Report for Policy Recommendation System

For this project, in order to enhance Canada's innovation ecosystem, we used the dataset provided by the course instructor in the Google Drive folder in order to know which kinds of innovation strategies are currently implemented in the fastest-growing countries and how innovations are measured in these countries. The datasets we used are: "Innovation Better Canada for a What We Heard", "Annual Report 2017—2018", "How Talent Can Help Unlock the Innovation Potential of Canadian SMEs", and "Bridging the Gap: The Role of Innovation Intermediaries in Canada".

In the process of finding how innovations are measured in the fastest-growing countries, the first thing we need to do is import these PDF files into our Python code to let them become our dataset. We converted these PDF files to text page-by-page and imported them into our Python code. However, in order to enhance data analysis accuracy and let us just focus on relevant information, we then implemented text preprocessing in our imported dataset. The reason why we implemented the text preprocessing is that it can eliminate irrelevant information and standardize the format which can allow us to do more meaningful analysis. There are three text-preprocessing methods we are going to use which are tokenization, lemmatization, and removing stop words. Firstly, the reason why we did tokenization is that it breaks down complex text into manageable tokens which can allow a natural language processing (NLP) algorithm to analyze the sentence structure. And then, we used the lemmatization method to let each token in our text be changed into its basic form which makes our text more generalizable across different word forms which can let us get more accurate results in sentiment analysis and text classification. Lastly, since we want to remove the influence of common words like the, a, an, to, and of, we decided to use the removing stop words method to diminish this influence.

After applying the text preprocessing to our text, we can finally get our imported data which lets us be able to analyze the key factors which drive innovations in the fastest-growing countries. By using the ChatGPT APIs to analyze our text, we got the top ten factors which drive innovations in these countries which are Human Capital, Research and Development (R&D) Spending, Government Policy and Support, Collaboration Between Universities and Industry, Access to Capital, Intellectual Property Rights (IPR) Protection, Entrepreneurial Ecosystem, Technology Transfer Mechanisms, Infrastructure, and Market Demand and Economic Conditions. Since we want to study from those fastest-growing countries' experience which we can use their experience and strategies as a reference, we applied the ChatGPT APIs to our text to find which countries have a similar industrial structure and innovation ranking nearly the same as Canada. The countries which we got which have the nearly same background as Canada are: the United States, Germany, Japan, and the United Kingdom. We selected two of them which are the United States and the United Kingdom as our reference and found which factors can help Canada to improve Canada's position relative to the United States and the United Kingdom. After analyzing by using ChatGPT API, we got the four key factors which can improve Canada's innovation scores which are: Human

Capital, Research and Development (R&D) Spending, Collaboration Between Universities and Industry, and Entrepreneurial Ecosystem. Lastly, in order to enhance Canada's position relative to the United Kingdom and the United States in the sphere of innovation, implementing a multifaceted strategy is necessary. To achieve this goal, we decided to make four sub-strategies to increase the four critical factors correspondingly. These four sub-strategies are: amplifying human capital through specialized STEM initiatives, targeted increase in R&D spending in clean energy and biotechnology, streamlining collaboration through technology transfer initiatives, and cultivating a global-leading entrepreneurial ecosystem in digital technologies.

In order to determine the correlation between the selected factors by ChatGPT and innovation, we referenced the Global Innovation Index 2023 report. The Global Innovation Index 2023 report was imported into the Python environment, after which we performed data preprocessing on the imported text to enable effective analysis. The techniques used for text data preprocessing included stopword removal, tokenization, and lemmatization. We've used these techniques before and explained why they're important. The cleaned-up text we ended up with is what we're going to analyze next. Our goal is to pinpoint the key factors that really drive innovation across different countries. To do this, we used ChatGPT APIs to analyze the global innovation text and came up with a list of the top ten factors influencing innovation from the Global Innovation Index 2023 report. Then, we compared these factors with the ten we found in our collected dataset. The results of this comparison can be found in Table 1 in the appendix.

We then used ChatGPT APIs to identify countries with a similar industrial structure and innovation ranking as Canada in the Global Innovation Index 2023 report. The countries that we got are Switzerland, Sweden, the United States, Germany, Netherlands, Singapore and the United Kingdom. The United States and the United Kingdom are two countries that appear both in the collected dataset result and the Global Innovation Index 2023 report result. Therefore, we chose the United States and the United Kingdom as our reference points. We tasked ChatGPT APIs with generating the four key factors influencing Canada's innovation position, based on information from the Global Innovation Index. Similarly, we compared these four factors with those obtained from the collected dataset. The results of this comparison can be found in Table 2 in the appendix.

Two tables demonstrate that the results from our collected data and the results from the Global Innovation Index have some similarities. The ChatGPT API was used as an algorithm to analyze the datasets and generate the desired results. The natural language processing (NLP) is another algorithm to analyze the text. We used TF-IDF in an Information Retrieval (IR) system to evaluate the algorithms' accuracy by calculating the similarity scores between the results from two datasets. TF-IDF stands for Term Frequency-Inverse Document Frequency. TF-IDF represents each document as a numerical vector, and the numerical values inside represent the importance of each term in the document. Term Frequency (TF) calculates the number of times a term appears in a document divided by the total number of terms in the document. Inverse Document Frequency

(IDF) measures how unique or rare a term is across all documents in a corpus. The TF-IDF score is obtained by multiplying the TF score by the IDF score. Then the TF-IDF score will be vectorized, and each document will be represented as a vector. Cosine similarity measures the cosine of the angle between the TF-IDF vectors of the two documents, which is a common metric to evaluate the similarity between two documents. A higher cosine similarity score shows a high similarity between documents, while a lower cosine similarity score shows a low similarity between documents. In our study, we computed the similarity scores between 10 factors extracted from our collected dataset and 10 factors listed in the Global Innovation Index 2023 report. We also determined the similarity scores between selected countries featured in our dataset and those highlighted in the Global Innovation Index 2023 report. Additionally, we analyzed the similarity scores between four key factors identified within our dataset and four factors outlined in the Global Innovation Index 2023 report. The similarity scores can be found in Table 3 in the appendix.

The similarity scores that we calculated are greater than 0.7, which means that there is a moderate to high similarity between the results from our collected data and the results from the Global Innovation Index 2023 report. The Global Innovation Index 2023 report is published by the World Intellectual Property Organization, so it is considered a reliable source for the analysis of a country's innovation. The factors that affect innovation we got are similar to those that affect Innovation in the Global Innovation Index 2023 report, and the performance of ChatGPT API is good. Therefore, the four key factors that we selected are reasonable. In the later part of the report, we will come up with a proposal about Canada's ecosystem development strategy based on four factors: Human Capital, Research & Development (R&D) Spending, Collaboration Between Universities & Industry and Entrepreneurial Ecosystem. The main strategy will be split into four sub-strategies by ChatGPT APIs, and each sub-strategy corresponds to a factor contributing to the improvement of Canada's innovation.

Sub-Strategy: Human Capital

SUMMARIES OF EXPERIENCE OF OTHER COUNTRIES – USA & UK

The U.S. strategy documents and the UK's "Build Back Better" plan both emphasize the critical role of human capital in driving forward key technological areas like artificial intelligence (AI), renewable energy technologies, and quantum computing. In the U.S., the sentiment is highly positive and strategic foresight, focusing on innovation, global leadership, and the strategic importance of investing in human capital to maintain a competitive edge. Specific sectors like AI, renewable energy, and quantum computing are highlighted for their potential to advance national security, economic prosperity, and technological leadership, with human capital playing a central role in achieving these goals.

The UK document, while more implicitly connected to these technologies, shares a similarly positive outlook on human capital's role in recovery, growth, and innovation. Emphasizing science and technology investment, green jobs, and skills development, it underlines the importance of human talent in driving sustainable growth and positioning the UK as a science and technology superpower.

Both documents showcase an optimistic vision for leveraging human capital to navigate and lead in the rapidly evolving technological landscape. They highlight strategic investments in human capital, collaboration, and fostering innovation as essential for maintaining competitiveness in critical and emerging technologies. This reflects a shared understanding of the importance of skilled, creative, and adaptable workforces in achieving technological advancement and economic prosperity.

CANADA STRATEGY

Creating a comprehensive human capital program in Canada, inspired by the USA and UK, and focused on emerging technologies such as artificial intelligence (AI), renewable energy, and quantum computing, demands a multifaceted strategy. This strategy encompasses developing a highly skilled workforce, engaging the public through effective communication, and fostering international collaborations. Here's a breakdown of how Canada can achieve this, focusing on the pivotal roles of human capital development and public relations strategies.

Human Capital Development Strategy:

- Aim: Equip Canadians with the skills to excel in and support advancements in key technology sectors.
- Key Components:
    - Launch targeted training programs and foster industry-academic partnerships.
    - Increase public awareness and support through PR campaigns.
    - Boost R&D funding and collaboration between academia and industry.
    - Engage in international partnerships for knowledge and best practice exchange.
    - Provide reskilling opportunities for workers impacted by technology shifts.

Implementation:

A collaborative effort involving government, educational institutions, and industry stakeholders is essential. Committing to long-term investments in education, R&D, and PR, and continuously

adapting strategies based on technological and workforce developments, will ensure the program's success.

This streamlined approach aims to develop a skilled workforce and engage the public, positioning Canada as a global leader in AI, renewable energy, and quantum computing.

Sub-Strategy: Research and Development (R&D) Spending

SUMMARIES OF EXPERIENCE OF OTHER COUNTRIES – USA & UK

Sentiment analysis of the provided USA materials leads to the conclusion that the discussion about R&D spending in clean energy and biotechnology tends to have a generally positive sentiment. This positive outlook is due to the association of clean energy with environmental sustainability and job creation in a new-age industry, along with the advancements and health improvements attributed to biotechnology research. The United States has a long history of supporting R&D through federal funding, private sector investment, and policy initiatives aimed at fostering innovation. The U.S. has been increasing its investments in clean energy technologies to address climate change, enhance energy security, and lead in global energy markets. The Department of Energy (DOE) characteristically receives significant investments aimed at supporting renewable energy research, grid modernization, and energy efficiency advancements. Biotechnology receives attention for its potential to revolutionize health care, agriculture, and industry. The National Institutes of Health (NIH) often represents a substantial part of U.S. R&D spending, funding essential research in medicine and health-related technologies.

The prevailing sentiment around R&D spending on clean energy and biotechnology is predominantly positive in the UK. This is due to several factors: environmental sustainability, technological advancement, healthcare improvements, economic growth and job creation. The U.K. behaves as an engaged player in R&D spending, seeking to drive innovation, stimulate economic growth, and address environmental challenges. This sentiment is similarly reflected in public sector strategies and private sector engagement alike, with a general consensus on the importance of such investments both for immediate advancements and long-term strategic benefits.

CANADA R&D SPENDING IN CLEAN ENERGY & BIOTECHNOLOGY STRATEGY

1. Strengthening SR&ED (Scientific Research and Experimental Development) Program:

- Expand and enhance the SR&ED tax incentive program to incentivize businesses of all sizes to invest more in R&D activities related to clean energy and biotechnology.

- Simplify the application process and provide clearer guidelines to encourage more companies, especially small and medium enterprises (SMEs), to participate in R&D projects.

- Increase the tax credit rates for eligible R&D expenditures in clean energy and biotechnology sectors to further stimulate innovation and technological advancements.

2. Establishing Specialized R&D Centers with Government Funding:

- Allocate government funds to establish specialized R&D centers focused on clean energy and biotechnology innovation. These centers could serve as hubs for collaborative research, development, and commercialization activities.

- Partner with universities, research institutions, and private sector organizations to ensure a diverse range of expertise and resources are available at these centers.

- Offer grants and funding opportunities for projects conducted within these centers, prioritizing initiatives that demonstrate potential for significant environmental impact or economic growth.

3. National Strategy and Global Collaboration:

- Develop a comprehensive national strategy for clean energy and biotechnology R&D, outlining specific goals, targets, and timelines for investment and innovation in these sectors.

- Foster international collaborations and partnerships to leverage global expertise, resources, and best practices in clean energy and biotechnology research. Participate actively in international initiatives such as the Paris Agreement and collaborate with other nations on joint R&D projects.

- Establish bilateral agreements with countries leading in clean energy and biotechnology to facilitate knowledge exchange, technology transfer, and joint funding opportunities.

Sub-Strategy: Collaboration Between Universities and Industry

SUMMARIES OF EXPERIENCE OF OTHER COUNTRIES – USA & UK

According to the document, there is a positive outlook on the collaboration between universities and industry, particularly in the context of digital health and smart manufacturing, as part of a comprehensive strategy by the United States Department of Defense to enhance technological innovation and secure the national defense ecosystem against competitors like the People's Republic of China. The narrative is anchored by key themes such as the acceleration of technological progress, capitalizing on America's distinct advantages, fostering international research collaborations, swift transformation of technological breakthroughs into operational solutions, and substantial investments in both infrastructure and human capital. Central to this strategy are efforts to prioritize critical technological domains, conduct thorough analysis for strategic technology investments, nurture a dynamic defense innovation landscape, enhance international technology partnerships, and overhaul digital infrastructures. This strategic posture not only underscores a commitment to maintaining a competitive technological edge but also

acknowledges the imperative of safeguarding technological assets and the continuous need for innovative collaboration and strategic foresight in navigating the complexities of global defense and security dynamics.

The UK prioritizes collaboration between universities and industry in sectors like fintech and health tech, aiming to spur sustainable growth in partner countries by fostering ecosystems that attract investment and create jobs. It promotes digital literacy and inclusion, targeting gender and rural-urban divides with specific initiatives like Computers for Schools. Through the Digital Access Programme and Tech Hub Network, the UK boosts startups and digital innovation, focusing on digital skills and entrepreneurship. It leads in international efforts to bridge the digital divide, advocating for accessible digital services in forums like the ITU, and supports cyber resilience strategies in partner countries by sharing cybersecurity expertise. These efforts signify the UK's commitment to leveraging university-industry partnerships for global economic growth, security, and democratic values.

Canada

Establishing Specialized Technology Transfer Offices (TTOs)

Canada is poised to strengthen its collaboration between universities and industry in digital health and smart manufacturing, drawing insights from the UK and US models. The proposal includes establishing specialized Technology Transfer Offices (TTOs) in universities with strong programs in these fields. These TTOs would serve as bridges between academia and industry, facilitating patenting, licensing, and commercial partnerships. The plan emphasizes the need for comprehensive training for TTO staff, government support through funding and policy, including tax incentives and grants for translational research, and aims to replicate the UK's mission-driven R&D and the US's emphasis on rapid technological advancement.

Creating Government-Funded Innovation Clusters

The strategy also calls for the creation of government-funded innovation clusters in strategic locations, leveraging existing university and industry strengths. This initiative encourages the co-location of research labs and companies to spur innovation, supported by shared infrastructure like labs and incubators, and business services for startups and SMEs. It looks to emulate the US's focus on swift innovation deployment and the UK's successful international collaborations to boost technological capabilities.

Launching Mentorship and Investment Programs

Additionally, the plan suggests launching mentorship and investment programs to support startups from academic settings, focusing on digital health and smart manufacturing. These programs would offer seed funding, mentorship by industry veterans, and facilitate partnerships with venture

capitals and angel investors, organizing events for pitching and networking. This mirrors the US's approach to a vibrant defense innovation ecosystem and the UK's commitment to digital skills and inclusion, aiming to build a skilled workforce for technology development and adoption.

In summary, by adapting effective strategies from the UK and US to its context, Canada aims to significantly improve its university-industry collaborations in key technological sectors. The approach includes setting up specialized TTOs, forming innovation clusters, and initiating mentorship and investment programs, all supported by government policy and funding. These measures are designed to be dynamic, with regular evaluations to ensure they stay relevant and aligned with both global trends and Canada's specific needs.

Sub-Strategy: Entrepreneurial Ecosystem

Summaries of experience of other country - USA

The "National Defense Science & Technology Strategy 2023" presents a strategic vision centered on bolstering the entrepreneurial ecosystem within the defense sector to enhance innovation and technological advancement. The strategy emphasizes fostering a dynamic defense innovation ecosystem through partnerships that integrate both traditional and non-traditional stakeholders, highlighting the critical role of startups in driving technological innovation and application. This inclusive approach aims to facilitate the rapid transition of emerging technologies, such as AI, cybersecurity, and advanced computing, from conceptualization to deployment, underscoring the strategic importance of R&D and creative innovation in maintaining global competitive superiority. By creating a supportive environment for startups, the strategy not only aims to strengthen national security but also promote economic growth and social well-being. The document's focus on leveraging the nation's unique capabilities and fostering an ecosystem where startups can thrive is positioned as essential for sustaining technological leadership and ensuring comprehensive national advancement.

Canadian Entrepreneurial Ecosystem Enhancement Plan

To elevate Canada's position in the international innovation landscape, particularly in the realms of blockchain, Internet of Things (IoT), and cybersecurity, a strategic blueprint drawing from the successful aspects of the United States entrepreneurial ecosystem is proposed. This plan is tailored to align with Canada's distinct economic and technological framework, ensuring feasibility and effectiveness.

1. Enhanced Tax Incentives and Funding Mechanisms:

Inspired by the US model of innovation stimulation through government grants and targeted funding, Canada should adopt similar fiscal strategies. This involves:

- Implementing robust R&D tax credits specifically for startups engaged in blockchain, IoT, and cybersecurity.

- Initiating government-backed investment funds akin to the US's SBIR and STTR programs, focused on these strategic technology sectors, to provide vital early-stage capital.

2. Expansion of Accelerator and Incubator Programs:
Utilizing the US's collaborative model between academia and startups, Canada can bolster its innovation ecosystem by:
- Establishing specialized accelerator and incubator programs with dedicated tracks for blockchain, IoT, and cybersecurity.
- Promoting active collaborations between Canadian higher education institutions and technology startups to foster innovation and knowledge exchange.

3. Creation of a Large-Scale Investment Fund:
Drawing from the US approach of leveraging asymmetric advantages, Canada should:
- Set up a substantial investment fund specifically for startups in the targeted technology domains, emphasizing Canada's strengths like its educated workforce and stable tech sector to attract both domestic and international investment.
- Foster public-private partnerships to support this fund, ensuring a balanced risk-reward ratio for investors and a solid financial base for innovative ventures.

By integrating successful strategies from the US within the unique context of Canada's economic and technological landscape, this plan aims to enhance Canada's entrepreneurial ecosystem. Implementation should be progressive, starting with policy reforms and supportive financial infrastructures, expanding incubation and acceleration initiatives, and establishing a significant investment fund. Continuous stakeholder engagement is crucial to navigate and adapt to evolving industry dynamics, ensuring Canada's improved standing in the global innovation index.

IMPROVEMENT IN CANADA’S INNOVATION SCORE OVER TIME

With the implementation of our multifaceted innovation strategy, comprising human capital development, strategic R&D spending, enhanced collaboration between universities and industry, and a vibrant entrepreneurial ecosystem, Canada's innovation landscape is poised for significant advancement. By leveraging talent, increasing research funding, fostering partnerships, and supporting startups, Canada is on track to elevate its position as a global innovation leader. This holistic approach ensures that Canada remains at the forefront of technological advancement, driving economic growth and addressing societal challenges. As we continue to execute our strategy, we anticipate a steady rise in Canada's innovation score, reflecting our commitment to sustained progress and excellence in innovation.

PUBLIC RELATIONS (PR) STRATEGY

Our PR strategy aims to maximize the visibility and impact of our innovation initiatives through targeted communication across multiple channels. We'll leverage platforms like Twitter, LinkedIn, and Facebook to highlight our strategies and milestones, using hashtags like #InnovationCanada and #TechAdvancement for broader reach. We'll also engage with journalists and media outlets to secure coverage in national and industry-specific publications. Participation in local events and workshops will allow us to showcase our projects and gather feedback from communities. Regular updates on our innovation efforts will be shared to increase visibility and engagement, fostering awareness and support for Canada's innovation ecosystem.

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Appendix

Table 1: Comparison of 10 factors

10 factors from the collected dataset	10 factors from the Global Innovation Index 2023 report
Human Capital	Human Capital
Research and Development (R&D) Spending	Research & Development (R&D) Expenditure
Government Policy and Support	Public-Private Collaboration
Collaboration Between Universities and Industry	Intellectual Property Rights Protection
Access to Capital	Investment in ICT Infrastructure
Intellectual Property Rights (IPR) Protection	Market Sophistication and Access to Capital
Entrepreneurial Ecosystem	Government Policy and Incentives
Technology Transfer Mechanisms	Cultural Support for Innovation and Risk
Infrastructure	Global Collaboration and Openness
Market Demand and Economic Conditions	Environmental and Energy Research

Table 2: Comparison of 4 key factors

4 key factors from the collected dataset	4 key factors from the Global Innovation Index 2023 report
Human Capital	Research & Development (R&D) Expenditure
Research and Development (R&D) Spending	Public-Private Collaboration
Collaboration Between Universities and Industry	Market Sophistication and Access to Capital

Entrepreneurial Ecosystem	Global Collaboration and Openness

Table 3: Similarity score between the results from two datasets

Similarity score for 10 factors between two datasets	0.781
Similarity score for countries between two datasets	0.935
Similarity score for 4 key factors between two datasets	0.705

Figure 3: Line Chart of Score for UK and USA in 2019 to 2023

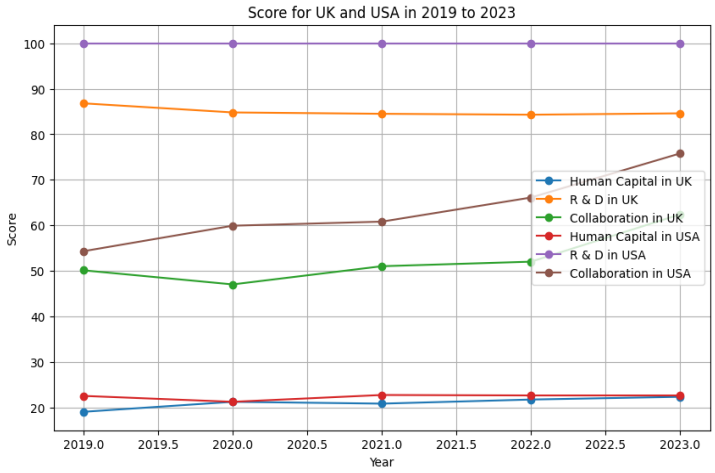

Figure 4: Word Cloud for Most Frequently Appearing Words for Innovation Canada