Charles University in Prague

Faculty of Social Sciences
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MASTER THESIS

Determinants of pharmaceutical expenditures on cardiovascular diseases

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Declaration of Authorship

I hereby declare that I elaborated this master thesis independently, using only the listed literature and resources.

Prague, January 7, 2013

Signature

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I take opportunity to sincerely acknowledge to my parents and fiancé for their love and support. This work would not have been possible without their support and encouragement.

Abstract

The thesis analyzes the determinants of pharmaceutical expenditures on cardiovascular diseases with particular focus on Central Europe. We show how the pharmaceutical expenditure varies across the countries. We try to empirically verify that factors such as age, GDP, total health expenditure, education and prevalence of a particular disease cause the variation. Applying the fixed effect model on selected countries in the period 2000–2009, we find that the increase in pharmaceutical expenditures on cardiovascular diseases is explained mainly by aging population and prevalence of the diseases. Additionally, countries with higher GDP tend to also have somewhat higher pharmaceutical expenditures on cardiovascular diseases.

Key words

Pharmaceutical expenditures, cardiovascular diseases, GDP, health expenditure, fixed effect model, prevalence of a disease, aging of population.

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Acronyms

CEE	Central and Eastern Europe
CVD	Cardiovascular Disease
DDD	Defined Daily Dose
EU	European Union
FE	Fixed Effects
FGLS	Feasible Generalized Least Squares
GDP	Gross Domestic Product
OECD	The Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
R&D	Research and Development
RE	Random Effects
USD	United States Dollar

Master thesis proposal

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Proposed Topic: Determinants of pharmaceutical expenditures on cardiovascular diseases

Topic Characteristics:

Pharmaceuticals are one of the largest components of expenditure on health-care. The majority of drug expenditure is spent on treatments. Along with the rise of treatment expenditure, the availability and costs of medicaments have also increased, especially for serious diseases such as heart stroke or cancer. Thus, finding the optimal drug financing policy has become an essential issue. My thesis will expand the current research on determinants of pharmaceutical expenditure. I will attempt to empirically verify my hypotheses on recent data and focus on the policy recommendations relevant for the Czech Republic.

Hypotheses:

1. Factors such as age, income, health expenditure and burden of particular disease can explain cross-country variation of pharmaceutical expenditure on certain diseases.
2. Different economic policies on pharmaceuticals have significant effect on pharmaceutical expenditures.
3. Economic policy on pharmaceuticals in the Czech Republic is relevant if various factors are accounted for.

Methodology:

I will use comparative analysis to show how countries vary in pharmaceutical expenditures and how they are rising in all countries over the time. To examine whether the factors such as age, income, health expenditure and burden of particular disease can explain cross-country variation, I will use a multivariate regression analysis. I will also analyze different pharmaceutical policies and try to draw conclusions relevant for the Czech Republic. As a source of data, I will primarily use OECD health data.

Outline:

1. **Theoretical Frameworks:**
    - 1.1. Pharmaceutical markets with all its specific characteristics.
    - 1.2. Review of empirical literature
2. **Methodology and Models:**
    - 2.1. Analysis of factors influencing pharmaceutical expenditure.
    - 2.2. Comparative analysis of different pharmaceutical policies
3. **Empirical Results:**
    - 3.1. Testing hypotheses
    - 3.2. Interpretation of results
    - 3.3. Policy implications relevant for Czech republic

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Author

Supervisor

1. Introduction

Good health is considered as the commodity without which all the others have no value. In the last decades, a healthy lifestyle has become particularly important around the world with people caring more about improving the quality of their lives. New technologies, other people's experience and development of the medical science have made more reachable and affordable for people to attain a satisfying health status. There are many factors influencing the demand for healthcare which are a result of the heterogeneous and individual-specific nature of the health itself. Growth and aging of the population, along with easy access to healthcare are considered as the most important determinants that lead to a significant increase in demand for healthcare. Moreover, technologies are constantly being developed and treatments improvements are becoming more advanced and therefore much more expensive for the average individual consumer. All these factors lead to rising health expenditures. During the last years, healthcare spending has outpaced economic growth in OECD countries.

Information technology enables better awareness of patients concerning their health status as well as it causes providers to lose the monopoly over health information. Patients are becoming more emancipated and more responsible regarding their own health. Heterogeneous patients' preferences (regarding the treatment type, risk aversion, waiting time, etc.) together with different patients' needs make the healthcare market very complex and individual specific.

Nowadays, many diseases may be prevented, cured and managed effectively by using various drugs. Thus, pharmaceuticals are one of the largest components of total health expenditures. There are differences in pharmaceutical spending across countries, but in all analyzed countries expenditures on medical goods still continue to rise. It is expected that the growth in pharmaceutical expenditures will continue

over the next decade.[1] Hence, it is very important for policy makers to understand the reasons that lie behind the increased pharmaceutical expenditures in order to better evaluate the benefits that might come from alternative allocation of health resources.

Among various pharmaceutical goods, drugs for cardiovascular diseases are on the very top place of bestseller drugs in all over the world. Cardiovascular diseases (CVD) appear to be the biggest cause of deaths worldwide. CVD cause nearly half of all death in Europe (48%) and in the EU (42%).[2] These diseases have significant economic implications from a health policy perspective.[3] Many patients suffering from CVD are chronic patients obliged to use drugs to prevent an unexpected death. For such patients drug therapy continues for the rest of their lives. All these factors have led to a significant and constant growth in cardiovascular drug use and expenditures in the last decade. As a result of such growth, various questions relating to pharmaceutical expenditures on cardiovascular diseases have attracted attention of economists.

In the thesis we will show the cross-country variation in pharmaceutical expenditures and analyze the reasons of increased drug costs for cardiovascular diseases. The thesis contributes to the economic research in this area by analyzing a panel data for several countries. Based on our knowledge, no such complex economic analysis has been performed so far. Only few studies have assessed the effects of economic factors together with public health factors on pharmaceutical expenditures and from which only few examined the factors specifically for cardiovascular diseases.

The thesis is structured as follows: the following chapter introduces health data and statistics and gives the reader a picture of cross-country variation in pharmaceutical expenditures. It also describes the market for cardiovascular diseases in Central Europe and presents literature review with various views about increased

[1] Heffler, Smith et al. 2005
[2] European cardiovascular disease statistics, 2008
[3] Dickson and Jacobzone 2003

pharmaceutical costs. The third chapter describes pharmaceutical markets with all its unique aspects. After analyzing the demand and the supply side of the market, relevant features about the market failures and the government interventions are explained. The fourth chapter of the thesis is the empirical part, where we will present the methodology, data specification and results of our analysis. The very last chapter provides the interpretation of results followed by some discussion and conclusions.

2. Pharmaceutical expenditures

Pharmaceuticals are one of the largest components of total health expenditures. Pharmaceutical expenditures may include spending on prescription medicine and self-medication, often referred to as over-the-counter products. It also includes pharmacist's remuneration when the latter is separate from the price of medicine.[4]

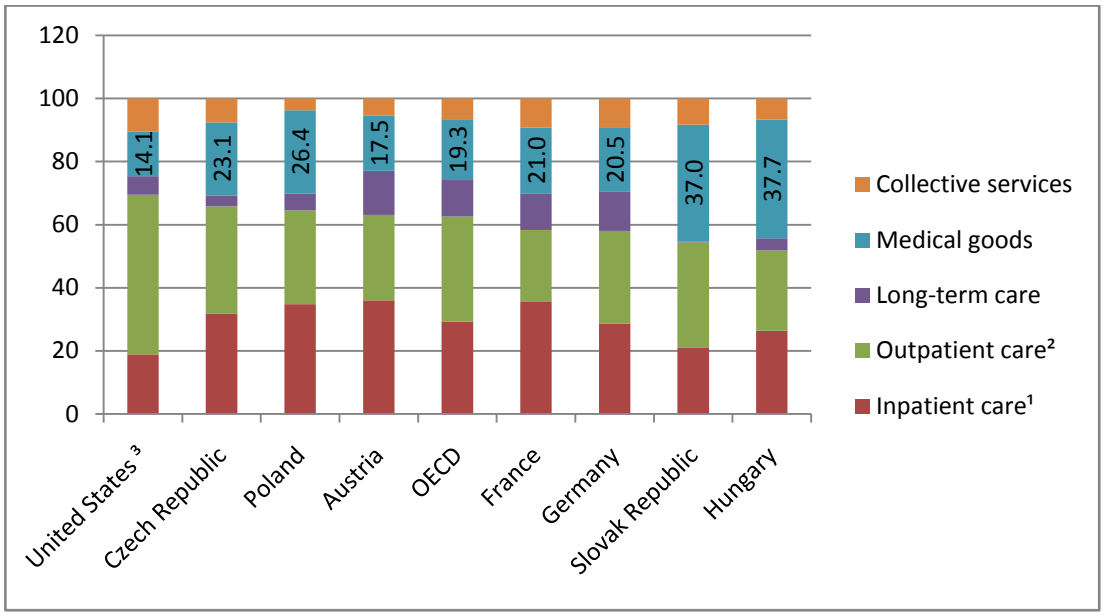
2.1 Overview of pharmaceutical expenditures

Pharmaceuticals and other medical non-durables are typically aggregated with expenditures on therapeutic appliances and other medical durables into a cost category of medical goods. However, the majority of medical goods expenditures are accounted for by pharmaceuticals. Pharmaceutical costs are pivotal to healthcare expenditures, as medical goods represent one of the largest cost component of health care spending; accounting for more than 19% of total health spending for OECD average in 2009 (**Figure 1).**

The importance of pharmaceuticals is even more important in emerging countries than in developed countries. However, there are significant differences between individual countries (**Figure 1**).The proportion of medical goods on total health spending in the Czech Republic (23.1%) and Poland (26.4%) is only slightly higher than the OECD average (19.3%), while in the Slovak Republic (37.0%) and Hungary (37.7%) medical goods account for more than a third of all health spending.

[4]OECD (2011), *Health at a Glance 2011: OECD Indicators*, OECD Publishing

Figure 1: Current health expenditure by function of health care in 2009



Source: OECD (2011), "OECD Health Data: Health expenditure and financing", OECD Health Statistics (database).

Notes: (1) Impatient care refers to curative-rehabilitative care in in-patient and day-care settings.

(2)Outpatient care includes home-care and ancillary services.

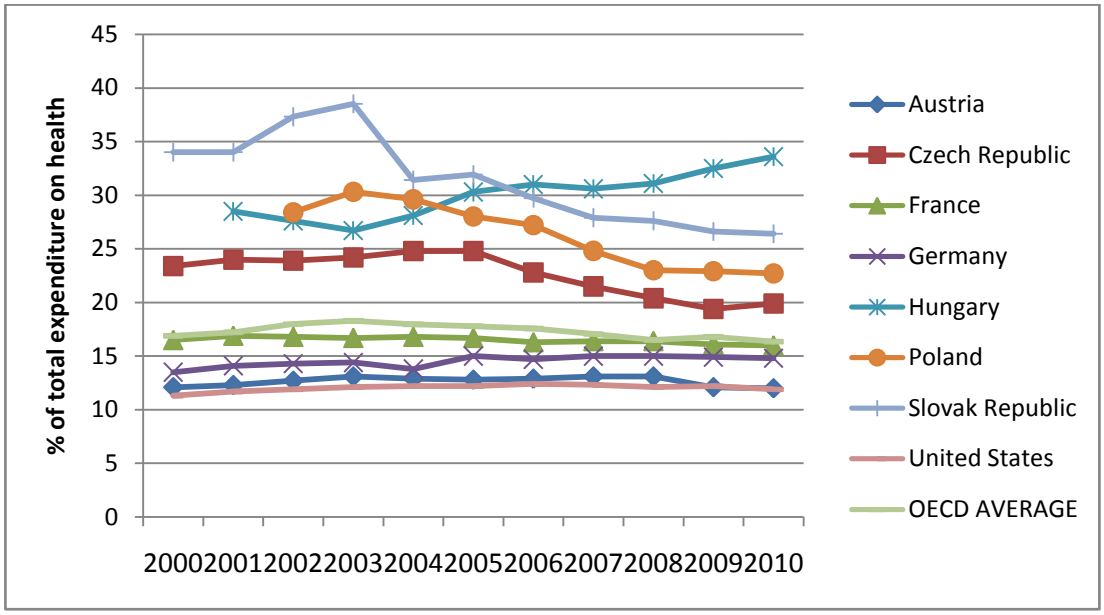
(3) Inpatient services provided by independent billing physicians are included in outpatient care for the United States.

Since 2000 pharmaceutical expenditure as a proportion of total health expenditure has increased in most of the countries[5] (**Figure 2**). There was a decline in the period 2005–2008 in the Czech Republic but from 2009 it began to grow again. In the Slovak Republic there was a sharp drop in 2004 and it continued to decrease. The biggest increase in pharmaceutical expenditures has been encountered in Hungary, where a slight decrease was observed only in 2002–2003.

The data on pharmaceutical expenditure per capita (PPP$) reveals that pharmaceutical expenditure in absolute terms has risen in all countries (**Figure 3**).

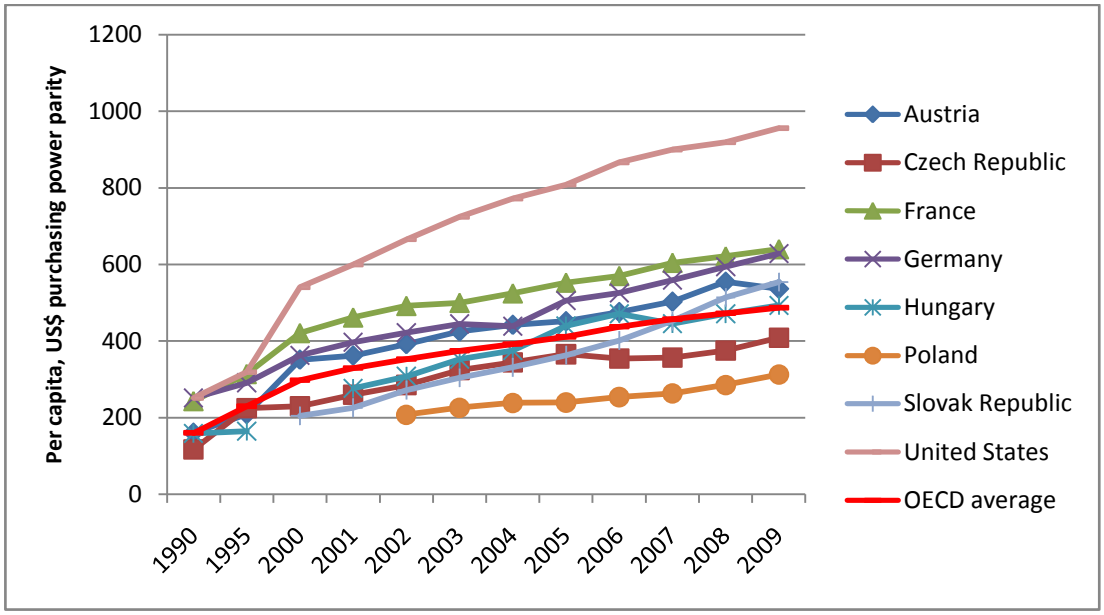
[5]Health trends in the EU, 2010.

Figure 2: Pharmaceutical expenditure as a % of total expenditure on health, 2000-2009



Source: OECD (2011), "OECD Health Data: Health expenditure and financing", OECD Health Statistics (database).

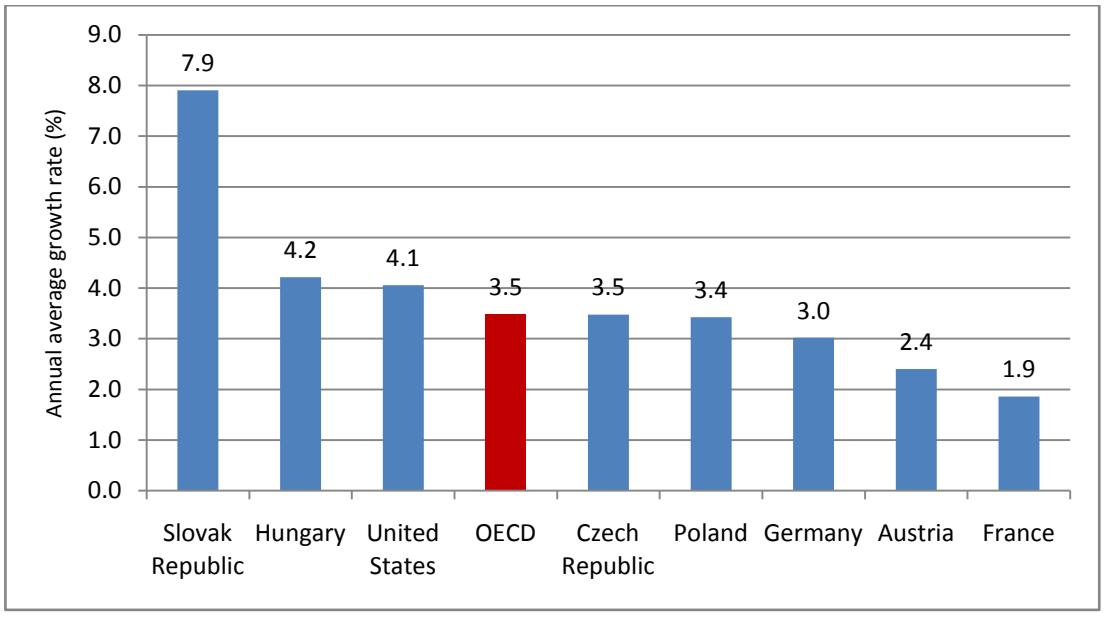
Figure 3: Expenditures on pharmaceuticals and other medical non-durables 1990–2009



Source: OECD (2011), "OECD Health Data: Health expenditure and financing", OECD Health Statistics (database).

Since 1990, average spending on pharmaceuticals has risen by almost 30% in real terms.[6] In 2009 pharmaceutical expenditures per capita as OECD average was 487 USD[7]. As we can see in **Figure 3**, the United States, France, Germany, Austria, the Slovak Republic and Hungary are above this average, while the Czech Republic and Poland are below the average. However, also in these countries spending on medical goods continue to rise.

Figure 4: Annual average growth in real per capita pharmaceutical expenditure, 2000–2009



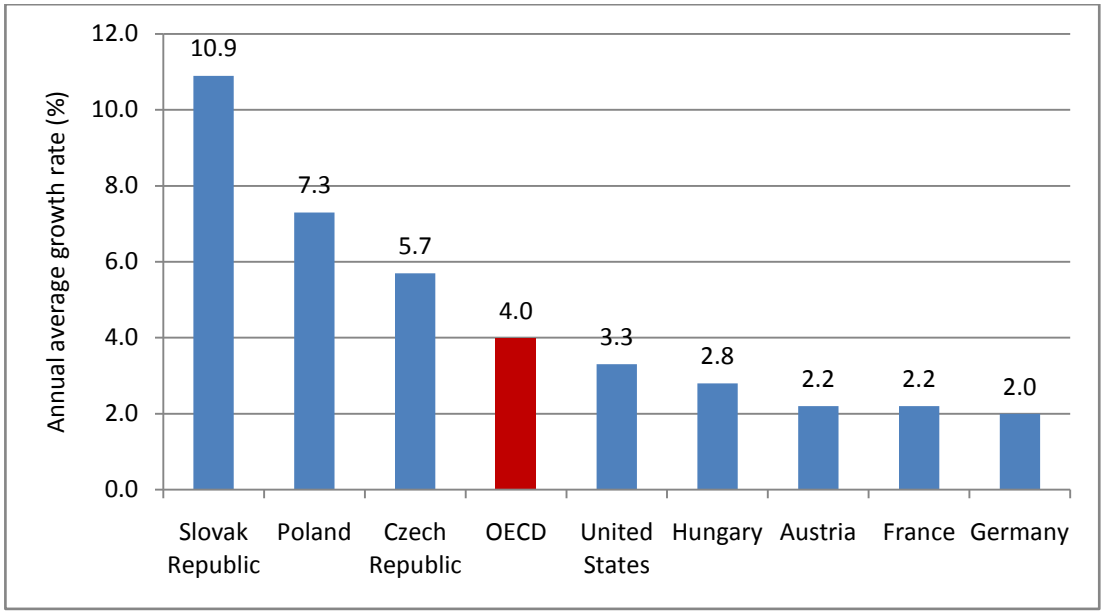
Source: OECD (2011), "OECD Health Data: Health expenditure and financing", OECD Health Statistics (database).

In the past, pharmaceutical spending in OECD countries had tended to rise at a faster rate than total health spending.[8] However, since 2000 the situation has changed. As we can see from **Figure 4** and **Figure 5,** between 2000 and 2009, real pharmaceutical expenditure grew by around 3.5% per year on average in OECD

[6] Health trends in the EU, 2010.
[7] OECD (2011), *Health at a Glance 2011: OECD Indicators*, OECD Publishing
[8] OECD (2011), *Health at a Glance 2011: OECD Indicators*, OECD Publishing

countries, while total health spending has increased by 4%.There are significant differences in pharmaceutical expenditures across countries, reflecting differences in consumption patterns and price levels. In the Slovak Republic the highest growth rate of pharmaceutical expenditures was encountered (7.9%), while in France, Austria and Germany the rate was relatively slow. In the Czech Republic the growth rate was exactly as the OECD average (3.5%).

Figure 5: Annual average growth rate in health expenditure per capita in real terms, 2000 –2009



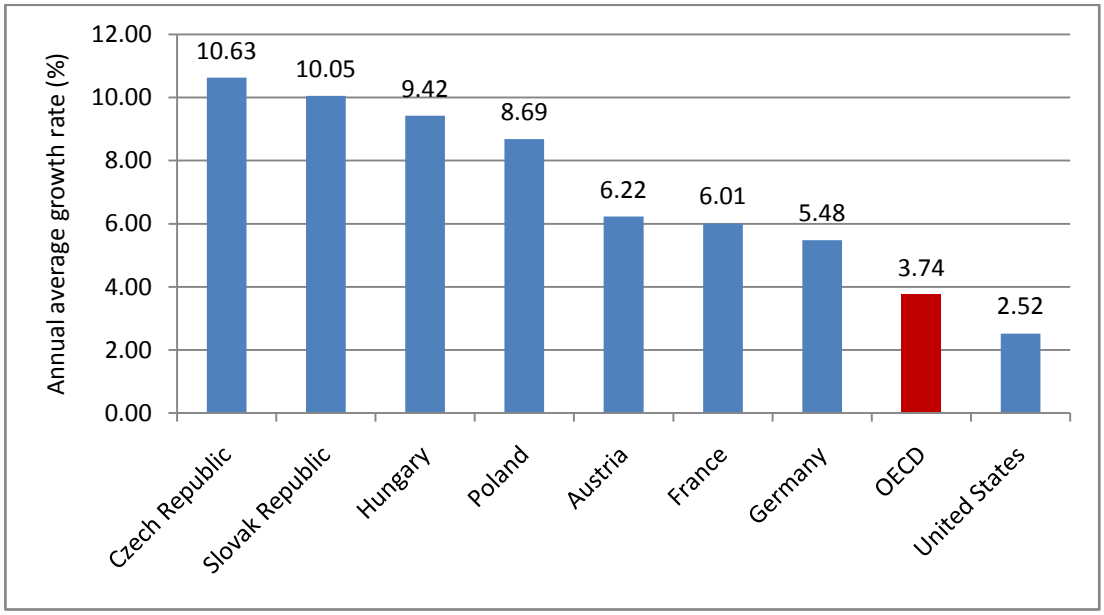
Source: OECD (2011), "OECD Health Data: Health expenditure and financing", OECD Health Statistics (database).

Note: Total expenditure on health measures the final consumption of health goods and services (*i.e.* current health expenditure) plus capital investment in health care infrastructure. This includes spending by both public and private sources on medical services and goods, public health and prevention programs and administration (OECD 2011).

Although health expenditures growth has outpaced GDP growth in some countries since 2000, the majority of below analyzed countries has had a higher GDP growth than the growth in total health expenditures (**Figure 5** and **Figure 6**).

The opposite has been true for OECD average, per capita health spending has grown by 4.0% annually on average while GDP has increased only by 3.7%. The reasons of higher growth of health care expenditures include technological progress in healthcare, economic development, demographic and other factors (Moroney and Kual 2003). Health expenditure growth in the Slovak Republic and Poland, for example, has been more than twice the OECD average since 2000; however, Austria, France and Germany have had relatively low growth rates.

Figure 6: Annual average growth of GDP per capita, 2000–2009

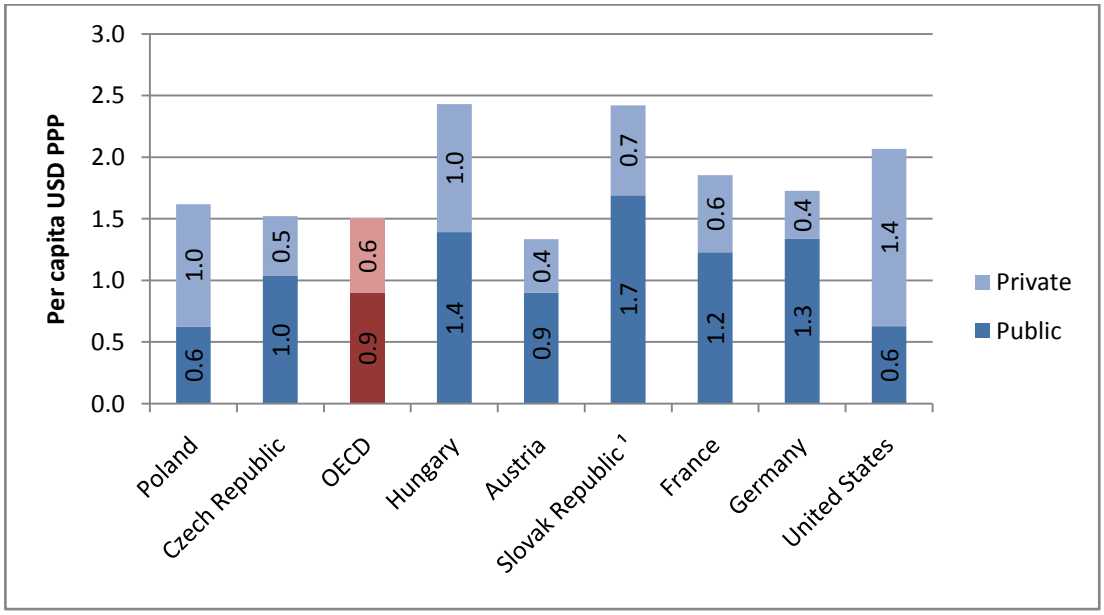


Source: OECD (2011), "OECD Health Data: Health expenditure and financing", OECD Health Statistics (database).

In the analyzed countries, the health care expenditures as a share of GDP have tended to rise strongly during economic recessions and more or less stabilize during the periods of economic expansion. Despite the attempt of countries to reduce health spending during the recessions, often those reductions were short term because of huge supply and demand of health services, which led health expenditures to grow rapidly (Scherer and Devaux, 2010).

Relative to the economy as a whole, in 2009 pharmaceutical expenditure accounted for 1.5% of GDP on average in OECD countries (**Figure 7**). From the analyzed countries, pharmaceutical spending as a share of GDP accounted for less than the OECD average in Austria, while it reached close to 2.5% of GDP in Hungary and the Slovak Republic.

Figure 7: Expenditure on pharmaceuticals per capita and as a share of GDP, 2009

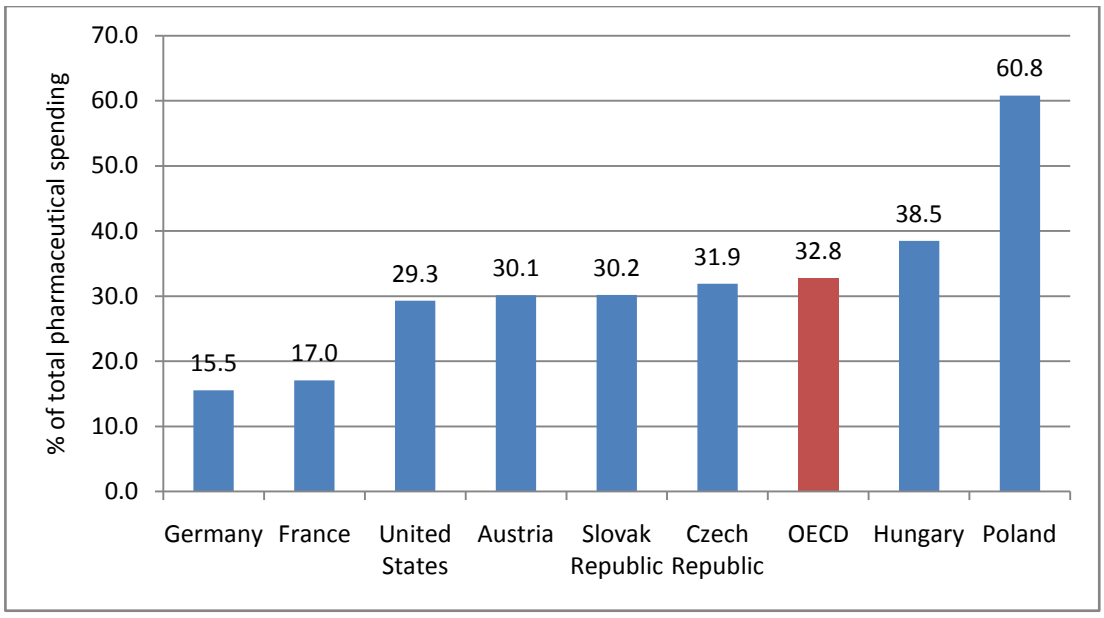


Source: OECD (2011), "OECD Health Data: Health expenditure and financing", OECD Health Statistics (database).

Notes: (1) The figure includes prescribed medicines only.

Expenditures for pharmaceuticals are financed through third-party payers in most OECD countries either through the public or private health insurance. A third of the total on average is covered from out-of-pocket expenditures (**Figure 8**), which is a much higher ratio than for physician and hospital services. In countries, such as Germany and France, the burden of pharmaceutical spending falling onto the households is less than 20%, while in Poland this ratio is around 60% of the total pharmaceutical spending. In the Czech Republic this ratio is 31.8%, which is slightly below the OECD average.

Figure 8: Out-of-pocket expenditure as a share of total pharmaceutical expenditure, 2009



Source: OECD (2011), "OECD Health Data: Health expenditure and financing", OECD Health Statistics (database).

Based on the above mentioned discussion medical goods in general and pharmaceuticals in particular represent an important share of healthcare expenditures in most countries. Since 1990, average spending on pharmaceuticals has risen by almost 30% in real terms. There are differences in pharmaceutical spending across countries, but in all analyzed countries spending continues to rise. Increased pharmaceutical expenditures contribute to an increase in overall healthcare spending. OECD data shows that healthcare spending has outpaced economic growth over the last ten years, even during the economic downturn. Expenditures for pharmaceuticals are financed through third-party payers in most OECD countries either as public or private health insurance. Pharmaceutical expenditure tends to be funded more from private sources; this is due to higher copayments on pharmaceuticals and because of lack coverage of pharmaceuticals under public insurance schemes (OECD, 2003b).

2.2 Pharmaceutical expenditures on cardiovascular diseases

In the pharmacology, a drug is a chemical substance used in the treatment, cure, prevention, or diagnosis of a disease or used to otherwise enhance physical or mental well-being.[9] As there exist a huge number of diseases that are covered by the pharmaceutical industry, in the same manner there are numerous drugs with different effects. That is, drugs may be prescribed for a limited duration curing the current and acute diseases or can be prescribed regularly for chronic disorders. Among the various pharmaceutical goods drugs for cardiovascular diseases are on the top of bestseller drugs in all over the world, implying the importance of its price and effect on the welfare of the individual. According to the pharmaceutical journal "Chemical & Engineering News" in 2011 top seller drug was Atorvastatina cholesterol-lowering medication marketed by Pfizer with sales of $12.5 billion.[10]According to Finkelstein (2008) a blockbuster drug is one that achieves acceptance by prescribing physicians not for the most acute event but most commonly for a highly prevalent chronic condition, when the patients often take the medicines for long periods or even for the rest of their life.

Cardiovascular diseases (CVD) are a class of diseases that involve the heart or blood vessels (arteries, capillaries and veins).[11]Cardiovascular diseases remain the biggest cause of deaths worldwide. CVD cause nearly half of all deaths in Europe (48%) and in the EU (42%).[12] According to the European cardiovascular disease statistics (2008), cardiovascular diseases were not only the main cause of the death in Europe but also the main reason of the year lost due to an early death. CVD caused more than 35% of years of life lost in Central and European countries.

Some research conclusions have put a stress on the significant differences in death and mortality rates between European countries. Death rates from

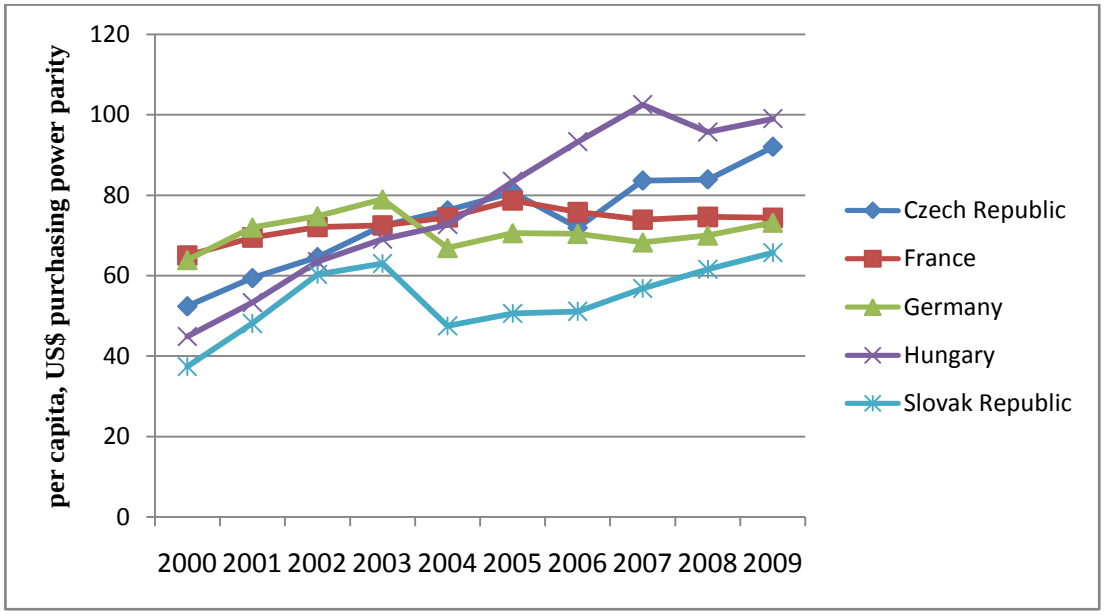
[9]Dictionary.com
[10]"Before the Storm". Chemical & Engineering News
[11] Maton, Anthea (1993).
[12]European cardiovascular disease statistics, 2008

cardiovascular diseases are generally higher in Central and Eastern Europe than in Northern, Southern and Western Europe. Moreover, the mortality or cases of cardiovascular diseases are falling faster in most Northern, Southern and Western Europe, while in some Central and Eastern European countries these ratios were even raising rapidly.[13] Given the above statistical data, we decided to analyze countries such as Czech Republic, Hungary and Slovak Republic as well as Germany and France, with increasing number of people with chronic conditions[14]. One of the main focuses of the researchers is weather the pharmaceutical expenditures is higher in the countries with higher cardiovascular diseases, as it would be logically expected.

There are a lot of risk factors that explain the high prevalence of CVD. Some of them are not yet known to the medicine industry as the life of a human is influenced by a lot of hidden factors. However, a recent research has found that some of the factors causing those diseases are age, gender, high blood pressure, high serum cholesterol levels, tobacco smoking, excessive alcohol consumption, family history, obesity, lack of physical activity, psychosocial factors, diabetes mellitus, air pollution.[15] Although it is possible to reduce the risk of having cardiovascular disease by lifestyle change (low-fat, exercises, healthy feeding and avoiding alcohol and tobacco smoking), some of these risk factors such as age or family history are immutable and a medical treatment might be needed. Millions of dollars are spent for R&D related to cardiovascular drug development and the costs are rising. Increased cost results in more expensive drugs appearing on the market and per capita pharmaceutical sales for cardiovascular drugs continue to rise (**Figure 9**).

[13] European cardiovascular disease statistics, 2008
[14] Büscher, A. Sivertsen, B. and White, J. (2009)
[15] Bridget B. Kelly; (2010).

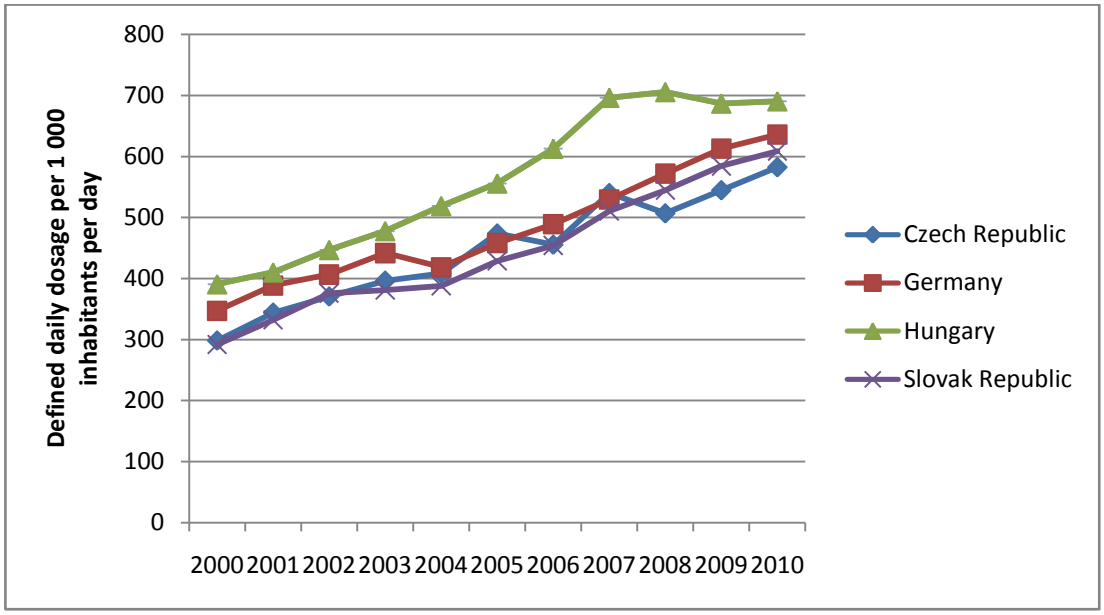
Figure 9: Per capita pharmaceutical sales for cardiovascular drugs



Source: OECD (2011), "OECD Health Data: Health expenditure and financing", OECD Health Statistics (database).

For all above analyzed countries pharmaceutical sales for cardiovascular drugs increased during the period 2000–2009. There were sharp decreases for Germany and Slovak Republic in 2004 but it continued to rise. It is interesting that even during the financial crisis the figures did not decrease, which clarifies that pharmaceutical goods are highly related to the "necessity" of consumers. Once a person is ill he has to purchase the drug and the customer's preference does not play a big role (Schweitzer, 1997).

Figure 10: Per capita pharmaceutical consumption for cardiovascular drugs



Source: OECD (2011), "OECD Health Data: Health expenditure and financing", OECD Health Statistics (database).

Notes: (1) Defined daily dose (DDD) is the assumed average maintenance dose per day for a drug used for its main indication in adults. DDDs are assigned to each active ingredient in a given therapeutic class by international expert consensus.

(2) No data available for France

Along with increased pharmaceutical sales for cardiovascular drugs there is also significant growth in pharmaceutical consumption (**Figure 10**). The main factor contributing to this rise is a growing demand for drugs to treat ageing-related diseases,16 which was mainly caused by the growth and aging of the population, as well as by the high prevalence of cardiovascular diseases.

According to Dickson and Jacobzone (2003) the consumption for cardiovascular disease varies across countries, but the reason of the increased consumption is hard to interpret. Authors argue that increased use of less expensive cardiovascular drugs are related to "needs" and that use of newer, more expensive

[16]OECD (2011), *Health at a Glance 2011: OECD Indicators*, OECD Publishing

drugs is higher among those countries that spend a greater percentage of GDP on health.

Thus the pharmaceutical expenditures on cardiovascular disease increased not only in terms of pharmaceutical sales but also due to increased pharmaceutical consumption. As a result of this growth, various questions relating to pharmaceutical expenditures on cardiovascular diseases come to the forefront. The most interesting ones, as already mentioned in the introduction part of the study, are the factors which have positive and those that have negative influence on that growth.

2.3 Literature review

Rising pharmaceutical expenditures raise the interest for the factors influencing this growth. It is very important for policy makers to understand the reasons of increased pharmaceutical expenditures in order to better evaluate the benefits that might come from alternative allocation of health resources.

There are a lot of papers analyzing drug expenditures from different point of view. Patricia Danzon has done plenty of research devoted to this issue. Danzon and Soumerai (2002) agree that the insurance coverage is the most powerful factor explaining rising pharmaceutical expenditures. Insurance makes not only patients but also the physicians who prescribe the drug, be less aware to prices, the phenomenon known as moral hazard. People with insurance coverage consume more drugs and have higher cost per prescription. Cleanthous (2011) also argues that there is a moral hazard problem in pharmaceutical market due to the existence of prescription drug insurance coverage.

Danzon et al. (2007) describe another interesting issue of drug insurance. The authors argue that health insurance reduces the demand elasticity and creates incentives to charge higher prices than it would occur due to patents. So in developing countries with limited insurance coverage patent system induces under-

consumption and leads to a welfare loss. However, welfare loss estimates are sensitive to demand elasticity and can be reduced by price discrimination. Cleanthous (2011) formulates an empirical methodology that quantify patient welfare benefits from pharmaceutical innovation in the U.S. antidepressant market in the period 1980–2001 and finds out that drug price estimates sensitivity decreases with patient income and drug insurance. The wealthier the patient is the more insurance coverage and more preference for brand new drugs he has.

Clemente, Marcuello and Montanes (2008) examine several OECD countries in the time period 1960–2003 and find out that the value of income elasticity is greater than 1 for almost all developed countries, thus they consider pharmaceutical goods as a luxury commodity. They also discovered that the rate of growth in demand for pharmaceuticals outpaced the rate of per capita income and believed that this fact was due in a large portion of the elderly people in the population.

Almost all researchers agree that one of the main reasons of raised pharmaceutical expenditures appears to be the growing ratio of the elderly people in the population.

Kildemoes et al. (2006) examine the Denmark pharmaceutical market and find out that the age is one of the most important factors determining pharmaceutical expenditure as elder people use more drugs to extend their life capacity. Morgan and Cuningham (2011) model changes in inflation-adjusted expenditure per capita between 1996 and 2006 in Canada as a function of two demographic factors (population aging and changes in age-specific mortality rates) and three non-demographic factors (age-specific rates of care use, quantities of care per user and inflation-adjusted costs per unit of care). They find that population aging has a positive effect on pharmaceutical care spending and changes in age-specific mortality rates actually reduce hospital expenditure by 0.3% per year.

Vandegrift et al. (2005) examine the factors driving prescription drug expenditures in the U.S. They provide quantitative measures for all fifty states for the

period 1990–1998. The analysis suggests that in addition to the aging population, changes in income, obesity, and new drug approvals appear as the important determinants of rising prescription drugs expenditures; and the increases in the unemployment rate exert a significant negative effect on per-capita prescription drug expenditures. Their results indicate that public health, population over the age of 65, new pharmaceutical products, and income are all important in explaining prescription drug expenditures.

Reinhardt (2001), Berndt (2001) and Lundin (2000) also estimate the effects of income on drug spending and find a positive effect. Sisto and Zanola (2005) use Italian regional data to investigate the determinants of pharmaceutical expenditures. The findings show that the determinants of public drug expenditures are not only income and aging but also the past level of public drug expenditure, education and health federalism.

Some people think that raised pharmaceutical expenditures are not problematic for the country as it leads to better health outcomes and reduces other health care costs. Cremiuex et al. (2005) investigate Canadian drug spending over the period 1981–1998.They use linear models to estimate non-drug and drug spending on six health outcomes, using generalized least squares. They measure infant mortality and life expectancies at birth and at age 65, as proxies for overall health and find out a positive relationship between pharmaceutical expenditures and total health outcomes, especially for infant mortality and life expectancy at 65. They conclude that the higher pharmaceutical expenditure is, the better health outcomes we should expect. The authors also suggest that this relationship is stronger for private drug spending than for public drug spending.

There is a very interesting finding in the work by Civan and Koksal (2009). They take annual data for the USA from 1993 to 2004 and estimate panel data model to analyze the effects of the new technology on health care expenditures. They agree that technological progress on pharmaceuticals raises costs of newer drugs.

Moreover, those newer drugs improve health outcomes and life quality, so they reduce the demand on other types of medical services and thus reduce the total spending on healthcare.

Danzon et al. (2011) analyze the determinants of ex-manufacturer drug prices in the middle and low income countries using a pooled sample with indicator variables to test for differential effects for each license-channel category. They find out that drugs are the least affordable relative to income in the lowest income countries. Moreover, income inequality within a country leads to high drug prices. They suggest a protected procurement channel, informed buyers with minimum quality standards, increased price competition and target drugs to low income subgroups to achieve differential pricing within the country and lower prices for poor populations than is possible in the retail sector.

However, not all the factors cause the growth in pharmaceutical expenditures. Lack insurance coverage and big financial burden of drugs may decrease the consumption of drugs. Lundin (2000) shows that patients with large out-of-pocket expenses are more likely to choose generic drugs, while consumers with full health insurance coverage have little incentive to search for low-cost alternatives to branded drugs. McLeod et al. (2011) use data from a nationally representative household expenditure survey to analyze the financial burden of prescription drugs. They argue that some households do not purchase needed prescription drugs because of the expenses.

Another important factor for pharmaceutical expenditure is high cost of research and development (R&D). For developing new and more effective drugs firms need lots of finance. Nowadays new technologies give firms new possibilities to make research on drugs, but also increase expenditures. According to Danzon and Soumerai (2002) increased pharmaceutical expenditures are also due to newer and more expansive drugs on the market and the price inflation on existing drugs. Berndt (2001) also argues that successful introduction of new pharmaceutical products can

raise pharmaceutical expenditures, thanks to effective pharmaceutical R&D some of the recent innovations have been developed which had not existed before.

Dubois et al. (2000) and Reinhardt (2001) argue that the prevalence of a specific identified disease makes pharmaceutical spending grow. Thomas et al. (2001) and Kaufman et al. (2002) provide data and statistically prove that increase in drug consumption is mainly due to higher incidence of cardiovascular and other chronic diseases.

Halpin et al. (2010) study various risk factors for cardiovascular diseases and argue that the education might reduce the number of cases of CVD. These may include school-based and work place health promotion or public awareness campaigns. Authors suggest that the education leads to positive health effects and reduction of pharmaceutical expenditures as highly educated people use tobacco less, eat healthier food and lead more active lifestyles. Winkleby et al. (1992) use data on 2,380 participants and examine the independent contribution of income and education to a set of risk factors associated to cardiovascular diseases, such as (tobacco use, blood pressure and the level of cholesterol in blood). The results show that the higher risk was associated with lower level of education. The authors conclude that the education is the best predictor of good health.

3. Pharmaceutical market overview

The primary and at the same time the most important role of pharmaceuticals is to save lives and improve the quality of life of people. Functioning of the pharmaceutical market is crucial for the country as it is a key for the economy in terms of employment and production.[17]

Pharmaceuticals represent a form of therapy that does not involve injuring or removing organs while permitting causal treatment in several instances.[18] Pharmaceuticals are usually in the dosage form and may be replaced by other drugs, in the case of side effects.

Pharmaceutical markets have several key characteristics that need to be taken into account when approaching market definition. [19]

- Firstly, these markets are characterized by an unusual structure where the consumer (patient) differs from the decision maker (doctor) as well as from the payer (national or private insurance). Because of its unique structure, there is usually very limited and specific price sensitivity regarding the decision makers.
- Secondly, unusually high costs of R&D, which implies a high rate of technical change and critical importance of patent protection. The prices of patented drugs are usually regulated. Firms are not free to set prices, and, in particular, they cannot increase prices over time, even if it is profitable to do so. On the other hand, firms are generally free to reduce prices when facing strong competition, indicating that stimulating the competition can bring the benefits for the patients.

[17] Have et, al (2009)
[18] The market of pharmaceuticals, Health Economics, 2009
[19] Market definition in the pharmaceutical sector, Charles River Associates, 2006

Thus, pharmaceutical market is unique and differs from other markets as in terms of demand and also in supply side.

3.1 The demand for pharmaceuticals

Demand for pharmaceuticals is derived from demand for health itself (Schweitzer, 1997). Consumer demand for drugs is different from demand for many other goods in the economy. Market demand actually represents the willingness of a consumer to pay for a product or service, implying that the demanded quantity is related to consumer's income. In health care markets we face the "need", which is different from consumer's preferences and is a very poor predictor of consumer's behavior.

3.1.1 The doctor-patient relationship

The pharmaceutical market is different from other markets by its marketing efforts, especially due to customer-agent relationship. An agency relationship arises whenever one or more individuals delegate decision-making authority to another person to take actions on his behalf. Normally, the consumer is not the person who decides which drug to use and/or purchase as he or she is not competent to make those decisions. Purchases of prescription drugs by patients must be authorized by physicians.[20] Thus, the solution is left to a physician, who is not only a producer in the market but also an agent, who decides not only the kind of drug for patient but also a daily dose.[21] In this case patients cannot be sure that agents (physicians) act in their best interests as both theory and experience have confirmed that 90% of individuals behave according to their own interest. The deviation from the consumer's

[20] Schweitzer (1997)

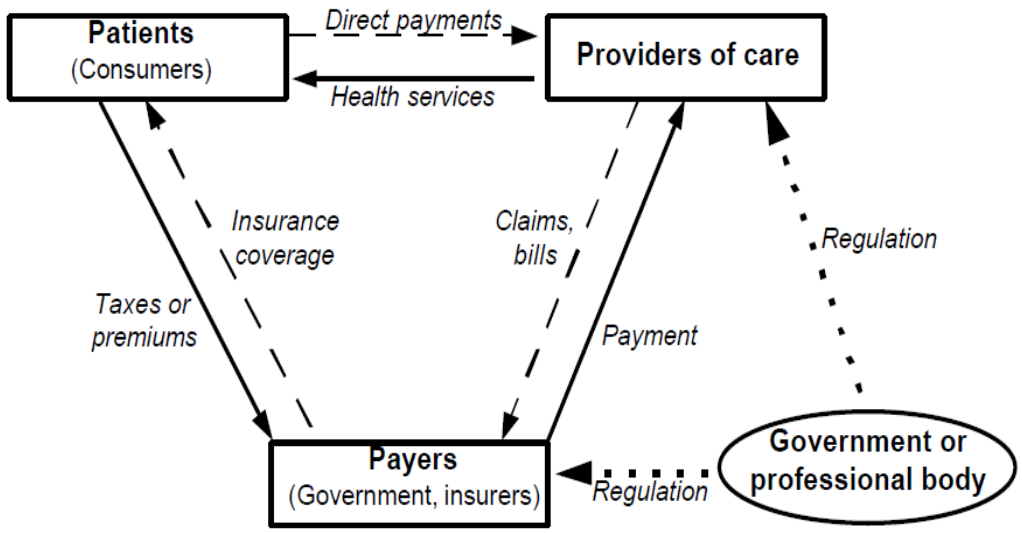
[21] Defined daily dose (DDD) is the assumed average maintenance dose per day for a drug used for its main indication in adults. DDDs are assigned to each active ingredient(s) in a given therapeutic class by international expert consensus. OECD health at a glance, 2011

interest by the agent appears very often and in the literature is called 'agency costs.[22] This aspect of the demand for prescription drugs raise interesting information issues that are absent in many other consumer goods markets.

3.1.2 Third party payment

Patients often do not pay directly for healthcare. Contrary to a usual market there are only two participants, the producer and the consumer, in the healthcare market so called "third party" plays an important role. Patients pay for the health through the taxes to the government or the insurance premiums to the insurers (**Figure 11**).

Figure 11: Agents in health care financing



Source: WHO. *In: Evaluation of recent changes in the financing of health services: Report of a WHO study group*. Geneva: World Health Organization; 1993: 1-74. WHO Technical Report Series, N° 829.

[22] Bebchuk, L. and Fried, J. (2004)

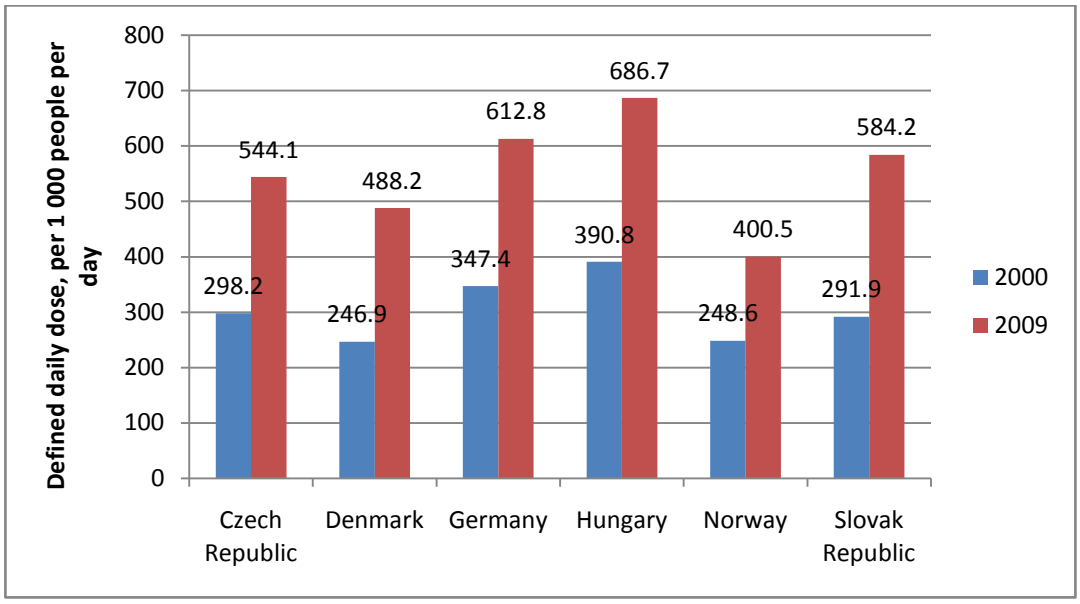
In most standard markets prices play the most important role for both, consumers and suppliers as they are the primary drivers of the market participants' decision-making. Pharmaceutical markets are characterized by price inelastic demand and that is mainly due to extensive medical insurance. The individuals who are ill pay only a small fraction of the price while the insurer is paying for the biggest part. Accordingly, prices cannot perform the same central role of bringing supply and demand into balance as in the market with normal goods. Thus prices have a little effect on the choice for consumer to buy or not the drugs and also on the choice between alternative drug treatments.

In the healthcare market there are private or public insurance companies, or other institutions (sometimes the government) that are in charge of paying for the treatment or drug use instead of patients. Third party payment makes pharmaceutical demand even more inelastic, encouraging pharmaceutical firms to charge higher prices (Danzon 2007).

Since patients have insurance coverage and do not pay the full price of the product, moral hazard problem appears making the patients ignore the higher costs of drugs and also consume more than they would in absence of insurance. Thus the situation where people use more prescribed drugs than needed occurs making the cost per prescription rising significantly. This derives the conclusion that moral hazard leads to increasing consumption of pharmaceuticals, resulting in increase overall pharmaceutical expenditures. Thus insurance companies have a goal to reduce their costs and they try to achieve it mostly by offering to the patients various types of cost-sharing agreements, such as coinsurance, copayments and etc.[23]

[23] Schweitzer (1997)

Figure 12: pharmaceutical consumption for cardiovascular drugs



Source: OECD (2011), "OECD Health Data: Health expenditure and financing", OECD Health Statistics (database).

In order to manage costs, insurance companies are establishing the plan of treatment with the aim to reduce the use of unnecessary care. They often use controlled formularies and also negotiate with pharmaceutical companies for discounted price and limited number of drugs.

Yet insurance coverage for pharmaceuticals is less comprehensive than for other healthcare services. Although it covers almost all the population in below analyzed countries (**Table 1**) the percentage of out-of-pocket expenditures on medical goods is high (**Table 2**).

Table 1: Government/social health insurance for pharmaceutical goods as a percentage of total population 2003-2010

	2003	2004	2005	2006	2007	2008	2009	2010
Austria	98	98	98	98.5	98.7	98.8	99	99.3
Czech Republic	100	100	100	100	100	100	100	100
France	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9
Germany	89.9	89.8	89.6	89.5	89.4	89.4	89.2	89.1
Hungary	100	100	100	100	100	100	100	100
Poland	..	..	97.3	99.3	98.1	97.8	97.6	97.5
Slovak Republic	96.9	95.6	97.6	96.3	95.5	95.4	95.2	94.8

Source: OECD (2011), "OECD Health Data: Health expenditure and financing", OECD Health Statistics (database).

Another empirically documented reason of increased out-of-pocket expenditures on pharmaceuticals might be self-medication and self-prescription. Medication itself represents an act to set medicaments to somebody, while self-medication is defined as an act where the person sets medicament to himself. Self-prescription refers to an individual decision which does not follow the doctor's advice. Self-prescription shows us the leak of the knowledge about the medicines in the population. The reason for the existence of self-prescription can be the fact that patients in many cases do not trust doctors completely or they think they can substitute drugs prescribed by the doctor by another more accessible or even cheaper drugs. Self-prescribed medicines are often not necessary and sometimes have unfavorable effect on population's health and also their income. Self-prescription is often promoted by the pharmaceutical companies who run intensive advertising business and also by its employees who work in the pharmacies and have direct contact with customers. Because the purchase of medicines is a big burden on

families' budgets, government is expected to provide some programs to educate the people about the medicines usage and its long-term health consequences.

Table 2: Out of pocket expenditure on medical goods as a percentage of current expenditure on health 2003_2010

	2003	2004	2005	2006	2007	2008	2009	2010
Austria		6.6	6.4	6.5	6.5	6.3	6.2	6.2
Czech Republic	8	8.1	8.4	8.9	9.9	10.5	8.2	9.5
France	3.5	3	3.3	3.2	3.4	4	3.8	3.7
Germany	4.9	5.1	5.3	5.1	4.9	4.8	4.5	4.7
Hungary	11.6	11.5	11.8	11.2	13.7	14.3	14	14.3
Poland	19.7	20.8	19.6	18.8	17.8	16.4	16.3	15.7
Slovak Republic			14.8	14.1	15.2	14	15	15.1

Source: OECD (2011), "OECD Health Data: Health expenditure and financing", OECD Health Statistics (database).

3.2 The supply of pharmaceuticals

As already discussed in previous chapters, the pharmaceutical industry is a very complex due to its complicated supply chain which is a result of its need to use profit margins to pay for substantial R&D. Regarding the supply side there can be often found big R&D costs, which are associated with discovery of new drugs. Moreover, the process of researching, developing and launching new drug is quite long and expensive.

3.2.1 Development of pharmaceutical research

According to Calfee (2000) there have been three “revolutions” in the pharmaceutical research. The first was the unexpected discovery of antibiotics and other natural substances in 1940.

Second one occurred in the 1960s and 1970s, when people started to understand the mechanisms by which the pharmaceuticals work in the body. These foundations led to the drugs such as ulcer treatments that block the secretion of stomach acid; beta-blockers, serum cholesterol-reducers, and other heart medications.

The third pharmaceutical revolution was based on the molecular biology together with the development of new technology and computer sciences in medicine such as magnetic resonance imaging and computed tomography.

If two earlier revolutions were mainly based only on the scientific foundations, the third one is linked to new technologies, which leads to the higher costs of research and development.

3.2.2 R&D

The pharmaceutical industry is characterized by unusually high costs of R&D. Danzon (2007) argues that high costs are also caused by regulation of R&D which focus on safety and efficiency of new drugs. Risks and benefits of pharmaceuticals are not obvious; they can differ across patients and can be known only in the long run. In order to collect and analyze such information large population and time is needed, which leads to delays in launching new medicines on market and increases.

3.3 Pricing pharmaceuticals

The pharmaceutical market differs from other markets also in setting price of the goods. In competitive markets prices are linked to the marginal costs. However, taking into account very high cost of research and development for pharmaceuticals, the price cannot be set according to the marginal costs, otherwise pharmaceutical goods will be very expensive. In this case the pharmaceutical market appears as oligopolistic, allowing prices to exceed the marginal cost in the long run; as on the long run no R&D cost will be made. There are only few drugs in pharmaceutical industry which allow pharmaceutical market act as a competitive market. Many other drugs are unique or have very few substitutions, especially drugs for cardiovascular diseases or cancer.

Lu and Comanor (1996) found out that the drugs, entering the market with already existing products from other brands, are priced lower than they would have been prices if those "branded" products did not exist. Therefore, we cannot reject the idea that the competition also plays an important role in determining the price of pharmaceutical goods.

According to Schweitzer (1997) consumers are much more sensitive to the prices of pharmaceutical products than other much expensive health services.

In general, drug prices do not depend very much on direct production costs. Neither are they related to the manufacturers' costs, as the cost for new drug can be much higher and the price relatively low. A characteristic of pharmaceutical market is an ability of seller to charge different prices for different buyers which is in economic theory known as the price discrimination. Buyer can be individual client, some health plan or distribution company for drugs. Prices are charged to the buyers regarding their own sensitivity to the prices. The market power of the seller has an inverse relationship with the price elasticity. That is, a seller's market power increase as the price elasticity of demand for a buyer decreases. Price elasticity theoretically

represents a buyer's behavior with respect to the price changes of a particular good. When the price demand is very elastic it will be high sensitive to price changes, meaning that small price changes will result in big changes in corresponding demand and vice versa. There are several factors influencing the price elasticity.

The first one is the number of substitutions of a particular good. If there are many substitutes for the good, increased price may lead the buyer to purchase substitutes because other goods will give him utility but for the lower price. In the case that there are no substitutions, buyer may continue to buy the good or stop it which will depend on his preferences, income and urgency of the situation.

The second factor is necessity of the good itself. The more necessary is the good the less elastic demand it is, since the consumer cannot afford himself to skip the consumption of such a good. This means that, regarding the highly necessary goods, small price changes will result in none (if demand has zero elasticity) or smaller changes in the corresponding demand. Price elasticity varies across buyers in pharmaceutical markets, as different types of medicines have different number of substitutions and have different necessity. Thus the similar conclusion as that made in the previous sections follows. That is, sellers on pharmaceutical markets can charge different prices for different types of buyers and may have incentives to charge higher price for "necessary" goods.

3.4 Market failure

The pharmaceutical market is also characterized by several important market failures. First of all and the most important one is the asymmetric information between different parties on various levels (between pharmaceutical producers and physicians, patients and producers or patients and physicians).

Information asymmetry on the healthcare market mainly consists of two parts: firstly, physicians' behavior due to possession of much more information regarding the whole health system (i.e. services, alternatives, procedures and duration), and secondly, the limited knowledge of patients as being exposed to scarce information availability regarding the state of their health, implications of the treatments as well as all the available alternatives. Demand inducement represents the direct consequence of information asymmetry and in the economic literature it is defined as the power of physician to choose the quality and quantity of treatment that is often different from the one that the average patient would choose for himself under the condition of having the identical information as the physician itself. Hence, the threat that physician may over-treat the patient, overprescribe the drugs or make recommendations to certain medical specialists (resulting from the possible partnership with other doctors and pharmaceutical companies) will always exist. Another source also appears both in economic literature and everyday practice. As already explained, uncertainty of the health itself represents another cause of the information asymmetry due to the fact that the product itself cannot be tested prior to the consumption, making the trial and error method impossible to apply.

Individual patients should have a timely access to high quality medicines to maintain good health. However, the market is facing some another characteristics (high R&D costs and price limits) that lead to the possible lack of investment on specific diseases and free-riding behavior in the use of R&D.

Another important characteristic is over consumption. Due to third party payer level of pharmaceutical use may increase as consumers do not directly bear the costs of consumption and moral hazard problem occurs.

Finally, pharmaceutical markets are influenced by restrictions of competition. High initial investment (in relation to R&D) can act as a barrier of entry for new firms and thus reduce competition.

3.5 Government regulations

The government tries to avoid the possible negative effects of the various types of market failures of the pharmaceutical industry through different types of interventions, including patents, marketing authorization and pricing and reimbursement.

In order to stimulate innovations there is a market power associated with the patent system protecting new chemical compounds from being copied within a given period. Given the high cost of research and development and low marginal costs of production, patents represent the tools for R&D firm to recoup their investments. Through patent protection, innovators very often become monopolists for a limited period of time. On the other hand, patents are violating the principles of perfect competition where the relative prices of goods reflect their relative marginal utility on the demand side and at the same time affecting the relative marginal cost of production on the supply side. Existence of monopolies allows the relative prices of goods to be different from their relative marginal costs as opposed to the case of perfect competition. Thus, the patent protection is responsible for the long-term deviations from the optimal state of the economy (Zweifel et. el 2009). Patent protection is principally linked to national markets.

Marketing authorization mostly aims to ensure the effectiveness, safety and quality of drugs before they are officially allowed to enter the market. After receiving a required permission, the pharmaceutical companies have to apply for a decision on the price and/or reimbursement for their product in many countries, before the product can be sold. Such policy increases the safety and level of the pharmaceutical market, which is required by its own nature and product business.

Government can also influence the use of pharmaceuticals through the either impact on the supply side for pharmaceutical production or the influence through the demand side for consumption of pharmaceutical products. Supply side interventions

include regulation of product price, control of expenditures, industry regulation, and product reimbursement. In order to control the demand side of pharmaceutical market government implements policies aiming to influence behavior of all the physicians, pharmacists and patients. These interventions are both necessary and very important because they help to maintain the incentives for research and development procedure. The last but not the least, they also prevent the market from unsafe product entering and they help to reduce the overall cost treatment.

However, these regulatory actions are very costly and hence government should implement pharmaceutical policies very carefully. When implementing various polices government should take into account not only the features of pharmaceutical markets, but also the various factors influencing pharmaceutical expenditures in order to make the whole industry work properly and in the interest of the patients.

4. Empirical model and data

The main aim of the thesis is to examine whether factors such as age, income, total health expenditure and burden of a particular disease can explain cross-country variation in pharmaceutical expenditure on cardiovascular disease. From the literature review we have seen a lot of papers examining the factors influencing the growth of pharmaceutical expenditures, but only few of them analyzed the pharmaceutical expenditures on cardiovascular disease. While some studies (Halpin et al., 2010 or Winkleby et al., 1992) have estimated the effects of economic factors such as income, insurance coverage on prescription drug spending or education, they do not account for the role of public health factors. Other studies (Thomas, 2001 or Kaufmann, 2002) while highlighting the significance of public health factors (such as age and prevalence of cardiovascular disease) in drug spending, do not control for effects of economic variables. We will try to include both economic and public health factors to draw a relevant picture for policy makers for better understanding the reasons of the increased pharmaceutical expenditures on CVD.

We will use a panel dataset allowing to analyze a number of important questions which cannot be addressed using cross-sectional or time-series data alone.

4.1 Selection of model

Empirical studies examine prescription drug expenditures determinants through various models. Lundin (2000) and Sturm (2002) use cross-sectional models while Berndt (2001 & 2002) employ time-series. Some researchers combine cross-section and time-series data and simply pool the data (e.g. Suraratdecha, 1996). Civan and Koeksal (2009) estimate a panel-data model to analyze the effects of newer drugs on healthcare expenditures. Sisto and Zanola (2008) investigate determinants of pharmaceutical expenditures using pooled time-series as well cross-section data.

Sampayo and Vale (2012) perform their research in a panel data context controlling for both cross-section dependence and unobserved heterogeneity.

According to Baltagi (2002), repeated cross-sectional and time-series data gives a rich source which allows for more efficient parameter estimation. Estimating model using only time-series or cross section data gives us a small sample size, which reduces the statistical reliability of results and limits the number of hypotheses that can be tested simultaneously. Moreover, panel datasets allow better understanding of complex issues of dynamic behavior.

Before examining whether the factors such as age, income, total health expenditure and burden of a particular disease can explain cross-country variation of pharmaceutical expenditure on certain diseases, we will try to determine the main indicators influencing pharmaceutical expenditures.

4.1.1 Determinants of pharmaceutical expenditures

This section discusses the reasons for including the selected factors in the analysis of pharmaceutical expenditures. A number of recent papers examine the causes of increased pharmaceutical expenditures. Vandegrift and Datta (2006) analyze many previous researches arguing that explanations have focused on the demand side of pharmaceutical market and identify five basic causes of raised drug expenditure:

- Pharmaceutical spending is a part of total healthcare expenditures;
- Increased share of insured population for prescription drugs;
- Introduction of newer drugs with higher prices;
- Aging of the population; and
- Public health factors such as obesity, smoking or alcohol consumption.

To better analyze pharmaceutical policy actions, we provide some quantitative estimates of the factors that have contributed to the increase in drug expenditures. We think that pharmaceutical policy responses to rising pharmaceutical expenditures will vary based on the source of the growth.

GDP per capita – pharmaceutical expenditures on chronic diseases can be different for individual patients at a country level as the volume of consumption is related to the relative income of a country. Many of researchers such as Reinhardt (2001), Berndt (2001) and Lundin (2000) found a positive relationship of income on drug spending. Also countries with higher GDP are likely to spend more on R&D for pharmaceuticals, which itself cause increase in pharmaceutical expenditures.

Health expenditure – Countries with higher health expenditures are likely to use more expensive pharmaceutical therapy and spend more on drugs in general. Developed countries with higher GDP and higher healthcare costs relative to GDP should have higher drug costs than countries with relatively low healthcare spending.

Aging of population – Countries with a high proportion of older people face higher demands on healthcare systems, simply because age brings with it an increase in chronic diseases. Thus, countries with a high proportion of elder population might have higher drug costs than countries with younger population. Thomas et al. (2001) and Kaufman et al. (2002) show that prescription drug usage is the highest among the elderly due to a higher incidence of cardiovascular diseases and other chronic conditions.

Out-of-pocket expenditure on health – Berndt (2001) and Reinhardt (2001) argue that insurance coverage for drug costs creates problems of moral hazard. According to Vandegrift and Datta (2006) patients are more likely to use lower-priced generic products when they have to pay a large portion of costs from their own budget out-of-pocket, rather than when it is covered by a third party. To support their argument they provide evidence from the US pharmaceutical market where the percentage of out-of-pocket drug spending fell from 92% to 26% during 1965–1998,

which caused an increase in prescription drug use. Lundin (2000) provide data showing that patients with large out-of-pocket expenditures are more likely to choose generic drugs. Thus we expect negative effect of health out-of-pocket expenditure on pharmaceutical costs.

Burden of a disease – Burden of a disease is also one of the factors causing raise in pharmaceutical expenditures. We think the prevalence of a particular disease can be used as an indicator of its burden. Higher prevalence means more and much expensive drugs for treatment, which will lead to higher pharmaceutical expenditures.

Education – Sisto and Zanola (2005) argue that education has been shown to be a powerful predictor of health expenditures. Halpin et al. (2010) examine various factors preventing chronic diseases. Authors suggest that highly educated people use tobacco less, eat healthier food and lead more active lifestyles. This leads to positive health effects and reduction of pharmaceutical expenditures.

4.2 Data description

Based on the discussion above, we regress per-capita pharmaceutical expenditures on cardiovascular diseases (PPE) on GDP per capita (GDP), percentage of the total population over 65 years of age (AGE), total per capita health expenditure (PHE), per capita out-of pocket expenditure on health (OOP), percentage of regional population with at least secondary education (EDU) and mortality rate as a total number of death caused by cardiovascular diseases (PREV). The model is hence as follows:

$$PPE_{it} = \beta_0 + \beta_1 GDPit + \beta_2 PHEit + \beta_3 AGEit + \beta_4 OOPit + \beta_5 PREVit + \beta_6 EDUit$$

The data contains annual observations on each variable across five selected countries, the Czech Republic, Germany, France, Hungary, and the Slovak Republic for each year during the period 2000–2009 (10 years and 5 cross sections).

The data for the study was collected from OECD health data (out-of-pocket health expenditures, total health expenditures, cardiovascular drug sales, mortality rate) and from the World Bank data (percentage of the total population over 65 years of age, percentage of regional population with at least secondary education and GDP per capita). **Table 3** reports means, standard deviations, and definitions for the dependent and independent variables.

Table 3: Descriptive statistics (2000–2009)

Variable	Definition	Obs.	Mean	Std. Dev.	Min	Max
PPE	Per capita pharmaceutical drug sales for cardiovascular diseases, US$ purchasing power parity	50	65.9	14.2	37.5	102.4
GDP	GDP per capita, US$ purchasing power parity	50	23,008	7,296	10,983	37,114
PHE	Total health expenditure per capita, US$ purchasing power parity	50	2,107	1,067	605	4,225
AGE	Percentage of regional population 65 years old and over	50	15.2	2.47	11.1	20.2
OOP	Out-of-pocket expenditure on health per capita, US$ purchasing power parity	50	295	136	69	634
PREV	Number of death caused by cardiovascular diseases, percentage of total number of death	50	46	9.3	27	55
EDU	Percentage of regional population with at least secondary education	50	64.7	13.2	43.9	80.2

As the number of observations suggests the data is balanced, we have data for all the countries and for all time periods (**Table 6** of Appendix).

We expect that an increase in any of the independent variables (except for education and out-of-pocket health expenditures) would cause an increase in per-capita drug expenditure. Countries with higher GDP are supposed to spend more on health and on pharmaceutical costs as well. Higher health expenditure means more financial sources and possibly more expensive pharmaceutical therapy. The burden of a particular disease has to have positive effect on drug expenditure as well. Increase in the number of deaths caused by this disease should involve increase in pharmaceutical expenditures in general. Cardiovascular disease is the main cause of death before 65 in Europe,[24] so the age should also be a powerful predictor of increase of cardiovascular drug sales. With the aging of population risk of having cardiovascular disease increase, which leads to higher costs of cardiovascular drugs.

Out-of-pocket expenditures and education are supposed to have a negative effect on drug costs. Patients with large out-of-pocket expenditures are more likely to choose much cheaper drugs, as they are not sharing the cost with third party payer (insurance company or government) and moral hazard does not play a role in decision-making process of patient. The same effect should have education on pharmaceutical expenditures. More educated people follow a healthy life style which leads to a decrease in the prevalence of cardiovascular diseases. In addition, people with higher education can make correct decision by choosing the right treatment and medication; they do not depend only on the decisions of doctors.

4.3 Description of panel data models

Panel data are repeated measures of one or more variables on one or more persons (repeated cross-sectional and time-series).[25]

[24] European cardiovascular disease statistics (2008)
[25] Brüderl (2005)

According to Baltagi (2002), pooling the data gives a richer source of variation which allows for more efficient estimation of the parameters. Moreover, one can get more reliable estimates and test more sophisticated behavioral models with less restrictive assumptions. Another advantage of panel datasets is their ability to control for individual heterogeneity. Not controlling for these unobserved individual specific effects may lead to bias in resulting estimates. Panel data sets are also better able to identify and estimate effects that are simply not detectable in pure cross-sections or pure time series data. In particular, panel datasets are better able to study complex issues of dynamic behavior.

Most of the panel data applications utilize a one-way error component model for the disturbances:

$$\boldsymbol{Y_{it} = \beta_1 X_{it} + u_{it}}$$

$$\boldsymbol{u_{it} = \mu_{it} + v_i}$$

Where disturbance μ_{it} assumed to be uncorrelated with explanatory variables, has zero mean and constant variance. Additionally, $\boldsymbol{v_i}$ is assumed is assumed to be time-invariant individual specific effect that is not included in the regression.[26] If $\boldsymbol{v_i}$ is correlated with one of the explanatory variables, it leads to heterogeneity bias. However, if we assume that all explanatory variables captures all characteristics of the individual, there will not be any unobserved effect and v_i will be dropped, thus pooled OLS regression may be used to fit the model. [27]

4.3.1 Pooled OLS

This type of regression is the easiest to run. We simply pool the data and estimate an OLS regression.

[26] Balatagi (2008)
[27] Dougherty (2007)

$$Y_{it} = \beta_0 + \beta_1 X_{it} + u_{it}$$

According to Johnston & Di Nardo (1997) the pooled OLS estimators ignore the panel structure of the data, assuming observations to be serially uncorrelated with error term over the time for a given individual. However, very often this estimate is biased due to unobserved heterogeneity. Thus, panel data alone do not remedy the problem of unobserved heterogeneity and a special regression models such as the fixed or random effects model have to be applied.

The fixed effects model is better if data on all members of the population is available. If the population is too large and the data are only a sample of this population then the random effects model is more appropriate.

4.3.2 The fixed effect model

In the fixed effect model, the individual-specific effect is a random variable that is allowed to be correlated with the explanatory variables.[28] The fixed effect model eliminates v_i by demeaning variables using within transformation. Firstly it transforms data into individual means and transforms data into deviation from individual means.

$$\overline{Y_i} = \beta_1 \overline{X_i} + v_i + \overline{\mu_i}$$

$$Y_{it} - \overline{Y_i} = \beta_1 (X_{it} - \overline{X_i}) + (v_i - v_i) + (\mu_{it} - \overline{\mu_i})$$

Since v_i is constant, it disappears, thus there is no longer need of the assumption that v_i is uncorrelated with X_{it} and unobserved heterogeneity is not a problem anymore.

However, the fixed effects model has several disadvantages. In such a model we cannot include a time-constant variable because the fixed effects model cannot

[28] Schmidheiny (2012)

estimate effect of the variables which vary across the individuals but not over time such as sex, culture, race, place of birth.

Another important assumption of this model is the strict exogenity of explanatory variables. In other words all time invariant characteristics should be unique for individuals and not correlated with other individual characteristics.

Thus, the fixed effect estimator is not always the best estimator, especially when $\boldsymbol{v_i}$is uncorrelated with explanatory variables. In this case the fixed effect model appears inefficient and we have to apply the random effects model.

4.3.3 The random effects model

In the random effects model, the individual-specific effect is a random variable that is uncorrelated with the explanatory variables.[29] The rationale behind the random effects model is that, unlike the fixed effects model, the variation across entities $\boldsymbol{v_i}$ is assumed to be random and uncorrelated with all regressors, which allows time-invariant variables to be included in the model as explanatory variables.

The random effect model uses both within and between group variation, which makes best use of the data and is efficient. It can be shown that the RE estimator is obtained by applying pooled OLS to the data after the following transformation: [30]

$$\left(\boldsymbol{Y_{it}}-\overline{\theta \boldsymbol{Y_i}}\right) = (\mathbf{1}-\theta)\boldsymbol{\beta_0} + \left(\boldsymbol{X_{it}}-\overline{\theta \boldsymbol{X_i}}\right)\boldsymbol{\beta_1} + ((\mathbf{1}-\theta)\boldsymbol{v_i} + (\boldsymbol{\mu_{it}} - \theta\overline{\boldsymbol{\mu_i}}))$$

Where theta θ measures the weight given to between group variation, and is derived from the variances of v_i and μ_{it}

[29] Schmidheiny (2012)
[30] Brüderl (2005)

$$\theta = \mathbf{1} - \sqrt{\frac{\boldsymbol{\sigma}_{\mu}^{2}}{\boldsymbol{T}\boldsymbol{\sigma}_{v}^{2} + \boldsymbol{\sigma}_{\mu}^{2}}}$$

Normally θ is between zero and one. However, if theta equals to zero the RE estimator becomes bias and identical with pooled OLS estimator.

In the random effects models feasible generalized least square (FGLS) is the standard way of estimation (Baltagi, 2002). The variance-covariance matrix might be estimated as: [31]

$$\widehat{\boldsymbol{\Omega}} = \boldsymbol{N}^{-1} \sum_{\boldsymbol{i}=1}^{\boldsymbol{N}} \widehat{\boldsymbol{v}}_{\boldsymbol{i}} \widehat{\boldsymbol{v}}_{\boldsymbol{i}}'$$

Where $\hat{\hat{v}}_i$ would be pooled OLS residuals.The FGLS estimator is consistent if random effect assumptions hold.

The random effects model has the disadvantage of assuming that the error associated with each cross-section unit is uncorrelated with the other regressors. However, the opposite effect is more likely to happen. If the assumption is not satisfied the random effect estimator is biased.

4.3.4 Hausman specification test

In principle, the random effects models seem more attractive as explanatory variables that remain constant for each individual are retained in the model. This type of model does not lose n degrees of freedom as in the case of the fixed effects model. However, if one of the assumptions of the random effect model is violated, the fixed effects model appears more efficient.

[31] Wallace and Hussain (1969)

To be able to conclude which model (the fixed effects or random effects) is more appropriate, Hausman specification test is applied. It tests if the disturbances are correlated with the independent variables. Thus we can formulate the following hypotheses:

H_0: E(u/X) = 0

H_1: E(u/X) ≠ 0

Table 4: Hausman specification test

Estimates/Hypotheses	H_0	H_1
(Random Effects Model) $\hat{\beta}_{GLS}$	BLUE, consistent and asymptotically efficient	Biased and inconsistent
(Fixed Effects Model) $\tilde{\beta}_{Within}$	Consistent, inefficient	Unbiased and consistent

Source: *Baltagi (2002)*

The natural test statistics based on the following equation:

$$\hat{q} = \hat{\beta}_{GLS} - \tilde{\beta}_{Within}$$

Hence, the Hausmann test statistic is given by:

$$m = \hat{q}^T [\text{var}(\hat{q})]^{-1} \hat{q}$$

Under H_0, the test statistic is asymptotically distributed as X_K^2 , where K denotes the dimension of the slope vector β. Based on the test statistic, if we do not reject null hypothesis the preferred model is the random effects.

4.3.5 Breusch-Pagan Lagrange multiplier test

There is one question remaining: How can we be sure that we need the random effects and cannot simply use OLS? If there are no unobserved effects, pooled OLS becomes more efficient with its finite-sample properties (no estimation of variance).

One standard method to test the presence of individual-specific random effects is the Breush-Pagan Lagrange multiplier test based on OLS residuals. Breusch and Pagan (1980) have formulated the hypothesis the following way:

$\boldsymbol{H_0: \sigma_\alpha^2 = 0}$

$\boldsymbol{H_1: \sigma_\alpha^2 \neq 0}$

The test statistic is:

$$LM = \frac{NT}{2(T-1)}\left[\frac{\sum_N(\sum_T e_{it})^2}{\sum_N \sum_T e_{it}} - 1\right]^2$$

Where e_{it} are residuals from pooled OLS estimation of the model. The test statistic has a chi-squared distribution with one degree of freedom under the null hypothesis of no random effects.

5. Results and interpretation

We use panel data from selected OECD countries for the period 2000–2009 to investigate selected variables effect on pharmaceutical expenditures on cardiovascular diseases. The estimates should allow better projections of the cost of rising drug expenditures.

Using the obtained data, the pooled OLS model is run in STATA, which is formed as follows:

$$PPE_{it} = \beta_0 + \beta_1 GDPit + \beta_2 PHEit + \beta_3 AGEit + \beta_4 OOPit + \beta_5 PREVit + \beta_6 EDUit + uit$$

In the linear panel regression the estimation shows that only total health expenditure, education, and out-of-pocket expenditure on health have significant coefficient on dependent variable at 5 percent significance level while others are insignificant (**Table 7** of Appendix).

As we mentioned earlier the panel data alone do not remedy the problem of unobserved heterogeneity. Thus the results from the random effects models are presented and compared to the results from the pooled OLS estimations to analyze the importance of controlling for unobserved heterogeneity.

We assumed the random effect in the disturbance term and run the random effects model (**Table 8** of Appendix). Comparing with the pooled OLS model we got similar results, with only two insignificant variables age and prevalence of CVD. Moreover, the standard errors of variables have not changed, which means that the random effects model does not give us more efficient estimated parameters than pooled OLS. This is because the weight given to between group variations (Ɵ theta) equals to zero (**Table 9** of Appendix). Similar results in both pooled OLS and RE model raise the question of the presence of individual-specific random effects. To test it, we applied Breush-Pagan Lagrange multiplier test (**Table 10** of Appendix). The

results show that the chi^2 statistic is 0.97 and p-value stands at 0.3241, thus the H-null hypothesis of no individual-specific random effect cannot be rejected.

In order to solve the problem of unobserved heterogeneity, the fixed effects model was presented (**Table 11** of Appendix). In this model the individual-specific effect is a random variable that is allowed to be correlated with the explanatory variables. By using the fixed effects model we eliminate the unobserved effect, which is due to the fact that fixed effect estimation is based only on the within-panel over-time variation.

From the fixed effect estimation we got all variables with the same effect on pharmaceutical expenditures on cardiovascular diseases as was expected, all positive except education and out-of-pocket expenditure on health. However, standard errors of the variables increased which means that we got less efficient coefficients comparing with pooled OLS or the random effects model.

To test which model (the fixed effects or random effects) estimates better the given variables, Hausman's specification test is applied (**Table 12** of Appendix)

Since the test result shows that chi^2 statistic is 26.50 and p-value stands at 0.0001, we reject the H-null hypothesis that the random effects model is more efficient. So we reject that there is no correlation between right hand side variables and the unobserved effect and hence the fixed effects model might be more appropriate to control for country-specific differences. Under these circumstances we will interpret our estimated results from the fixed effect model estimation.

Table 5: Determinants of pharmaceutical expenditures on cardiovascular diseases, FE model

PPP	coeff.	std.error	t	P>t	[95% Conf. Interval]	
GDP	0.003981	0.0012843	3.1	0.004	0.0013834	0.0065787
PHE	0.000909	0.0114021	0.08	0.937	-0.0221539	0.0239721
AGE	6.262488	3.665324	1.71	0.095	-1.151329	13.6763
OOP	-0.06662	0.028963	-2.3	0.027	-0.125203	-0.008
EDU	-1.79101	1.688757	-1.06	0.295	-5.206842	1.624827
PREV	6.824134	2.569706	2.66	0.011	1.626412	12.02186
CONS	-301.322	203.4383	-1.48	0.147	-712.8143	110.1712

Source: Author's computations in STATA

Note: For more information regarding the results of fixed effects model, see Table 11 in Appendix.

The results support the hypotheses concerning the expected signs of the explanatory variables, even though some of them are not significant. There was no significant effect for health care expenditures on cardiovascular drug sales. It seems that no matter how much the country is spending on health, there are other more important factors which can cause the increase in spending on cardiovascular drugs.

Estimation results show that education has a low significance as well because no matter the proportion of educated people in a country is, one cannot assume that they have the proper health education.

The most powerful predictors of increased cardiovascular drug expenditures are prevalence of VCD and aging of population. The growth of the total population over 65 years old will cause increase in cardiovascular drug sales and growth in the

number of death caused by cardiovascular diseases as percentage of total number of death will lead to increase in cardiovascular drug expenditure.

The results show that the pharmaceutical expenditures on cardiovascular diseases are greater in high-income countries, even though it has smaller effect on cardiovascular drug spending than prevalence of the disease and aging of population.

Out-of-pocket expenditures have negative effect on pharmaceutical drug spending for CVD. Growing financial burden of patients own budget leads to decrease in drug spending but only by a small ratio. This is because, as we already mentioned above, drug are related to the "need" of patients and they cannot avoid buying such a commodity.

5.1 Policy implications

We showed that countries vary in pharmaceutical expenditures and the cost is determined by various economic or public health factors. Thus, policy makers cannot imply actions similar for every county. It is necessary to analyze the social and demographic situation of a specific country, as well as its economic conditions. Okunade and Suraratdecha (2006) used multiple regression analysis and maximum likelihood estimation method. They took OECD countries and computed drug expenditure elasticity using each country's optimal regression model estimates. Authors found different significant effect of demographic and economic factors on drug spending across the countries and suggested country-specific policy implications for controlling the drug expenditures.

However, government can reduce the risk associated with cardiovascular drug diseases. According to Halpin et al. (2010) there are several evidence-based interventions that are effective in preventing the risks related to CVD. Those interventions can be implied at three levels:

- At the level of society – government can change the environment, as well as individual behavior through the regulation of tobacco products and alcohol selling, taxation or banning advertising and etc.
- At the level of the community – government can promote the health through the activities of local institutions e.g. school-based and workplace health promotion, public awareness campaigns and health education. Health education is the profession of educating people about health.[32] For example in USA some of the states require the teaching of health education. Health promotion programs will make people to avoid the risk of having cardiovascular disease by changing their lifestyle, regulating their weight, healthy feeding and reducing alcohol consumption and tobacco smoking.
- At the level of the individual – through the provision of clinical preventive services including screening, counseling, chemoprophylaxis, and immunization.[33]

It is also important to regulate existing drugs on market. Kildemoes et al. (2006) suggested policy implications focusing on rational drug therapy as well as the promotion of prescription of cost-effective pharmaceuticals, rather than controlling the drug use between elder populations or reducing their reimbursement.

[32] McKenzie, J., Neiger, B., Thackeray, R. (2009)
[33] Halpin et al. (2011)

6. Conclusion

The thesis has analyzed the effect of both economic and public health factors on per capita pharmaceutical spending on cardiovascular diseases. We have used comparative analysis to show how countries vary in pharmaceutical expenditures and how these costs are rising in all countries over the time.

Based on comparative analysis, medical goods represent an important share of health care expenditures in most countries. There are differences in pharmaceutical spending across countries, but in all analyzed countries spending on medical goods continues to rise. Increased pharmaceutical expenditures contribute to the increase in overall health care spending. OECD data show that healthcare spending has outpaced economic growth over the last ten years, even during the economic downturn.

According to the European cardiovascular disease statistics (2008) cardiovascular diseases were the main cause of the death in Europe and the main reason of the year lost due to an early death as well. Comparative analysis for pharmaceutical spending on cardiovascular diseases has shown that in all analyzed countries pharmaceutical expenditure on cardiovascular drugs increased during the period 2000–2009 both in terms of drug sales and consumption.

From the theoretical point of view we have determined the main factors specific for pharmaceutical expenditures on cardiovascular diseases. Age, GDP, health expenditure, education, out-of-pocket expenditures and prevalence of a particular disease were considered as the main indicators that are able to explain the cross-country variation of pharmaceutical expenditure on certain diseases. All selected variables were supported by already existing literature and many empirical studies. However, none of studies have estimated the effects of economic factors together with public health factors on pharmaceutical expenditures on cardiovascular diseases. We included both economic and public health factors to draw a relevant

picture for policy makers for better understanding of the reasons of the increased pharmaceutical expenditures on CVD.

We have used a multivariate regression analysis in five selected countries, using panel data specification. According to the Hausman specification test the fixed effect model appear more appropriate to control for country-specific differences.

Estimation results show that the increase in pharmaceutical expenditures on cardiovascular diseases is mainly caused by aging of population and prevalence of the disease. Age is considered as one of the main risk factors for cardiovascular diseases, thus countries with a high proportion of older people face higher demands for cardiovascular drugs, which leads to increased cost for cardiovascular drug spending. Prevalence of cardiovascular disease was another powerful indicator for rising drug costs. High prevalence of cardiovascular diseases requires more and much expensive drugs for treatment, which leads to higher pharmaceutical expenditures as well.

Even though, there was no significant effect of education on pharmaceutical expenditures on CVD, we cannot reject effect of health programs on pharmaceutical expenditures. Because no matter how much the proportion of educated people has a country one cannot assume that they have the proper health education. Unfortunately, we were not able to test the effect of health education on pharmaceutical expenditures as there was no data available.

Another interesting finding was the positive effect of GDP on drug spending. Countries with higher GDP tend to spend more on the research and development for cardiovascular drugs allowing newer and more expensive drugs to come on market, which itself leads pharmaceutical expenditures to rise.

One of the important issues is high out-of-pocket expenditures on pharmaceutical spending, even though, in all selected countries government/social health insurance for pharmaceutical goods covers almost the whole population. Estimation results show that increase in out-of-pocket expenditures makes drug

spending to decrease, as patients are more likely to use lower-priced generic products when they have to pay a large portion of costs from their own budget. However financial burden of patients' own budget leads to decrease drug spending but only by a small ratio. This is because of the unique feature of cardiovascular drugs, as they are related to the "need" of patients, which decrease price sensitiveness for CVD drugs and lowers consumer's preferences.

At the end of the thesis we have concluded some government intervention, which can reduce the risk associated to CVD, from which, health education and promotion programs appear the most important and effective policy.

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Appendix

Table 6: descriptive analyses of data

Variable	Obs	Mean	Std. Dev.	Min	Max
year	50	2004.5	2.901442	2000	2009
countrycode	50	3	1.428571	1	5
ppp	50	65.938	14.22184	37.5	102.4
gdp	50	23007.77	7296.19	10983.44	37114.74
phe	50	2107.14	1066.623	605	4225
age	50	15.2438	2.473527	11.08	20.18
oop	50	295.2492	135.7549	69.44	633.82
edu	50	64.668	13.20426	43.9	80.2
prev	50	45.9802	9.343937	26.96	55.03

Source: Author's computations in STATA

Table 7: results from pooled OLS estimation

```
. reg  ppp gdp phe age oop edu prev
```

Source	SS	df	MS
Model	5609.62244	6	934.937074
Residual	4301.15551	43	100.026872
Total	9910.77795	49	202.260775

```
Number of obs =      50
F(  6,    43) =    9.35
Prob > F      =  0.0000
R-squared     =  0.5660
Adj R-squared =  0.5055
Root MSE      =  10.001
```

ppp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
gdp	.0023277	.0012453	1.87	0.068	-.0001836	.0048391
phe	-.0255899	.0090541	-2.83	0.007	-.0438492	-.0073306
age	1.413	1.365398	1.03	0.307	-1.340586	4.166587
oop	.0479069	.0178379	2.69	0.010	.0119334	.0838804
edu	-1.258329	.5421742	-2.32	0.025	-2.351728	-.1649308
prev	.242135	.7363256	0.33	0.744	-1.242807	1.727077
_cons	100.8596	23.42105	4.31	0.000	53.62659	148.0927

Source: Author's computations in STATA

Table 8: Results from random effects model estimation

```
. xtreg  ppp gdp phe age oop edu prev, re

Random-effects GLS regression                   Number of obs      =        50
Group variable: countrycode                     Number of groups   =         5

R-sq:  within  = 0.1686                         Obs per group: min =        10
       between = 0.9675                                        avg =      10.0
       overall = 0.5660                                        max =        10

Random effects u_i ~ Gaussian                   Wald chi2(6)       =     56.08
corr(u_i, X)       = 0 (assumed)                Prob > chi2        =    0.0000

------------------------------------------------------------------------------
         ppp |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |   .0023277   .0012453     1.87   0.062     -.000113    .0047684
         phe |  -.0255899   .0090541    -2.83   0.005    -.0433356   -.0078442
         age |       1.413   1.365398     1.03   0.301     -1.26313    4.089131
         oop |   .0479069   .0178379     2.69   0.007     .0129453    .0828684
         edu |  -1.258329   .5421742    -2.32   0.020    -2.320971   -.1956874
        prev |    .242135   .7363256     0.33   0.742    -1.201037    1.685307
       _cons |   100.8596   23.42105     4.31   0.000     54.95522    146.7641
-------------+----------------------------------------------------------------
     sigma_u |           0
     sigma_e |  8.3700802
         rho |           0   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Source: Author's computations in STATA

Table 9: Results from the random effects estimation for theta

```
. xtreg  ppp gdp phe age oop edu prev, re theta

Random-effects GLS regression                   Number of obs      =        50
Group variable: countrycode                     Number of groups   =         5

R-sq:  within  = 0.1686                         Obs per group: min =        10
       between = 0.9675                                        avg =      10.0
       overall = 0.5660                                        max =        10

Random effects u_i ~ Gaussian                   Wald chi2(6)       =     56.08
corr(u_i, X)       = 0 (assumed)                Prob > chi2        =    0.0000
theta              = 0

------------------------------------------------------------------------------
         ppp |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |   .0023277   .0012453     1.87   0.062     -.000113    .0047684
         phe |  -.0255899   .0090541    -2.83   0.005    -.0433356   -.0078442
         age |       1.413   1.365398     1.03   0.301     -1.26313    4.089131
         oop |   .0479069   .0178379     2.69   0.007     .0129453    .0828684
         edu |  -1.258329   .5421742    -2.32   0.020    -2.320971   -.1956874
        prev |    .242135   .7363256     0.33   0.742    -1.201037    1.685307
       _cons |   100.8596   23.42105     4.31   0.000     54.95522    146.7641
-------------+----------------------------------------------------------------
     sigma_u |           0
     sigma_e |  8.3700802
         rho |           0   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Source: Author's computations in STATA

Table 10: Results from Breusch-Pagan test

```
Breusch and Pagan Lagrangian multiplier test for random effects

        ppp[countrycode,t] = Xb + u[countrycode] + e[countrycode,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                 ---------+-----------------------------
                     ppp |    202.2608        14.22184
                       e |    70.05824         8.37008
                       u |           0               0

        Test:   Var(u) = 0
                                 chi2(1) =     0.97
                              Prob > chi2 =     0.3241
```

Source: Author's computations in STATA

Table 11: Results from fixed effects model estimation

```
. xtreg  ppp gdp phe age oop edu prev, fe

Fixed-effects (within) regression               Number of obs      =        50
Group variable: countrycode                     Number of groups   =         5

R-sq:  within  = 0.4433                         Obs per group: min =        10
       between = 0.0138                                        avg =      10.0
       overall = 0.0326                                        max =        10

                                                F(6,39)            =      5.18
corr(u_i, Xb)  = -0.9260                        Prob > F           =    0.0005

------------------------------------------------------------------------------
         ppp |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |   .0039811   .0012843     3.10   0.004     .0013834    .0065787
         phe |   .0009091   .0114021     0.08   0.937    -.0221539    .0239721
         age |   6.262488   3.665324     1.71   0.095    -1.151329     13.6763
         oop |  -.0666198    .028963    -2.30   0.027     -.125203   -.0080367
         edu |  -1.791007   1.688757    -1.06   0.295    -5.206842    1.624827
        prev |   6.824134   2.569706     2.66   0.011     1.626412    12.02186
       _cons |  -301.3216   203.4383    -1.48   0.147    -712.8143    110.1712
-------------+----------------------------------------------------------------
     sigma_u |  34.686243
     sigma_e |  8.3700802
         rho |   .9449744   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(4, 39) =     5.60                 Prob > F = 0.0012
```

Source: Author's computations in STATA

Table 12: Results from Hausman specification test

	Coefficients (b) fixed	(B) random	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
gdp	.0039811	.0023277	.0016533	.000314
phe	.0009091	-.0255899	.026499	.0069305
age	6.262488	1.413	4.849488	3.401512
oop	-.0666198	.0479069	-.1145267	.0228181
edu	-1.791007	-1.258329	-.5326779	1.599359
prev	6.824134	.242135	6.581999	2.461954

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 26.50
Prob>chi2 = 0.0001
(V_b-V_B is not positive definite)

Source: Author's computations in STATA