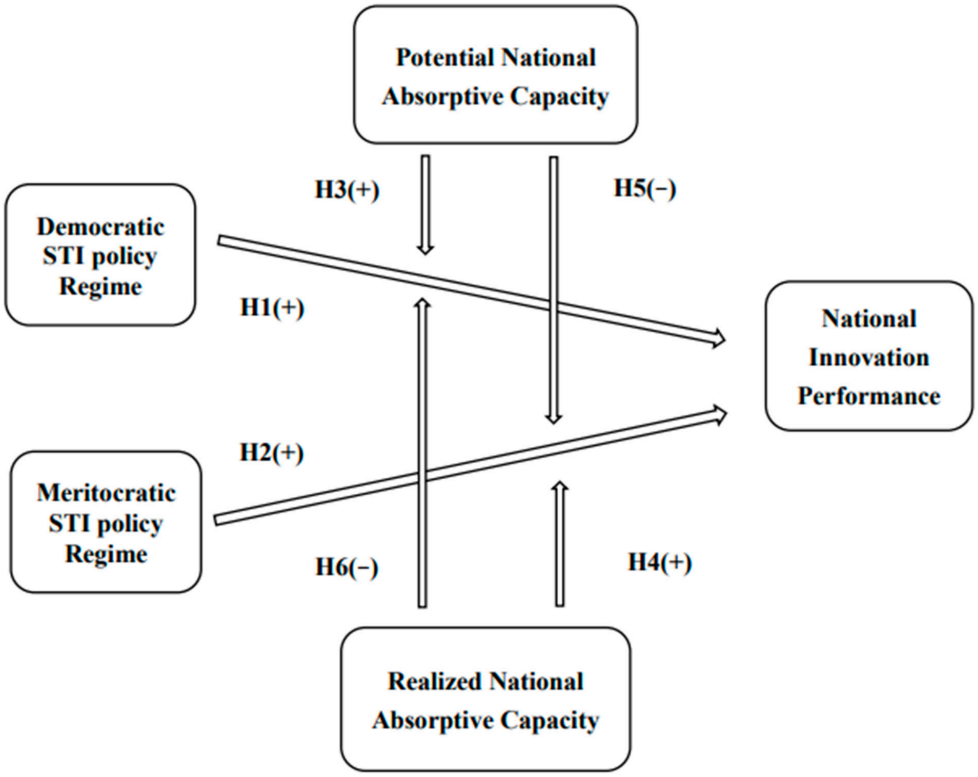


Figure 1. The conceptual model of STI policy regimes, NAC, and innovation.

3. Methodology

3.1. Data and Variables

This study collects panel data from 38 OECD countries. The time period ranges from 2011 to 2022 for the dependent variable, and 2010 to 2021 for the independent variables. The total number of samples is 456.

3.1.1. Dependent Variable

The main dependent variable is the OECD country's annual innovation output sub-index of the Global Innovation Index (GII) from 2011 to 2022. The index's score value ranges from 0 to 100. The index contains knowledge, technology, and creative outputs. Knowledge & technology outputs are chiefly composed of knowledge creation, impact, and diffusion, covering activities in patents, journal publications, and high-tech exports. Creative outputs are chiefly composed of intangible assets, creative goods & services, and online activity, covering activities in trademarks, brand value, cultural exports, and mobile app creations. The GII output sub-index has been widely used by innovation scholars as the proxy for national innovation performance [169].

3.1.2. Independent Variables

The main independent variable refers to dual STI policy regimes that are broken down into two main categories: democratic and meritocratic. This study chooses indicators of democracy and governance as proxies for STI policy regimes, since these indicators reflect fundamental dimensions in policy values, power arrangement, policy paradigms, policy-making mechanisms, governance modes, political institutions, and embedded culture. Both variables are lagged one year considering the path dependence and time they take to affect the dependent variable. This one-year lagging technique is widely adopted by previous research on the impact of either democracy [95,96] or governance [141] on innovation.

This study adopts the weighted average of a country's five Varieties of Democracy (V-Dem) sub-indices (electoral, liberal, participatory, deliberative, and egalitarian democracy) in year $t-1$ as the proxy for the "democratic STI policy regime" variable. Here, this study uses the technique of "exploratory factor analysis" (EFA), which assumes that if a common method variance exists, then a single factor will emerge and account for the majority of the covariance among the components [170]. EFA shows that there is a single dominant factor, while all five sub-indices have high loadings and constitute 93.5% of the total variance. Accordingly, the democratic STI policy regime variable is constructed using the formula below.

$$\begin{aligned}\text{Democratic STI policy regime} = {} & 0.983 \times (\text{electoral democracy index}) + 0.987 \times (\text{liberal democracy index}) + \\ & 0.937 \times (\text{participatory democracy index}) + 0.976 \times (\text{deliberative democracy index}) + 0.951 \times (\text{egalitarian democracy index})\end{aligned} \quad (1)$$

This study adopts the weighted average of a country's four sub-indices (government effectiveness, regulatory quality, rule of law, and control of corruption) from the World Governance Indicators (WGI) in year $t-1$ as the proxy for the "meritocratic STI policy regime" variable. The other two sub-indices of WGI, voice & accountability and political stability, are ruled out because of their low relatedness to meritocracy. EFA shows that there is a single dominant factor, while all four sub-indices have high loadings and constitute 85.2% of the variance. Accordingly the meritocratic STI policy regime variable is constructed using the formula below.

$$\begin{aligned}\text{Meritocratic STI policy regime} = {} & 0.973 \times (\text{government effectiveness index}) + 0.981 \times (\text{rule of law index}) + \\ & 0.939 \times (\text{regulatory quality index}) + 0.965 \times (\text{control of corruption index})\end{aligned} \quad (2)$$

3.1.3. Moderating Variables

Moderating variables contain two dimensions of NAC: potential NAC (PNAC) and realized NAC (RNAC). Empirical research has tried to use different ways to measure

NAC, such as R&D intensity, scientific documents, patent applications, human capital, international openness, infrastructures, and even social cohesion [157–159]. Regarding PAC and RAC, Jansen et al. [149] devised a standardized approach of applying various scales of items in questionnaires to operationalize in terms of acquisition, assimilation, transformation, and exploitation.

Considering the nature of PNAC in knowledge acquisition and assimilation, this study uses a country's openness to international trade as the proxy for PNAC, which is measured by the ratio of total exports and imports to GDP. International openness facilitates accesses to ideas from external sources [171] and has been used by scholars as the proxy for NAC [159] since trade acts as an important channel for knowledge accumulation [154], as well as technology infusion and diffusion [172]. International trade promotes technological spillover and learning effects by means of facilitating the exchange of ideas horizontally through industry counterparts and labor mobility, and vertically through supply chain partners, thus accelerating the diffusion of technology [173]. This effect grows stronger in the era of digitalization as digital service trade accelerates the process of knowledge spillover [174].

Considering the nature of RNAC in knowledge transformation and exploitation, this study uses a country's degree of diversification in exported products as the proxy for RNAC. Thus, RNAC is measured by a country's export product diversification index, which is the difference of one and the Herfindahl–Hirschman index (HHI) in exported product (the sum of the square of the relative percentage in value of various types of products a country exports to the world). The export product HHI reflects how well a country commercializes its knowledge stock into diverse products sold in the global market. Previous research has shown that competing in international markets provokes the "learning by exporting" effect [175–177] that increases the scope of learning [178] and makes a country more keenly aware of potential innovation opportunities. Furthermore, it erodes excessive profits and exerts pressure on firms to learn and innovate in order to survive [179]. As a result, product portfolio diversification becomes one of the main "upgrading pathways" [180] for countries to transform and exploit acquired knowledge to reduce risks and raise competitiveness.

3.1.4. Control Variables

Considering previous research on the determinants of national innovation performance [24,181], this study includes five control variables covering aspects of a country's innovation investment (GERD), international capital inflow (FDI), innovation protection (IPR), competitive/antitrust policies (COMP), and venture capital markets (VC) for innovation funding. GERD and FDI are chosen to reflect the innovation inputs that are part of the input–output mechanism in the national innovation system [20]. IPR, COMP, and VC are chosen to reflect the institutional factors that are part of the common innovation infrastructure of the national innovation system [24]. Like explanatory variables, all control variables are lagged one year considering the time they take to affect the dependent variable.

All the variables are listed and defined in Table 3.

Table 3. Definition and sources of variables.

Variable	Full Name	Definition	Source
Dependent variable: Innovative performance			
$OUTPUT_t$	GII output sub-index	A country's score (0–100) in innovative output in year t	WIPO global innovation index annual report
Independent variables			
$DEMO_{t-1}$	Degree of democratic STI policy regime	EFA-based weighted average of a country's five democracy indices in year $t-1$: electoral, liberal, participatory, deliberative, and egalitarian democracy	Author computation from the V-Dem (Varieties of Democracy) database

Table 3. *Cont.*

Variable	Full Name	Definition	Source
$MERIT_{t-1}$	Degree of meritocratic STI policy regime	EFA-based weighted average of a country's four indices in year t − 1: government effectiveness, regulatory quality, rule of law, and control of corruption	Author computation from the World Bank Governance Indicators database
Moderating variables			
$PNAC_{t-1}$	Potential national absorptive capacity	The sum of imports and exports divided by the GDP in year t − 1	World Bank national accounts data
$RNAC_{t-1}$	Realized national absorptive capacity	The difference of one and a country's Herfindahl–Hirschman index (HHI) in export products in year t − 1	UNCTAD statistics database
Control variables			
$GERD_{t-1}$	General R&D expenditures	Total R&D expenditures in all sectors divided by the GDP in year t − 1	OECD science and technology indicators
FDI_{t-1}	Openness to international inflow of capital	The sum of inward foreign direct investments divided by the GDP in year t − 1	World Bank national accounts data
IPR_{t-1}	Strength of IPR protection	Average survey response by global business executives on a 1–10-point scale regarding the degree to which intellectual property is adequately protected and enforced in year t − 1	IMD World Competitiveness Online
$COMP_{t-1}$	Stringency of antitrust policies	Average survey response by global business executives on a 1–10-point scale regarding whether a country's competition legislation is efficient in preventing unfair competition in year t − 1	IMD World Competitiveness Online
VC_{t-1}	Development of venture capital markets	Average survey response by global business executives on a 1–10-point scale regarding whether a country's venture capital is easily available for start-ups or business activities in year t − 1	IMD World Competitiveness Online

3.2. Model Specification

To investigate the impact of a country's STI policy regimes and absorptive capacity on innovation, this study establishes the following fixed-effects panel regression model, controlling for both the country fixed-effect and yearly fixed-effect. Considering the unobservable differing dimensions across countries, this study uses fixed-effects panel regression as a unit-specific approach to model heterogeneity [182]. Fixed-effects (FE) panel regression has been widely accepted as a reliable tool in estimating ceteris paribus effects since it assumes an arbitrary correlation between unobserved effects and explanatory variables [183]. The FE panel regression, along with other statistical analyses, are conducted with the open-sourced R-4.3.3 software package, a reliable statistical toolkit extensively used by data scientists and social sciences researchers.

For Hypotheses 1 and 2, the model is specified in Equation (3) as follows:

$$(OUTPUT_{i,t}) = \alpha + \beta_1(DEMO_{i,t-1}) + \beta_2(MERIT_{i,t-1}) + \Sigma(Controls_{i,t-1}) + F_i + Y_t + \varepsilon_{i,t} \quad (3)$$

For Hypotheses 3–6, the model is specified in Equation (4) as follows:

$$\begin{aligned}(OUTPUT_{i,t}) = {} & \alpha + \beta_1(DEMO_{i,t-1}) + \beta_2(MERIT_{i,t-1}) + \beta_3(PNAC_{i,t-1}) + \beta_4(RNAC_{i,t-1}) + \\ & \beta_5(DEMO_{i,t-1} \times PNAC_{i,t-1}) + \beta_6(MERIT_{i,t-1} \times PNAC_{i,t-1}) + \beta_7(DEMO_{i,t-1} \times RNAC_{i,t-1}) + \\ & \beta_8(MERIT_{i,t-1} \times RNAC_{i,t-1}) + \Sigma(Controls_{i,t-1}) + F_i + Y_t + \varepsilon_{i,t}\end{aligned} \quad (4)$$

In the models, *i* denotes individual countries; β_1 to β_8 are coefficients of the main independent variables, the moderators, and the interactions between main independent variables and the moderators; Σ represents the coefficients of control variables; F_i is the

time-invariant, country-specific effect for country *i*; Y_t is the time-specific fixed effect for year t; and $\varepsilon_{i,t}$ is the error term of the model.

Regarding the model fit analyses, common methods include R-squared, Araike information criterion (AIC), and Bayesian information criterion (BIC). AIC and BIC calculate prediction error for multi-model inference and are derived from a least-squares estimation in linear regression modelling or in likelihood analyses [184]. Therefore, this paper deems the R-squared method a more suitable indicator to assess model fitness in FE panel regression modelling. The value of R-squared is calculated with a difference of one and the ratio of the explained variation (sum squared regression, SSR) to the total variation (total sum of squares, SST).

4. Empirical Results

4.1. Fixed-Effects Panel Regression

Table 4 presents the descriptive statistics and the correlation matrix for the dependent variable, independent variables, and control variables.

Table 4. Descriptive statistics and correlation coefficients for all variables (*N* = 456).

	Mean	SD	Min	Max	1	2	3	4	5	6	7	8	9	10
1. OUTPUT	42.44	9.82	18.02	68.63	1.00									
2. DEMO	3.53	0.61	0.85	4.17	0.46	1.00			.					
3. MERIT	4.59	2.43	−2.27	8.02	0.74	0.69	1.00							
4. PNAC	100.20	60.46	23.38	388.12	0.18	0.13	0.14	1.00						
5. RNAC	0.84	0.10	0.52	0.95	0.15	−0.06	0.02	0.14	1.00					
6. GERD	1.89	1.08	0.19	5.71	0.67	0.26	0.54	−0.13	0.17	1.00				
7. FDI	4.31	13.37	−41.65	138.21	0.05	−0.03	0.05	0.32	0.01	−0.11	1.00			
8. IPR	6.90	1.40	2.69	9.20	0.74	0.49	0.86	0.08	0.15	0.61	0.03	1.00		
9. COMP	5.97	1.22	2.15	8.51	0.56	0.39	0.79	−0.01	0.17	0.44	0.01	0.83	1.00	
10. VC	4.93	1.31	1.72	8.32	0.50	0.20	0.59	0.06	0.14	0.43	0.02	0.69	0.70	1.00

Table 5 demonstrates the fixed-effect regression results for Equations (3) and (4). The F-tests of all four models show the across-the-board model validity. The value of R-squared increases with the addition of moderators, as well as the control variables.

Table 5. Coefficient estimates of fixed-effects panel regression results (dependent variable: national innovation performance).

	Model I	Model II	Model III	Model IV
		Main variables		
$DEMO_{t-1}$	3.379 *** (0.923)	14.921 * (8.272)	2.426 * (0.964)	12.063 (8.412)
$MERIT_{t-1}$	0.923 † (0.551)	−1.376 (2.066)	1.280 * (0.559)	−0.774 (2.059)
$PNAC_{t-1}$		−0.142 † (0.074)		−0.135 † (0.073)
$RNAC_{t-1}$		39.767 (30.133)		34.906 (30.812)
$(DEMO \times PNAC)_{t-1}$		0.078 *** (0.020)		0.081 *** (0.020)
$(MERIT \times PNAC)_{t-1}$		−0.028 *** (0.008)		−0.028 *** (0.008)
$(DEMO \times RNAC)_{t-1}$		−22.713 * (8.913)		−20.730 * (9.137)
$(MERIT \times RNAC)_{t-1}$		6.357 ** (2.329)		6.048 ** (2.315)

Table 5. *Cont.*

	Model I	Model II	Model III	Model IV
			Control variables	
$GERD_{t-1}$			−0.275 (0.729)	−0.570 (0.735)
FDI_{t-1}			−0.003 (0.014)	0.008 (0.013)
IPR_{t-1}			−0.709 (0.509)	−0.755 (0.490)
$COMP_{t-1}$			−0.573 (0.447)	−0.389 (0.437)
VC_{t-1}			−0.546 † (0.305)	−0.559 † (0.300)
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	456	456	456	456
F test	11.983 ***	8.767 ***	6.252 ***	7.076 ***
R^2	0.0545	0.1461	0.0962	0.1851

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, and † $p < 0.10$. Standard errors are in parentheses.

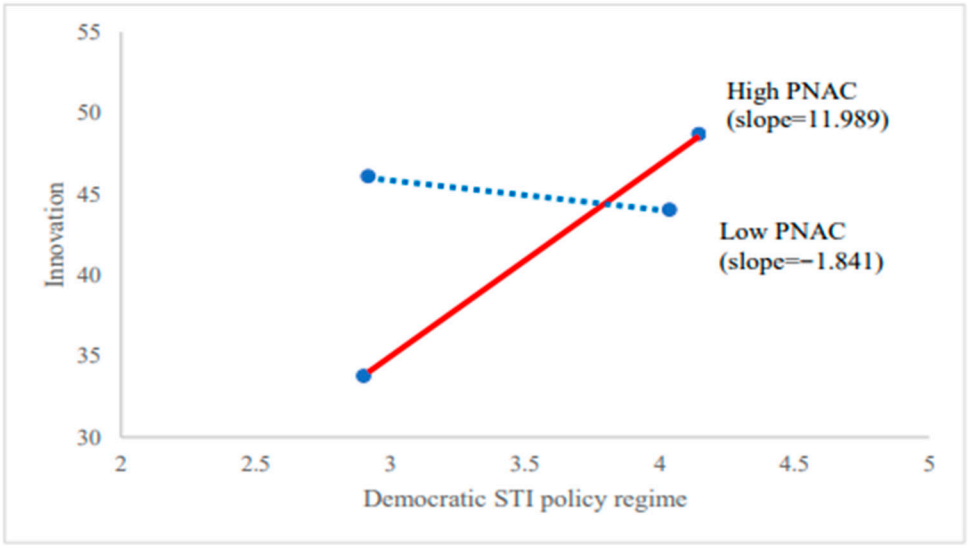
Model I contains only the explanatory variables. It shows that both democratic and meritocratic policy regimes are significantly positively correlated with innovative output, as Hypotheses 1 and 2 predict. It is noticeable that the effect of a democratic policy regime on national innovation performance is much more significant than that of a meritocratic policy regime.

Model II includes the two main explanatory variables and the moderating variables. According to Baron and Kenny [185], a moderating effect occurs when "the interaction of the predictor and the moderator produces a significant effect on the outcome variable". The results show PNAC positively moderates the relationship between a democratic policy regime and innovation performance, as Hypothesis 3 predicts. At the same time, RNAC positively moderates the relationship between a meritocratic policy regime and innovation performance, as Hypothesis 4 predicts. In contrast, PNAC negatively moderates the relationship between a meritocratic policy regime and innovation performance, as Hypothesis 5 predicts. At the same time, RNAC negatively moderates the relationship between a democratic policy regime and innovation performance, as Hypothesis 6 predicts.

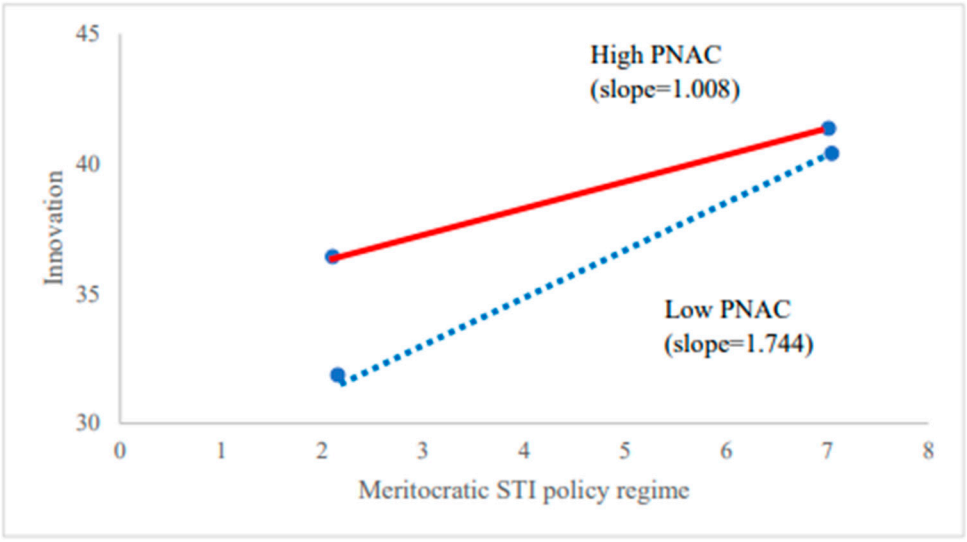
Model III includes the two main explanatory variables and all the control variables. It shows similar results as Model I. As for control variables, only VC carries slightly negative significance. Model IV combines the two main explanatory variables, moderating variables, and the control variables. We call tell that PNAC and RNAC maintain their respective moderating effects.

However, the lowness of R-squared values could be a cause of concern since it reflects the low fitness of the models. This indicates that though the two main explanatory variables along with moderators significantly affect the dependent variable, they account for only a small portion of all the possible explanations. This means that the specified model in this paper contains high validity and relevance but still leaves a large amount of unexplained variation that requires further investigation.

To further identify the moderating effects of NAC, this study divides the sample data based on top 50% and bottom 50% of PNAC and RNAC, respectively. Thus, four sub-sample data groups are constructed: High PNAC, Low PNAC, High RNAC, and Low RNAC. Then, this study uses one standard deviation above and below the mean of the dependent variable to demonstrate the moderating effect of each sub-sample data group. The results are presented into four interaction plots in Figure 2a–d.



(**a**)



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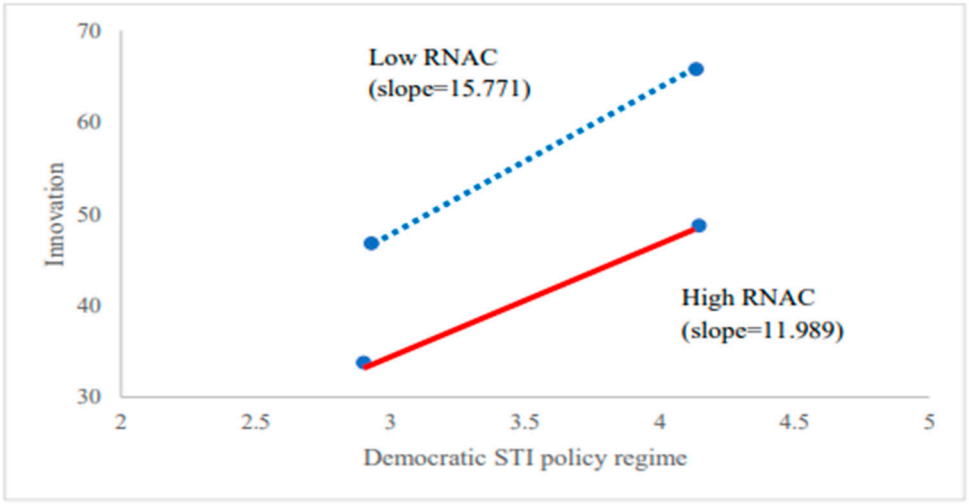
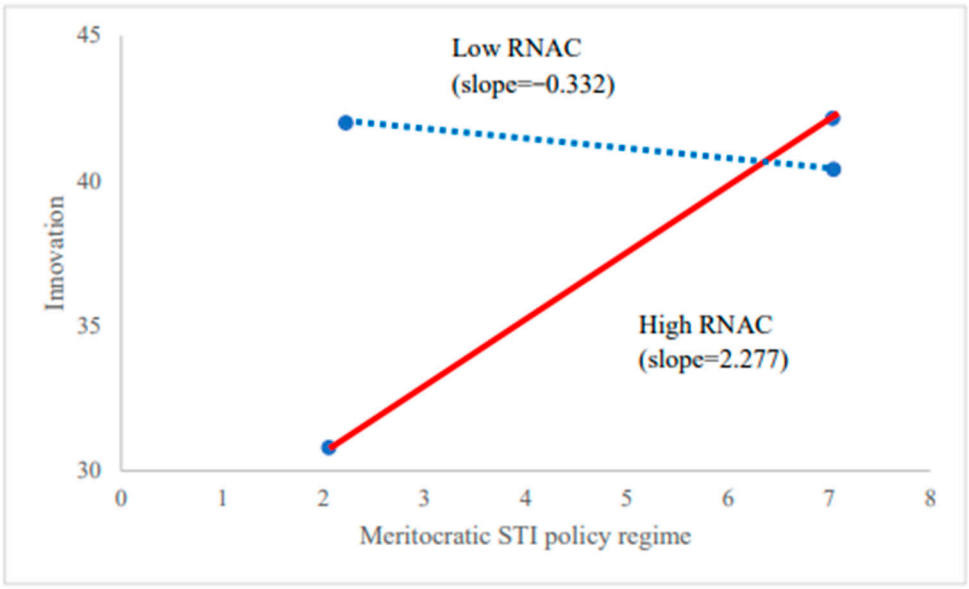


(**c**)

Figure 2. *Cont.*



(**d**)

Figure 2. (**a**) Moderating effect of PNAC on the relationship between a democratic policy regime and national innovation performance. (**b**) Moderating effect of PNAC on the relationship between a meritocratic policy regime and national innovation performance. (**c**) Moderating effect of RNAC on the relationship between a democratic policy regime and national innovation performance. (**d**) Moderating effect of RNAC on the relationship between a meritocratic policy regime and national innovation performance.

4.2. Robustness Analysis

This study uses several ways to further assess empirical meanings of the data and check the robustness of the fixed-effects panel estimates.

4.2.1. Random-Effects Panel Regression

The first one is to conduct a supplementary analysis of the panel data using random-effects panel regression, which shows similar results while the effects of both democratic and meritocratic policy regimes on national innovation performance are much more significant. Table 6 demonstrates the results. The statistical significance of the intercept confirms that the difference across groups of countries and years does matter in the regression analysis. This justifies the use of fixed-effects panel regression as a better statistical approach to conduct a country-level panel data analysis.

Table 6. Coefficient estimates of random-effects panel regression results (dependent variable: national innovation performance in year t).

	Model I	**Model II**	**Model III**	**Model IV**
		Main variables		
Intercept	24.312 *** (2.881)	−1.273 (25.432)	28.090 *** (3.803)	22.854 (24.866)
$DEMO_{t-1}$	2.512 ** (0.864)	14.513 † (7.642)	1.886 * (0.888)	6.960 (7.555)
$MERIT_{t-1}$	2.016 *** (0.356)	−1.221 (1.782)	2.402 *** (0.376)	−0.230 (1.701)
$PNAC_{t-1}$		−0.155 * (0.062)		−0.164 *** (0.059)
$RNAC_{t-1}$		46.426 † (27.676)		24.040 (27.230)

Table 6. *Cont.*

	Model I	Model II	Model III	Model IV
$(DEMO \times PNAC)_{t-1}$		0.076 *** (0.018)		0.074 *** (0.019)
$(MERIT \times PNAC)_{t-1}$		−0.021 *** (0.006)		−0.016 ** (0.006)
$(DEMO \times RNAC)_{t-1}$		−22.655 ** (8.352)		−14.496 † (8.303)
$(MERIT \times RNAC)_{t-1}$		6.300 ** (2.099)		4.983 * (2.013)
Control variables				
$GERD_{t-1}$			1.773 ** (0.560)	1.653 ** (0.579)
FDI_{t-1}			−0.002 (0.014)	0.007 (0.014)
IPR_{t-1}			0.132 (0.478)	0.167 (0.469)
$COMP_{t-1}$			−0.808 † (0.440)	−0.686 (0.437)
VC_{t-1}			−0.565 † (0.302)	−0.670 * (0.297)
Observations	456	456	456	456
Chi Square	70.714 ***	104.713 ***	127.201 ***	154.643 ***
R^2	0.1350	0.1898	0.2211	0.2592

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, and † $p < 0.10$. Standard errors are in parentheses.

This study uses the Hausman test, a common way to compare the model validity of the fixed-effects and random-effects estimates. A significantly high chi-square value causes the rejection of the random error hypothesis, indicating that the use of fixed-effects panel regression is more appropriate [183,186]. The results show that fixed-effects panel regression is a better approach to deal with the panel data, as Table 7 demonstrates.

Table 7. Results of the Hausman test of fixed-effects and random-effects estimates.

	Model I	Model II	Model III	Model IV
Null hypothesis	Rejected	Rejected	Rejected	Rejected
Chi-square	10.229 **	24.87 **	103.22 ***	45.108 ***

*** $p < 0.001$, ** $p < 0.01$.

In addition, the random-effects model allows this study to calculate the variance inflation factors (VIFs) to check the problem of multi-collinearity among independent variables. A low value of VIF (usually less than 4) indicates a low degree of correlation between the variable and the other independent variables. The values of VIFs range from 1.026 to 1.961, as Table 8 shows.

Table 8. Variance inflation factors among independent variables.

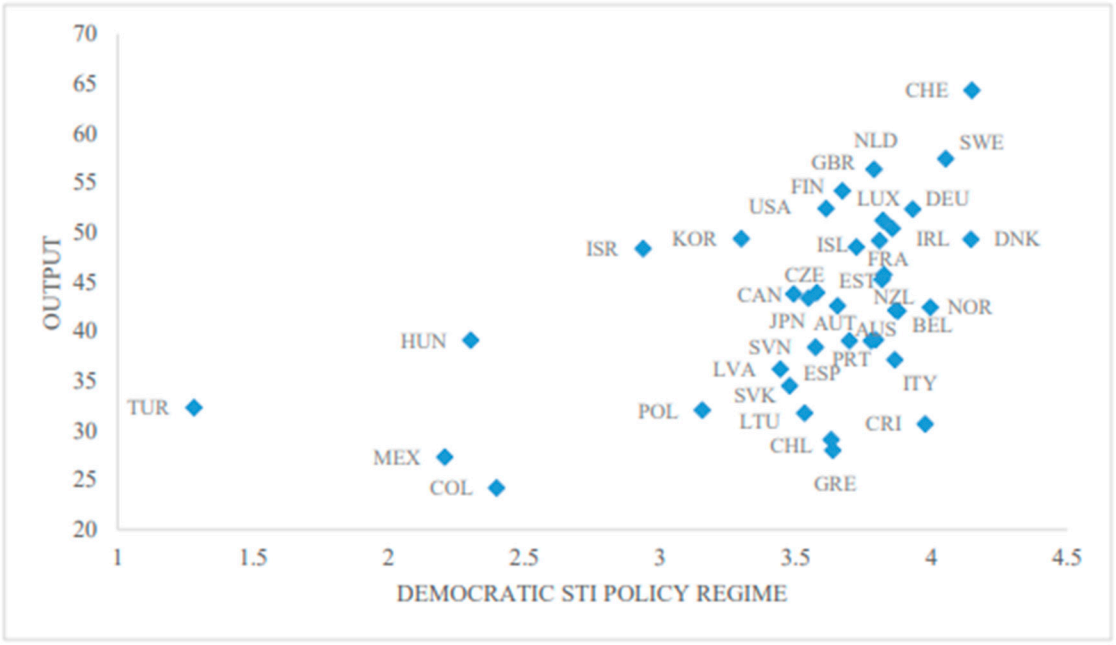
	DEMO	MERIT	PNAC	RNAC	GERD	FDI	IPR	COMP	VC
VIF	1.507	1.961	1.056	1.048	1.270	1.026	1.902	1.915	1.609

4.2.2. Country-Level Analysis

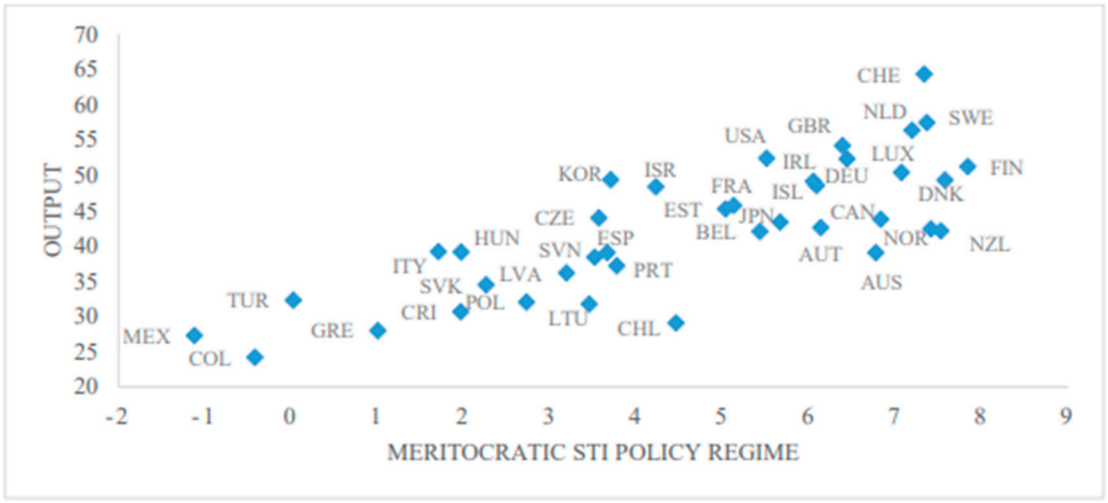
Regarding the country-level analysis, first, this study uses variance component analysis (VCA) to distinguish the respective effects on total variance of the country fixed-effect

and year fixed-effect. VCA has proven helpful in assessing how much of the total variance in the dependent variable could be attributed to unspecified firm, industry, and year differences [187,188].

The VCA of national innovation performance shows that the country fixed effect occupies a much larger portion (87.89%) of the total variance than the year-fixed effect (2.48%). In order to further elaborate the country fixed-effect, this study calculated every country's average values in the dependent variable and two main explanatory variables. The results are graphed in scatter plots in Figure 3a,b.



(**a**)



(**b**)

Figure 3. (**a**) Country-level scatter plots of the democratic policy regime and innovation. (**b**) Country-level scatter plots of the meritocratic policy regime and innovation.

The two country-level scatter plots show a clear trend of strong positive effects of democratic and meritocratic STI policy regimes on national innovation performance. This confirms the primary findings from the fixed-effect analysis.

4.2.3. Removal of Outliers

The third way is to use a sub-sampling method [189]. This study rules out the extreme values of the main explanatory variables that fall outside the range of mean values plus or minus two standard deviations in order to mitigate the exaggerated effect of outliers [190]. The results are consistent with the primary findings.

4.2.4. Alternative Measure of Explanatory Variables

The fourth way is to use a different way of operationalizing the main explanatory variables. This study uses the Economist Intelligence Unit's (EIU's) country data as the main source. For the democratic policy regime variable, this study chooses three sub-indices: election process and pluralism, political participation, and civil liberties. The proxy for the democratic policy regime is constructed based on EFA as follows:

$$\begin{aligned}\text{Democratic STI policy regime} = {} & 0.955 \times (\text{election process and pluralism}) + 0.336 \times (\text{political participation}) \\ & + 0.879 \times (\text{civil liberties}).\end{aligned} \quad (5)$$

As for the proxy for the meritocratic policy regime, this study uses EIU's "functioning of government" index, which measures "the capability of the civil service to implement policies".

The fixed-effects panel regression shows similar results as the original one. The only difference is that PNAC shows no moderating effect on the relationship between a meritocratic policy regime and national innovation performance.

5. Discussion

5.1. Theoretical Implications

The findings suggest that national innovation performance is significantly affected by STI policy regimes and by the interactions between STI policy regimes and NAC. STI policy regimes reflect a country's domestic political, economic, and social structures, while NAC reflects a country's degree of exposure to and exploitation of global flows of scientific and technological knowledge. Previous studies of cross-national aspects of national innovation center on the internationalization of innovation systems [191], innovation networks [192], and knowledge flows [193]. This study shows that a country's ability in global knowledge absorption only counts when appropriate STI policy regimes are established.

In essence, a democratic STI policy regime seeks to broaden the horizon of exploration and strives to create an environment that maintains, protects, and promotes freedom, equality, and public deliberation. Political, economic, and social freedoms give firms, institutes, and individuals unfettered intellectual leeway to expand the horizon of knowledge and to explore every possible opportunity in science and technology. Social equality ensures individuals have equal participation in explorative activities and equal access to resources mobilization so that more scientific discoveries could be achieved.

In contrast, a meritocratic STI policy regime serves seeks to deepen the scale of exploitation and strives creates an environment that maintains and sustains bureaucratic efficiency, rule of law, and adequate regulation. All these factors constitute a mechanism of good governance that ensures firms, institutes, and individuals engaging in exploitative activities are endowed with due legal protection in their innovative production, as well as in the ensuing commercialization endeavors. Hence, individuals, firms, and institutes with high innovative capabilities are well motivated to pursue innovative activities to turn their novel ideas into commercializable applications and earn reasonable rewards.

At the same time, NAC provides channels of knowledge transfer and technology spillover for all relevant local actors in a national innovation system to tap into international sources of technological knowledge and technical information. All these international linkages interact with innovation inputs and policy regime factors in the national innovation system to produce new knowledge and upgrade existing technologies, which coalesce to determine national innovation performance. This phenomenon echoes what Castellacci and Natera [159] described as the "co-evolution" of national innovative capabilities and NAC.

Specifically, PNAC serves as the knowledge gatekeeper [194] that soaks up and filters cross-national knowledge spillovers. RNAC serves as the knowledge shepherd [194] that gathers and reassembles these knowledge spillovers into practical applications. Furthermore, gatekeeping PNAC interacts with an exploration-oriented democratic STI policy regime to strengthen its positive impact on innovation outputs. Shepherding RNAC interacts with an exploitation-oriented meritocratic STI policy regime to strengthen its positive impact on innovation outputs.

This study further extends the argument by stating that a country's national innovation system belongs to the global innovation system (GIS) composed of innovation subsystems and valuation subsystems [195]. Within this gigantic system of subsystems, a country's firms, institutes, and individuals pursue knowledge-sharing strategies [196], participate in knowledge networks, and facilitate market access [197] so as to promote innovation activities, produce innovation outputs, and profit from innovation endeavors.

5.2. Policy Implications

Democracy and meritocracy do not exist as lonesome policy regimes. They could support each other in a complementary manner. A democratic policy regime requires rule enforcing and governance actions from technocrats to make sure that it will not sink into mob rule. A meritocratic policy regime requires constant surveillance and participation from civil groups to make sure that it will not sink into an authoritarian dystopia. Briefly speaking, the mutual complementarity and embeddedness of a democratic policy regime and meritocratic policy regime generate a kind of "state–society synergy" [48] in the process of co-production in innovation output.

So how should a country use STI policy regimes and NAC to enhance national innovation performance? The first answer is to pursue a well-balanced set of STI policy regimes with two pillars of democracy and meritocracy so that the expertise of technocrats and activism of civil groups could both be well harnessed. The second answer is to raise a country's NAC so that firms, institutes, and individuals can take part in knowledge search activities that fit into their needs and motivations. To achieve these goals, a country should expand its scientific knowledge stock and pursue a policy of international openness in order to be exposed to international flows of technological knowledge and technical information. A country should also establish a diversified portfolio of exported products so that the application of existing knowledge will not be constrained by a narrowed knowledge base.

6. Conclusions

This study builds a theoretical model with six major hypotheses and conducts a quantitative analysis of how countries' STI policy regimes along with their NAC jointly determine their innovation performance. The findings show that both democratic and meritocratic policy regimes have significant positive effects on national innovation performance, with the democratic effect being more significant. The findings also show the opposite moderating effects of potential and realized NAC on the connection between STI policy regimes and national innovation performance. All these carry crucial theoretical and policy implications, as stated in the previous section.

This study carries some limitations. First, this study uses OECD countries as major sources of sample data, and so the major findings may be more applicable to developed countries than to developing countries or under-developed countries. Further analysis of non-OECD emerging economies like BRICS countries may be needed to expand the empirical evidence. Additionally, this study uses panel data from 2010 to 2022 across OECD countries and assumes a continuous path of industrial development and technological advance. However, there may have been some key events or critical policy shifts in a country that sent shockwaves to the supply and demand sides of innovation, which form a considerable part of the variance in differences in national innovation performance, but are not accounted in the panel regression models.

As for the continuation on the very topic of national innovation performance, this study suggests several future directions. The first is a more nuanced analysis of the effect of STI policy regimes on innovation output. Different STI policy regimes may have different effects on different innovation outputs. For example, a democratic policy regime might be more conducive to radical innovations, while a meritocratic policy regime might be more conducive to incremental innovations. The second is a more detailed analysis of how a country's absorptive capacity interacts with STI policy regimes to affect national innovation performance. This may require a more subtle model of a country's knowledge search activities, as well as their scope and depth. The third is a more historical approach. A country's STI policy regime, absorptive capacity, and innovation performance may have a much longer and a more complicated relationship that quantitative data alone might not suffice to identify. A qualitative analysis of a country's historical innovation path may also be needed to clarify how these factors play into the national innovation function. Finally, the high causal significance but low explaining power of the empirical results in this paper demonstrate that the full set of determinants of a country's performance in innovation outputs may be much larger than what the existing research has identified. Hence, the daunting task to solve the "missing piece to national innovation rate puzzle" [28] truly demands more joint efforts from innovation scholars from diverse fields in social sciences. This paper marks only the beginning of such renewed endeavors and wishes to see more remarkable research on this intriguing topic in the near future.

Traditional thinking tells us that in order to raise innovation outputs, a country ought to double down R&D investments and create an innovator-friendly environment [33,198]. All are necessary but not necessarily sufficient, as this study finds. A country needs to establish a balanced set of dual STI policy regimes to encourage both exploration and exploitation. A country also needs to leverage its absorptive capacity to trigger more knowledge exposure and technology transfer. The optimal combination of STI policy regimes and absorptive capacity shall contribute to induce more innovation in knowledge, technology, and sustainability.

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