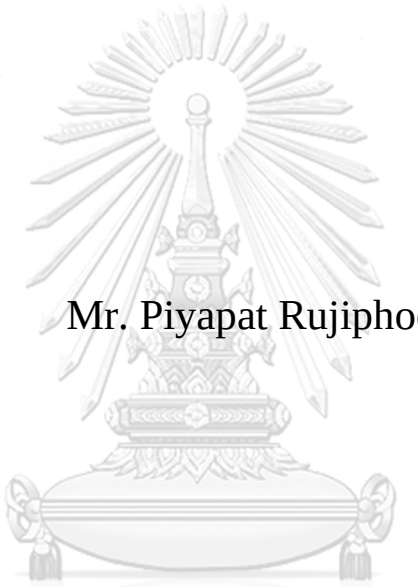
# The impact of STEM workforce, Gross capital formation, Government budget in scientific research and development, patent on invention, Foreign Direct Investment and Global competitiveness rank of the nation on Thailand GDP during 2009 and 2018

Mr. Piyapat Rujiphoch





An Independent Study Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Arts in Business and Managerial Economics
Field of Study of Business and Managerial Economics
FACULTY OF ECONOMICS
Chulalongkorn University
Academic Year 2020

# ผลกระทบของแรงงานด้านวิทยาศาสตร์และเทคโนโลยี การสะสมทุนเบื้องต้น งบประมาณรัฐบาล ในด้านการวิจัยและพัฒนทางวิทยาศาสตร์ สิทธิบัตรการประดิษฐ์ การลงทุนโดยตรงจากต่างประเทศ อันดับความสามารถในการแข่งขันระดับโลก ต่อ ผลิตภัณฑ์มวลรวมของประเทศไทย ระหว่างปี 2552-2561

นายปิยะพัฒน์ รุจิโภชน์



สารนิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาศิลปศาสตรมหาบัณฑิต
สาขาวิชาเศรษฐศาสตร์ธุรกิจและการจัดการ สาขาวิชาเศรษฐศาสตร์ธุรกิจและการจัดการ
คณะเศรษฐศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2563

| | |
|---|---|
| Independent Study Title | The impact of STEM workforce, Gross capital formation, Government budget in scientific research and development, patent on invention, Foreign Direct Investment and Global competitiveness rank of the nation on Thailand GDP during 2009 and 2018 |
| By | Mr. Piyapat Rujiphoch |
| Field of Study | Business and Managerial Economics |
| Thesis Advisor | Assistant Professor PACHARASUT SUJARITTANONTA, Ph.D. |

Accepted by the FACULTY OF ECONOMICS, Chulalongkorn University in Partial Fulfillment of the Requirement for the Master of Arts

INDEPENDENT STUDY COMMITTEE

..... Chairman
(Assistant Professor RATIDANAI HOONSAWAT, Ph.D.)

..... Advisor
(Assistant Professor PACHARASUT SUJARITTANONTA, Ph.D.)

..... Examiner
(Associate Professor Chalaiporn Amonvatana, Ph.D.)

ปิยะพัฒน์ รุจิโภชน์ : ผลกระทบของแรงงานด้านวิทยาศาสตร์และเทคโนโลยี การสะสมทุนเบื้องต้น งบประมาณรัฐบาลในด้านการวิจัยและพัฒนาทางวิทยาศาสตร์ สิทธิบัติการประดิษฐ์ การลงทุนโดยตรงจากต่างประเทศ อันดับความสามารถในการแข่งขันระดับโลก ต่อ ผลิตภัณฑ์มวลรวมของประเทศไทย ระหว่างปี 2552-2561. ( The impact of STEM workforce, Gross capital formation, Government budget in scientific research and development, patent on invention, Foreign Direct Investment and Global competitiveness rank of the nation on Thailand GDP during 2009 and 2018) อ.ที่ปรึกษาหลัก : ผศ. ดร.พัชรสุทธิ์ สุจริตตานนท์

การพัฒนาทุนมนุษย์โดยพื้นฐานในด้านวิทยาศาสตร์ เทคโนโลยี วิศวกรรมศาสตร์ และคณิตศาสตร์(สะเต็ม) ได้รับการรับรู้ท่ามกลางเหล่าประเทศเศรษฐกิจเกิดใหม่ ว่าเป็นเครื่องจักรในการเติบโตที่สำคัญยิ่ง ในการสนับสนุนส่งเสริม การวิจัยและการพัฒนา ตลอดจนการยกระดับสถานะเศรษฐกิจของประเทศโลกที่สาม และ การพัฒนาประเทศให้หลุดพ้นจากกับดักประเทศที่มีรายได้ปานกลาง อย่างไรก็ตามจากมุมมองของรัฐบาล มันยังคลุมเครือว่าการลงทุนอย่างมากในปัจจัยที่เกี่ยวข้องกับสะเต็มนั้นจะเพียงพอที่ใช้ขับเคลื่อนเศรษฐกิจหรือไม่ แทนที่จะลงทุนเพียงแค่ในทุนมนุษย์เกี่ยวข้องกับการศึกษาด้านสะเต็ม ปัจจัยทางด้านการลงทุนภายในประเทศที่มากมาย การใช้จ่ายภาครัฐในด้านวิทยาศาสตร์และเทคโนโลยี สิทธิบัติการประดิษฐ์ การลงทุนทางตรงจากต่างประเทศ และอันดับความสามารถในการแข่งขันของประเทศไทย ควรถูกนำรวมเข้ามาพิจารณาด้วย

รายงานการศึกษาฉบับนี้ประเมินผลกระทบของ การสะสมทุนเบื้องต้น งบประมาณรัฐบาลในการวิจัยและพัฒนาทางด้านวิทยาศาสตร์ จำนวนของสิทธิบัตรสิ่งประดิษฐ์ที่จดทะเบียนในประเทศไทย แรงงานด้านสะเต็ม และอันดับความสามารถในการแข่งขันของประเทศไทย ต่อ ผลิตภัณฑ์มวลรวมในประเทศ ตั้งแต่ปี 2552-2561

ตัวแปรอิสระทั้งหกนี้ ถูกใช้เป็นพื้นฐานสำกรับศักยภาพแรงงาน ความสามารถของชาติ นวัตกรรมและการลงทุนภายในประเทศ ตลอดจนผลผลิตของประเทศ บนพื้นฐานหลักการของฟังก์ชั่นการผลิตสะสมแบบคอบบ์- ดักลาส ด้วยการใช้ตัวแปรทั้งหกนี้ ข้าพเจ้าตั้งสมมติฐาน และทดสอบสหสัมพันธ์ที่มีพื้นจากข้อสมมติฐาน หลังจากนั้น ข้าพเจ้าสร้างสมการถดถอยที่ประยุกต์ใช้ วิธีกำลังสองน้อยสุด เพื่อเลือกตัวแปรที่ผ่านการทดสอบที่จะเป็นตัวแปรที่เหมาะสมกับตัวแบบ สุดท้ายข้าพเจ้าแสดงปริมาณผลกระทบและผลลัพธ์ของแต่ละตัวแปรอิสระที่เลือกต่อผลิตภัณฑ์มวลรวมประเทศ

ผลลัพธ์แสดงว่า การเพิ่มขึ้น 1 หน่วยของ การสะสมทุนเบื้องต้น ในประเทศไทยทำนายการเพิ่มขึ้น 1.8 หน่วยของ ผลิตภัณฑ์มวลรวมในประเทศ การเพิ่มขึ้น 1 หน่วยของ งบประมาณด้านการวิจัยและพัฒนาจากรัฐบาล คาดการณ์การเพิ่มขึ้น 9.1 หน่วยของผลิตภัณฑ์มวลรวมในประเทศ และการเพิ่มขึ้น 1 หน่วยของแรงงานด้านสะเต็มต่อทุก 10,000 แรงงานที่ได้รับการว่าจ้าง ก่อให้เกิดการเพิ่มขึ้น 301.2 หน่วยของผลิตภัณฑ์มวลรวมในประเทศ ในทางกลับกัน จำนวนของสิทธิบัตรการประดิษฐ์ การลงทุนทางตรงจากต่างประเทศ และอันดับความสามารถในการแข่งขันของประเทศไทย ไม่สำคัญอย่างมีนัยยะสำคัญทางสถิติในการนำมารวมในตัวแบบ

ผลลัพธ์จากการศึกษานี้สามารถมีประโยชน์ต่อผู้วางนโยบายของชาติ ในการตัดสินใจว่า ทิศทางการศึกษาของชาติ การลงทุนภายในประเทศ แผนแม่บทยุทธศาสตร์ชาติ แบบใดที่ควรถูกนำมาใช้เพื่อเอาชนะสถานะการเป็นประเทศกำลัง

| | | |
|---|---|---|
| สาขาวิชา | เศรษฐศาสตร์ธุรกิจและการจัดการ | ลายมือชื่อนิสิต ..... |
| ปีการศึกษา | 2563 | ลายมือชื่อ อ.ที่ปรึกษาหลัก ..... |

# # 6284112029 : MAJOR BUSINESS AND MANAGERIAL ECONOMICS
KEYWOR D: STEM, GDP

Piyapat Rujiphoch : The impact of STEM workforce, Gross capital formation, Government budget in scientific research and development, patent on invention, Foreign Direct Investment and Global competitiveness rank of the nation on Thailand GDP during 2009 and 2018. Advisor: Asst. Prof. PACHARASUT SUJARITTANONTA, Ph.D.

.

Developing human capital, fundamentally in science, technology, engineering, and mathematics (STEM), is perceived as crucial growth engine among emerging economies for encouraging R&D and escalating the third world economy status and developing nations out of the “middle income trap. Nevertheless, it is obscure whether what the Government view on investing intensively on STEM-related factors to drive the economy is sufficient. Rather than merely invest in human capital in STEM education, a number of domestic investment, the Government spending on Science and technology, invention patent, Foreign Direct Investment, and Thai global competitiveness rank should also be embraced and taken in to consideration.

The result revealed that adding 1 additional unit of GCF in Thailand is predicted to cause 1.8 unit increase in GDP. Enhancing 1 more unit in Research and development budget from the Government is forecasted to result in 9.1 in GDP and increasing 1 more unit of Stem labor force per 10,000 people employed contributes to 301.2 unit increase in GDP. On the other hand, the number of patent on invention, Foreign Direct investment, and Thailand global competitiveness rank are statistically insignificant to be incorporated in the model.



| | | |
|---|---|---|
| Field of Study: | Business and Managerial Economics | Student's Signature ..... |
| Academic Year: | 2020 | Advisor's Signature ..... |

# ACKNOWLEDGEMENTS

I would like to gratitude my family both Rujiphoch and Nakatong sides. For those who passed away, my grand father Colonel Prapin Nakathong, my number 1 role model, my father Vorapas Rujiphoch, my number 2 role model. You two are the primary latent reason I decided to pursue my second master degree here at Chulalongkorn University. Furthermore, I am thankful for MABE faculty members and staffs especially for Professor Jessica and Professor Yong Yoon for grooming fundamental knowledge of conducting research and Professor Pacharasut for your patience and guideline. Additionally, for MABE classmates, I'm glad to meet you guys whom I am able to speak English with. Last but not least, K. Yaowaree Lengnoi, my beloved and respected direct manager at SCB who encouraged me to pursue in Econ business level rather than pure Econ.

Piyapat Rujiphoch

# TABLE OF CONTENTS

**Page**

# LIST OF TABLES

**Page**

# LIST OF FIGURES

**Page**

## Chapter 1: Introduction

Sciences and technology capability is a main component in developing economic and society. Fostering science education at all educational levels and scientific literacy, in general, is a ground structure resulting in building a country's advancement in sciences and technology. STEM is education management incorporating Sciences, Technology, Engineering, and Mathematics aimed to solve problems in which students encounter to enhance problem solving experience, life skills, creativity and to prepare new generation citizen's readiness for operating in multi-tasks requiring skill sets and knowledges of Sciences, Mathematics, and Technology. STEM is essential foundation of advance learning. STEM education learning process is learning process through activities or projects integrating with Sciences, Mathematics, annexed to Engineering design process to attain Technology.

National accomplishment in STEM is notably perceived and empirically proven among the nations to be the key successful detriment for escalating national competitiveness. STEM advancement brings about to technological progress, nation-own innovations which are crucial factors of economy growth. U.S., the most influence nation of the current era after the termination of World Wat ll, attracts a number of scientists and engineers migrating from around the globe and utilize these highly educated people to create modern technological advancement and intrigue new generation of U.S. born citizens to pursue in STEM related-fields of study. U.S. deploys nurtured scientists and engineers in Research and Development(R&D) to cultivate scientific-based innovation. The innovation becomes a building block in energizing U.S. economy, society, and country. The emerging of innovation triggers higher living condition and contributes to economic heightening in the long run (Atkinson and Mayo, 2010). Winters (2013) mentions that, in the U.S., when comparing the STEM graduate contributions with the contributions generated by other graduate degrees, STEM graduates seem to generate abundant positive consequences to the U.S. economy. Hossain and Robinson (2012) stated that if we glance at the contemporary developments creating a better world living standard, the majority result of them will be a part of STEM-related contribution.

Owing to the fact pointed out in the above, the Governments in developing and developed countries, alike, intentionally devote their resources to invest in STEM human capital (Kozak,2019). Romer (1990) and Romer (1994) indicate that incremental productivity through technological advancements, innovations, suitable institutions and human capital accumulation are the main drivers of economic growth.

According to the manufacturing base transfer from developed countries possessing high wages i.e. U.S., Germany, and Japan, several emerging economies; China, Vietnam, Indonesia, Latin America countries, Eastern Europe countries, have attained high rates of economic growth through obtaining low- to medium-technology manufacturing transfer. Although several of these countries are no longer considered low-income, they occasionally discover that it was burdensome to develop more technologically advanced industries and services. As a result, they encounter circumstance termed "the middle-income trap". Kharas and Kohli (2011) purposefully

point that the clarification for undeveloped countries to flee from the moderate income-generating tragedy is to enhance 2 growths in 1) skill-intensive manufacturing sectors and 2) a high-productivity service industry. However, well-trained human capitals in STEM disciplines—fields of study generally associated with technological innovation— in the 2nd and 3rd world countries are frequently sparse.

Thailand is unescapable from this fact. In the 1980s and early 1990s, the nation experienced agile economic growth due to capital inflow and Foreign Direct Investment (FDI) from multi corporations from U.S., Japan, and European countries. However, this growth was inadequate to transform the so-called 5th tiger of Asia economy into the high-income country category with Japan, Hong Kong, Singapore, Taiwan, and South Korea (Jimenez et al., 2012). Thai government apprehended that to escalate national economy status to be one of developed economy, Thailand ought to capitalize in being proficient in STEM to create adequate scientists, engineers, its own innovations and to attract more FDI which eventually, in turn, bring about technological transfer, high skilled labor employment. In early 2000s, Thai policymaker issue long term education program in STEM to attract the talented, to pursue in. From the upper stream, the designated government high schools selected the finest quality students with potential academic achievements and submit them to the particular study programs drastically emphasized in STEM. In higher education, the Government also supports current Sciences and technology institutions to produce STEM graduates in both master and doctoral levels.

However, considering the supporting of STEM education to generate additional STEM labor force to be center of gravity to boost GDP to bring about national wealthiness might not be regarded as all-around analysis. From the further consideration, as a result, I select other 5 independent variables to full fill the analysis completeness. They are all related to the STEM labor force, the primary factor of this study consideration, in certain aspects. The additional focused variables are 1) Gross capital formation 2) Research and development budget from the Government 3) Patent on invention 4) Foreign Direct Investment and 5) Global competitiveness rank of Thailand.

Gross capital formation is a term deployed to illustrate the net capital accumulation within an accounting period for a specific nation. This term mentions to increasing of capital goods. For example, machine and equipment, tools, transportation or vehicles and electricity power. Nations require capital goods to substitute the former ones which are utilized to produce products or provide services. In some cases, the capital goods might not be in damaged status, their condition might be ready for production, yet they might be obsolete resulting in low efficiency which in turns lead to losing in competitiveness. If one nation could not afford to substitute capital goods as the come to the termination of their useful lives, eventually, the production will unavoidably decline. Presumably, a nation with higher capital formation tends to grab the faster economy and this nation could nurture its aggregate income.

Manufacturing more goods and services generally gives rise to a rise of national income levels. To aggregate additional capital, a nation requires to generate savings and investments from household or relied on the Government policy. Nations with higher rate of household saving leans to accumulate more fund to produce capital goods more rapidly, and the Government operating on a surplus could invest the surplus in additional capital goods.

The data of Gross capital formation used in this study comes from the World bank database. The world bank performs a financial and technical assistance to the developing countries with the paramount goal to terminate extreme poverty through the World bank's consulting program. The World bank traces back gross capital formation, which it describes as outlays on addition to fixed assets, plus the net change in inventories. Fixed assets incorporate with property, plant, building, machinery and equipment used to produce goods and services. Inventories consist of raw materials and goods available for sales.

Capital formation is measure by the World bank by appraising the change in net savings. If the household saving rate rises, savers might be interested in investing the additional dollar and purchase other securities such as stocks and bond. When the household does more saving, the nation may face a cash surplus, which is a decent indicator for capital formation. The World bank also informs the Government liability outstanding compared to the Gross Domestic Product, which is the total of all goods and services produced by specific nation. If the country's rate of capital formation enhances, the national GDP will rise as well.

Research and development budget from the Government is perceived as one of the main factors to nurture and trigger the advancement of national science and technology. Generally, in order to foster the innovation, people presume that the higher investment in fundamental R&D will bring about the higher advanced research. Although the fundamental research, by itself, doesn't leap the country to the technological advancement yet the applied research does intrinsically rely on the basic one. The advance research and development will consequently enhance the number of inventions. Afterwards, the inventions will contribute to a variety of advance products which eventually encourage manufactures to produce high end products to gain higher margin. This primary conceptual framework of innovation creation causes the investment in domestic R&D to be a gist of technological advancement. For simplicity, the higher investment in R&D from the Government will be leading to higher innovation-creating capacity, which will navigate the country to economic growth.

Patent is a title that granting patent owner the lawful right to prohibit other individuals or agencies from creating, deploying, or merchandising an invention for a limited period of time, normally in years, in exchange for publishing public disclosure of invention. Patent on invention is presumed to be directly and positively related to the discovery of innovation since when the researchers could discover in something new, unprecedented in sciences and technology, there is high tendency for them to register for the paten to prevent other individual, firms, foreigners to copy their discoveries. The patent on invention would makes the researchers could focus on continuously

improving, correcting, and developing what they have discovered. When they could develop their inventions and the firms could commercialize the products or services based on the paten-protected invention, the firm would leapfrog to obtain more income while other competitors. staring from the initial point, still have no chance to generate income from the invention. The nation with numerous patents on invention would probably be beneficial to have higher GPD since no other countries could have the right to use the invention.

Foreign Direct Investment (FDI) is the investment caused by a company, an individual in a nation into business located in other nations. FDI occurs when some foreign investors establish business operations or purchase foreign business assets, entities, in oversea company. On the contrary, FDOs are characterized from portfolio investment which an investor solely purchases stocks of foreign-based firms. FDI are practically found in open markets instead of closed market for investors. Foreign Direct Investment generally exists in open economies providing skilled-labor with low wages, low regulated legal enforcement compared to in rigid restricted economies. Foreign direct investment often relates to more than just a capital investment. It might combine provisions of management or technology. The essence of foreign direct investment is that FDI creates either managerial control or substantial influence over the management of an oversea business.

Foreign direct investments are generically classified in to 3 types as horizontal, vertical or conglomerate. The horizontal FDI stands for the investor creating the similar type of business operation in oversea countries as it operates in its home country, for example, apple phone provider based in the United States but open shops in Congo. The vertical FDI is that when a manufacturing company acquires an interest in a oversea company supplying parts or raw materials required for the manufacturing company to assembly its products. The conglomerate type of FDI is one which a company or individual does a foreign investment in a business that is irrelevant to its current business in its homeland. Since this type of investment involves entering an industry where the investor has no historical proficiency, it frequently takes the pattern of a joint venture with an existing foreign company already operating in the business.

FDI facilitates, fosters and encourages economic progress, both for the FDI recipient nation and for the country providing the investment. For example, a developing economy might be beneficial from inflow FDI as a path of subsidizing the construction of modern infrastructure or offering employment for oversea local workers. On the contrary, MNCs could be beneficial from FDI since they use it as a means to elaborate their steps into global markets. Nevertheless, since FDI requires a lot of participation with several Government agencies, it gravitates to bring about higher level the political risk.

One of the crucial current illustration of Foreign Direct Investment (FDI) is the One Belt One Road (OBOR) initiated by the Chinese government. This trade program, entails in contribution of gigantic FDI toward an area of infrastructure development programs began in Asia towards Africa, and even some regions of European continent.

The FDI is normally financed by Chinese state-owned enterprises or other agencies associated with the Chinese government-related. Similar trade activities are also offered by other countries, for example Japan, U.S, and the EU.

In 2018, Thailand was ranked at 30th in the World Competitiveness Yearbook , an annual report published by the Swiss-based International Institute for Management Development (IMD) on the competitiveness of nations. The World competitiveness yearbook has been published since 1989. The yearbook benchmarks the performance of 63 countries based on 340 criteria measuring various views of competitiveness. It uses two types of data:

The report evaluates the potential of nations to offer high levels of prosperity to their people. On the other hand, this relies upon how productively a nation utilizes accessible resources. As a result, The World competitiveness captures the group of policies, institutions, and factors that establishes the sustainable concurrent and middle-term levels of economic growth.

This paper attempts to assess to what the impact of STEM labor force, gross capital formation, research and development budget from the Government, Patent on invention, Foreign Direct Investment and Global competitiveness rank of Thailand on Thailand GDP

By using the data from data center of sciences, technology and innovation, national statistical office, Open Government development agency, department of intellectual property, World bank and Bank of Thailand statistic data bases, this paper quantified the effect of those independent variables on GDP after adjusting some qualified independent variables into the regression model. The analysis revealed that Thailand GDP was positively affected by the number of STEM work force.

This paper is organized as follows. the relevant literatures on STEM education as a method of national competitiveness development, are reviews in Chapter 2. The model and conceptual frame work exploited in this study are referred in Chapter 3. Data, empirical analysis, and outcome are represented in Chapter 4. Chapter 5 unearths summary and policy proposal obtained from this analysis.

**Chapter 2: Literature review**

Among several growth theories represented by well-regarded global economists, the growth model initiated by Romer (1994) is still the on-going eminent theory among the top of growth theory field. Romer (1994) raises 2 sides of work coincided underneath the highlight of endogenous growth. The first one, generally empirical, questions whether there is any propensity for impecunious countries to reach to the opulent countries within one generation? The another, typically theoretical, asks what calibrations are indispensable to create a theory of aggregate growth that rigorously integrate the economics of disclosure, innovation, technological alteration? He stated that innovation achievement could heighten imperishable growth. Consequently, several countries, the developed, the developing, and the pended developing countries still embed in this economic development theory and invest

attentively in human capital to construct national-own innovation, and knowledge base society because these factors are components of unceasing economic welfare.

Hulten and Ramey (2018) try to answer “How does human capital affect to the GDP growth? From their study, economic historian and education-specializing economists generally regard academic attainment and educational progress as critical factors of the economic growth process. Knowledge base is the gist of national development in both economy and society dimensions. Nations inattentive this fact will be agonizing whereas those, admitting it and capitalizing on it, will becoming prosper. Additionally, not only the mean level of education that matter the national welfare, it was those people in the upper tail of the knowledge distribution who were capable of the technological advancement and use it to drive the industrial revolution. From the study, the incremental wage premium for a college graduated degree partially brings about the increase approximately from 5 percent in 1950 to 30 percent in 2010 in the proportion of people with college degrees older than twenty-five.

The paper also interests in “Which channels through the skills, education of the labor force could impact GDP growth?” The authors infer factors into 5 channels;

1. Work productivity: Education raises marginal productivity of worker. When individual productivity, education, cognitive skill, and individual characteristics, are accumulated, they inherently constitute possibly significant source of growth in actual GDP.

2. Skill-based technical change: technology promotes demand for educated labor forces, thus granting them to demand higher wages. Change in the nature of technology in recent decades have displaced the demand for labor skill. Education is one determinant that accommodate skill-biased technical change

3. Innovation: The education is the superior source of new ideas and perspectives contributing technical innovation and education is also essential for the technological implementation and diffusion.

4. Knowledge spillover: The advancement and transfer of knowledge involves spillover externalities in which the social return in both education and research and development surpasses the private return.

5. Social capital: Although education is a segment of the infrastructure maintaining social, political, and economic institutions, on the other hand, it might not as much a particular channel as it is an infrastructural investment in building or maintaining social capital, yet Thomas Jefferson said it best” If the children are untaught, their ignorance and vices will in future life cost us much dearer in their consequences than it would have done in their correction by a good education”.

In summary of the paper, the authors conclude that education attainment and human capital development are the crucial factors of economic growth process.

Rindermann (2008) researches the relationship between national cognitive abilities of student and national gross domestic product (GDP) since the cognitive abilities are perceived to be crucial for the economic and non-economic success of individuals and societies. For international level analyses, the national cognitive level

is highly correlated with its educational level. In international tests, national acuity also substantiates a high correlation with GDP. On the contrary, in cross-sectional studies, the causal relationship between intelligence and national prosperity is ill-defined to determine. In longitudinal analyses with various samples of countries, education and cognitive abilities gravitate to be more substantial as developmental factors for GDP than economic freedom.

Hartog (2000) expresses that hat despite human capital is the key driver to understand personal performance with respect to education and labor market, the measurement is quite tentative and trivial detailed than the characterization of the demand side of the labor market. Investigating further the relation between amalgamate human capital and demand-side variables (intelligence, spatial aptitude, form perception, etc) is inviting to contest.

Capelli (2008) expressed that for individuals, education is broadly accepted as a prime of economic achievement. A well-literate person, being able to pass through the graduate levels gravitates to gratitude with higher purchasing power in each addition level of degree. Nevertheless, the author questions that is there any empirical conclusion that higher levels of schooling foster national economic welfare? since the traditional economic insight regards that a country's economic position is corresponded to physical capital, not human capita. Does changes global economic system has some linkages to promote overall national education level as a current key driver of economic wealth? In his study, it founded that receiving more education enables an individual to earn more income and be less tendency to face unemployment. However, if everyone had the similar professional certificates, all of them might not obtain more money since supply and demand set wage levels. Professional degree work forces generate more money when the demand for their skills relatively matched with the available supply. He inferred that adding more years in conventional education system is not only one way to boost economic growth, yet to span work-based education through cooperation between classroom and work place on the job training, so called "apprenticeships" is a determinant to drive more economic benefit.

Kirby (2007) indicates that the Governments have long realized that education could be regarded as an agency that capable of encouraging economic wealth through cultivating innovation and facilitating ample human capital. According to human capital theory, policy makers and governmental agencies have emphasized the substance of education as a domestic economic investment. Documents and reports from OECD, tenaciously inferred that in terms of the return in labor market participation, productivity and economic development, the increased state investments provided high yield return. Undeniably, the post-secondary education has always been materialized of economic and non-economic purposes. The corresponded interconnection emerging between the academic-humanist and economic-utilitarian objectives of post-secondary education has been decisively mentioned that the economic objectives composed of preparing people to be productive workers in

professional and other occupations and research which contributing to new products, technologies and greater economic efficiency.

In several studies, STEM for national development is taken in to consideration, Hussain and Robinson (2012) propose that STEM workers, as a group, earned about 70 % more than national average, and every major group of STEM worker enjoyed overall median earnings above the national average. STEM-related effect in GDP is also taken into account in certain studies. Though the relevant agencies included the Government, educators, numerous organizations, put effort to create STEM related parties; students, academics, professions, to meet the national present demand, the U.S. ability to produce those is unable to satisfy. Unless federal policy makers and planner take curing action to domestically produce or import sufficient STEM experts, the entire situation stipulates that the U.S is probably unable to sustain its global excellence in the field of Sciences, Mathematics, and Technology professions. This unsatisfied perspective is not beneficial for American educators and legislators struggling to remedy the current economic destitution by certifying the advance technology nation status. The crucial inquiry is whether the U.S. education system and career markets are deteriorating to trigger and revivify American students to go after STEM education and jobs in these field.

Accomplishment in STEM demands both technical and no-technical skills and inclinations. Thirst of knowledge and logically and inventively problem-tackling and communication prowess, and teamwork are compulsory to outwit STEM professions. Students ought to be elated in STEM disciplines since in the initial point of middle school grades with coursework and extracurricular activities convening honing problem -solving skills in the secondary level. The explication to the STEM education concern should be alleviated with an integrated discipline practice. Pursuing in STEM related field ought to be regarded as an education goal for graduate students, later on gaining some experiences, grow to be the future STEM college faculty members. Substantial preparation of STEM higher education should be matched with the requirement of being a technology-driven country.

DiCorrado, Kayla, and Wright (2015) illustrates that from 27 various nation observations, the nations with better performance on STEM-related PISA tests are, in fact, more likely to show better economic strength as measured by each nation's GDP per capita. The researchers also examine whether a country's political structure contributes to a role on determining the education and economic performance, they fragmented 27 nations into 2 groups based upon the level of democratic freedom emerging in a specific nation. In consonant with the analysis, the study shows that countries exhibiting more authoritarian political form have minimally higher STEM test scores than that of are more democratic. A result could be drawn from more stringent political structures being able to be more efficient in responding to nationwide education action than more flexible democratic and bureaucratic countries. In conclusion, pinpointing at STEM education is essential to a country long run economic growth and the survival.

Ahmadov (2020) recommends that the improvement in the share of STEM employee in the overall labor force of Azerbaijan is beneficial to the increase in GDP per capita. By using the estimated marginal effect of STEM labor force on 28 EU countries during 1992-2015, the paper analyzes the feasible contribution of STEM labor force on economic activity in Azerbaijan. Every 28% increase in STEM labor force in Azerbaijan, is generally predicted to result in $1,102 in GDP per capita. The paper inferred that there are three main directions that should be considered as initiative in short, mid and long-term periods:

1. Increase the amount of STEM graduates by establishing more STEM-related universities
2. Create compatible investment program for qualified STEM graduate to fit in STEM careers and enhance their productive capabilities that will generate an economic worth.
3. Promote STEM specialists to create the short-term increase in the STEM labor force market

Kozak (2019) emphasizes that investment in R&D and number of STEM field graduates influence GDP growth. The paper depicts certain correlations between the R&D investment the Government spent and the amount of STEM-related researchers/doctors of science/graduates and their impacts on GDP growth by using the example of Croatian to be a representative of Eastern European country. Although new generation STEM graduates continuously seeking for employment abroad increase, the Croatia Government doesn't rigorously solve the problem. This could be the threat to the Croatia economic constancy as it could deteriorate the country's competitiveness.

Augustine (2005) stresses the connections between U.S. prosperity and knowledge-intensive occupations dependent on sciences and technology, and innovation. Robert Solow, an Economics Nobel Prize recipient, point out that during the first half of the twentieth century, beyond half of the growth in U.S. output per hour, could be attributed to advancements in technological knowledge. The National Academies Gathering Storm committee concluded that the science and engineering advancement-based innovation, is a primitive factor of the future economy and coactive job creation. Four percent of the U.S.'s labor force, composed of scientists and engineers, disproportionately create jobs for the other 96 percent in U.S.

## Chapter 3: The conceptual frame work and model

### 3.1 The conceptual framework

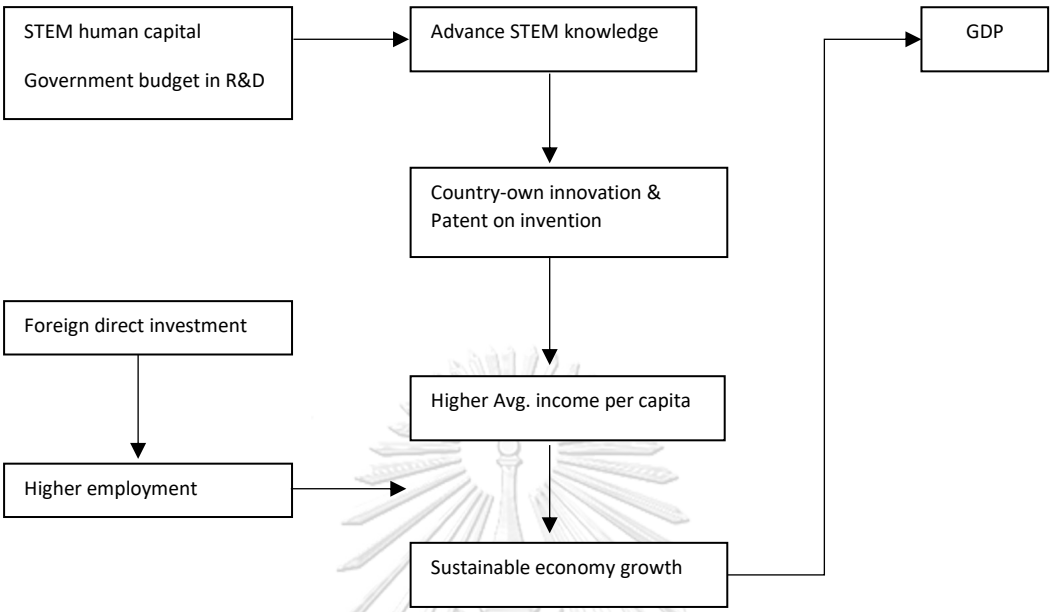



***Figure 1:*** *Conceptual framework*

The above conceptual framework of this study connects the linkage between STEM Human capital and Government spending in research and development, original stepping stones, through the later processes. According to the path of economic growth, reflected by GPD, rather than entirely purchase and rely on exorbitant technology, know-how, and products from the abroad, the Thai Government should allocate its limited but valuable annual budget to specifically develop the human capital in STEM, support STEM research and development budget. The higher number of scientists and engineers dedicating their lives for conducting research, the higher result that the country could discovers advance STEM knowledges.

After the scientific and engineering discoveries, a number of patents on invention is registered within the country. As a result, Thailand would gain benefits from owning its patent and innovation. The private sectors could utilize nation's own patent and innovation to apply and develop to their business manufacturing processes, improve more efficient service, and produce value-added products. In addition, the innovations will contribute to technological progress giving rise to sustainable economic growth. Thailand becomes more attractive country for investment. Eventually, it will reflect in higher GDP since the country could have higher competitiveness, income, consumption, better standard of living, private sector investment both domestic and abroad, employment from MNC, Foreign Direct Investment, Government spending, and export exceeding import.

**3.2 Assumption**

1. Gross fixed capital formation (formally known as gross domestic investment) has relationship in the same direction as GDP.
2. Government budget in research and development has relationship in the same direction as GDP.
3. Patent on invention registered in Thailand has relationship in the same direction as GDP.
4. STEM labor force has relationship in the same direction as GDP.
5. Foreign Direct Investment inflow to Thailand has relationship in the same direction as GDP.

**3.3 Model**

In the empirical model, the previous relevant research on STEM-related factors and GDP uses the Cobb–Douglas production function since production coefficient that is calculated from the equation will represent the elasticity of production factors which, in turn, could be applied to analyze the linear equation. The Cobb–Douglas production function is as follows:

$Q_t$ = f(K, L) = A$K_{it}^{a}L_{it}^{b}$……....(1)

Where

$Q$ stands for output or real income which is measured by GDP.

$A$ stands for total factor productivity

$K$ stands for total capital.

$L$ stands for total labor force.

a and b stand for the output elasticities of capital and labor, respectively. These two values are constant determined by available technology.

The production function displays constant returns to scale, implying that doubling the usage of Capital(K) and Labor(L) could result in double output(Q). This hold in case of $\alpha + \beta = 1$.

The function could be rewritten as follow,

f(mK, mL) = A$(mK_{it})^{a}(mL_{it})^{b}$ = A$m^{(a+b)}K_{it}^{a}L_{it}^{b}$ = A$mK_{it}^{a}L_{it}^{b}$ = $mAK_{it}^{a}L_{it}^{b}$ = m f(K, L)……..(2)

If $a + b$ >1, it means production function has increasing return to scale.

If $a + b$ <1, it means production function has decreasing return to scale.

From the Cobb-Douglass production function, I modify it to be in form of logarithm linear equation to estimate regression coefficient as follows:

$\log GDP_t = C + a \log GCF_t + b_1 \log RDGovBgt_t + b_2 \log Inpt_t + b_3 \log StemLF_t + b_4 \log FDI_t + b_5 \log GComp_t + u_t$……...(3)

Where
*GDP* stands for Gross Domestic Product (GDP).
*GCF* stands for the gross fixed capital formation.
*RDGovBgt* stands for the Government budget in R&D
*Inpt* stands for the number of patent on invention.
*StemLF* stands for the STEM labor force per 10,000 people employed.
*FDI* stands for the number of foreign direct investment inflow to Thailand.
*GComp* stands for national competitiveness rank of Thailand.

From equation 3, I modify it to be a liner equation as follows

$$GDP_t = C + \alpha GCF_t + \beta_1 RDGovBgt_t + \beta_2 Inpt_t + \beta_3 StemLF_t + \beta_4 FDI_t + \beta_5 Comp_t + u_t \quad \text{.....(4)}$$

## Chapter 4: Data and empirical analysis

### 4.1 Data collection

Measuring the economic growth-human capital correlation by using employment data. STEM capacity is measured by the number of STEM field workforce (STEM labor force) obtained from National Statistical Office of Thailand (NSO). Other statistics are collected from several sources. Gross capital formation was taken from World bank database. Research and development budget of Thailand Government was gathered from Open Government Data of Thailand, Digital Government Development Agency (Public Organization) (DGA). The patent on invention was accumulated from Department of Intellectual Property. Foreign Direct investment was combined from Bank of Thailand database and Global competitiveness data was brough form National Research Council of Thailand (NRCT). According to time of study limit and data availability constraints, some information requires official permission form the Government organizations. Some information is partially released on public. As a result, this paper uses all publicly available data for all related data for 10 years from 2009-2018. The measurements are as follow

### 4.2 Statistics summary

| Variable | N | Minimum | Maximum | Mean | S.D. |
|---|---|---|---|---|---|
| *GDP* | 10 | 281,710 | 506,514 | 399,640 | 60,993 |
| *GCF* | 10 | 58,135 | 127,577 | 97,739 | 19,175 |
| *RDbudgt* | 10 | 716 | 6,079 | 2,453 | 1,975 |
| *Inpt* | 10 | 893 | 1,098 | 987 | 74 |
| *STEM* | 10 | 492 | 650 | 581 | 63 |
| *FDI* | 10 | 2,346 | 16,484 | 9,855 | 4,964 |
| *Gcomp* | 10 | 26 | 30 | 28 | 2 |

***Table 1**:Statistics summary*

To summarize all variables, statistics summary for all the variables utilized in the empirical model both independent and dependent for this study depicts in the table above. From time-to-time observations, since 2009-2018, Thailand GDPs, dependent variable, were in rising trend, average GDP was 399,640 MUSD. As expected, 2018 GDPs accounted for the maximum level along 10 years historical record with the amount of 506,514 MUSD. In 2009, the year aftermath the hamburger crisis occurred 2008, GDP was the lowest level of 281,710 MUSD. In 2015, after the great flood situation paralyzed the national industrial manufacturing supply chain and logistic in 2014, Thailand's GDP was lower at 401,296 MUSD. The country GDP recovered since then afterward until 2018.

GCF were also in the gradually increasing pattern. Average GCF was 97,739 MUSD. GCF trend had been in rising during 2009-2013, from 58,135 MUSD in 2009 to 115,411 MUSD in 2013. Nevertheless, it was sluggish in 2014 until 2016. It began to revitalize since 2017, with amount of 104,625 MUSD. For the RDbudgt, its average was 2,453 MUSD. It seems that the Government paid more attention to research and development budget after 2014, proven by the higher budget from year to year. In 2018, RDbudgt reached to the maximum at 6,079 MUSD, risen by almost 220 % from 2014.



For Inpt, its average number was 987 patents. Inpt line trend was in relatively downward since 2015 until 2018. In 2015, the number of patent on invention registered in Thailand was 1,098 patents whereas the amount was decreasing to 904 patents in 2018.

For StemLF, the average amount between 2009-2018 was 581 employees per 10,000 people employed. The amount of stem labor force in Thailand had been gradually increasing every year which was positive sign of country for developing by intellectual capability. However, Stem labor force growth rate during 2019-2018 was still relatively low at 3.1% per annum.

The last observed independent variable, Gcomp, the global competitiveness of Thailand, illustrated average of 28$^{th}$ rank. The most desirable rank Thailand could reach was 26$^{th}$ in 2009. Afterwards, Thailand global competitiveness rank was rarely improved. The rank weas around 27$^{th}$ to 30$^{th}$ during 2012-2018.

**4.3 Analysis of relationship between independent variables**

In order to prevent occurrence of multicollinearity which is the existing of high intercorrelations among two or more independent variables in a multiple regression model. Multicollinearity can lead to skewed or misleading results when a researcher or analyst attempts to determine how well each independent variable can be used most effectively to predict or understand the dependent variable in a statistical model. As a result, it is compulsory to inspect the relationship among the independent variables to be certain that the independent variables are fitted in to be used in the model.

The analysis of the relationship between the independent variables is constructed by setting the hypothesis

$H_o$: There is no relationship between 2 independent variables.

$H_1$: There is a relationship between 2 independent variables.

Later, we will determine Sig. (2 tailed). If the value of Sig(2-tailed) is less than 0.5, we will reject $H_o$and accept $H_1$ which means that there is a relationship between 2 independent variables. On the contrary, if the value if Sig(2-tailed) is greater than 0.5, we will accept the $H_o$ which, in turns, means there is no relationship between 2 independent variables. Afterwards, we will analyze the level of variable relationship by determining the correlation coefficient according to the following criteria:

Where *r* stands for correlation coefficient.

If $r \leq 0.2$, low relationship between variables.

If $0.21 \leq r < 0.4$, relatively low relationship between variables.

If $0.41 \leq r < 0.6$, moderate relationship between variables.

If $0.61 \leq r < 0.8$, relatively high relationship between variables

If $r \geq 0.8$, high relationship between variables.

| | *GDP* | *GCF* | *RDbudgt* | *Inpt* | *STEM* | *FDI* | *Gcomp* |
|---|---|---|---|---|---|---|---|
| GDP | 1.00** | 0.86** | 0.83** | -0.28 | 0.83** | 0.23** | 0.59** |
| GCF | 0.86** | 1.00** | 0.48** | -0.49 | 0.46** | 0.43** | 0.52** |
| RDbudgt | 0.83** | 0.48** | 1.00** | -0.09 | 0.86** | 0.08** | 0.36** |
| Inpt | -0.28 | -0.49 | -0.09 | 1.00** | 0.16** | -0.27 | 0.20** |
| STEM | 0.83** | 0.46** | 0.86** | 0.16** | 1.00** | -0.11 | 0.64** |
| FDI | 0.23** | 0.43** | 0.08** | -0.27 | -0.11 | 1.00** | 0.09** |
| Gcomp | 0.59** | 0.52** | 0.36** | 0.20** | 0.64** | 0.09** | 1.00** |

** Correlation is significant at 0.01 level(2-tailed)

***Table 2:*** *The analysis of relationship among independent variables*

From table 2, when we consider Sig.(2-tailed) at 0.01 significant level, we found that almost independent variables have significant relationship ($P<0.01$) with other independent variables except Inpt and StemLF which has P value grater than 0.01. For GDP, GCF, RDGovbgt, and StemLF have high relationship with. Th GDP. Gcomp has moderate relationship with GDP while FDI has relative low relationship with GDP. On

the contrary, Inpt has negative relationship with GDP. For GCF variable, GDP has high relationship with GCF whereas RDGovbgt, StemLF, and FDI have moderate relationship with GFC, yet Inpt has negative relationship with GCF. For RdGovbgt , GDP and StemLF have relatively high relationship with RdGovbgt whereas GCF has moderate relationship with it. FDI has low relationship with GCF while Inpt has negative relationship with GCF. For Inpt, GDP, GCF, RDGovBgt, and FDI has negative relationship with it. For StemLF, GDP, RDGovbdgt, and Gcomp have high positive relationship with it. However, Inpt has low relationship with it. Moreover, FDI has negative relationship with StemLF. For FDI, GCF is the only independent variable having moderate relationship with. GDP has relatively low relationship with FDI. RDGovbdgt, and Gcomp have relatively low relationship with FDI. On the other hand, Inpt is the only one independent variable which has negative relationship with it. For the last independent variable, Gcomp, StemLF has relatively high relationship with it whereas GDP and GCF have moderate relationship with Gcomp. RDgovbgt and Inpt have relatively low relationship with it.

From the data obtained, we found that high relationship level of independent variables might constitute to the impact on multi regression analysis. Consequently, to inspect whether applying these independent variables in the model would bring about multicollinearity, I examine the relationship by using Variance Inflation Factor (VIF) and found that Variance Inflation Factor values of every independent variable are less than 10 except StemLF which has severe multicollinearity. As a result, it can be inferred that almost every independent variable do not have any relationship level among all independent variables except StemLF.

**4.4 Regression result**

For the first round of regression analysis, all independent variables are taken in to account in the research model. These independent variables are the gross capital formation, the research and development budget of the Government, the patent on invention, STEM labor force per 10,000 people employed, Foreign Direct Investment (FDI), and Global competitiveness rank.

The results from each regression analysis are illustrated as follow. In the first model, all 6 independent variables are incorporated in. All independent variables include gross fixed capital, Government's research and development budget, patent on invention registered in Thailand, STEM labor force, foreign direct investment, and Thailand global competitiveness rank.

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.999 |
| R Square | 0.999 |
| Adjusted R Square | 0.996 |
| Standard Error | 3999.810 |
| Observations | 10 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 6 | 3.34E+10 | 5.57E+09 | 348.2931 | 0.000 |
| Residual | 3 | 47995447 | 15998482 | | |
| Total | 9 | 3.35E+10 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* |
|---|---|---|---|---|---|
| Intercept | 50967.039 | 28182.692 | 1.808 | 0.168 | -38722.865 |
| GCF | 1.823 | 0.138 | 13.208 | 0.001 | 1.384 |
| RDbudgt | 7.464 | 1.848 | 4.040 | 0.027 | 1.584 |
| Inpt | -22.549 | 28.666 | -0.787 | 0.489 | -113.776 |
| StemLF | 379.045 | 73.800 | 5.136 | 0.014 | 144.181 |
| FDI | 0.012 | 0.361 | 0.032 | 0.976 | -1.138 |
| Gcomp | -1642.043 | 1474.628 | -1.114 | 0.347 | -6334.966 |

***Table 3**: Round 1 result*

According to the first-round result, when we consider at R square value = 0.999. It means that all 6 independent variables we used in the first round could explain 99.9% of the variance of the dependent variable, GDP. Consequently, it could be inferred that this model is statistically significant. However, when we consider each independent variable P-value, it seems that P-values of all independent variables are less than 0.05 which means they are all statistically significant except Inpt, FDI, and Gcomp which have P-value beyond 0.05.

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.999 |
| R Square | 0.997 |
| Adjusted R Square | 0.996 |
| Standard Error | 3905.312 |
| Observations | 10 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 3 | 33389448936 | 1.11E+10 | 729.7542 | 0.000 |
| Residual | 6 | 91508760.5 | 15251460 | | |
| Total | 9 | 33480957696 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* |
|---|---|---|---|---|---|
| Intercept | 23284.698 | 21202.421 | 1.098 | 0.314 | -28595.757 |
| GCF | 1.831 | 0.078 | 23.558 | 0.000 | 1.640 |
| RDbudgt | 9.135 | 1.295 | 7.052 | 0.000 | 5.965 |
| StemLF | 301.209 | 40.441 | 7.448 | 0.000 | 202.253 |

***Table 4:*** *Round 2 result with 3 independent variables*

In the round 2 regression analysis, we get rid of all 3 independent variables with P-value exceeding 0.05 from the first round which are Inpt, FDI, and Gcomp. It turns out that the validity of the model is not affected. R square is unchanged at 0.997 meaning that all remaining 3 independent variables, GCF, RDbudgt, and STEM are capable of explaining 99.7% of variance of dependent variable, GDP. Consequently, it could be inferred that this model is statistically significant. After considering all 3 independent variables P-values, all of them are less than 0.05, implying that these 3 variables are statistically significant. The coefficient of these 3 variables could be used to explain the impact from each of them to the dependent variable, GDP. We can infer the result of the multi regression analysis as followed;

Gross capital formation (GCF), Research and Development budget of the Thai Government, and STEM labor force per 10,000 people employed (StemLF) have influences on Gross Domestic Product(GDP) at 0.05 significant level. We could re-write down equation from this model as below:

$$GDP_t = 23{,}284.7 + 1.8GCF_t + 9.1RDGovBgt_t + 301.2StemLF_t + u_t \text{.....(5)}$$

Interpretation

All 3 focused independent variables positively affect to GDP.

1. Coefficient of GCF, 1.8, means that the additional 1 unit of Gross Capital Formation (formally known as Gross Domestic Investment) will result in 1.8 unit increase in GDP.
2. Coefficient of RDGovBgt, 9.1 means that the additional 1 unit of Government spending in research and development will bring about 9.135 unit increase in GDP.
3. Coefficient of StemLF, 301.2 means that the additional 1 unit of STEM labor force per 10,000 people employed will bring about 301.2 unit increase in GDP.

## Chapter 5: Summary and suggestion

### 5.1 Summary

This study walks through the impact of Gross Capital Formation, Government budget in scientific research and development, a number of patent on invention registered in Thailand, STEM workforce, and Thailand's Global competitiveness rank on 10-year GDP range from 2009 to 2018.

Initially, the paper detects the effect of Gross Capital Formation consisting of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories, the amount of Government spending on research and development measured by how much the Government spent in Sciences , and Technology, the number of patent on invention as a measurable outcome of R&D, STEM labor force, measured by the number of workers in STEM occupations as a measurement of highly educated, potential workforce, Foreign Direct Investment(FDI) as measurable by how attractive Thailand could be on foreign investors' eye view and Global competitiveness rank of Thailand as an indicator of how capable of Thailand is among the globe. These 6 independent variables are used as the ground for workforce potential, national capability, innovation and domestic investments, and productivity in a country as opposed to educational attainment used mostly for developed countries. Later on, based on the Cobb-Douglas aggregate production function concept, by using these 6 variables, I set up the assumption and tests correlation grounded on the hypothesis. Afterwards, I construct the regression equation applying the least squares method to select which independent variables are qualified to be fitted in the model. Finally, I quantify the effect and the result of each selective independent variables to the GDP.

According to the study, I obtain the regression model used to explain the effect of these variables:

$$GDP_t = 23{,}284.7 + 1.8GCF_t + 9.1RDGovBgt_t + 301.2StemLF_t + u_t$$

The result revealed that adding 1 additional unit of GCF in Thailand is predicted to cause 1.8 unit increase in GDP. Enhancing 1 more unit in Research and development budget from the Government is forecasted to result in 9.1 in GDP and increasing 1 more unit of Stem labor force per 10,000 people employed contributes to 301.2 unit increase in GDP. On the other hand, the number of patent on invention, Foreign Direct

investment, and Thailand global competitiveness rank are statistically insignificant to be incorporated in the model.

The result from this study could be benefits for the national policy makers to decide which directions of national study, domestic investment, national strategic master plan should be gravitated to overcome the developing country status and become the developed county within planned timeline.

**5.2 Suggestion**

Thai Government, not matter which means they used to be positioned in the parliament should be considering to focus on well-planned long term STEM human capital development, infrastructure development, research and development budget since these three essential economic drivers could potentially increase national GDP. The higher number of STEM labor force in all levels from undergraduate to graduate levels, the higher investment in the infrastructure, and the higher research and development in sciences and technology, the higher the GPD country could generate. Once the nation could overcome the middle-income trap, the next generation will capitalize on the higher living standard.

# Appendix

## Data used in regression analysis

| Year | GDP | GCF | RDbudgt | Inpt | StemLF | FDI | Gcomp |
|---|---|---|---|---|---|---|---|
| 2009 | 281,710 | 58,135 | 716 | 1,062 | 497 | 7,477 | 26 |
| 2010 | 341,105 | 86,493 | 716 | 922 | 492 | 15,536 | 26 |
| 2011 | 370,819 | 99,348 | 716 | 893 | 524 | 2,346 | 27 |
| 2012 | 397,558 | 111,412 | 716 | 1,068 | 558 | 13,363 | 30 |
| 2013 | 420,333 | 115,411 | 1,901 | 929 | 558 | 16,484 | 27 |
| 2014 | 407,339 | 97,432 | 1,901 | 983 | 615 | 5,376 | 29 |
| 2015 | 401,296 | 89,712 | 2,822 | 1,029 | 633 | 10,175 | 30 |
| 2016 | 413,430 | 87,243 | 3,785 | 1,098 | 639 | 4,206 | 28 |
| 2017 | 456,295 | 104,625 | 5,171 | 979 | 645 | 9,375 | 27 |
| 2018 | 506,514 | 127,577 | 6,079 | 904 | 650 | 14,207 | 30 |
| Unit | MUSD | MUSD | MUSD | paper | Head per 10,000 people employed | MUSD | rank |
| Data source | World bank | World bank | Open Government Data of Thailand | Department of Intellectual Property | National statistics bureau | Bank of Thailand | IMD global competitive rank |

## Descriptive statistics

| Variable | N | Minimum | Maximum | Mean | S.D. |
|---|---|---|---|---|---|
| *GDP* | 10 | 281,710 | 506,514 | 399,640 | 60,993 |
| *GCF* | 10 | 58,135 | 127,577 | 97,739 | 19,175 |
| *RDbudgt* | 10 | 716 | 6,079 | 2,453 | 1,975 |
| *Inpt* | 10 | 893 | 1,098 | 987 | 74 |
| *STEM* | 10 | 492 | 650 | 581 | 63 |
| *FDI* | 10 | 2,346 | 16,484 | 9,855 | 4,964 |
| *Gcomp* | 10 | 26 | 30 | 28 | 2 |

## Correlation

| | *GDP* | *GCF* | *RDbudgt* | *Inpt* | *STEM* | *FDI* | *Gcomp* |
|---|---|---|---|---|---|---|---|
| GDP | 1.00 | 0.86 | 0.83 | -0.28 | 0.83 | 0.23 | 0.59 |
| GCF | 0.86 | 1.00 | 0.48 | -0.49 | 0.46 | 0.43 | 0.52 |
| RDbudgt | 0.83 | 0.48 | 1.00 | -0.09 | 0.86 | 0.08 | 0.36 |
| Inpt | -0.28 | -0.49 | -0.09 | 1.00 | 0.16 | -0.27 | 0.20 |
| STEM | 0.83 | 0.46 | 0.86 | 0.16 | 1.00 | -0.11 | 0.64 |
| FDI | 0.23 | 0.43 | 0.08 | -0.27 | -0.11 | 1.00 | 0.09 |
| Gcomp | 0.59 | 0.52 | 0.36 | 0.20 | 0.64 | 0.09 | 1.00 |

* means this variable is significant at p value <0.05 but not 0.01.
** means this variable is significant at p value <0.01

| | alpha | r critical value |
|---|---|---|
| *p value<0.05 | 0.05 | 0.631896865 |
| **p value<0.01 | 0.01 | 0.764592497 |
| n=10 | | |

VIF

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.999 |
| R Square | 0.999 |
| Adjusted R Square | 0.996 |
| Standard Error | 3999.810297 |
| Observations | 10 |

$$VIF_j = \frac{S_{x_j}^2 (n-1) SE_{b_j}^2}{S^2}$$

ANOVA

| | *df* | *SS* | *MS* | *F* | *Sig F* |
|---|---|---|---|---|---|
| Regression | 6 | 3E+10 | 6E+09 | 3E+02 | 0.000 |
| Residual | 3 | 5E+07 | 2E+07 | | |
| Total | 9 | 3E+10 | | | |

| | *Coeff* | *Std Error* | *t Stat* | *P-value* | *VIF* | *Sxj* |
|---|---|---|---|---|---|---|
| Intercept | 50967.039 | 28182.692 | 1.808 | 0.168 | | |
| GCF | 1.823 | 0.138 | 13.208 | 0.001 | 3.94 | 19175.345 |
| RDbudgt | 7.464 | 1.848 | 4.040 | 0.027 | 7.50 | 1975.320 |
| Inpt | -22.549 | 28.666 | -0.787 | 0.489 | 2.55 | 74.285 |
| STEM | 379.045 | 73.800 | 5.136 | 0.014 | 12.04 | 62.685 |
| FDI | 0.012 | 0.361 | 0.032 | 0.976 | 1.81 | 4964.314 |
| Gcomp | -1642.043 | 1474.628 | -1.114 | 0.347 | 3.26 | 1.633 |

# REFERENCES

Ahmadov, D. (2020). Science, Technology, Engineering, and Math (STEM) effect on GDP in EU countries: Labor force perspective. Journal of Eastern European and Central Asian Research (JEECAR), 7(1), 114-121.

Committee on Prospering in the Global Economy of the 21st Century. (2007). Rising above the gathering storm: Energizing and employing America for a brighter economic future. Washington, DC: National Academies Press.

Cappelli, P. (2008). Schools of dreams: More education is not an economic elixir. Issues in science and technology, 24(4), 59-64.

DiCorrado, E., Kelly, K., & Wright, M. (2015). The relationship between mathematical performance and GDP per capita.

Hartog, J. (2000). Human capital as an instrument of analysis for the economics of education. European Journal of Education, 35(1), 7-20.

Hulten, C. R. (2018). Education, skills, and technical change: implications for future US GDP growth (Vol. 77). University of Chicago Press.

Hossain, M. (2012). How to motivate US students to pursue STEM (science, technology, engineering and mathematics) careers. *Online Submission*.

Kirby, D. (2007). Reviewing Canadian post-secondary education: Post-secondary education policy in post-industrial Canada. *Canadian Journal of Educational Administration and Policy*, (65).

Kozak, D. (2019). Study Programs in STEM Field in Eastern European Countries vs. Brain Drain. In *Advances in Manufacturing Engineering and Materials* (pp. 3-10). Springer, Cham.

Rindermann, H. (2008). Relevance of education and intelligence at the national level for the economic welfare of people. *Intelligence*, *36*(2), 127-142.

Romer, P. M. (1990). Endogenous technological change. *Journal of political Economy*, *98*(5, Part 2), S71-S102.

Romer, P. M. (1994). The origins of endogenous growth. *Journal of Economic perspectives*, *8*(1), 3-22

# VITA

| | |
|---|---|
| **NAME** | Piyapat Rujiphoch |
| **DATE OF BIRTH** | 13 April 1986 |
| **PLACE OF BIRTH** | Lampang |
| **INSTITUTIONS ATTENDED** | Mahidol University |
| **HOME ADDRESS** | 142/76 Suanpak 29 Talingchan Bangkok |