

**THE EFFECT OF RESEARCH AND DEVELOPMENT ON GROSS  
DOMESTIC PRODUCT: CROSS-COUNTRY EVIDENCE**



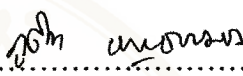
**PHUDIT HARNTHAMTONG**

**A THEMATIC PAPER SUBMITTED IN PARTIAL  
FULFILLMENT OF THE REQUIREMENTS FOR  
THE DEGREE OF MASTER OF BUSINESS ADMINISTRATION  
(BUSINESS MODELING AND ANALYSIS)  
FACULTY OF GRADUATE STUDIES  
MAHIDOL UNIVERSITY  
2012**

**COPYRIGHT OF MAHIDOL UNIVERSITY**

Copyright by Mahidol University

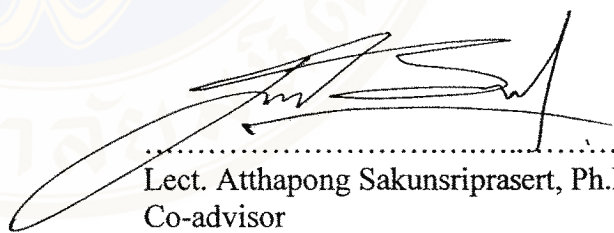
Thematic Paper  
entitled  
**THE EFFECT OF RESEARCH AND DEVELOPMENT ON GROSS  
DOMESTIC PRODUCT: CROSS-COUNTRY EVIDENCE**




.....  
Mr. Phudit Harnthamtong  
Candidate



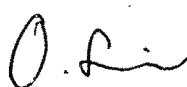
.....  
Lect. Pandej Chintrakarn, Ph.D.  
Major advisor



.....  
Lect. Atthapong Sakunsriprasert, Ph.D.  
Co-advisor




.....  
Prof. Banchong Mahaisavariya,  
M.D., Dip Thai Board of Orthopedics  
Dean  
Faculty of Graduate Studies  
Mahidol University



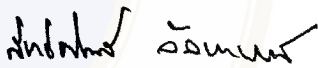
.....  
Lect. Ornlatcha Sivarak, Ph.D.  
Program Director  
Master of Business Administration  
Program in Business Modeling and  
Analysis  
International College  
Mahidol University

Thematic Paper  
entitled  
**THE EFFECT OF RESEARCH AND DEVELOPMENT ON GROSS  
DOMESTIC PRODUCT: CROSS-COUNTRY EVIDENCE**

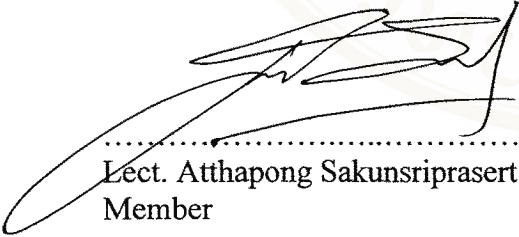
was submitted to the Faculty of Graduate Studies, Mahidol University  
for the degree of Master of Business Administration (Business Modeling and Analysis)  
on  
February 10, 2012




.....  
Mr. Phudit Harnthamtong  
Candidate



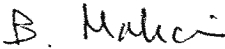
.....  
Asst. Prof. Sittisak Leelahanon, Ph.D.  
Chair




.....  
Lect. Atthapong Sakunriprasert, Ph.D.  
Member



.....  
Lect. Pandej Chintrakarn, Ph.D.  
Member



.....  
Prof. Banchong Mahaisavariya,  
M.D., Dip Thai Board of Orthopedics  
Dean  
Faculty of Graduate Studies  
Mahidol University



.....  
Prof. Maleeya Kruatrachue, Ph.D.  
Dean  
International College  
Mahidol University

## ACKNOWLEDGEMENTS

I would like to express my gratitude to my advisor, Lect. PandejChintrakarn, for his great patient, as well as, his supports, suggestions and comments that help me finish this research.

I would like to thank the MBA MUIC staffs for their assistance in reminding me when and what to do to complete the requirement throughout the thematic process. Thanks to my friends who helped me through all the classes. For nong, thank you for being by my side and never give up on me. Lastly, thanks to my family for their support, especially my parents for paying the entire tuition fee.

PhuditHarnthamtong

**THE EFFECT OF RESEARCH AND DEVELOPMENT ON GROSS DOMESTIC  
PRODUCT: CROSS-COUNTRY EVIDENCE**

**PHUDIT HARNTHAMTONG      5138500 ICMA/M**

**M.B.A. (BUSINESS MODELING AND ANALYSIS)**

**THEMATIC PAPER ADVISORY COMMITTEE: PANDEJ CHINTRAKARN,  
Ph.D., ATTHAPONG SAKUNSRIPRASERT, Ph.D.**

**ABSTRACT**

This research aimed to identify the effects of research and development (R&D) on gross domestic product (GDP). The model in this research is based on the study of Wong, Toh, and Ho (2009) and the R&D Capital Stock model (Griliches and Lichtenberg, 1984). The study should point out whether R&D has a positive or negative impact on GDP.

The methodology applied in this research was calculated for linear regression by using the STATA program. The data used in this experiment was a dataset from the World Development Indicators. The selected dependent and independent variables are GDP, labor force, gross domestic savings, and R&D.

The result showed that the R&D expenditure rate has a positive effect on the nation's GDP.

**KEY WORDS: R&D/ EFFECT /GDP**

25 pages

ผลของการวิจัยและพัฒนาที่มีต่อผลิตภัณฑ์มวลรวมในประเทศ:หลักฐานข้ามประเทศ  
THE EFFECT OF RESEARCH AND DEVELOPMENT ON GROSS DOMESTIC PRODUCT:  
CROSS-COUNTRY EVIDENCE

ภูดิท หาญธรรมชง 5138500 ICMA/M

บช.ม. (การวิเคราะห์และการสร้างตัวแบบธุรกิจ)

คณะกรรมการที่ปรึกษาสารนิพนธ์: ปานเดช ชินตระการ Ph.D., อรรถพงษ์ สกฤตศรีประเสริฐ Ph.D.

บทคัดย่อ

งานวิจัยนี้มุ่งศึกษาผลของผลกระทบที่การวิจัยและพัฒนา(R&D)จะมีต่อผลิตภัณฑ์มวลรวมของประเทศ(GDP) โดยการมุ่งเน้นที่จะนำค่าใช้จ่ายในการวิจัยและพัฒนา รวมถึงการคิดคำนวณค่าผลิตภัณฑ์มวลรวมของประเทศ เพื่อที่จะศึกษาว่าการวิจัยและพัฒนา มีผลกระทบอย่างไรต่อค่าผลิตภัณฑ์มวลรวมของประเทศบ้าง

วิธีการวิจัยในการศึกษาชิ้นนี้ประกอบด้วย การวิเคราะห์ค่าสัมพัทธ์ของการวิจัยและพัฒนา กับค่าผลิตภัณฑ์มวลรวมของประเทศ โดยใช้ชุดข้อมูลจากครรชนีแสดงการพัฒนาโลก(World Development Indicators) มาคิดคำนวณ โดยโปรแกรม STATA

ผลวิจัยได้แสดงว่าการวิจัยและพัฒนานั้นส่งผลบวกให้กับค่าผลิตภัณฑ์มวลรวมของประเทศ

25หน้า

## CONTENTS

	<b>Page</b>
<b>ACKNOWLEDGEMENTS</b>	<b>iii</b>
<b>ABSTRACT (ENGLISH)</b>	<b>iv</b>
<b>ABSTRACT (THAI)</b>	<b>v</b>
<b>LIST OF TABLES</b>	<b>vii</b>
<b>LIST OF FIGURES</b>	<b>viii</b>
<b>CHAPTER I INTRODUCTION</b>	<b>1</b>
1.1 Background	1
1.2 Significant of the research	3
1.3 Objective	4
1.4 Scope	4
1.5 Benefit	4
<b>CHAPTER II LITERATURE REVIEW</b>	<b>6</b>
2.1 Research and Development	6
<b>CHAPTER III METHODOLOGY</b>	<b>11</b>
3.1 The Model	11
3.2 The Command	13
3.3 Data	13
<b>CHAPTER IV RESULTS and ANALYSIS</b>	<b>15</b>
4.1 Descriptive statistics	15
4.2 Results	17
4.2.1 Table Analyzing	18
4.2.2 Comparing with Other Articles	19
<b>CHAPTER V CONCLUSION</b>	<b>20</b>
<b>FUTURE STUDY</b>	<b>22</b>
<b>BIBLIOGRAPHY</b>	<b>23</b>
<b>BIOGRAPHY</b>	<b>25</b>

## LIST OF TABLES

<b>Table</b>		<b>Page</b>
2.1	Contribution of return to R&D capital to growth in adjusted GDP alternative scenarios: Lowest contribution, base case, and highest contribution (as a percent of GDP growth rate)	8
2.2	Estimated rates of return to private R&D	9
4.1	The summarize of the selected nine variables used in the equation	16
4.2	The regression of the equation	17

## LIST OF FIGURES

<b>Figure</b>	<b>Page</b>
2.1 Productivity Growth VS GDP PPP	7
2.2 Real gross expenditure on R&D and R&D intensity, between 1976-77 to 2002-03	7
2.3 R&D growth over the business cycle	10

## CHAPTER I

### INTRODUCTION

#### 1.1 Background

Gross domestic product or GDP is a measure of the market value for all of the goods and services produced in a country in a specific time period, generally per annum. It is one of the indicators that are used to measure the well-being of a country's economy. It is the first thing that anyone who is looking into a nation's profile will be seeking for. GDP is usually a comparison to the previous time. For example, if the year-to-year GDP is up 1%, it means that the economy has increased by 1% from the last year. GDP per capita (per person) is an indicator of a country's standard of living, not the standard of living in an economy.

GDP is calculated in a clear and standardized way, which makes it a very good indicator. It is easy to compare the nation's GDP with its previous years GDP or with other countries' GDP. GDP can be calculated in three ways, which should give the same result. They are the product approach, the income approach, and the expenditure approach. The product approach can also be called as net product or value added method. The income approach is to measure the total income. It is sometimes referred to as the gross domestic income (GDI). GDI can be calculated by adding up total compensation to employees, gross profits for incorporated and non-incorporated firms, and taxes less any subsidies. The most common way of the three approaches is the expenditure approach, which will be used in this experiment. It is calculated by adding total consumption, investment, government spending and net exports.

$$\text{GDP} = \text{private consumption} + \text{gross domestic saving} + \text{government spending} + (\text{exports} - \text{imports})$$

However, the method used in this experiment will not be straight forward like this, see methodology section (Chapter III).

One of the problems for GDP is that it does not explain for black and grey market. Some nations, like Thailand, that have heavy trafficked of pirates and black markets may not fully represent the actual GDP. It does not account for the quality of the goods and services produced, nor the purpose of producing those goods and services. A country might spend a lot of money to recover from a severe disaster, for example flooding in Thailand. It may help to increase the GDP, but it does not link to the economic growth.

Why is it important to study GDP? GDP is a significant factor which indicates whether the country's economy will be prosperous or not. High GDP growth rates can lead to the increasing of the currency's value. This is because any investors, especially foreign investors, will be interested to invest in a country with successful economy. Hence, the currency of the country will be increased automatically. Moreover, companies in the country with higher GDP growth rate tend to perform better. This also will lead investors to be more active in the company. The company with high performance increased their turnover, and profit, as well as, profit margin. This can lead to a good economy and result as low unemployment rate. Everyone will be happy. Moreover, the wage can be increased as the demand for labor should be increased in the growing economy. In addition, the change of GDP can also affect the stock market. Therefore, the result is good for everyone in the country.

It is significant to study the effect of research and development (R&D) on GDP. According to the Organisation for Economic Co-operation and Development (OECD), the expenditure on R&D is a shown indicator that government or private sector was trying to obtain competitive advantage (OECD, 2003). This is one of the signals that should draw attentions from investors, which will be an indirect way of helping to boost the nation's GDP. Therefore, by studying in R&D expenditure rate, it should help on improving the GDP of the nation.

Naturally, benefits from R&D do not accumulate only to the original investors of the products, technologies, or strategies. Achievements from R&D would occur in form of spill over throughout a wide range of varieties. It is summarized by Griliches (1992): 'In spite of difficulties, there has been a significant number of

reasonably well-done studies, all pointing in the same direction: R&D spillovers are present, their magnitude may be quite large, and social rates of return remain significantly above private rates'. In order to see the total effect of R&D, it is essential to create a link to see the total effect of R&D via economic growth, which will also, reflect the spillovers.

R&D can be a range from nothing to millions or billions of dollars. How much should be spent on R&D all depends on what type of business there is. The amount of money spent on R&D can literally determine the future of that company. However, intangible assets such as R&D are counted as costs rather than investments. There has been a research on whether to treat R&D expenditure as an investment by Parham (2007) and he concluded as 'lesser of two evils'. Nevertheless, if it was treated as investments, the GDP of U.S. would have been increased, on average, by 2.7 percent between 1998 and 2007 (BEA, 2010). Just by treating R&D differently, it could help in increasing the GDP of U.S. by percentage.

According to Nationmaster.com (2011), R&D is something that many powerful countries in the world are interested. According to nationmaster.com, those countries spent some amount of percentage from GDP to R&D. Here are the percentage of GDP those countries spent on R&D in 2007, Japan 3.45%, U.S. 2.67%, Singapore 2.61%, Germany 2.55%, France 2.1%, U.K. 1.84%, China 1.49%, Russia 1.12%, Brazil 1.02%, India 0.8%, Turkey 0.71%, Pakistan 0.67%, and Malaysia 0.64%. Unfortunately, in 2007, Thailand only spent 0.25% of its GDP for R&D. This shows that R&D is worth looking into. Why waste more time introducing? Let's look into it.

## **1.2 Significant of the research**

This research should show the importance of R&D expenditure for economic growth. Consequently, this research does not only provide the analysis on significance of R&D expenditure on GDP, but the expenditure on R&D that could be recommended to adjust and to improve GDP.

### **1.3 Objective**

To examine any significant effect of R&D expenditure rate on the country GDP. Furthermore, to propose the necessity of increasing or decreasing R&D expenditure rate to improve the GDP of Thailand or its neighbor countries based on the results.

### **1.4 Scope**

This research is a study of the relationship between GDP and R&D expenditure rate. The correlation coefficients provided from the model are being measured by emphasizing on the R&D expenditure rate factor to examine the GDP. Additionally, the GDP are being analyzed by observing significance effect on using R&D expenditure rate within the given data. This research shall conclude with recommendations whether the increasing rate of R&D expenditure should be applied to Thailand or not, in order to help develop Thailand's GDP into the positive way.

### **1.5 Benefit**

GDP is important because it indicates the present economic status of a country to the world. This may affect various ways to the country with high or low GDP. For example, the number of investor invested in that country may increase or decrease. R&D is something that many powerful countries in the world are interested. Since GDP is an important factor to a country's economic, it is ideal to study the effect of R&D expenditure rate to the countries' GDP. Should increasing expenditure on R&D significantly enhances GDP, Thailand may consider increasing expenditure on R&D and share the technology with its neighbor as soon as possible. This is to encourage other countries to do the same and share their technologies with us. Consequently, it would be beneficial for everyone who is trying to do business in Thailand, as well as, people who are trying to do business with other countries. Moreover, if the results in this experiment show that increasing in R&D expenditure rate will help increased the country's GDP, this should sure help to change the mind of

governments to improve their relationship with neighbor's countries in order to obtain technology from R&D.



## **CHAPTER II**

### **LITERATURE REVIEW**

#### **2.1 Research and Development**

Research and development (R and D, or R&D) refers to “creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.” (OECD, 2003) The Organisation for Economic Co-operation and Development (OECD) also suggested that expenditure on R&D is a shown indicator that government or private sector was trying to obtain competitive advantage. It shows the likelihood for a country to innovate new products or new processes. Moreover, it is also an investment for knowledge.

Griliches (1998) studied the productivity growth and R&D in the 1970s. Griliches suggested that, in the total factor productivity, R&D expenditure, or R&D investment, has a significant positive effect on the growth rate. The rise and fall of the growth in GDP per capita tends to have the same trend as the growth in labor productivity (Koenig, 2000).

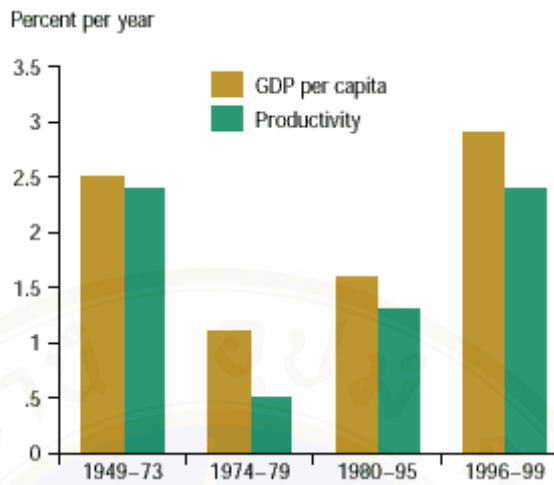


Figure 2.1: Productivity Growth VS GDP PPP Sources: Koenig, 2000.

According to OECD, R&D accounted for 2.3% of GDP for the OECD in 2007. Finland, Sweden, Japan, and Korea were the only OECD countries that the R&D to GDP ratio exceeded 3%. For China, the growth in R&D spending has been growing faster than GDP; R&D spending has exceeded 20% per year since 2000 (increased from 0.9% in 2000 to 1.4% in 2007).

Australian expenditure on R&D, between mid-1970s and early-2000s, shows the upward-trend line throughout the whole time period. The real gross expenditure on R&D has expanded more than threefold since the mid-1970s (Shanks and Zheng 2006). These raised a point about the important of R&D expenditure.

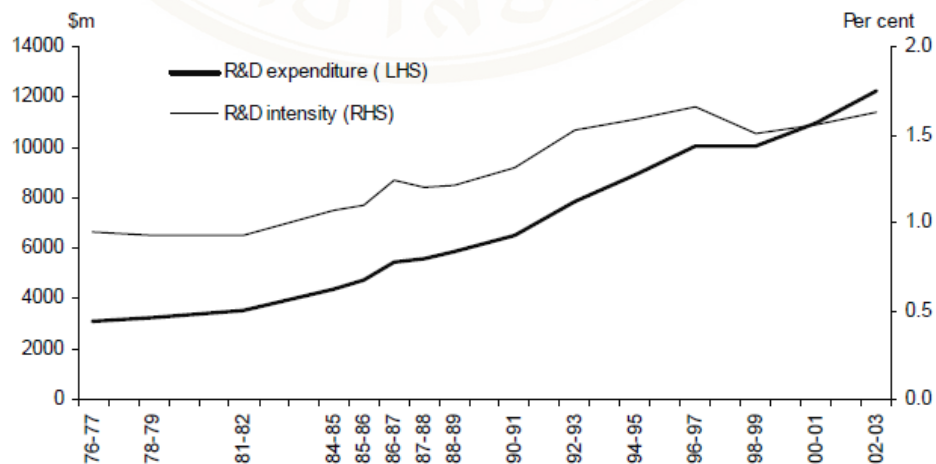


Figure 2.2: Real gross expenditure on R&D and R&D intensity, between 1976-77 to 2002-03

*Data sources:* Commission estimates based on ABS (*Research and Experimental Development, All Sector Summary, Australia, Cat. No. 8112.0, various issues*); ABS (*Australian System of National Accounts, Cat.No. 5204.0*).

Researchers and policymakers have long been interested in R&D because of its possible impact on economic growth or GDP. There has been several numbers of studies of R&D expenditure and the effects to the nation (Fraumeni and Okubo 2002, ABS 2004, Robbins 2006, Edworthy and Wallis 2006). If R&D was treated as an investment, estimates of output would be higher. ABS (2004) suggested that Australia's GDP would lift roughly by 1.5 percent. Moreover, Fraumeni and Okubo (2002) studied the effect of R&D by treating it as investment rather than current expenditure. Their analysis showed that, in economic and productivity growth, R&D is a significant contributor. The lowest contribution of R&D for 1961-2000 is 4 percent of overall GDP growth rate and the highest is 15 percent. They estimated that the effects of capitalization, such as R&D, would increase the wealth of U.S. by 2 percent.

Table 2.1 Contribution of return to R&D capital to growth in adjusted GDP alternative scenarios: Lowest contribution, base case, and highest contribution (as a percent of GDP growth rate). From Fraumeni and Okubo 2002

Period	Lowest	Base case	Highest
1961-66	4	11	12
1967-73	6	12	14
1974-95	4	10	17
1996-2000	3	9	12
1961-2000	4	11	15

Fraumeni and Okubo (2002) also determine the rate of return to privately funded R&D using selected eight studies.

Table 2.2 Estimated rates of return to private R&amp;D. From Fraumeni and Okubo 2002

Source	Private Return	Social Return
Sveikauskas (1981)	7-25%	50%
Bernstein and Nadiri (1988)	10-27%	11-111%
Bernstein and Nadiri (1991)	15-28%	20-110%
Nadiri (1993)	20-30%	50%
Mansfield et al. (1997)	25%	56%
Goto and Suzuki (1989)	26%	80%
Terleckyj (1974)	29%	48-79%
Scherer (1982, 1984)	29-43%	67-147%

Table 2.2 is the estimated rates of return to private R&D from the lowest to the highest private rate-of-return. These percentages of private return reflect the returns received by the innovator or the one that sponsor the R&D, whereas, the percentages of social return include the spillover benefits. Private rates of return range from 20 to 30 percent. For social rates of return, it is higher but it also had a wider range of 30 percent to 80 percent. However, table 2.2 is weight heavily too much on industry studies of direct and indirect returns. The estimates are unreliable because they depend too much on indirect returns to R&D on the amount of complementary investment (Sveikauskas, 2007). Nevertheless, these studies showed that R&D really does have positive return to the firms, industries, or social.

According to Battelle Memorial Institute (Battelle, 2010), the world's largest independent research and development organization, more than 60 percent of the global R&D spending came from U.S., Japan, China, and India. This shows that powerful countries do have concerns in R&D.

For OECD, the changed of gross domestic expenditure on R&D (GERD) do affect its GDP (figure 2.2). As you can see, the peaks of GERD and GDP lines are relatively at the same time.

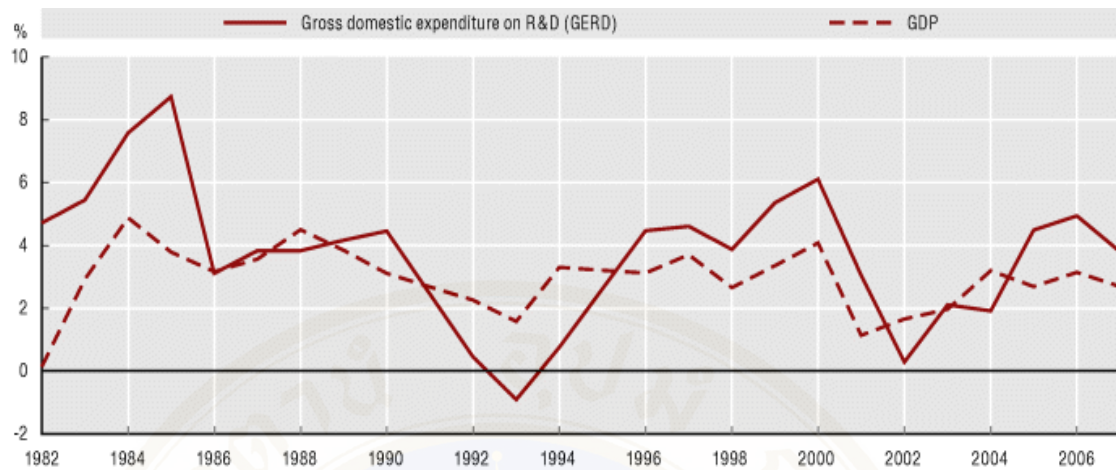


Figure 2.3: R&D growth over the business cycle, OECD, 1982-2007

Source: OECD iLibrary, <http://dx.doi.org/10.1787/742000505178>

In the research of Jan Van Hove, the trade-related R&D spillovers have a significantly positive impact on bilateral exports (Hove, 2008). This shows the importance of R&D because exports have a direct impact on GDP.

## CHAPTER III

### METHODOLOGY

#### 3.1 The Model

$$\log(GDP) = \alpha_i + \beta_1 \log(LF) + \beta_2 \log(S) + \beta_3 \log(R\&D) + \gamma_t \quad (\text{the equation})$$

Terms definition:

<i>GDP</i>	Gross domestic product of each country.
<i>LF</i>	Labor participation rate.
<i>R&amp;D</i>	Research and development expenditure (rate).
<i>S</i>	Gross domestic savings.
$\alpha_i$	Dummy variable (countries).
$\gamma_t$	Dummy variable (years).

This research used the linear regression as a tool to analyze the relationship between GDP and the selected variables, which included R&D expenditure rate. There are three types of variables in the model: dependent variables, independent variables, and dummy variables.

The model in this research is based on the study of Wong, Toh, and Ho (2009) and the R&D Capital Stock model (Griliches and Lichtenberg, 1984).

The selected variables are GDP, labor force, gross saving, and R&D expenditure rate. This research emphasize on analyzing the effect of R&D expenditure rate on GDP.

Here are the descriptions of each GDP component:

Gross domestic product (GDP) is a measure of the market value for all of the goods and services produced in a country in a specific time period, generally per annum. It is one of the indicators that used to measure the well-being of a country's economy. GDP is usually a comparison to the previous time. For example, if the year-to-year GDP is up 1%, it means that the economy has increased by 1% from the last year. The variable used in STATA will be GDP (constant 2000 US\$).

Labor force (LF), is a nation's combined workforce. Normally, labor force contains both employed and unemployed workforce. In this experiment, it only contains employed workforce. The labor force is the labor participation rate. The unit is percentage of total population workforce with age of 15 and above. This unit means the legal workforce.

Gross domestic savings (S), are income not spent. Putting money in a bank or pension plan is one of many methods for saving. It is to save for the future. Saving and investing are closely related. By not using income to buy goods and services, it provides resources for investment. Investment is to put money for goods or services to be used for future production. For GDP, investment could be business investment, for example, in equipment and does not include exchanges of existing assets. However, saving does not always link to increase investment. If savings were not planned wisely, it will be devalued according to the inflation. The most common way of saving would be depositing the money into a financial intermediary like a bank. The variable used in STATA will be gross domestic savings (% of GDP).

Research and Development costs (R&D costs) are the costs a company incurs in process of developing and introducing new products (goods and services) to market. In this experiment, these costs are considered as investments and will be put as one of the independent variables for calculating GDP. It is the one we are focusing on to the effect it caused to GDP. By looking at the results, we could determine whether increasing the R&D expenditure rate is useful to increase the nation's GDP or not. The variable used in STATA will be research and development expenditure (% of GDP).

Dummy variables,  $\alpha$  and  $\gamma$ , also known as an indicator variable, will take the values of 0 or 1 to verify the presence of the data set in a categorical variable way. In this experiment, the dummy variable will be the country and the year.

The program STATA 11 will be used in order to get the linear regression. The coefficient (Beta,  $\beta$ ) of each variable will be present along with their t-value and p-value, as well as the r-squared. The final results will be concluded via the results table from STATA.

### 3.2 The Command

The command used in the experiment was not 'regress' but 'xtreg'. What is xtreg and how is it differing from regression? In STATA, xtreg function is to fit regression models to the panel data (multi-dimensional data). In particular, xtreg with the 'fe' option, it uses fixed-effects within regression estimator. The fixed variables are countries and years.

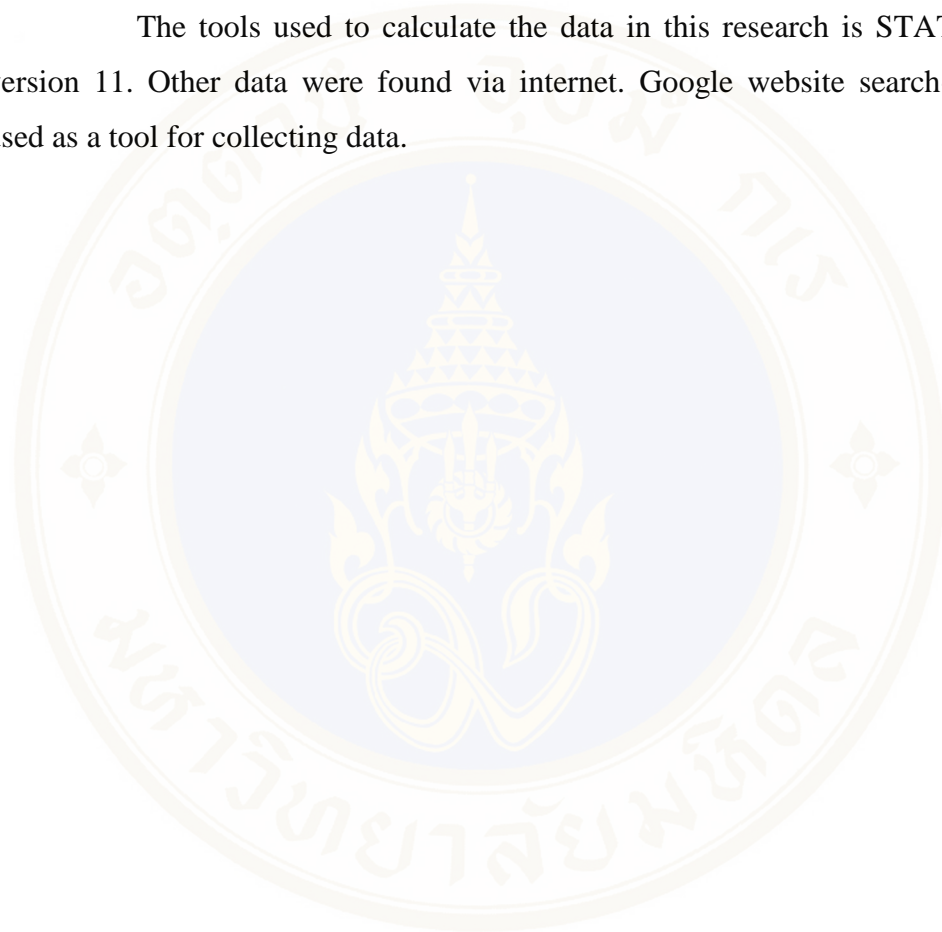
In fixed-effects, there will be three r-squared; within, between, and overall. R-squared 'within' is the r-squared from the mean-deviated regression; ordinary r-squared. R-squared 'between' is the r-squared computed by fitted values using the fixed-effects parameter vector and the within-individual means of the independent variables. Then calculates the r-squared as the squared correlation between those predicted values and the within-individual means of the original y variable. R-squared 'overall' computes fitted values using the fixed-effects parameter vector and the original, untransformed independent variables. Then calculates the r-squared as the squared correlation between those predicted values and the original, untransformed y variable.

### 3.3 Data

The dependent variable and independent variables that were used in this experiment are the data set from World Development Indicators (WDI), merge 5. World Development Indicators (WDI) is the World Bank's most popular dataset used

in economic statistic. The WDI includes data over one-thousand indicators spanning from 1950 to 2010. In this experiment, only nine variables were selected to be used in the equation to calculate for linear regression. The name and summary of the chosen variables can be found on Table 4.1. In Table 4.1, the range year is from 1950 to 2010 but the range used in this experiment is only between 1996 and 2006.

The tools used to calculate the data in this research is STATA program version 11. Other data were found via internet. Google website search-engine was used as a tool for collecting data.



## CHAPTER IV

### RESULTS AND ANALYSIS

#### 4.1 Descriptive statistics

This section will present the summary of the selected data variables, as well as, the finding of the experiment. Table 4.1 exhibits the label of the four variables used in the equation to calculate for the linear regression. Table 4.2 shows the regression coefficients, standard errors, t-values, p-values, and 95% confident intervals of all the independent variables.

Table 4.1 also illustrates the summary statistics of the variables used in the equation to estimate the linear regression. There are four variables in table 4.1. The table presents the variables' name, number of observations, standard deviation, minimum value, mean value, and maximum value of each variable. All the variables in table 4.1 have the minimum and maximum range in the positive area, except for gross domestic savings. However, the mean of gross domestic savings is in the positive area. The range year of the dataset is 1950 to 2010. Nevertheless, the actual range year of the data used in this experiment is 1996 to 2006, only.

Table 4.1: The summarize of the selected nine variables used in the equation.

Variable	Obs.	Std. Dev.	Min	Mean	Max
GDP (constant 2000 US\$)	8059	2.80e+12	7776779	5.79e+11	4.03e+13
Labor force, total	5623	2.91e+08	24092.98	7.09e+07	3.10e+09
Gross domestic savings (%GDP)	7361	15.31825	-86.4486	17.71396	88.86061
R&D (%GDP)	921	0.920973	0.0061673	1.015512	4.772824

## 4.2 Results

**Table 4.2: the regression of the equation**

R-sq: within = 0.8445; between = 0.9504; overall = 0.9370

	<i>Coef.</i>	<i>Std. Err.</i>	<i>t</i>	<i>P&gt; t </i>	<i>95% Conf. Interval</i>
<b>Log GDP (constant 2000 US\$)</b>					
<b>Log Labor force, total</b>	0.0941084	0.0533909	1.76	0.078	-0.0107094 0.1989262
<b>Log Gross domestic savings (current, US\$)</b>	0.121296	0.0065851	18.42	0.000	0.108368 0.134224
<b>Log R&amp;D (%GDP)</b>	0.0563679	0.0109607	5.14	0.000	0.0348497 0.0778862
<b>cons</b>	21.13615	0.8947355	23.62	0.000	19.37959 22.89271

#### 4.2.1 Table Analyzing

Based on equation in the previous chapter, Table 4.2 provides the regression results from including R&D expenditure rate as a part to calculate GDP during the year 1950 to year 2010, Table 4.2 is the result from using STATA program to calculate. The R-square of the equation is at 84.45%. This statistical measurement shows that the regression line is well fit for the real data points. It is very close to 1. It tells that the model is likely to be able to predict the future out come by 84.45 percent. Considering t-stat at 95% confidence interval, the results show that the t-stats of all regression coefficients (betas) of the variables (excluding dummy variables), except for labor force, are found to be significant (more than 3 or less than -3). To ensure the significant, their p-values are also present in the table, which are very low p-values (0.000). This shows that gross domestic savings and R&D expenditure rate are significant at 5% level. As for labor force, the t-stat of its beta is not significant. To confirm the significant, its p-value was examined. The p-value of labor force's beta is at 0.078. It can be said that the beta of labor force is significant at 10% level.

T-stat and p-values give the firm sure that these variables are significant to the GDP. Moreover, the regression coefficient of log R&D expenditure rate is in a positive relationship. In addition, the 95% confidence interval of R&D expenditure rate's regression coefficient is in a positive zone. This means that with two standard deviation from the mean, the effect of R&D will be in positive range, it will always give an addition to the GDP. This also goes for gross domestic savings. However, it cannot be applied for labor force. The 95% confidence interval for labor force is between -0.0107094 and 0.1989262.

The logarithm is used in this experiment. The logs were applied to both dependent variable and independent variables. This makes it easy to interpret the meaning of the regression coefficient.

The regression coefficient of labor force is 0.0941084. It is in a positive form. Therefore, if there is an increase in labor force by 1 percent, the nation's GDP will also increase by 0.0941084 percent. This suggests that, the higher the labor force, the higher the nation's GDP will be.

The regression coefficient of gross domestic savings is 0.121296. The number looks really small, but if you really look into the mean, it is not that small. The

meaning of the result is that if gross domestic savings increased by 1 percent, the nation's GDP will be increased by 0.121296 percent. Some article suggested that if people increased their portion of savings, the GDP will be decreased. The result in this experiment recommend otherwise.

Lastly, but the most important in this experiment, the regression coefficient of research and development is also a positive value. Its beta is 0.0563679. The number looks small with the same reason as the beta of savings. Therefore, the meaning of the result is that if R&D expenditure rate increased by 1 percent, the nation's GDP will be increased by 0.0563679 percent. This suggests that R&D expenditure rate is a significant variable that will help in increasing the nation's GDP.

#### **4.2.2 Comparing with Other Articles**

The positive regression coefficient of R&D expenditure rate in this experiment supports the studies of Griliches (1998), Koenig (2000), Fraumeni and Okubo (2002), ABS (2004), Robbins (2006), and Edworthy and Wallis (2006) that R&D expenditure has a significant positive effect on the growth rate or GDP.

Using the information from table 4.2, if the R&D expenditure rate is increased, the nation's GDP will also increase. For example, Thailand's R&D expenditure rate in 2003 increased from 2002 by 0.01788794%. If R&D expenditure rate was included in calculating for GDP, Thailand's GDP in 2003 should be higher by 0.0001%. The number is so small because Thailand spent only small number on R&D. However, this number support what Fraumeni and Okubo (2002) and ABS (2004) had stated. ABS (2004) suggested that Australia's GDP would lift roughly by 1.5 percent, as well as, the studied of Fraumeni and Okubo (2002) show that it would increase the wealth of U.S. by 2 percent.

## CHAPTER V

### CONCLUSION

The purpose of conducting this experiment was to show the importance of research and development and its effect on economic growth in terms of GDP during the period of year 1950 to year 2010, by including the R&D variable into the equation when calculating for GDP. The two main objectives in this research was to examine any significant effect of R&D expenditure rate on the country's GDP and to indicate whether increasing or decreasing the R&D expenditure rate will be beneficial on improving the GDP in overall. The objectives have been examined and analyzed.

From the analytical results, table 4.2, research and development expenditure (in term of percentage of GDP) shows that its regression coefficient contained a positive relationship to GDP and it was significant for both t-value and p-value. Moreover, its 95% confidence interval was in the positive range. This indicated that, by all means, increasing in R&D expenditure rate will only result as gaining benefit. Here is the linear equation for GDP that include the R&D expenditure rate:

$$\log(GDP) = 21.13615 + 0.0941084\log(LF) + 0.121296 \log(S) + 0.0563679 \log(R\&D)$$

The findings in this experiment confirmed the significant of R&D expenditure rate upon the growth of a country's GDP. By looking into the beta of R&D expenditure rate, if R&D expenditure rate is increased by 1 percent, the nation's GDP will be increased by 0.0563679 percent. However, do always remember that this number is not always straight forward. The reason was that there still has an effect of R&D spill over to the neighbor countries or even across all over the world. The concept of R&D spill over will be a positive relationship to everyone, if and only if, we all share for the benefits. Moreover, Thailand should spend more on R&D.

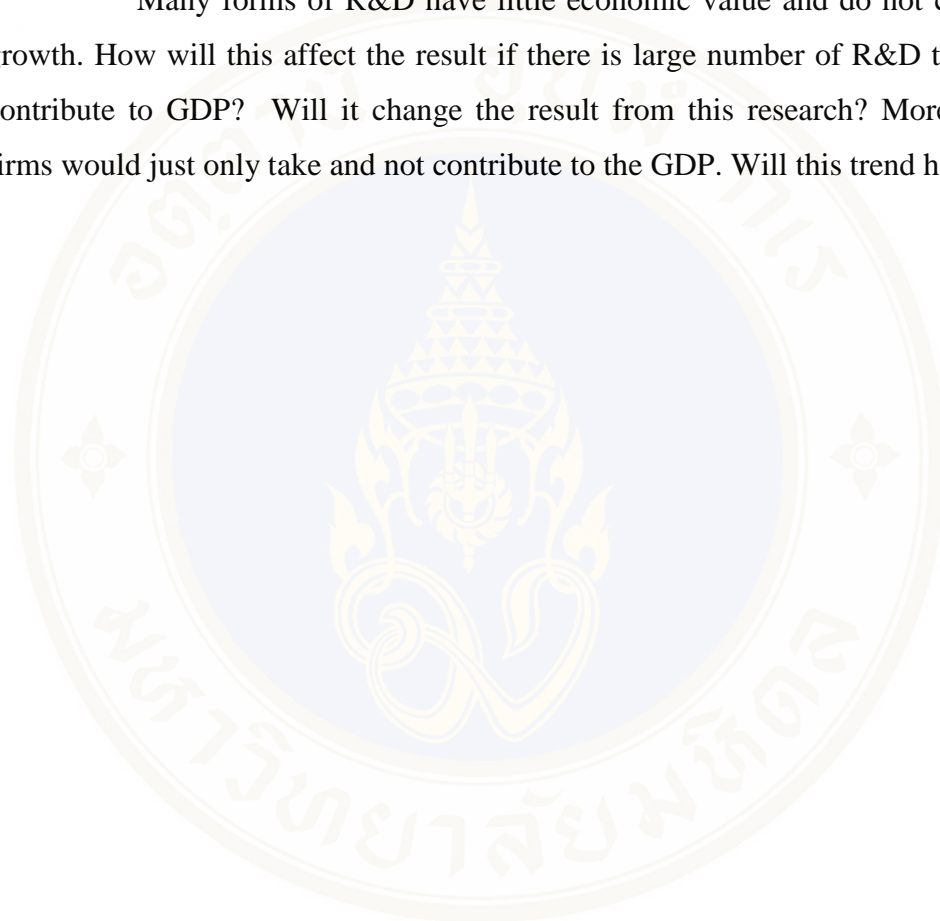
Because the amount spent on R&D has a direct affect to how much the GDP will be increased.

In conclusion, R&D expenditure may seem to be a cost rather than an investment, but increasing in R&D expenditure rate does proved to help on improving the nation's GDP. It would be a good idea to increase Thailand's R&D expenditure rate to improve the GDP.



## **FUTURE STUDY**

Many forms of R&D have little economic value and do not contribute to growth. How will this affect the result if there is large number of R&D that does not contribute to GDP? Will it change the result from this research? Moreover, many firms would just only take and not contribute to the GDP. Will this trend happen?



## BIBLIOGRAPHY

- ABS (2004), 'Capitalising Research and Development in the National Accounts', Paper prepared by the National Accounts Research Section for the Canberra II Group meeting, Washington, 17-19 March.
- Battelle (2010), '2011 Global R&D Funding Forecast', R&D Magazine, December.<http://www.battelle.org/aboutus/rd/2011.pdf>
- BEA (2010), 'News Release', Bureau of Economic Analysis, U.S. Department of Commerce, June.[http://www.bea.gov/newsreleases/general/rd/2010/pdf/R&DSA\\_2010.pdf](http://www.bea.gov/newsreleases/general/rd/2010/pdf/R&DSA_2010.pdf)
- Edworthy, E. and Wallis, G. (2006), 'Research and Development as a Value Creating Asset', Paper presented to the Comparative Analysis of Enterprise (Micro) Data Conference, Chicago, September.
- Fraumeni, B. and Okubo, S. (2002), 'R&D in the National Income and Product Accounts: A First Look at its Effect on GDP', Paper presented at the Conference on Measuring Capital in the New Economy, WP2002-01, Bureau of Economic Analysis, Washington, April.  
<http://www.nber.org/chapters/c10624.pdf>
- Griliches, Z. (1992), 'The search for R&D spillovers', *Scandinavian Journal of Economics*, vol. 94, pp. 29–47.
- Griliches, Z. (1998), 'R&D and Productivity: The Econometric Evidence', University of Chicago Press. <http://www.nber.org/chapters/c8344.pdf>
- Griliches, Z. and F Lichtenberg (1984). 'R&D and productivity growth at the industry level: Is there still a relationship?' In *R&D, Patents, and Productivity*, Z Griliches(ed.). Chicago: University of Chicago Press.
- Hove, J. V. (2008) "The Impact of R&D Spillovers on Export Value: Does the Transmission Channel matter?" Working Paper 2008.3, [http://www.infer-research.net/files\\_publications/WP2008.3.pdf](http://www.infer-research.net/files_publications/WP2008.3.pdf)

- Koenig, Evan (2000), "Productivity Growth," Federal Reserve Bank of Dallas *Expand Your Insight*, March 1, <http://www.dallasfed.org/eyi/usecon/0003growth.html>
- Nationmaster.com (2011) [http://www.nationmaster.com/graph/eco\\_res\\_and\\_dev\\_exp\\_of\\_gdp-economy-research-development-expenditure-gdp](http://www.nationmaster.com/graph/eco_res_and_dev_exp_of_gdp-economy-research-development-expenditure-gdp)
- OECD (2003), 'Proposed Standard Practice for Surveys of Research and Development (Frascati Manual)', OECD, Paris. <http://titania.sourceoecd.org/vl=22011746/cl=11/nw=1/rpsv/factbook/070101.htm> 20.09.2011
- Parham, D. (2007), 'Empirical analysis of the effects of R&D on productivity: Implications for productivity measurement?' Productivity Commission, May. <http://www.oecd.org/dataoecd/10/1/37511005.pdf>
- Robbins, C. A. (2006), 'Linking Frascati-based R&D Spending to the System of National Accounts', Paper prepared for the Conference of the Group on Measurement of Non-financial Assets, Canberra, March 29th – April 1 2005.
- Shanks, S. and Zheng, S. (2006), 'Econometric Modelling of R&D and Australia's Productivity', Staff Working Paper, Productivity Commission, Canberra, April. <http://unpan1.un.org/intradoc/groups/public/documents/apcity/unpan027017.pdf>
- Sveikauskas, Leo. (2007), "R&D and Productivity Growth: A Review of the Literature," Bureau of Labor Statistics Working Paper 408, U.S. Department of Labor, U.S. Bureau of Labor Statistics, Office of Productivity and Technology, September 2007  
<http://www.bls.gov/osmr/pdf/ec070070.pdf>
- Wong, PohKam, Toh, Mun-Heng, and Ho, Yuen Ping (2009), 'The Impact of R&D on the Singapore Economy: An Empirical Evaluation,' *The Singapore Economic Review*, Vol. 54, No.1.

## **BIOGRAPHY**

<b>NAME</b>	PhuditHarnthamtong
<b>DATE OF BIRTH</b>	21 May 1983
<b>PLACE OF BIRTH</b>	Bangkok, Thailand
<b>INSTITUTIONS ATTENDED</b>	Mahidol University International College, 2004-2008 Bachelor of Science (Biomedical Science) Mahidol University, 2009-2012 Master of Business Administration (Business Modeling and Analysis)
<b>HOME ADDRESS</b>	43/33 Preamsook Village, Lad Phrao 63, SaphanSong, Wangtonglang, Bangkok 13010 Tel. +66 81 639 5445 Email: topo_wind@hotmail.com
<b>PUBLICATION / PRESENTATION</b>	“The Effect of R&D on GDP: Cross- Country Evidence” Mahidol University Presentation on February 5, 2012