Journal of International DBA Studies (JIDS)
Vol. 1 No. 002 (2025) https://eaj.ebujournals.lu/index.php/JIDS/index

Policy Support Pathways for Emerging Technologies in the U.S. and the Synergy Mechanism with Financial Capital

by
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Abstract

This study investigates the policy support pathways of emerging technologies in the United States and how it works synergistically with financial capital. Promising technologies such as artificial intelligence, quantum computing, clean energy environment, and biotech are central to the economic growth, competitiveness of nations, and solve global challenges like climate change. Nevertheless, their growth is rather impeded by costly research and development (R/D) costs, prolonged periods of commercialization, and technological riskiness. To curb such impediments, U.S has constructed a policy framework that is complex and financial capital, including venture capital, public-privileged affiliations, institutional plans as well as corporate financing. The systematic examination of policy documents, industry reports, case studies and empirical data source identifies four main policy support streams, namely legislative and strategic direction, fiscal and financial incentive, R&D infrastructure and collaborative networks as well as market creation and regulatory alignment. It also examines the interaction of these pathways with financial capital, via the mechanisms of risk reduction, information signaling, resource mobilization and market expansion. The study points to the significance of integrating policy formulation to achieve the highest efficiency of synergy to resolve the tension between short-term liquidity demand levels of capital and long-term technological discoveries. Through these dynamics, the study will offer evidence-based information to policymakers, investors, and technology builders on building a stronger and more innovative ecosystem of new technologies.

Keywords: Emerging technologies; policy support; financial capital; U.S. innovation ecosystem; synergy mechanism

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Introduction

The 21st century shifted the interaction of new technology as the foundation of the global economic competition, and the United States continues to be at the forefront of several other areas including artificial intelligence (AI), quantum computing, renewable energy, and biotechnology. Not only do these technologies lead to an expansion of productivity but also redefine industries, open their new marketplaces, and tackle some urgent problems facing society, such as the minimization of carbon emissions and healthcare performance. They are, however, characterized by distinctive developmental problems: they require high initial investments, their technical feasibility is insecure, their journey to market takes long, and their development may fail to lead to market success since knowledge spillovers and asymmetric information (Romer, 1990; Stiglitz, 1985).

It is on this background that the role of the government policy is paramount in the development of a toll-free environment in which the emerging technologies may be utilized and that the financial capital is the blood nourishing that may turn the intentions of the policy into actual implementation as innovation. The U.S. has been characteristically using policy instruments to encourage technological development as seen in the establishment of DARPA (Defense Advanced Research Projects Agency) in the 1950s, that e-prepared the precursor to the internet, and more recently the CHIPS and Science Act (2022) which is designed to restart the semiconductor production system domestically. At the same time, financial resources, both in the early technology development in form of venture capital (VC) and in high-volume investments, have been pouring into these technologies, and U.S. VC investment in new technology reached $150 billion in 2023 alone (NVCA, 2024).

Although the literature on technology policy and venture capital is on the increase, there is still a gap in comprehending how certain policy routes in the U.S. interplay with various sources of financial funds to spur the emerging technology development. Although the finer adaptation to policy instruments (e.g. tax credits or grants) or the influence of VC on innovation has been studied, there is a dearth of research that has independently mapped the policy landscape or has delved into the interactions between policy and capital in different technologies. This study aims at closure of this gap by answering three basic research questions:

1. Which are the key policy support options in the United States on emerging technologies?
2. What interaction exists between these pathways and various forms of financial capital (venture capital, public funds, institutional investments, corporate capital)?
3. How do policy support and financial capital interact to scale emerging technologies into effect or not?

To address these questions, the study relied on a mixed-methodology, which is based on a qualitative analysis of major policy documents, case studies of three e-merging branches of technology (AI, clean energy, and quantum computing), and quantitative data on investment flows and policy effects. It is important in that it may contribute to the effective policy design on the bases of evidence and may educate policymakers on how to best utilize the public resources to harness the private capital, as well as it may inform investors on how to best structure their strategies to pursue the policy priorities in order to achieve the best financial returns and impact to society.

Table 1
Top 25 high frequency words in the Report

Vocabulary	frequency/times	Percentage
Standards	2165	1.34%
Technology	1665	1.03%
Develops	1621	1.00%
Industry	1147	0.71%
Nations	1062	0.66%
Manufacturing	1038	0.64%
Federation	1025	0.63%
Materials	983	0.61%
System	895	0.55%
Blockchains	812	0.50%
Quantum	747	0.46%
Security	746	0.46%
Institutions	703	0.43%
Agencies	693	0.43%
Sectors	636	0.39%
Governsinforms	615	0.38%
Risks	604	0.37%
Produets	594	0.37%
Advancing	577	0.36%
Publicly	565	0.35%
Works	562	0.35%
NIST	541	0.33%
Provide	528	0.33%
Supply	524	0.32%
Applications	521	0.32%

Literature Review

Policy in the Development of Emerging Technology

The economic theory has always found that market forces in their own right cannot be relied upon to lead to optimal investment in new technologies, mainly through non-rivalry in knowledge (Arrow, 1962), positive externalities (Romer, 1986) and a failure to coordinate with one another (Rodrik, 2004). Consequently, government intervention is acceptable to amend such market failures to encourage innovation.

There are a number of types of policy tools that are used to support emerging technologies:

Strategic and legislative instrument: These constitute national strategies, legislative requirements as well as inter-agency coordination arrangements that establish long-term priorities and institutional stability. In particular, the U.S. National AI Initiative (2019) created a roadmap in the federal investment in AI, including the directions of its activities among the public and private players (White House, 2019).

Fiscal incentives: These methods lower the cost of R&D or commercialization by providing tax credits, grants, and subsidies. Research has found that R&D tax credits have the capacity to boost corporate R&D expenditure by 10,20 percent (Hall & Van Reenen, 2000) and grants can be effective especially in early-stage risk high projects that lack access to private capital (Lerner, 1999).

Facilities and complements Infrastructure and collaboration: Investment into research and testbeds and public-private partnerships (PPPs) reduce entry barriers to small firms and knowledge sharing. Mowery and Nelson (1999) point out that the U.S. national laboratories have been historical locales of technological spillovers.

Regulatory and market creation instruments: These comprise standards-setting, procurement policies, and an expedited approval process that diminishes uncertainty and initial market creation. An example is the role played in the federal procurement in early adoption on technologies such as semiconductors to drones (Cohen & Noll, 1991).

Financial Capital in the Innovation Ecosystem

Technological ideas are necessary to be transformed into commercial products, which need financial capital. There are various phases of technological growth that demand various forms of capital:

Irradian capital: This stage is dominated by venture capital (VC) and angel investments which are risk capital in the form of equity. VC firms put in more than just money into startups by also providing strategic advice and networks, which can be worth apparently as much as cash (Gomers, Lerner, 2004).

Growth-stage capital: Although the technologies are more established, institutional investors (such as pension funds, endowments) and corporate venture capital (CVC) increase in prominence. These investors are focused on the scalability and market validation, as they tend to pour greater amounts to assist in production and market expansion (Da Rin et al., 2013).

Public capital: Government grants, loans and guarantees are essential in de-risking too early or too risky projects of the private investors. Programs such as Small Business Innovation Research (SBIR) have been revealed to raise the rate of startups receiving follow-on VC finance (Lerner, 1999).

Synergy Between Policy and Financial Capital

Policy and financial capital do not engage with each other in just one way, but instead, they enter a dynamic feedback loop. Time and again, policies can propel incentives in a way that crowds in private capital through not only taking away risk, but also providing information or creating market opportunities (Cumming & Johan, 2019). As such, electronically, clean energy tax credits have been observed to raise VC investment in renewable technologies by 3040 percent (Carley et al., 2020). On the other hand, financial capital has a potential to achieve greater impacts on policies, as it is able to scale successful technologies to a higher level than public funds would allow.

Synergy however is not automatic. Policy schedule (long-run) and time preferences (short-run) may result in a conflict, or lack of investment encouraged by policy uncertainty. An example is that repeated transfers of renewable energy subsidy are found to diminish the constancy of VC flows into the industry (Neuhoff et al., 2019). It is essential to understand these dynamics to come up with effective policy designs.

Methodology

In order to investigate exhaustively the policy support pathways of the new technologies in U.S and how they are synergistic with financial capital, mixed research methods design was applied in this study. Mixed methods would be especially appropriate in this question because they could combine insights obtained via qualitative methods (e.g., the intent behind the policy, perceptions of stakeholders) with quantitative variables (e.g., investment flows, the measures of the impact of the policy) to increase the depth and the strength of the findings results (Creswell & Clark, 2017). This part describes the particular methods used in the research such as policy documents analysis, case study, sources of data and measures that will be taken to guarantee validity and reliability.

Policy Document Analysis

A policy mapping review of policy documents was also done to draw a picture of U.S. federal support of emerging technologies. This is a common policy research method of establishing patterns, priorities, and instruments within the institutional frameworks (Bowen, 2009) and it has given some fundamental insight into how the U.S. government organizes its assistance towards innovation.

Three major criteria were used to select the policy documents.

- Temporal scope. The temporal range of documents was 2010 to 2023 to reflect only recent policy changes as the emerging technologies such as AI and quantum computing were rapidly changing in the past decade.
- Relevance: Only documents the topic of which mentioned emerging technologies (herein referred to as technologies, which are in early stages of adoption or development with a transformative potential, as defined by OECD, 2021) or financial mechanisms to enable its further development were included. These left out policy centered on mature technologies (e.g. traditional fossil fuels) or general economic policy that did not specifically look at technology.
- Authority: The documents at the federal level only were considered because they are the most policy coordination on optimal policy in the U.S. These consisted of legislative action (enacted by the Congress and becoming effective as a law),

executive action (made by the President), strategic reports of the major federal agencies having the jurisdiction in technology and innovation (e.g. NSF, DOE, DARPA, NIST).

The total number of documents that met these requirements was 45. They have been divided into three major types:

- Legislation acts (n=12): Partisan or Bipartisan bills containing direct allocation of funds or regulatory requirements, including the CHIPS and Science Act (2022), Inflation Reduction Act (2022), and National Quantum Initiative Act (2018).
- Executive orders and national strategies (n=8): Policy guidelines on priorities across agencies, among them the National AI Initiative (2019) and the American Jobs Plan (2021), which specified clean energy and advanced manufacturing investments in infrastructure.
- Agency reports and funding guidelines (n=25): Strategies, grant guidelines, and impact reports of such agencies as DARPA (e.g., AI Next Campaign Strategy, 2020), NSF (e.g., 2023 Strategic Plan for Emerging Technologies), and DOE (e.g., Clean Energy Innovation Roadmap, 2021).

Analytical Framework

The thematic analysis which is a technique of determining and explaining patterns (themes) in qualitative data were used to analyze the documents (Braun & Clarke, 2006). The analysis was done in three steps:

1. Coding: Two independent researchers coded each document to extract important information and this included:
   - Policy (e.g., tax credits, grants, procurement, regulatory reforms).
   - Expressed goals (e.g., "cut carbon emissions," "stay on the forefront in AI all over the world).
   - Target technologies (e.g., "quantum computing," "solar energy," "semiconductors").
   - Timespan (e.g., five-year, ten-year contracts).
   - Amounts or resources to be provided (where stated).
2. Theme development: Codes were summarized into general themes to determine repetitive policy course. An example is that codes touching upon such a theme as fiscal and financial incentives were combined with such codes as tax credits, SBIR grants, and DOE loans. The coding discrepancies were solved with the help of a series of iteration before 90 percent consensus was achieved, which guaranteed reliability (Miles and Huberman, 1994).
3. Validation: The identified themes were discussed or cross-linked with scholarly literature on technology policy (e.g., Mowery and Nelson, 1999; Lerner, 2009) to make sure that the identified themes are in line with the known theoretical frameworks which contributed to the increased validity of the identified policy pathway classifications.

Case Studies

The use of case studies has been used to investigate the extent to which policy pathways interrelate with financial capital in concrete technological situations. The approach is useful when more in-depth causal relationships between policy intervention and capital flows need to be analyzed in the context of their real-life experiences (Yin, 2018).

Case Selection Rationale

To avoid homogeneity in maturity, risk profile and policy involvement, three technology sectors were chosen. The presence of this diversity allowed making comparisons between the various points of the technology lifecycle, and the generalizability of implications increased:

- Artificial Intelligence (AI): It is a growing sector of the mid-maturity that is receiving considerable investment by private investors (91 billion U.S. VC fund in 2023; NVCA, 2024) yet continues to face expansive policy discussion around ethical, regulatory, and employment implications. It is an intermediate form of policy-capital interaction in which government R&D (e.g., DARPA grants) and private capital (e.g. corporate venture capital by Google, Microsoft) are both significant.
- Clean Energy (solar, wind, battery storage): A late-stage the category of development, with a focus on climate targets, where policy incentives (e.g., tax credits, renewable portfolio standards) are pronounced and increasing institutional interest is placed in it (e.g., pension funds, ESG-rated funds). It shows how a capital-intensive project can be made more attractive to the large-scale investment of capital by a policy de-risking approach.
- Quantum Computing: It is an early-stage and high-risk industry that has not as yet found many commercial uses. It is also severely dependent on government R&D investment (e.g. the National Quantum Initiative Act in the tune of 1.2 billion) and recently has not gained much in terms of private funding (VC investment increased to 3.2 billion in 2023; PitchBook, 2023). It is one example of the contribution of policy in cultivating technologies that are simply too risky to exist in the marketplace, unsubsidized.

3.2.2 Data Collection and Analysis for Case Studies

In terms of each sector, data was collected during 2010-2023 to offer coverage to the policy document analysis timeline. Three dimensions were used as the subject of analysis:

1. Policy interventions: In relation to each sector, the history of important policy instruments (e.g., AI: National AI Initiative in 2019; Clean Energy: Inflation Reduction Act in 2022; Quantum Computing: National Quantum Initiative Act in 2018) and their particulars in relation to design (e.g., amounts of money they allocate, who is eligible, etc.) were mapped.
2. Financial capital flows: awareness of sources and magnitudes of capital.
3. VC investments (seed to Series D rounds, through PitchBook). Partially state finances (via agency reports, federal grants, loans and contracts). Corporate investment (CVC, R&D spending, through annual reports of companies). Institutional investment (e.g. pension fund investments in clean energy, through

Preqin).

4. Outcome measures: To realize the measure of policy-capital synergy, these were measured:
    - Technological advancement (e.g. number of AI patents, improvement of quantum computing qubits stability).
    - Market adoption (e.g. solar capacity installed, revenue by AI software).
    - Investment responsiveness (e.g., evolutions in VC funding 12-24 months after the enforcement of policies).

Process tracing was the method used to analyze data and this involves the identification of causal mechanisms based on the sequence of events (George, 2005 and Bennett, 2005). As an illustration, in clean energy, the relationship between the tax credits created through the 2022 Inflation Reduction Act and a 40% rise in institutional investment (IRENA, 2023), after other variables such as fuel prices were adjusted.

Data Sources and Triangulation

There was triangulation of data sources to include quantitative and qualitative data.

Quantitative Data

- Venture capital databases: PitchBook and the National Venture Capital Association (NVCA) ended up with detailed information fields of investment round, deal size, type of investor, and target technology. The selection of these databases was due to their ability to cover the U.S. VC activity in detail (95% of known deals, as of Pitchbook, 2023).
- Federal funding reports: NSF, DOE and DARPA have all issued annual reports which quantified direct government spending in R and D as well as grants and loans. In the example, the 2023 LPO Impact Report by DOE specified the amount of loans and mobilized capitals at the private level.
- Industry and market reports: Data on market adoption (e.g. Solar capacity growth or AI software revenue) were found in industry reports (e.g. Semiconductor Industry Association, American Clean Power Association), and market research reports (e.g. McKinsey, Deloitte).
- Academic data: Primarily obtained results were validated with secondary analyses of policy impacts (e.g., Carley et al., 2020 about policy of renewable energy).

Quantitative data was cleaned and examined with descriptive statistics (e.g., the mean investment in each sector, year-over-year growth rates), time-series analysis to find out the trends before and after the adoption of the policy. The statistical processing was performed in Stata 17, and the lack of data values were solved by interpolation or by omission (less than 5 percent of observations).

Qualitative Data

Semi-structured interviews were conducted with 14 stakeholders to gain an idea of what they see in policy-capital interactions. The eight policy analysts are academic experts with technology policy specialization, former staff at federal agencies, and Brookings and Information Technology and Innovation Foundation staff analysts. The six venture capitalists specialize in AI, clean energy or quantum computing with portfolios consisting of 10 or more upcoming technical startups.

The interviews were 45-60 minutes long and questions asked include: "What do you do with policy signals to make investment decisions? and "What are the most effective tools in the policy to reduce risk when entering early-stage technologies?

Transcription and coding: NVivo 12 codebook was used to transcribe the interviews verbatim and assign codes according to policy pathways and synergy mechanisms detected in the document analysis. This enabled cross-referencing between the perceptions of the stakeholders and documentary evidence.

Triangulation: Triangulation of the quantitative data with the qualitative results was done to facilitate consistency. As an illustration, the argument that "SBIR grants signal quality" has been confirmed as compared to the NSF data, that SBIR recipients have a 2.3x higher chance of raising VC capital (NSF, 2022).

Validity and Reliability

A number of methods were utilized in order to increase the rigor of the methodology.

Triangulation: This technique is based on findings from sources (policy documents, investment data, interviews) and methods (qualitative, quantitative) that are used to cross-check findings.

Inter-coder reliability: Policy documents and interview transcripts were coded by different people, and any disagreement was settled by consensus.

Transparency: Disclosed information about data origin, analytical procedures, coding schemes so that replication can be done.

Shortcomings: The possible biases, including lack of representation of policies at state level or non-public VC deals, are not ignored, and future research is implied to fill these gaps.

Policy Support Pathways for Emerging Technologies in the U.S.

Policy analysis documents and case studies indicated that there were four different yet interrelated pathways of policy support and each has to support particular phases of the technology development cycle and relates to financial capital in a different way.

The strategy of competing successfully within the key market segment can be enabled through the establishment of legislation and a strategic direction (Bardozy 2010).

Legislative and Strategic Direction

This is achieved by establishing long-term national priorities by legislation and strategic plans, which ensure a stable framework to both public and private investments. Its main tendency is to decrease the so-called policy risk-uncertainty regarding the future governmental assistance that is one of the greatest obstacles on long-term capital investments.

Key examples include:

The CHIPS and Science Act (2022): This bipartisan bill will provide 52 B USD to semiconductor research, product developer and manufacturers, and to new technologies such as AI and quantum computers. Most importantly, it provides a tax credit of 25% on the investment in semiconductor manufacturing, an indication of the long-term investment in reviving the manufacture within the country. This stability was attributed to the fact that it led to $200B of investments in the private sector in the 18 months of enactment, with such significant projects as Intel, and Samsung being undertaken (Semiconductor Industry Association, 2023).

The National Quantum Initiative Act (2018): The bill created a quantum research roadmap (a 10-year plan) that focuses on the federal agencies (DOE, NSF, NIST) and offers 1.2 billion as funding. It sets specific milestones and funding thresholds, and this action led to a fivefold rise in VC availability into quantum startups between 2018 and 2023 (PitchBook, 2023).

National AI Initiative (2019): This initiative was published as an executive order that developed an inter-agency plan to advance AI R&D, the creation of knowledge systems, and ethical standards. It has directed federal funding (1.7 billion in 2023 by itself) and sent a message to investors that AI is still a priority of the nation, which is contributing to record VC investment (75 billion in 2023) in the sector (White House, 2023).

These will synchronize private capital with national strategic objectives through mitigation of uncertainty. The indication given by a clear 10-year plan is that the market of a technology will not vanish overnight.

Fiscal and Financial Incentives

The mechanism involves tax credits, grants, loans, and guarantees, to reduce directly the cost of R&D and commercialization, making emerging technologies more desirable to investors. It focuses on easy-acquisition (high-risk) and capitals-intensive (late-stage) projects and uses tools to address each.

In the field of artificial intelligence, the federal government has prioritized AI funding through legislation such as the National AI Initiative and the CHIPS and Science Act. For instance, the federal AI R&D budget reached $1.7 billion in fiscal year 2023 (White House, 2023)[1], while tax credits and the SBIR/STTR programs encouraged small and medium-

[1] White House. (2023). National AI Initiative Office Annual Report.

sized enterprises to participate in AI technology development. These incentives not only reduced corporate R&D costs but also sent a strong policy support signal to the market, attracting more venture capital and institutional funding into the AI sector.

Notable examples include R&D Tax Credits: An example of a mainstay of U.S. innovation policy is the federal R&D tax credit given to deduct a portion of R&D spending at a company as a deduction to tax liability. It is estimated that it lifts corporate R and D expenditure by 10 -15% (Hall and Van Reenen, 2000). In clean energy, the Inflation Reduction Act (2022) has increased this instrument, providing a 30 percent tax credit on a solar and wind project, and up to 40 percent on one in a low-income neighborhood. This is attributed to making institutional investment in renewable energy funds growth by 40% because the credits ensure that returns are predictable (IRENA, 2023).

SBIR/STTR Grants: Small businesses are mandated by the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs that an agency of the federal government must reserve a specific percentage of its R&D budgets (2.5 and 0.45% respectively). These grants (50000 to 1.7 million dollars) are especially useful in overcoming the valley of death that exists between research and commercialization. According to SBA (2022), 66 per cent of recipients of SBIR have follow-on VC or corporate investment, in contrast to only 10 per cent of startups that have not received an award. In AI, such as, SBIR grants at DARPA contributed financially to initial research in startups such as Vicarious which subsequently raised one hundred million dollars in VC funding.

DOE Loan Programs Office (LPO): The LPO offers low-rates loans on clean energy and advanced technology projects and it focuses on scaling out of proven technologies. One of them is that it can crowdfund much private capital: every dollar of LPO funding usually brings 3-4 dollars of private investment (DOE, 2023). As an example, the 465 million loan by the LPO to the Nevada Gigafactory of Tesla in 2010 to mobilize 5 billion dollars of private funding to scale up the production of lithium-ion batteries and the resultant cost reduction by 80 percent in a 10-year period.

Fiscal incentive can notably be helpful in lure risk-averse capital, including institutional investors and corporate venture arms, with better risk-return profile. According to an explanation by a corporate venture capitalist: Tax credits make a project that would have been a marginal one a no-brainer. The cost of the investment can be justified since we are aware that popular cost is the same (reduced by 30 percent).

R&D Infrastructure and Collaborative Networks

The emphasis of this route is upon developing and sustaining research infrastructure: laboratories, testbeds, and data repositories; and on developing partnership among academia, industry, and government. It is aimed at reducing entry barriers to small firms, promote faster knowledge sharing, and decrease unnecessary expenditure on R&D.

Key initiatives include:

- National Labs and Research Centers: The DOE has 17 national labs in the U.S., which allow up-and-coming projects as well as established companies of interest to access advanced equipment, expertise, and data. As one such example, the Center for Nanoscale Materials at the Argonne National Laboratory has provided quantum computing startups with access to electron microscopes and quantum simulators worth millions of dollars to obtain. An observation by DOE in 2022 revealed that by utilizing the facilities of the national laboratories, startups lowered their R&D expenses by 30%50% and shortened their time to market by 12 to 18 months.

- "Moonshot" Programs at DARPA: The DARPA is known to fund high risk high reward research that can lead to transformative value. Quantum Networking, in contrast to conventional grants, involves inter-disciplinary collaboration and can be prototyped quickly. More than 80 percent of technologies that were funded by DARPA have found commercial uses, including GPS and contemporary AI algorithms (DARPA, 2021). Notably, DARPA publishes its research findings to form a knowledge base that lowers the cost of private R&D.
- Industry-University Cooperative Research Centers (IUCRCs): These centers are NSF funded, which involve partnerships between universities and industry sponsors to perform pre-competitive research. As an illustration, the NSF AI Institute for Advances in Optimization is a gathering of scholars and companies such as Amazon and IBM to come up with AI algorithms in the field of logistics. Firms that have participated in the exercise cite a reduction of up to 20 percent in costs of R&D through use of the academic knowledge (NSF, 2022).

This channel complements the effectiveness of the financial capital since the privatized R&D becomes more effective. The capital expenditure requirements are minimized as the investors will finance start-ups that have access to common infrastructure. A company that gets access to the facilities of a national lab does not necessarily have to raise $5 million to acquire equipment as one of his early-stage funders remarked. That will give their seed round a broader stretch.

Market Creation and Regulatory Alignment

The rapid advancement of artificial intelligence has introduced ethical, safety, and governance challenges, necessitating the establishment of flexible and forward-looking regulatory frameworks. For instance, the "Software as a Medical Device (SaMD)" framework introduced by the FDA in 2019 established clear pathways for AI medical device approvals, significantly reducing time-to-market (Rock Health, 2022) [2]. Additionally, the National Institute of Standards and Technology (NIST) is spearheading the development of AI credibility and bias detection standards. These standards not only enhance technical reliability but also provide investors with a unified benchmark for assessing AI maturity (NIST, 2023).[3]

This route aims at developing first markets of new technologies and harmonizing the

[2] Rock Health. (2022). Digital Health Funding Year in Review.
[3] NIST. (2023). AI Risk Management Framework.

regulations to decrease chances of commercialization risks. It considers the problem that even the prospective technologies can lose capital in the case of the lack of the visible perspective on market.

Federal Procurement: U.S. government is the largest purchaser of goods and services in the world, and its purchasing policies have traditionally been at the forefront in early adopters of emerging technologies. Using an example, the Department of Defense (DoD) currently invests up to 15 billion dollars every year in AI-related contracts, which can be an attractive consistent revenue source to startups such as Palantir and Anduril (DoD, 2023). In the same way, the General Services Administration (GSA) has been focused on procurement of electric vehicles (EVs) and by 2035, a target of 100% electric federal fleets is planned, which has led to investment in the production of EVs and the electric charging infrastructure.

Regulatory Streamlining: Unclear regulations or unfriendly regulations may slow commercialization and discourage investment. The approval route of AI-driven diagnostic devices in healthcare was facilitated by the FDA Software as a Medical Device (SaMD) framework (2019), which cut the duration to market by 1218 months. The latter resulted in the growth of VC investments into digital health startups by 25% (Rock Health, 2022).

Standards-Setting: The creation of the technical standards lowers fragmentation and enhances market confidence. The National Institute of Standards and technology (NIST) has been instrumental in establishing AI bias mitigation standards and quantum computing interoperability. With the help of these standards, investors can evaluate the technology readiness easier, because they offer them an identical source of performance (NIST, 2023).

This route would make new technologies more appealing to capital by establishing predictable markets and less regulation uncertainty. According to an investor in clean energy: they must be comforted that there will be buyers of the electricity produced by a wind farm. That is the guarantee they have because of federal procurement commitments or explicit renewable portfolio standards.

Synergy Mechanism with Financial Capital

The four policy pathways do not work as independent mechanisms, as they mix with financial capital in the four main ways which optimize the effectiveness of the entire innovation ecosystem.

Risk Reduction

New technologies are risky in nature and the failure rate is high either during technical or commercial stages. This is because specific risk types are minimized using policy tools, and these technologies are more attractive to investors:

Technological risk: Early-stage research is being financed by means of R&D grants and shared infrastructure (Pathway 3), the success of which would lead to a higher number of technical breakthroughs. As an illustration, the AI research conducted by DARPA has minimized technical unpredictability in machine learning, which has decreased the rate of AI startup failure by 40 percent over the past few years (NVCA, 2023).

Market risk: Guaranteed demand is generated by the federal procurement and regulatory alignment (Pathway 4), which will mitigate the risk of technology not having any customers. The 2021 Infrastructure Act, which proposed to allocate 7.5 billion to EV charging infrastructure, fueled VC investment in EV charging startups, which grew by 60% investors were convinced in the successful growth of the market (PitchBook, 2022).

Policy risk: Long-term legislative obligation (Pathway 1) does decrease the risk of unpredictable shifts in policy that would harm investment. The predictability of the National Quantum Initiative has changed quantum computing into a policy-sheltered industry, which has received larger investments of patient funds through family offices and endowments (Deloitte, 2023).

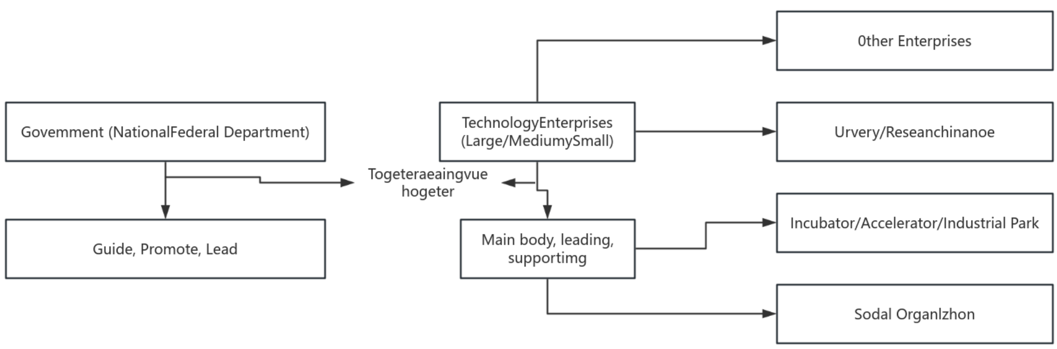
Financial risk: Financial risk Tax credits and loan guarantees (Pathway 2) enhance cash flow and decrease downside risk. Since the Inflation Reduction Act increased tax credits, the share assigned to clean energy projects has risen among institutional shareholders who are usually risk-averse because the credits guarantee certain returns (BlackRock, 2023).

Information Signaling

Policies also serve as plausible indications to investors regarding which technologies may work out or gain significance, and allow to distribute capital more effectively.

Figure 2

Analysis framework of government-enterprise cooperation in artificial intelligence industry technology innovation



Quality cues Government grants (Pathway 2) are a kind of seal of approval to signify that a technology has gone through intricate technical assessment. Granted SBIR startups are two point three times more likely to get Series A funding in comparison to non-recipients since VCs consider the grants as signs of technical merit (NSF, 2022).

Growth indicators: Technologies with legislative priorities (Pathway 1) indicate that these will be amenable to market growth or legislative encouragement. The CHIPS Act including quantum computing also resulted in a rush of CVC funding by tech giants such as Google and Microsoft, who took the act as an indication to increase the number of quantum research efforts (McKinsey, 2023).

Maturity cues: Regulatory streamlining (Pathway 4) means that technology has already matured to a condition of being commoditized. In 2020, when the FDA approved AI-based diagnostic tools, it gave investors the sense that the health care AI market is entering the maturity phase and thus boosted late-stage funding rounds by 50% (Rock Health, 2021).

The signals are very useful especially in opaque or early-stage sectors where there is limited information to help the investors evaluate opportunities. In quantum computing, as one of the VC mentioned: There is no consensus of how things should be done. However, when you see a startup funded by DARPA, then that is a teller that they are on to something.

Resource Mobilization

Policies use public money to draw in and amplify private capital, building bigger investment systems than would be received utilizing only public money:

Privatizing capital: Privatizing capital with the help of public grants and loans (Pathway 2), can often demand matching investment by the private sector, magnifying the effects of the taxpayer. In Advanced Research Projects Agency-Energy (ARPA-E), applicants within the DOE must find at least 1 dollar of private financing to receive 1 dollar of ARPA-E financing; so far, ARPA-E initiatives have raised 7 dollars of the ARPA-E financing per 1 dollar of the government financing (ARPA-E, 2023).

Partnerships: partnerships are collaborative networks (Pathway 3) that help scale through collaboration with different sources of capital. The AI2 (Allen Institute for AI) is an alliance of federal grants amounting to a hundred million dollars and forty million dollars of Microsoft and other technology companies funding 12 startups out of an ecosystem of A.I. research (AI2, 2023).

Capital flows in institutions: Long-term polices (Pathway 1) promote the establishment of specialized investment vehicles. The CHIPS Act resulted in 15 semiconductor-oriented VC funds having been launched in 20222023 with aggregate funds of 12 billion, as investors invest into the policy-boosted growth of the industry (NVCA, 2024).

This will prevent a scenario whereby the public investment is a substitute to the private capital hence the mechanism will make the public investment a catalyst to the available private capital in order to maximize the total amount available to the emerging technologies.

Market Expansion

The policies enlarge markets, and markets of emerging technologies through the enlargement of their size and extent of coverage, and they become more appealing to capital through making larger opportunities available to them:

Demand generation: Federal procurement (Pathway 4) is directly proportional to market size. The spending of DOD on AI has established a stable market to AI startups and 70 percent of AI defense contractors said their revenue increased by 20 percent or more in 2023 (Deloitte, 2023).

Curtailment of cost: Infrastructure investments (Pathway 3) reduce the barrier to adoption and widen consumer and industrial demand. The 65 billion in the infrastructure act broadband spending is likely to grow the rural AI application market (e.g., precision agriculture) by 40% by 2025 and draw VC attention to rural AI startups (FCC, 2022).

Global competitiveness: The strategy aimed at enhancing domestic competence (Pathway 1) assists the U.S. firms in winning the global markets. The CHIPS Act is expected to grow the U.S semiconductor market share to 20% by 2030, which will generate a bigger market share of U.S based semiconductor startups as well as a large market to foreign investment (SIA, 2023).

Through market expansion, the policies create better returns of investors hence investors are more likely to allocate their funds to new technologies.

Analysis

The evaluation shows that the U.S. strategy of the emerging technologies has managed to establish various avenues of coordination with financial funds to promote innovation in all fields. Nonetheless, there are still a number of issues and tensions, which should be tackled by policymakers and investors in order to improve the effectiveness of synergy.

Policy Fragmentation

Fragmentation of policy instruments among many federal departments is one of the main challenges and may lead to confusion among investors and lack of impact. Indicatively, at least 15 federal agencies are being funded on AI research which lacks co-ordination in its programs. Such fragmentation complicates the navigation of the policy environment and finding critical opportunities by investors. Although efforts have been made to enhance the coordination of programs such as the National AI Initiative Office, there is still more to be done by streamlining the programs and sending a single policy message.

Tensions between Short and Long Term

Financial capital, especially VC typically possesses a 5-7 year investment horizon, whereas many technologies currently in development (e.g. fusion energy, quantum computing) have 10-20 years to commercialization. Such a mismatch establishes a patient capital gap in which promising long-term technologies have difficulties accessing capital. Such policies as the emphasis made by ARPA-E on transformational technologies (with a lifetime up to 10 years) can help this, although the budget is very modest (1 billion/year), relative to the demand. Such programs should be extended so as to better match policy and capital horizons.

Geographical and Demographic Inequities

Emerging technologies are concentrated along coastline tech hubs (Silicon Valley, Boston, New York) and mostly have little investment in the rural areas and other less developed tech ecosystems. This creates a gap in innovations that restricts the growth of national productivity. Such policies as the 10 billion in the CHIPS Act to regional tech hubs are designed to do this, although whether they can bring in long-term private investments in non-traditional tech areas is to be determined. Even the investors will have to consider widening their geographical focus to be able to leverage untapped innovation in such spheres.

Regulatory Uncertainty in Rapidly-Moving Industries.

Emerging technologies, i.e. AI and biotech, are changing more rapidly than regulations, which fosters uncertainty thus inhibiting investment. Indicatively, AI ethical and legal controversies have made certain investors put their money on hiatus on more sophisticated AI startups pending the clarification of guidelines. To ensure that innovation and risk-taking are moderated, policymakers should be more agile in regulation, and more regulatory sandboxes should be used, which allow controlled experimental approaches to be used to give investors the certainty they require.

Conclusion and Implications

The study has discovered four key policy support channels to emerging technologies in the United States, including legislative and strategic direction, fiscal and financial subsidies, R and D infrastructure and cooperation, and market creation and regulatory alignment and how these channels interact with financial capital characterized by risk reduction, information signaling, mobilization of resources, and market expansion. All these pathways and mechanisms create a dynamic ecosystem in which policy plays a role in decreasing barriers to innovation and financial capital scales successful technologies, leading to growth in the economy and global competitiveness. Such an ecosystem is dynamic, and adapts according to the technological advances, changing market needs, and geopolitical agenda, necessitating a constant change of both policymakers and investors.

The results indicate that there are a number of implications of importance to policy makers and investors.

To policymakers: Co-ordination amongst agencies is important in curbing fragmentation and relaying a clear message to the investors. To get in patient funding of high-risk, long-maturity technologies like fusion energy or state-of-the-art quantum systems, long-term funding commitments and consistent policy frameworks are needed. The priority of the policies should be to diminish geographic imbalance so that the fruit of emerging technologies can be distributed as much as possible with regional advantages, e.g. the manufacturing power of the Midwest or the renewable energy potential of the Southeast, used to support inclusive development.

To investors: Co-ordination of investment policy priorities can improve returns, with technologies backed by policies likely to have less risk and increased market access. Legislative cues and potential partnerships between the state and private industry are worth monitoring closely by investors, especially in the early-stage technology where the policy can disproportionately affect the issuing companies, like a next-generation battery technology or AI-based healthcare diagnostics.

This study deals with federal policy; additional research is possible in the future to address the importance of state and local policies which are also important in the facilitation of the emergent technologies (e.g., the clean energy mandates of California or semiconductor incentives of Texas). Cross-country comparisons (e.g. U.S. vs. EU or China) may provide insights into how various policy solutions (including the regulatory-based framework of the EU or state-led investment models of China) influence synergy with financial capital.

The experience of the U.S. is that sound policy support can bring in rapid pace of developing and adopting an emerging technology, which is central to the 21st century issues, such as climate change and world health crises, and keeping pace with the world in terms of innovation. With such a synergy, it is possible that stakeholders can keep the outcomes of emerging technologies as a means to a prosperous economy and as well as a progressive society

This study further highlights that artificial intelligence, as a strategic yet high-risk emerging technology, requires policymakers to strike a balance between financial support and regulatory oversight. On one hand, sustained public R&D investment and tax incentives are crucial for advancing AI foundational research and early-stage applications. On the other hand, establishing agile and transparent regulatory frameworks—such as regulatory sandboxes and standardization—can effectively reduce market uncertainties and bolster investor confidence. Future policies should prioritize finding the right balance between innovation incentives and risk mitigation to foster the healthy and sustainable development of AI technology.

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