Does the existence of option affect cross-listed stock prices?
- Empirical investigation of whether there is any effect on stock prices caused by option existence (a study on hardware & technology companies)

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Current work investigates whether existence of an option affects price disparity between cross-listed shares (CLS). Aside from classical Black Scholes model, this work assumes possibility of feedback effect from option derivative to its underlying asset. In contrast to previous works, which assumed the same feedback effect, this paper employs rather distinct and innovative approach. The study is conducted on the same cross-listed stocks on several exchanges compared to previous researches that focused on “similar“ shares of different companies, or on the same shares analyzed over time. Similarly, previous works in the field of CLS had focused on factors such as transaction cost, holding cost, regulatory cost, withholding/dividend tax trying to explain price difference on different exchanges on same stock. None of the factors gave exhaustive explanation to price disparity. Therefore the authors additionally examine whether the existence of option affects this price disparity. This study is conducted using 546 companies listed on at least 2 stock exchanges up to 8 stock exchanges; time horizon is from 2011 till March 2014. Price differences (price of a share on one exchange minus price of the same share on other exchanges) are calculated for each company and combined in three groups. Followed by a part where the paper inspects how arbitrage opportunity varies between groups of non-optioned shares, when one share is optioned and when both shares have options. The evidences found suggest that there is a “feedback“ effect of option; that price disparity has negative relationship with options existence, and price disparity is affected by existence of option. Results are highly significant for “feedback “effect, however option can not be regarded as exhaustive explanatory factor for price disparity due to low R square.
Key words: Cross-listed stocks, CLS, option instrument, Black and Scholes, BSM, effect of option, price discrepancy, market inefficiencies, market anomalies, feedback effect, option effect, arbitrage in cross-listed stocks

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Definitions

Arbitrage – Making risk free profits by taking advantage of existence of mispricing in the markets.

Cross-listed stocks (CLS) – Stocks that are listed on two or more stock exchanges at the same time. Exact number of cross listings varies depending on the stock. Cross listing can take place within the same country or abroad.

Diversification – A technique for eliminating or minimizing diversifiable risk by holding a portfolio of assets that are not perfectly correlated.

Endowment fund – is a fund made up of gifts and bequest where withdrawals are made for specific purposes and ongoing causes.

Holding cost - as the name suggests, it’s a cost incurred when an asset is not sold, but instead kept or stored

Idiosyncratic risk – Type of risk also known as unsystematic risk and firm specific risk. It’s a risk that is specific to that particular company and thus considered to be possible to eliminate through diversification.

Liquidity – Degree to which an asset can be easily converted into money, or in other words, sold and bought

Mergers and Acquisitions (M&A) – are activities carried out with the purpose of achieving various economic goals. Merger means two companies being combined into a single entity. Acquisition means buying other companies.

Option – a type of financial instrument that enables the owner to buy and sell securities without being exposed to the underlying asset.

Pension fund – Retirement fund created by the contribution of employee and employers, conducts investing activities to provide reliable and stable income to the contributors.

Price discrepancy/disparity – When the same stock is listed on two or more stock exchanges, prices differ usually by small amount.

Rational investor – an investor who makes choices with the aim of maximizing utility or benefit for his/herself

Risk Averse – means that an investor dislikes or avoids risk, or in other words, if two choices offer similar returns but different risk level, then the investor would choose the one with the lower risk level.

Systematic risk – Market wide risk that is inherent in nature, also called undiversifiable risk. This risk is deemed to affect the entire market and not possible to diversify away.
1. Introduction

This is the first chapter of our thesis, explaining the reasoning behind our research, providing background to the research question and specifying the knowledge gap to be filled by this research. The chapter begins by talking about international companies cross-listed across the world and the pros and cons of cross listing. Followed by a part on empirical evidences of existing price discrepancy in relation to CLSs. Followed by a brief explanation on effect of options on stock prices is given. Finally the chapter ends by defining our research question, audience and delimitation.

1.1 Research Background:

Cross listing is when companies list their stocks on two or more stock exchanges at the same time. An example would be a British company having its stocks listed at London stock exchange, NYSE and Hong Kong stock exchange. Couple of decades ago, US pension and endowment funds started to have substantial holdings in non-US stocks. Reasons behind these actions were to diversify their portfolio and earn higher returns than possible at the home market (Cochrane et al., 1996, p.241). The trend was not unique to US, with Britain and Japan following more or less the same path according to Economist (1995, as cited in Karolyi, 1998, p.1). This increased demand for foreign equity resulted in more companies raising capital in markets other than their home markets. Nowadays, companies list their stocks all around the world at various stock exchanges.

(Karolyi, 1998, p.34) found several benefits and costs associated with cross listing. These include initial share price increase, increased liquidity and trading volume, less exposure to domestic market risk. Downsides are increased legal and accounting fees, increased burden from regulatory requirements and accounting standard, and global market risk and exchange rate risk. (Miller, 1999, p.122) provides empirical evidence for higher share price and lower cost of capital due to cross listing. (Roosenboom et al., 2009, p.1899) states that four possible reasons explain the gains associated with cross listing, and it includes mitigation of market segmentation barriers, increased market liquidity, better transparency and more investor protection. These advantages can then in turn be assumed to lead to higher valuation. Overall consensus seems to support the idea that cross listing does lead to higher valuation, especially in the US, thanks to bigger market access (Doidge et al., 2004, p.235). Despite this, it's difficult to directly attribute any gain in the valuation to the cross listing of the stocks. Obviously financial results and stock performance subsequent to the cross listing depend on many other fundamental factors to a much larger extent, mainly on the performance of the company.

Cross border capital flow through equities led to intense competition between the major stock exchanges to attract new listings. Previous studies have pointed out the benefits of larger shareholder base, lower cost of capital, greater liquidity and prestige. However, there have been significant slowdown of cross-listings in the recent years and the total number of cross-listed companies has declined. This is attributed to the cost of cross listing, and the integration and globalization of the global financial markets (Karolyi, 2006, p.100). As we all know, thanks to the technological advancements of our time, now investors can make
transactions in a short amount of time, in an efficient manner, able to buy and sell the same securities globally at the same time, in different time zones and in different currencies.

1.2 Theoretical foundations and empirical results

In accordance with Arbitrage Pricing Theory (APT), Ross (1976) explained simple assets with the same payoffs should be priced the same at equilibrium price. Many papers test this theory and assumptions it makes (Chen, 1983, p.1409; Roll & Ross, 1980, p.1100) with different results. Nevertheless, APT is one of the fundamental and useful tools in capital pricing field. One of the implications of APT is that there should be no arbitrage opportunities or different pricing of same assets in the market when it is in equilibrium state.

No-arbitrage theory does not hold for CLS. Although both markets might be in competitive equilibrium, the prices of the underlying assets, essentially the same stocks, entitled for same series of cash flows, are priced differently on different exchanges. Previous works studied this anomaly and found sufficient evidence of price disparity between so-called “Siamese Twins” (De Jong et al., 2009, p.518; Froot & Dabora, 1999, p.214-215; Ghosh et al., 2010, p.106; Rosenthal & Young, 1990, p.141; Scruggs, 2007, p.103-104). Many of the papers found existence of profitable arbitrage opportunities due to price disparity of CLS. (De Jong et al., 2009, p.510) found that these opportunities could yield 10% annualized return adjusted for transaction costs, margin requirements and systematic risk. The share could be traded on one of the markets at -40,4% discount or at 127,4% premium according to (Gagnon & Karolyi, 2010, p.54).

Researchers have tried to explain the existence of price discrepancy between the same underlying stocks listed at different stock exchanges through different reasons. Based on their empirical study of 506 U.S. cross-listed stocks from 35 different countries, (Gagnon & Karolyi, 2010, p.53) suggests that arbitrage opportunity is enabled by the holding cost, short sale constraint, level of access to the market, trading and funding costs and market volatility. The study also suggest that the results could be affected by other factors that are difficult to measure, notwithstanding the development of technologies to facilitate the process, such as transaction costs, regulatory restriction cost and market environment. (De Jong et al., 2009, p.495) gives idiosyncratic or unsystematic risk as the main reason for the price discrepancy. Gagnon & Karolyi (p.53, 2010) points to the fact that there have been many studies on cross listed stocks in the past, in which the papers try to explain the price discrepancy of the same underlying security via tax, accounting, regulation and governance among others. What’s more, there are other studies such as Grammig et al. (2005), where special intraday data was used explain the price mismatch in cross-listed stocks. Overall there appears to be no concrete consensus on what actually causes the price deviations, different papers citing different reasons and almost all of the papers mentioning some kind of limitations in their studies.

Nonetheless none of the researchers have considered options in their study. Options are financial derivatives that give right to its owner to buy (call option) or sell (put option) underlying asset by a certain date for a certain price (Hull, 2012, p.8). In case of unfamiliarity of the reader with options, they will be explained in more detail in later
When it comes to CLS price disparity papers, none of the papers looked at the effect of existence of options instrument on underlying cross-listed shares. Intuitively one can imagine how options can affect the price of stocks. Exampli gratia options could provide extra liquidity for illiquid security, thus increase liquidity premium. Another example would be that options could help investors to evade short sale constraints or quantity constraints imposed by exchange, which could affect the price of the stock close to option expiration time. Some papers would state that option markets are informational superior and attractive for insider traders (Chen & Lu, 2013, p.6; Jin et al., 2012, p.5-6). In this respect, stocks with options on them might have a slightly higher value because of additional information that option might provide.


1.3 Research purpose

By bringing together the price divergence phenomenon associated with cross listing and potential effect of option on the prices of underlying stocks, this research strives to test something completely new and unique. Cross listing is a well-known concept with thousands of cross-listed companies around the world, as mentioned previously. Hence there are many research conducted on pros and cons of cross listing. In the following chapters, the paper will take a closer look at some of the previous work and discuss the papers separately and in connection. Previous researchers offered many different possible explanations to the price discrepancy that exists between CLSs but none of these researchers considered option instrument as one of the possible explanations that could be causing the divergence in price. Likewise, prior research papers done on the effect of options scrutinized the effects of options on stock prices in general, but there are no research focusing on effect of options on CLSs or the price disparity of CLSs. Most of the papers that have been written about the effects of option on stock prices are relatively new and many research papers are still ongoing and forthcoming. Furthermore, the researchers in the field of option and cross listing are very field specific, thus might not cross over to other research areas and conduct a study linking different fields. This assumption might be the reason for no prior research on this topic. Research linking these two fields of cross listing and price effect of options could have substantial implications for academicians as well as practitioners of finance. Therefore, the study aims to link these two fields of research, cross listing and option in order to see whether the existence of option has any effect on cross listed stock price disparity. Due to practical limitation that will be later explained in detail in the practical methodology chapter, the study is limited to companies belonging to hardware and technology companies. Hardware and technology category was
selected due to its inclusion relatively large number of companies with active options compared to other categories, making it suitable for our research purpose. Nevertheless, the results should be relevant and applicable to other types of companies as long as companies with active option instruments are part of the group.

1.4 Research question

Thus the research question is:
Does the existence of option affect prices of CLSs?

1.5 Research gap and contribution

This paper attempts to explain the price disparity of CLS shares due to existence of options instruments on the share. The findings would contribute scientific society in the way that it would add one more factor, which was overlooked in earlier studies but could have had an impact on price distortion of CLS shares. We consider this to be a potentially big contribution because there is no prior academic research on this topic and this would give new insight that were completely absent before. Therefore we would contribute to the theoretical field of asset pricing trying to explain this market deviation issue with fresh perspective. Moreover this would contribute to the field of derivative pricing as well, in the way that exploration of effect of options on the underlying asset would enrich BSM theorem with valuable findings, which might open a path to further researches. In other words, the findings would be relevant to both option researches, as well as cross listing research field.

Aside from theoretical contributions, this paper has practical value as well. As was mentioned in above sections, there were studies that concluded that there are arbitrage opportunities due to price difference in CLS shares. As for practitioners, such as traders and arbitrageurs, this paper would provide better picture of market and possibilities to find and understand arbitrage opportunities related to CLS shares. This in turn should lead to eliminating this opportunities and bringing the market back to its efficient and equilibrium state. In this respect practitioners can gain through better understanding of arbitrage opportunities and market players can benefit from eliminating these deviations and bringing global market back to its optimal state.

1.6 Audience

The intended audiences for our research are people who are engaged in investing and finance. Thus we expect the readers to have at least basic knowledge in the field of finance. Derivatives, options in particular and other concepts and theories related to cross-listing and price disparity could get rather overwhelming and difficult to understand to those with no prior knowledge in finance. Our topic is very much unexplored and there is enormous potential for further research, hence we believe it would be of interest to academics and scholars. In addition, traders and investors in international markets could be even more interested in this topic since this research touches the issue of arbitrage profit opportunities. Moreover, this paper is of interest and intended for business research at Umea University.
1.7 Delimitations

Our research doesn’t cover all the cross-listed stocks and limited to a certain industry. This is due to practical and time limitations constraining our research. Companies included in the industry selected for our research covers companies that have relatively more active options. Hence we can’t deny the possibility that the result could change depending on different sample selection. Companies in our sample are mostly listed on the US and European stock exchanges. This is somewhat expected and understandable considering the fact that options trading activities are dominantly concentrated in mature capital markets of the US and western Europe. Therefore, it would be difficult to generalize the results to other regions.

Our research is based on data between 01-01-2011 and 31-03-2014. It is reasonable to assume that the results might differ during different time horizons. For example, the financial markets were much more volatile during the 2008 crisis and the markets behaved very much different from the normal periods. Last but not least, the purpose of this paper is to observe if there is any effect of options in price discrepancy between CLSs, but not to explain the causal relationship. In case we do find an effect of options on prices of CLSs, we will not go further to explain the reasons for why and how, or the extent to which it affects the prices.

1.8 Disposition

Chapter 1: Introduction

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Chapter 2: Methodology of the research

This chapter deals with the issue of research methodology employed in our research. In order to carry out a successful research project, choosing the correct tools and methods first of all is vital; otherwise it is certain the project would fail. The chapter begins with a discussion on general philosophical considerations and moves onto other more specific areas such as research approach, design and strategy. Ending part answers questions of reliability, validity and ethics.

Chapter 3: Theoretical foundations

This chapter deals with and provides explanations and evidence to our theoretical and empirical background relevant to our research. The chapter begins by introducing theories and concepts related to market efficiency, imperfection, anomalies and arbitrage. Continued
Chapter 4: Practical methodology

In this chapter we illustrate and rationalize how the data was retrieved, sorted out and organized. First of all, selection of data sample and justification for the selection are given. Moreover, detailed explanation of how the data was processed, filtered and transformed to make it suitable for statistical analysis is provided.

Chapter 5: Empirical findings, discussion and analysis

This chapter is the quantitative and statistical part of the research. Various statistical tools and methods are employed to analyze the data and finally give answer to the question of whether there is an effect of options or not. Basic as well as more advanced statistical techniques such as random and fixed effects were used. The different statistical techniques were compared with each other to come to overall comprehensive results to the research question.

Chapter 6: Conclusion and further research

Based on the statistical analysis and discussions, the entire paper is concluded in this section. In addition, further research suggestions are provided and the chapter closes with an assessment of the quality of the research.
2 Methodology of the research

This chapter deals with the issue of research methodology employed in our research. In order to carry out a successful research project, choosing the correct tools and methods first of all is vital; otherwise it is certain the project would fail. The chapter begins with a discussion on general philosophical considerations and moves onto other more specific areas such as research approach, design and strategy. Ending part answers questions of reliability, validity and ethics.

2.1 Philosophical preconceptions and discussion

Referring to Ryan et al. if the research causes debates or doubts about the technique employed, it makes it ‘weak’, ‘misapplied’ and ‘defective’ in readers’ minds. Golden-Biddle & Locke (1993) in their article “Appealing work: An investigation of how ethnographic texts convince” has the same opinion. Even though the article is about ethnographic texts, it provides excellent framework for paper writing in any field, through illustrating the fundamental principles of building convenience power of the research. They emphasize that if authors’ line of argumentation is weak, not plausible and not critical, it diminishes convincing power of the paper. Ryan et al., says that disputes might arise in two dimensions: statistical sufficiency (whether methods employed are appropriate for this research and this data) and philosophical approach (whether the philosophical paradigm or stance is appropriate for this type of research). In order to protect this work from debates in both dimensions and raise its convincing power, the authors explain their philosophical stance in current section.

2.2 General considerations

Ryan et al. justifies the existence of philosophical disputes in social science through social issues, which are involved in it. He provides stark examples with physics, which studies the natural phenomena, thus not applied to social context. In his opinion, this makes it immune to discussions on philosophical level. This point of view is understandable. Why to argue if ‘the rocket science stuff’ works? However, we find this argument weak and believe that it is unfair to argue for natural sciences in this manner. Besides the relevance and importance of these disputes are questionable. In the same manner, scientific society might demand physicians, chemists, engineers and mathematicians to firstly prove that substance exists, and to prove that they are not studying themselves and studying something not created by their own imagination. Then let them refute the “Dream Argument” of Rene Descartes (Descartes, 1996, p.13), which consists of doubts about trustworthiness of senses and experience gained through them by making analogy to dreaming. In other words, Descartes questions existence of reality because he can not trust his own senses 100%, saying that same senses fools him when he sleeps and sees a dream. This could question the results of many experiments done by physicians. Luckily to them Descartes himself disproved this argument in his later works. However, George Berkeley after Descartes contradicted it with his so-called immaterialism (Descartes, R., 2010). As brilliant critique of previous works and keen mind himself, he developed Descartes ideas further till solipsim like state.
As the authors of this research, we would be interested in seeing natural scientists disproving Berkeley’s Master Argument (Gallois, 1974, p.55), which says that objects do not exist without the mind of an observer. All the objects are just ideas of the mind, there is no material substance out there. All the objects do exist only as ideas in our mind, furthermore they exist only when we perceive them and dissolve as we turn away. There are many more complex and interesting theories about reality and its existence like Gottfried Leibniz’s Monadology (Leibniz, 2013), which imply that physicians are studying not atoms, electricity or radio waves but Monads; Pantheistic dualism of Spinoze (Spinoza, 2013) that says that physicians are studying God himself, and this is terribly fascinating and funny at the same time. Doesn’t it seem absurd to make natural sciences to go into this type of discussions? We think that same holds for some social sciences. Alert reader might perceive this argument as far-fetched, since it does not relate to philosophy of knowledge. It does not connect to questions like: “What is knowledge?” “What is regarded as knowledge?” In order to answer this question, an illustration using physics example once more, wave element of the light was illustrated and used before it was proven and mathematically described. It was already accepted as ‘knowledge’ before it was proven simply because it worked.

Our positions upon above-mentioned questions coincide with physics because it is pragmatic, i.e. if it works it is valuable. Since our paper is mainly intended for stock traders, people who use applied finance and value practical applicability, we think this position is justifiable. In addition, the thesis is made with principles of epistemological anarchism of Paul Feyerabend (Feyerabend, 2012). It stands for freedom of existence of any paradigm, even most ridiculous one, however, the better the major paradigm in the research field is, the more precise and reliable results it gives. This suits this thesis because one of the main theories is used here is APT. It is used for wide range of cases starting from risk free valuation of bonds and goes to option pricing replacing binominal tree pricing method. However it does not work all the time for CLS stocks. This gives a chance for our paper to amend major paradigm and use it to solve CLS price disparity issue. Even if the hypothesis gets rejected, it would still yield practical value for traders and arbitrageurs.

To conclude this section, we as the authors wanted to emphasize that it seems like the major methodological debates in philosophical dimension arise in the field of organizational studies. This is understandable, because it is arguable whether mankind can ever obtain the form of knowledge that is independent from their own subjective mind, since there are transmitters of the knowledge. This questions objectivity itself, but we still believe that this issue can be applied only to those social sciences that do not have more or less value free measures. In other words, economics, finance and accounting are much closer to natural sciences than management studies, organizational change and organizational studies, since they use the language of abstract numbers. Moreover, these numbers most of the time express money terms. They are based on fundamental assumption of maximum utility behavior for the human being. Which means that more utility is preferred over less utility and even though some actions might seem irrational, they are still made with unconscious desires and yet yields maximum utility to the person in most cases, regardless of whether the person realizes it or not. It is a bold step to separate social sciences as such, but we believe that it is legitimate. Finance field should be free from this types of nonsensical discussions simply because it has close to value free measure – money.
As the authors of this paper, we both came from very diverse national backgrounds, studying abroad in Sweden and it provides some intercultural experience. With regards to this, experience of money is quite the same in most cultures. Based on our personal experience, both of us never met a rational person who would prefer less money to more or would treat money other way around than people around him. With this in mind we want to make parallel with temperature in physics. Even though some subjectivity exists in scale hot cold and everyone himself individually determines it, the order of degrees is what is important. The higher the degree the hotter it is or the more intrinsic energy substance has. Curious reader might draw similar sketch with money. Thus, if temperature can be considered as value free money can fulfill the same requirements. Therefore, finance field with value free measures need not to be involved with disputes relevant to organizational studies. Exception here might be the case of behavioral finance.

Choosing the appropriate research methodology is crucial to the successful completion of our research work because financial research of any type could be subject to criticism of serious and significant nature, if there is a flaw at the philosophical level, regardless of whether the methods employed were acceptable or not (Ryan et al., 2002, p.8–9). In other words, validity of our research could be considerably threatened in case there is a fundamental problem with the chosen research methodology, resulting in weak research foundation from the very beginning. Johnson et al. (2006) argues that its not necessarily a question of whether our research has to be philosophically informed, but more about whether we can reflect upon the philosophical choices we made and reasonably defend the rationale behind how the choices we made were better than the alternatives we could have adopted instead. In general, research in accounting and finance are accepted as being social scientific rather than natural science because it deals with social issues.

2.3 Historical traditions, development and choice of epistemology.

Short excursion in the history of finance methodology is fruitful for the paper and helps authors to contour their methodological position in a more contrastive way. Ryan et al. in his book states that in general financial researchers are strongly committed to what they call ‘objectivism’ (Ryan et al., 2002, p.4). Means that creation of precise and economical theories is endorsed by fine designed tests that are used on samples as large and unbiased as possible. It treats social world as concrete structure out there (Morgan & Smircich, 1980, p.492). Replicability and critical evaluation of results and methods are the indicators (golden standards) of this kind. Many authors claim that it gave rise to the positivism with a focus on empirical research of concrete relationships and made it mainstream in finance (Johnson et al., 2006, p.136; Morgan & Smircich, 1980, p.491; Ryan et al., 2002). Notwithstanding this, Ryan et al. mentions that finance and accounting fields has wide range of methods available in order to be able to fully explore this research field. Morgan & Smircich says that 1960s and 1970s were dominated by quantitative methods with objectivity and positivism (Morgan & Smircich, 1980, p.491). It can be explained as application of natural science and complex statistical methods such as multivariate statistics analysis to data. It reduces the role of humans as decision makers, or subjective elements that has effect on reality to more deterministic view. During that time, statistical tools were developed and positivist search for laws, causation and regularities are considered as basis for effective research (Morgan & Smircich, 1980, p.498). Nevertheless, Morgan and
Smircich (p.491) assumed that in 1980s, there would be qualitative pendulum swing of qualitative methods. This assumptions has some valid proofs such as “Accounting, Organisations and Societies”, which employs interpretivist position and quantitative methods became the second ranked journal within accounting as counterweight to first ranked “The Accounting Review” that mainly follows quantitative methods. That is shortened and concentrated general historical perspective on methodology in finance. Nowadays it is clear that Morgan and Smircich assumption of qualitative pendulum swing does not hold, rather it seems as if the methodology became more balanced and there much lesser skewness towards quantitative methods.

Some above-mentioned terms such as positivism relates to broader and much older philosophical problem known as epistemology. Epistemology is the branch of philosophy that seeks answers to the questions of: What knowledge is? How it can be acquired? It is so called “philosophy of knowledge”. It is always beneficial for one to define one's position upon this question, in order to be able to constructively collaborate with other researchers on the same grounds. They are doomed for counter productive dialog if it has two different meanings for what is knowledge. In terms of paradigms, this two would be operating in different scientific environments without any common point or any common instruments for discussion. Plato was one of the first who asked those questions and tried to answer them. In his attempts to answer it, while developing his line of thought he founded the rationalism. Rationalism claims that knowledge can be obtained through reason (Ryan et al., 2002, p.5). It relies heavily on mathematics and logics as tools to empower reason and compare theories. This position says that observations alone are not sufficient to be treated as knowledge, but it needs reason to be complete. Thus it was main school of thought in epistemological philosophy. Nevertheless, the development of professions and guilds in 17th, 18th and 19th centuries has led to change and gave rise to additional views upon knowledge. The prentice were studying the profession by observation. Carefully monitoring and practicing what their master was doing. This allowed for counter philosophy called empiricism to arise. It was suspicious of speculative method and emphasized experience via perception as the dominant criteria of knowledge and said that knowledge is acquired only through observation, not the reason.

Mathemetic and logic are just a ways of supplementing the observed truth. Modern empiricists are not that radical, as initial idea might seem to be. They do not claim that something that can be observed is the only source of knowledge, but they say that experience is still very important in terms of justification. Empiricism stressed the idea of value free science. It means that study shall be free from ideologies and subjective beliefs. Development of empiricist ideas gave birth to mainstream in finance, economics and accounting known as positivism. Positivists assume same principles as empiricists, but what strongly distinguishes them is their assertion that “meaningful statements are only those that can, in principle at least, be verified by appeal to observation”(Ryan et al., 2002, p.17). That is verification principle. In case of this paper the authors took rationalist stance because there are already theories and mathematical models of inefficient markets, incomplete information and information diffusion. They explain why the options as redundant instruments exist. It is due to the inefficient markets. The same reason applies for price disparity between cross-listed stocks. Yet options shall help markets to become more
complete and therefore affect price disparity. Therefore, the reasoning is developed and current paper attempts to supplement this reasoning with empirical observation.

In case of this paper we, the authors, took rationalist stance. There are several reasons for this choice. First of all, the theories and model that are used as the bases for this work represent strong commitment to rationalism. All the theories employed in this paper have been developed with heavy mathematical and advanced models. These models are based on reason, on mathematical expressions that explain relationship in involved factors. Then these models are tested on data to see if it does support the model or not. Thus dominance of reason is obvious. In this research the mathematical reasoning of previous theories are used. For example Black Scholes Merton Model of option pricing tells that option price is dependent on share characteristics of price and volatility. This cannot mathematically be rearranged, i.e. it is not possible to express share price or volatility through option price using Black Scholes Merton equation. Therefore it is not possible for current work to have empiricism stance while using mathematical derivations of rationalism. Second reason is that many aspects in this paper are not observable through observation. Options and price disparity are consequences of inefficient markets, referring to the so-called Efficient Market Theory. It cannot be observed through senses whether markets are efficient and to what extent, hence empiricism cannot be employed. Yet having options (which are redundant instruments in efficient market) and price disparity between cross-listed stocks (consequence of market inefficiency) as two main aspects in this study, we attempt to see whether existence of options makes markets more efficient by decreasing the price disparity. That is an attempt to confirm reason with data.

2.4 Ontology

Ontology is the study of existence and in this respect, defines what is considered to be ‘real’. Thus asks the questions of how we can define reality and how we would know whether something is true or false (Ryan et al., 2002, p.13). In order to answer this question, ontological issue considers two opposing views called objectivism and constructionism. Objectivism views the world in a way in which there is an external existence outside the subject’s mind or perception. Different attributes and qualities of its existence may vary between the entities or concepts in question, but the there is an actual existence within the object itself, regardless of how we perceive or interpret it, existing outside the human mind (Bryman & Bell, 2011, p.21). The contrary position is called constructionism, which defends the view that reality is constructed within the minds of social actors and their perception of the world. Hence, social phenomena and their meanings are continually being built up by social actors and in constant state of flux. Existence and its meaning is a dynamic concept rather than static one because they its in constant state of revision. Qualities such as color or texture are mental representations of sense - data and based on these attributes we form the concept of ‘reality’. Knowledge is created upon our perception of the world and this leads to a view based on one’s belief rather than correspondence with externally existing reality (Ryan et al., 2002, p.14)

In this research paper, we plan to make statistical inferences through regression analysis by employing different statistical methods and tests. Information such as the availability of option instrument and prices of different cross-listed stocks will be used. Thomson Reuters
Datastream Professional was used for collecting relevant data on the chosen industry and the companies. The questions we are going to answer are whether the existence of options affects the underlying stock prices and see if the price disparity in cross-listed stocks is the result of this. Verifying whether there is an existence of effect on the stock prices is basically the same as answering yes or no question. This is independent of our individual subjective opinion and how we try to interpret the results. Either confirming or denying the price effect shall not change depending on the person analyzing the results, unless the result itself is incorrect or inaccurate. This means the study adheres to the objectivist view, in which there is a reality independent of our view or belief of it. The objective of this research is to detect any effect on the stock prices caused by the options derivatives, not to measure the relative magnitude or extent of the effect, offering straightforward answer to the research question. This leaves no room for subjective interpretation of the result and the result is not expected to change over time as long as the study itself is accurate and free of error.

Statistical method and hypothesis testing to be employed are also free of different interpretations and perceptions subject to individual opinions. The proposed hypothesis will be concluded by either rejecting the null hypothesis or by not rejecting it. Leading to very unambiguous result, open to only one interpretation. Data used for the study is actual financial data provided by an independent third party which specialize in this kind of service. This shall uphold the objectivity of the data used. It is possible for numerical data to be interpreted or perceived in different ways in terms of relative size and category, however, this is irrelevant to our study because the study is not concerned with this aspect, as mentioned earlier. Therefore, in our view, it is more than reasonable to assert the ontological position is objectivist.

2.5 Research approach

Theory building can happen in two different ways, namely deductive and inductive, and similar to epistemology and ontology, these two approaches can be viewed as opposite positions. At conceptual and theoretical level, going from general statement to specific assertion is called deductive approach. As the name suggests, this approach deduces a conclusion regarding a specific instance based on broader theory or premise. Inductive approach is more or less the reverse of deductive approach, coming up with a general proposition based on observation of particular facts. In other words, using observational results related to particular facts and observations, the researcher proposes a theory that can be generalized to other cases (Zikmund et al., 2009, p.44). Being reverse and opposing approaches of each other does not imply that deductive and inductive processes are mutually exclusive. For example, the last phase of deductive process, revision involves inductive process, feeding the result of the hypothesis in the opposite direction and modifying the theory depending on the results. The same can be said for inductive process, involving deduction and going back and forth between the different stages comprising the process. This is commonly known as iterative strategy (Bryman & Bell, 2007, p.14).

Our research approach is clearly deductive one because we have proposed a hypothesis based on existing theories and assumptions, upon which statistical tests are going to be conducted to determine whether there is statistically significant evidence to claim that there
is an effect. The study is based on theories such as Arbitrage Pricing Theory (APT), Black & Scholes model, efficient market hypothesis (EMH). There are also empirical findings claiming to have found an evidence of options impact on the underlying stock price. Based on these foundations of theories, the goal is to find if there is any effect of options instrument specifically on CLS. This is in accordance with the flow of process described as deductive, going from general to specific.

2.6 Research design

(Saunders et al., 2009, p.139) states that research design is divided into three categories of exploratory, descriptive and explanatory, in general. This doesn’t mean that research has to be restricted to only one research design, so it is possible to utilize a combination of different designs. Exploratory research design is suitable when trying to understand the situation and seeking new insights into the area of research, especially useful in case of not having a good understanding of the problem and wish to obtain a clearer understanding (Robson, 2002, p.59). There are three main ways to carry out exploratory research (Saunders et al., 2009, p.140):

• A search of the literature
• Interviewing ‘experts’ in the subject
• Conducting focus group interviews

The only thing essential in exploratory design is that is must continue to remain flexible to accommodate research concerning different facets of a research problem when other issues need to be investigated by the researchers later on (Kothari, 2004, p.37). Unlike exploratory research, descriptive studies should be conducted after the researcher has a solid understanding of the topic being studied. Exploratory research could contribute to the development of this understanding (Zikmund et al., 2009, p.55). Descriptive research is ‘to portray an accurate profile of persons, events or situations’ (Robson, 2002, p.59). It could be an extension or precedent to exploratory research or a part of explanatory research. Deemed to be inferior to other designs such as explanatory since it doesn’t require higher-order skill needed for analyzing and drawing conclusion. Explanatory research studies different relationships in order to find causality between the relationships in question. Finding a relationship between different variables, and then explaining what causes the relationship to hold (Saunders et al., 2009, 140). Causal inferences are very powerful because they lead to greater control (Zikmund et al., 2009, p.56). These types of research not only require procedures for reducing bias and improving reliability, but also make it possible to draw statistical inference explaining the cause and effect relationship (Kothari, 2004, p.39).

We would argue that our research fits the category of explanatory research because establishing cause and effect relationship is what we are aiming for. Testing the relationship between options instruments existence and price disparity in CLS. Cause would be the existence of options and effect would be the price disparity caused by the existence of options, assuming the hypothesis is accepted. Previous researchers have tried to explain the effect of price disparity in CLSs using many different causes. In our research, the price disparity effect would be explained by the causality of options existence.
2.7 Research strategy

According to (Saunders et al., 2009, p.141), research strategies are divided into the following categories and brief description of each category is provided in table 1:

<table>
<thead>
<tr>
<th>Research strategy</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment</td>
<td>Whether a change in one independent variable produces a change in another dependent variable</td>
</tr>
<tr>
<td>Survey</td>
<td>Most frequently used to answer who, what, where, how much and how many questions.</td>
</tr>
<tr>
<td>Case study</td>
<td>Understanding of the context of the research and the processes being enacted</td>
</tr>
<tr>
<td>Action research</td>
<td>A research initiated to solve a current problem or a reflective process of problem solving through active participation</td>
</tr>
<tr>
<td>Grounded theory</td>
<td>Theory building’ through a combination of induction and deduction</td>
</tr>
<tr>
<td>Ethnography</td>
<td>Describing and explaining the social world the research subjects inhabit in the way in which they would describe and explain it</td>
</tr>
<tr>
<td>Archival research</td>
<td>Makes use of administrative records and documents as the principal source of data.</td>
</tr>
</tbody>
</table>

Table 1 Research strategies

The literature gives rather flexible view on the application of these different strategies, stating that no strategy is inherently superior or inferior to the other and it’s not necessary for different strategies to be used separately. It is viewed that each strategy could be used for exploratory, descriptive and explanatory research (Yin, 2003, p.45). Being consistent with the comparison of different research strategies, its clear that our study resembles the archival strategy the most. Datastream is a software containing large amount of financial data, and we will be making use of the official data stored in DataStream concerning different indicators such as stock price and options availability. Conducting statistical tests and regression analysis to draw a statistical inference on whether there is a significant result proving the options effect on stock prices.

2.8 Research method

Bryman & Bell (Bryman & Bell, 2012, p.35) asserts that distinguishing between quantitative and qualitative studies is still considered to be very much relevant to research, despite some claiming irrelevant to research. For many, the main distinction between quantitative and qualitative is about epistemology. Quantitative research is represented by deductive approach, testing of theories, has practices and norms of natural scientific model and positivism in particular and objective reality. On the other hand, qualitative research is
represented as mostly inductive, generation of theories, rejection of positivism in particular and social reality of constructionism. Fundamental differences are given in table 2:

<table>
<thead>
<tr>
<th>Theory in relation to research</th>
<th>Quantitative</th>
<th>Qualitative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deductive: testing of theory</td>
<td></td>
<td>Inductive: generation of theory</td>
</tr>
<tr>
<td>Epistemology</td>
<td>Natural science model, positivism in particular</td>
<td>Interpretivism</td>
</tr>
<tr>
<td>Ontology</td>
<td>Objectivism</td>
<td>Constructionism</td>
</tr>
</tbody>
</table>

Table 2 Source: Bryman & Bell, 2007, page 28

Hence, it’s easy to see that our research has quantitative method, based on the arguments we have made so far. Choices made in this research regarding principal orientation and ontological and epistemological considerations are consistent with the quantitative method as you can see in the table above.

2.9 Literature and Data source

Books, textbooks, articles and some online sources are utilized in the paper. Basically all the books are popular textbooks and all the articles, except the forthcoming and in progress ones, are peer reviewed. Articles were retrieved from the databases in Umea university library system as well as Google Scholar. A main criterion for choosing articles was that the articles had to be peer reviewed, thus it should be reliable and accepted by scholars. However due to the relatively new and unexplored nature of the research topic and lack of peer reviewed articles in such fields, we used several forthcoming articles that were not reviewed by scientific society yet. We were aware of possible bias in such a works, therefore used them as supplementary sources without relying on them heavily. Data used in our statistical analysis part is downloaded from Thomson Reuters Datastream. These trusted and reliable sources ensure the credibility of the data and literature used in our research. One thing to note is that some of the concepts and theories used in our research are fundamental and essential in finance and economics. Therefore, textbooks were mostly used in explaining them and are considered to be sufficient, without the need for exploring deeper into the original sources.

2.10 Ethical principles
Issue of ethics is pretty complicated in nature due to its subjectivity. It concerns our moral choices that affect the decision we make, thus it’s quite hard to set clear rules regarding ethics. Research in particular, due to factors such as inexperience and lack of clear rules and guidelines, could be prone to unethical actions even if it was not intentional. Sometimes our own conscience plays a bigger role rather than rules and guidelines (Greener, 2008, p.40). This is by no means the only way to break down ethical issues in research, but questions of ethics while conducting research has been outlined as below according to (Crandall & Diener, 1978, p.19):

- Whether there is harm to participants
- Whether there is a lack of informed consent
- Whether there is an invasion of privacy
- Whether deception is involved

First three ethical questions are clearly concerned with participants in the research. There is no subject or person involved in this research, on which a research is being conducted. Therefore, the first three questions are simply of no concern. This research follows the thesis manual and rules on deception such as plagiarism, citing and referring to the sources used in the research, so the last question should be in compliance as well. There are no other research subjects used in this research, thus the possibility of deception in relation to these subjects are absent from the beginning. After 4 years of study at the Umea University, we are both confident that we are competent enough to carry out this research based on our knowledge and ability, so there is no incentive for deception. Therefore, we believe these 4 issues should be of no concern.

In our opinion, our research result could have positive repercussions because if there is no relationship between options existence and CLS price disparity, then that would be the end of it and there would be no negative effect caused by the result, at the least. On the contrary, in case there is an effect of options existence on the price disparity of CLS, then it would help people, especially traders and investors, to better understand the arbitrage possibility enabled by the CLS price disparity and possibly reach more efficient market condition. Increase in the number of arbitrage opportunities would help the market to more quickly reach its efficient form, and eliminate price discrepancies and mispricing. Creating more efficient market and financial systems would benefit not only the people are directly engaged in it, but also the entire society in an indirect way. This is because financial market inefficiencies and financial crisis affect everyone directly or indirectly even though not everyone is involved or responsible for these inefficiencies or disasters and damages caused by it. On the other hand, if we assume there is no effect of options on stock prices is found, it would still be a beneficial finding for the entire society as a whole because the findings would just reinforce the view that the financial markets are relatively efficient. What’s more, this would increase the confidence of people in financial markets and systems. If people don’t believe in the robustness and efficiency of the financial markets and systems that govern it, then this would result in less investment, less economic growth and overall worse economic environment.
CHAPTER 3 Theoretical foundations.

This chapter deals with and provides explanations and evidences to our theoretical and empirical background relevant to our research. The chapter begins by introducing theories and concepts related to market efficiency, imperfection, anomalies and arbitrage. Continued with a section explaining the reasons for cross listing, as well as drawbacks that come with it. Next part of the chapter gives introduction to options derivative to the readers, and then proceeds to explain BSM model and previous researches on effect of options on underlying stock prices. The chapter ends with a summary.

3.1. Efficient Market Hypothesis

In 1953, Maurice Kendal published a paper claiming that stock prices followed no particular pattern. Price changes were independent from each other and identically distributed, this came to be known as ‘random walk’. Initially, Kendal wanted to find a recurring pattern in the prices, however, this surprise discovery is the basis for efficient market hypothesis and investors are rational. A market in which prices always “fully reflect“ all available information is called efficient. Three forms of efficient market hypothesis were developed, weak, semi-strong and strong. Weak form is when only historical price information is taken into account. Semi strong form tests whether prices adjust to publicly available information, in an efficient manner. Strong form is the most efficient form that is concerned with whether any certain group or people have monopolistic access to the relevant information (Fama, 1970, p.383).

Weak form implies that trend analysis or technical analysis is useless. Strong form is quite extreme and very unlikely to exist in its perfect form, in the real world. Essentially taking away the distinction between the insiders of the company from the outsiders. If it were the case, there would be no issues such as insider trading (Bodie et al., 2011, p.348-349). Most of fundamental analysis is also rendered useless according to the EMH because the price already reflects all publicly available information. EMH advocates passive investment strategy, with the objective of creating a tailored portfolio in line with specific needs rather than beating the market (Bodie et al., 2011, p.351).

Instead of talking only about what EMH implies, we could focus on what it doesn’t imply. EMH doesn’t mean that prices are always ‘correct’. EMH simply implies that expectations of the people are the best possible forecast of the price in the existing situation during a particular period. This leads to possible difference or error between forecasted price and the actual price:

$$\hat{P} = P + \epsilon$$

Sign $\epsilon$ signifies the error term. Existence of the error term doesn’t mean the markets are inefficient, as long as there was no other way for improvement. Thus, efficient markets can have forecast errors. In addition, people are not required to use all available information in EMH. Information is for free and people would acquire and use information only if the benefits outweigh the costs. Although the random walk is considered to indicate the rationality of majority of the investors in the real world, EMH does not require every market participant to act in a well informed, rational and wealth maximizing way (Howells et al., 2005, p.542).
Empirical results mainly support the weaker forms of efficient market hypothesis but not the stronger forms of EMH. Early researchers almost unanimously agreed that EMH held up well in the real world. Later on contradicting empirical results emerged along with other hypothesis and theories that don’t agree with EMH. There are too many puzzles and anomalies in the markets to ignore. From simpler anomalies such as earnings announcement puzzle and new-issue puzzle to more complicated ones where stock prices of companies that have claim on the same cash flow series diverge substantially, phenomenon known as “Siamese twins” (Brealey et al., 2011, p.323). Siamese twins are essentially the same as cross-listed stock and this is a concrete example of how EMH theory relates to our study.

Obviously, professional portfolio managers don’t agree with EMH since the theory basically implies that what the professional portfolio managers are doing is worthless. (Bodie et al., 2011, p.347) gives three reasoning behind why the debate over, namely magnitude issue, selection bias issue and lucky event issue. To briefly describe each one:

- **Magnitude issue**
A manager in charge of a massive portfolio can make substantial profit by improving the overall performance by an extremely small percentage. Considering the overall fluctuation in the market, it is almost impossible to detect these small performance improvements

- **Selection bias issue**
People are assumed to only disclose the investment schemes that don’t work because rational person would keep the strategy secret instead of reporting it. Therefore it’s argued that only the strategies that don’t work are reported, creating a selection bias

- **Lucky event issue**
Statistically it is possible that in few instances, investors can get lucky. For example, out of a sample of 1000 people tossing a coin, some would get either head or tail in most of the cases, even though the average probability each one is 50%.

It concluded the markets are generally efficient in a sense that superior performance can’t be achieved by employing simple methods and techniques because the market is already aware of the publicly accessible information. However, empirical results show that there is enough evidence to claim its possible to beat the market with the help of superior information and insights (Bodie et al., 2011, p.373). Our paper reflects to EMH in two ways. First of all it is evident that price disparity between exchanges is a consequence of mispricing, thus an evidence of market inefficiency. Secondly, it is connected through option derivative. Any derivative as well as option should be a redundant instrument in efficient markets. Even if the markets are inefficient, option instrument still plays an important role through elimination of mispricing and arbitrage opportunities, eventually leading to more efficient market. Hence, it is expected that options should decrease price disparity between exchanges and make markets more efficient. Application and existence of option in itself implies that markets are not efficient and therefore EMH does not hold (at least in strong form). However if the findings point to no effect of option on price disparity, it would be a result in favor of market efficiency and EMH or could mean that option does not affect market efficiency even though they should.

### 3.1.1 Imperfect arbitrage
An important argument for why the markets might not be efficient is due to the fact that there is a limit to arbitrage. From a theoretical perspective, arbitrage is risk free but that’s rarely the case in the real world. When securities are mispriced, arbitrage is the mechanism that brings it back to its equilibrium or the correct price. It’s a strategy where securities are sold at higher price and bought at lower price until the difference disappears. In an actual trading, it carries costs and could be difficult to execute. Price can deviate from its true value and stay that way if the costs outweigh the benefits in an arbitrage strategy (Brealey et al., 2011, p.328). In practice, it is much harder to find and buy underpriced securities and sell overpriced ones. Underpriced substitute has to be bought in the beginning and sometimes its difficult to find underpriced close substitutes available for trade. Unexpected good news could result in a very different outcome than what was expected. Another problem is the risk of time, where a deal involving imperfect or no substitute has to be closed and the price has actually diverged instead of converging. These practical problems demonstrate that arbitrage is much more difficult to carry out in practice than in theory (Howells et al., 2005, p.554). Efficient market hypothesis depends on three assumptions. First assumption asserts that investors are rational and efficient, and the second one assumes that even if some investors are not rational, their activities are uncorrelated. This means that their actions would cancel each other out, and rational investors would still determine the outcome. Third assumption is that even in the case of correlation between irrational investors, forces of arbitrage would fix the situation and leave the business up to the rational investors. This is where the arguments of arbitrage come into play. First two assumptions are rather weak and if the arbitrage argument deemed questionable as well, then it would become difficult to defend EMH (Howells et al., 2005, p.553).

3.1.2. Behavioral finance

Researchers and academics have been striving to provide explanation to events where EMH clearly failed and a relatively new field called “behavioral finance” emerged. This is in contrast with EMH and proposes ideas about investor’s attitude towards risk and probability based on human psychology. (Kahneman & Tversky, 1979, p.287-289) analyzed the behavior of people under risky circumstances and the outcome was very much different from what is expected by utility theory. The study made conclusions that came to be known as prospect theory. People prefer certainty and underweight alternatives with a probability of a possible loss. In other words, people become risk averse when there is a choice with guaranteed gain and become risk seeking when a loss is inevitable. What’s more, people have inconsistent preference when presented with choices with the same outcome in different forms. It is assumed that investors are risk averse, and would be extra careful especially if they had incurred losses earlier. Therefore, not only the current situation matters, but also the past performance has an effect on forward-looking decisions. In reverse, investors might be more willing to take risk if they had been on a good streak. Furthermore, investors tend to put too much weight on few recent events and make assessments based on it. Some investors are too conservative, very slow to adapting to new conditions and some are overconfident, believing they can beat the market (Brealey et al., 2011, p.326). These theories try to provide explanation to anomalies that often occur in the markets and offer views against the idea of EMH. Nonetheless, behavioral finance theories seem to be need to be taken with caution since the field is still in its infancy (Shleifer, 2000, p.20).
3.1.3. Asymmetric information

EMH assumes that prices fully reflect all available information and hence there can be no arbitrage opportunity or easy profit. In reality, different actors have access to different information, giving advantages to those who have access to more information. For example, sellers of goods usually have more information than buyers and insurance policy purchasers have more information than insurance companies selling the policy. Such situations where one party has more information than the other party is called information asymmetry (Lofgren et al., 2002, p.196). In his paper titled the market for lemons, (Akerlof, 1970, p.488-492) demonstrates the consequences and implications of information asymmetry between buyers and sellers by taking the automobile market as an example. The paper shows that the sellers of bad cars would drive the sellers of good cars out of the market. Sellers of the bad cars would drive down the market price, resulting in market equilibrium price too low for the sellers of the good cars to accept. Thus the concept of "adverse selection" is created, a situation where the buyers are prone to choosing the worse quality product over the good quality product, as a result of information asymmetry at the time of the purchase. Problem of adverse selection is more likely to be case in developing countries because of more market imperfection and less access to information. Counteracting concept to the situation of an adverse selection is called signaling. Purpose of signaling is to mitigate the problem of information asymmetry by providing signals concerning value and quality of the product to the party at informational disadvantage (Lofgren et al., 2002, p.199-203). Michael Spence introduces the concept of signaling and conveys the idea behind it by discussing about the job market as an example. This hypothetical case regarding the labor market uses education as the main tool in explaining signaling. It is based on assumptions that higher education is an indication of higher productivity and would require material cost. Hence, the applicants with no education who are assumed to have lower productivity would not be able to present education as a signal (Spence, 1973, p.355-358). Another strategy to reduce the problem of adverse selection is called screening and was developed by Joseph E. Stiglitz. In his paper written in 1976, he establishes the foundations of screening strategy by using insurance companies as an example, where the insurance companies have intention of revealing the risk level of individuals (Lofgren et al., 2002, p.203-204). Common cases in the real world in which this strategy is applied would be banking institutions and loan repayment. Banks use wide range of criteria and screen through them in order to determine whether the individual is capable of repaying the loan.

3.1.4. Corporate governance and agency problem

Information asymmetry is a source of other problems such as issues of effective corporate governance and agency problem. Agency problem arises when interests of owners and managers are not aligned and information asymmetry is one of the factors that enable this problem. There are several methods and tools aimed at countering this problem, including monitoring (Brealey et al., 2011, p.292). Previous research papers have found that cross listing improves corporate governance, and which in turn reduces agency problem. Firm's ability to identify and replace those CEOs with unsatisfactory results is considered to be an indication of effective corporate governance (Gibson 2003, p.231). In her paper, (Lel &
Miller, 2008, p.1933) found evidence in support of bonding hypothesis by examining the propensity to remove CEOs with poor performance. Results of the paper showed that cross-listed firms were much more likely to part with poorly performing CEOs and this trend was much stronger for companies listed at one of the major US stock exchanges. Bonding hypothesis suggests that firms cross-listed at US stock exchanges have better corporate governance due to tighter and demanding regulatory requirements (Coffee & John, 2002, p.1783). The US has harsher requirements due to numerous regulations and acts such as Sarbanes Oxley act, Foreign Corrupt Practices act, SEC, GAAP and IFRS (Huang et al., 2012, p.939). Increased regulatory requirements and transparency improve investor protection and decrease agency problem. For example, a paper by (Feng et al., 2011, p.1258) states that high quality accounting disclosures enhance governance by restricting the manager's potential ability to misuse corporate assets for his or her own benefit. Cross listing has positive correlation with higher degree of disclosure and transparency (Khanna et al., 2004, p.475). According to (Roosenboom et al., 2009, p.1899) tighter regulatory requirements could serve as disincentive for cross listing, however, some firms choose cross listing to assert it as a signal of commitment to transparency and robust corporate governance.

3.2. Capital market segmentation and home bias

As the globalization takes place and international capital markets become increasingly more integrated, it is getting easier for investors to invest in capital markets around the world. Having a portfolio of investments in different markets offer range of benefits, such as risk diversification. However the markets not fully integrated and imperfect, thus there are still several obstacles to investing abroad due to capital market segmentation and barriers. These obstacles include high withholding tax rate, and high cost of transaction as well as informational disadvantage (Stulz, 1995, p.17-18). (Cooper & Kaplanis, 1995, p.95-97) cites some additional reasons for investors to hold back investment abroad, such as restriction on foreign investment and ownership, capital control and differential access to markets. Nevertheless, capital market integration and ease of capital flow improved substantially. Therefore it would make sense for investors to diversify their portfolio and reduce risk by investing in foreign capital market consistent with the modern portfolio theory. However, the empirical results clearly show that vast majority of the international investors are investing in their own home markets despite the benefits of diversification. This phenomenon of international investors heavily preferring their home markets instead of foreign capital markets is known as "home equity bias puzzle". The rational reason for this phenomenon is not clear. Hedging from inflation and currency risks don't provide plausible explanations to the problem (Cooper & Kaplanis, 1995, p.98). There are numerous other explanations provided, including geographic proximity, political monetary boundaries, difference in regulations and culture, and information asymmetry (Coval & Moskowitz, 1999, p.2046). Whatever the reason might be, investors seem to have strong bias towards their home equity markets even though there are evidences of huge benefits from international diversification. Therefore, it is logical for listed companies to reach out first to international investors by cross-listing their companies in the international capital markets.

3.3. Arbitrage pricing theory
Stephen Ross, in his paper in 1976, by examining the arbitrage model of capital asset pricing, set the foundations of a model that came to be known as arbitrage pricing theory. The arbitrage pricing theory could be turned into a following simplified equation (Brealey et al., 2011, p.200-201):

\[ R = a + \beta_1 \times rfactor_1 + \beta_2 \times rfactor_2 + \beta_3 \times rfactor_3 + \ldots + \text{noise} \]  \hspace{1cm} (1)

The model assumes that stock return is dependent on several different macroeconomic factors, but doesn’t specify which factors. Factors would vary depending on different types of stocks. For instance, price of commodities would be an important factor for mining companies and price of fuel would be a crucial factor for airline companies. Sensitivity to each factor would depend on the beta of the particular factor. Specific risk that is unique to each company is represented by the “noise”. If we subtract risk free interest rate from both side of equation (1), then the equation will become:

\[ R-R_f = \text{Risk premium} = \beta_1 \times (rfactor_1 - r_f) + \beta_2 \times (rfactor_2 - r_f) + \ldots \]  \hspace{1cm} (2)

Relationship given by the formula above shall hold for well-diversified portfolios. For example, if two portfolios are constructed in a way that they both have exposure only to the first factor and the first portfolio is twice less sensitive to the factor compared to the second portfolio, then rate of return required from the first portfolio shall be twice less than the second portfolio. An arbitrage opportunity would arise if the relationship doesn’t hold and investors could make risk free profits by borrowing and buying the portfolio, or selling the portfolio and buying the relatively cheaper assets. If we assume this arbitrage pricing relationship hold for all well diversified portfolios, then it should hold for individual stocks as well, in general (Brealey et al., 2011, p.200-201). The law of one price asserts that if two assets are equal in all relevant economic aspects, then they should valued at the same level. One of the assumptions on which APT relies upon is that in an efficient and well functioning markets, arbitrage opportunities would not be able to last for a long time (Bodie et al., 2011, p.324). CLS are entitled to the exact same cash flows, having claims on the exact same assets. In other words, CLSs of the same company listed at different stock exchanges are equal in all relevant economic respects. However, the empirical evidence shows the persistence of price divergence between CLSs at different stock exchanges in different markets.

3.4 Reasons for cross listing

Issuance of equity in foreign markets would increase the visibility of a company and help to become more widely known and recognized to outside investors, may even enhance the company’s commercial profile. In addition, it could serve as a more important strategic tool, and the company would be able to better resist takeover pressures through diversification of the shareholder base. The company would be able to engage in M&A activities more effectively as well, thanks to its exposure to different markets. More than one market for its shares could also improve the incentives of offering stock compensations to the management (Buckley, 2004, p.562-563). Investor recognition hypothesis depends on
visibility to a large extent. (Baker et al., 2002, 516-518) conducted a study on visibility by examining non-domestic firms listed on LSE and NYSE, the two stock exchanges with the largest number of non-domestic stocks. The results showed significant increase in firm’s visibility in relation to the cross listing.

According to empirical results from McGoun (1987 as cited in Ngassam, 2001, p.9), there was a positive effect on the share price of US firms, from the announcement of intentions to list on Tokyo and London stock exchanges, the same result was obtained from the study by Alexander (1988), in which 34 non-American firms were analyzed (as cited in Buckley, 2004, p.566). (Sundaram & Logue, 1996, p.85) came to a conclusion that cross listing in the US enhances equity value, based on their research in which they conducted a study on foreign firms cross listed on New York and American Stock exchanges. (Doidge et al., 2004, p.235) came to similar conclusions, stating that the foreign firms listed on the US exchanges have higher valuations than other firms from their country not listed in the US, referring to this as cross listing premium. Several other papers such as Karolyi (1998, p.34), Foerster & Karolyi (1999, p.1008), Doukas and Switzer (2000, p.499), and Miller (1999, p.122) all find results supporting the idea of valuation gains associated with cross listing. However, (Roosenboom et al., 2009, p.1907) found that not all cross-listings are associated with valuation gain and destination does matter. The study results state that cross listings in more developed markets lead to more value for shareholders. This higher valuation in stock value in turn leads to higher firm value and market valuation.

One of the main reasons of gain in valuation is due to the increased liquidity and trading volume as a result of cross listing. Larger shareholder base and exposure to different markets lead to larger trading volume and better liquidity. The argument of cross listing leading to narrower spreads on the domestic market and increased trading activity is supported by research papers written by Kadlec and McConnell (1994), Noronha et al. (1996), Smith & Sofianos (1997) Foerster & Karolyi (1998) (as cited in Pagano et al., 2002, p.2655-2656). On average, trading volume increases after firms list their shares abroad and the liquidity improves. However, this depends on regulatory restrictions and listing locations (Karolyi, 1998, p.34). Based on their study of 20 firms cross listed on the US, (Bris et al., 2007, p.498) claimed that the effects of increased liquidity and wider market access as a consequence of cross listing was more important than the effect of investor protection. (Abdallah et al., 2011, p.615) carried out a research on 500 foreign firms from 34 different countries, cross-listed on US and UK stock exchanges. The research concluded that cross listing does result in greater trading volume and the effect is stronger on low-investor protected environments compared to higher investor protection environments. The more regulated the exchanges are, larger the increase in trading volume gets. They provide improved investor protection and reduced market segmentation as explanations.

Advantages from cross listing in the US are now considered conventional wisdom that includes increased liquidity, higher valuation and lower cost (King & Segal et al., 2009, p.2418). All in all, there are many advantages and benefits that come along with cross listing as you can see from the previous studies mentioned above. However, one thing that should be noted is that the majority of the studies are focused on US and other developed markets, thus the results could be biased and could have given different results depending on the market.
3.5. Investor recognition

Merton (1987) initially developed an investor recognition hypothesis while he was criticizing several assumptions made in financial theory. Frictionless markets, complete information and complete diffusion of information are not adequate assumptions to allow capture complex financial environment. (Merton 1987, p.484) In support of his criticism, he developed the model “Simple Model of Capital Market Equilibrium with Incomplete Information”. (Merton, 1987) relaxes the assumption about equal information available to all investors. Merton takes quite realistic guess that investors are not aware about all securities available, on the contrary they know only about sub sample of all securities. (Baker et al., 2002, p.496) In complete information capital pricing models of Sharpe (1964), Lintner (1965) and Mossin (1966), which are special cases of full information of Merton’s model, (Merton 1987, p.493) firm-specific risks are not priced, because they can be diversified away.

Nevertheless investors do not know some stocks, thus they can diversify only with securities they are familiar with, which makes complete diversification impossible. This results in altered expected returns. Previously, if expected returns used to be dependent on only market risk, now cost of incomplete information also affects them. Merton calls it “shadow costs” of incomplete diffusion of information among investors. (Merton 1987, p.491) Consequently higher risk implies higher expected returns. The effect is stronger when degree of investor recognition or in other words investor base is smaller because of higher “shadow cost”. Shadow costs are represented in his model as $\lambda_k$, which stands for the equilibrium cumulative shadow cost (per investor) for security $k$. (Merton 1987, p.493) In his model it takes form of:

$$\lambda_k = (1 - q_k)\Delta_k \text{ or equivalent to } \equiv \sum_{1}^{N} \frac{\lambda^j_k}{N}$$

Where $q_k = N_k/N$ - fraction of investors who are aware about security $k$. Lets call it investor base it shows degree of investor recognition; $\Delta_k = \lambda^j_k$ is the Kuhn-Tucker multiplier, which represents the constraint that investor $j$ does not know about security $k$, therefore he cannot invest in it. To explain it in simple words, it is the shadow cost of not being aware of security $k$ for the investor, which is same for all unaware investors and $\lambda_k$ is the shadow cost of all unaware investors combined together. According to Merton relationship between shadow cost and company’s value are described by the following equation:

$$V_k = \frac{V_k^*}{(1 + \lambda_k/R)}$$

Where $V_k$ is equilibrium value of company $k$ at the beginning of the period; $V_k^*$ is equilibrium market value of company $k$ if all investors were informed about it; $R$ is riskless rate of interest plus one. If one examines the equation closely, then one can clearly see that shadow cost in this case is just like additional discount rate that we add to the equation. Hence, leads to increase in investor recognition, results in lower equilibrium cumulative shadow costs, which makes denominator smaller and accounts for higher valuation of the
company \((q_k \not\Rightarrow \lambda_k \not\Rightarrow V_k \not\Rightarrow)\). The less the firm is known to investors, the greater the benefits of increased investor base. Additionally Merton takes partial derivative:

\[
\frac{\partial V_k}{\partial q_k} = V_k \delta x_k \sigma_k^2 / q_k^2
\]

Where \(\delta\) is the aggregate risk aversion coefficient, \(\sigma_k^2\) is the component of the stock's return variance unique for each firm, \(x_k\) stands for relative market value of the company and \(q_k\) is the fraction of investors who are aware about security \(k\). Derivative results in positive sign on the right hand side (RHS). Therefore he states: “Ceteris paribus an increase in the relative size of the firm’s investor base will increase the market value of the firm.” (Merton 1987, p.500) Partial derivative is shown in its final form since it would involve extensive and irrelevant (for current paper) mathematical derivations to show derivation process, while the initial aim is to see the effect of investor recognition on company’s value. Further information can be found in the initial article\(^1\).

### 3.6. Cost of capital.

Another important aspect of Mertons’ Simple Model of Capital Market Equilibrium with Incomplete Information is that rise in investor base shall be associated with a fall in covariance risk (risk sharing increases). Foerster & Karolyi, (Foerster & Karolyi ,1999, p.1005-1008) wrote that this shall lead to subsequent fall in the cost of capital for the company and higher valuation of the firm. Dodd (Dodd, 2013, p.84-85) stated that in Merton’s model, cost of capital reveals itself through required rate of return. Both terms are used interchangeably very often and essentially mean the same thing (Koller et al., 2010, p.236). The difference is in perspective. Cost of capital is used from company’s point of view, while required rate of return is employed to express external investor perspective. Still they both denote opportunity cost of investment choice reflecting market price of risk. The relationship of shadow cost and expected returns are expressed as:

\[
\bar{R}_k - \bar{R}_k^* = \lambda_k (\bar{R}_k^* / R)
\]

Where \(\bar{R}_k\) is the equilibrium expected return of company \(k\), \(\bar{R}_k^*\) is the equilibrium expected return of company \(k\), if all investors were informed about it. Therefore, total shadow cost is proportional to incremental equilibrium expected rate of return and inverse proportional to investor base. This makes expected rate of return to be lower when investor base is higher and shadow costs are lower. \((q_k \not\Rightarrow \lambda_k \not\Rightarrow \bar{R}_k \not\Rightarrow)\) This leads to higher valuation of the company, because growing its investor base via cross-listing and decreasing its cost of capital, the company’s weighted average cost of capital decreases but return on invested capital of new projects remains the same, resulting into higher number of profitable projects to invest in. As in case with investor recognition Merton derives partial derivative for equilibrium expected return:

\[
\frac{\partial \bar{R}_k}{\partial q_k} = -\bar{R}_k \delta x_k \sigma_k^2 / q_k^2
\]

---

\(^1\) Derivation is done in sections II-IV on pages 487-500.
However in this case RHS has negative sign, which means negative relationship between investor base and cost of capital. Merton concludes it with: “Ceteris paribus an increase in the relative size of the firm's investor base will reduce the firm's cost of capital and increase the market value of the firm. Thus, in our model, managers of the firm have an incentive to expand the firm's investor base. As is evident from equations the magnitude of the effect will be greatest for lesser-known firms (with small $q_k$) and for firms with large firm-specific variances.” (Merton 1987, p.500)

In this respect this might be one of the reasons for companies to cross-list on another exchanges. Moreover there are empirical evidences supporting Merton’s hypothesis that increasing investor base by cross-listing leads to reduction in the cost of capital (Errunza & Miller, 2000; Errunza & Losq, 1985; Jorion & Schwartz, 1986).


A derivative is financial instrument, a security whose value derives from (or depends upon) the values of others, more basic, underlying variables (Hull 2012, p.1). The most typical underlying assets are market indexes, commodities, stocks, currencies, bonds and interest rates. For instance cattle can be chosen as underlying asset and two parties would sign the contract on it. One party would agree to sell 10 000 pounds of live cattle one year from now for 15 000 $ and other party agrees to buy this amount one year from now for price given. This contract can be regarded as derivative and value of this contract is dependent on price of live cattle next year. If price next year will be 2 $ the value of contract is 5000 $. That is 5000 $ gain for buying party, because they can purchase 10k pounds of live cattle for 15k $ and simultaneously resell it for 20k $, which yields 5k $ profit. Other way round it is 5k losses for selling party. Initially derivatives were developed in order to provide farmers and cattlemen with hedging opportunities for their goods. In other words it gave them the opportunity to transfer the risk of the future price fluctuations by locking the future price today. Same benefits were provided for buyers. Derivative exchanges can be traced up to 1848, when The Chicago Board of Trade was established in order to meet farmers and merchants together. Soon speculators were more interested in trading these contracts themselves instead of actual grain. Then futures exchanges emerged in 1919. By that time contracts were standardized in terms of quality and quantity of underlying assets. Since that time derivative markets have grown substantially. It is much bigger than stock market in terms of underlying assets. The values of all the assets underlying outstanding derivatives are several times the world gross domestic output (Hull 2012, p.4). There are many types of derivatives available in the market nowadays, such as futures, forwards, options of all types (Plain Vanilla, American, European, Asian, barrier, Bermudian, shout, knock-in etc.), swaps and many more customer tailed products.

3.8 Options

3.8.1. General aspects
The prime concern of this article – option takes its start in 1973 on The Chicago Board Options Exchange. Options are financial derivatives that give right, but not the obligation, to its owner to buy (call option) or sell (put option) underlying asset by a certain date for a certain price (Hull 2012, p.1). As mentioned above there are wide variety of options, which differ in terms of underlying assets, dependent values and payoff structures. The simplest form of option is ‘plain vanilla’ option. It is option with simple expiration date and strike price and no additional features.

3.8.2. Option pricing and The Black-Scholes-Merton (BSM) Model.

In 1997 Robert Merton and Myron Scholes were awarded Nobel Prize in economics for model that they developed in the early 1970s (Black & Scholes, 1973). Unfortunately Fisher Black died in 1995; otherwise he also would have received it. The model is a considerable breakthrough in the pricing of European stock options (Hull 2012, p.299). This model has made big impact on traders and the way in which options and derivatives are priced. Black and Scholes derived their pricing equation using capital asset pricing model (CAPM) in order to find relationship between stock’s required return and return on the option that is required by the market. Merton used another approach to come up with the same results. He used replicating portfolio consisting of option and underlying stock and reasonably assumed that the return on the portfolio must be equal to risk-free rate in the short time span. Merton’s approach is superior in terms of methodology since it does not rely on CAPM assumptions (according to Occam’s Razor).

In order to derive BSM pricing formulas for European (This type of option can be exercised only on certain predetermined date) options BSM differential equation shall be used. Derivation of BSM equation depends on several assumptions:

1. The stock price follows geometric Brownian motion process:
   \[ \frac{ds}{s} = \mu dt + \sigma dz \]  
   where S – stock price, \( \mu \) – expected rate of return for stock, \( \sigma \)- volatility of stock price
2. The short selling of securities and full use of the funds acquired with it is allowed.
3. Absence of transactions costs and taxes. Securities are partible to any extent.
4. No dividends are paid during the existence of the derivative.(not strict requirement, which will be abandoned later)
5. No riskless arbitrage opportunities in the market.
6. Trading on securities is continuous.
7. Risk free rate equals for all maturities and remains the same.

Based on these assumptions BSM differential equation can be derived from Brownian motion Process and Ito lemma (Itô & Nisio, 1943). BSM differential equation final form looks like:

\[ \frac{\partial f}{\partial t} + rS\frac{\partial f}{\partial S} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 f}{\partial S^2} = rf \]  

(2)
Where \( f \) is the price of option, \( t \) is time, \( S \) – underlying assets’ variable, \( \sigma \)- volatility of stock price and \( r \) is a risk free rate.

The importance of this equation is that it applies to all derivatives. This equation must be satisfied by the price of any derivative with respect to its underlying asset. Another valuable aspect of this equation is that it does not include any variable that reflects risk profile of the investor. Initially \( \mu \), the required rate of return on stock, reflects risk preferences of the investor. On the other hand, the higher \( \mu \) is, the higher risk awareness of the investor is. Fortunately \( \mu \) drops out in derivation of equation 2 from equation 1.

Since equation lacks risk preferences of investor, it means that equation is independent of risk profile and risk profile does not affect its solution. Thus it allows making an assumption that investors are risk neutral. In this respect any security’s’ required rate of return in such a world would be equal to the risk free rate. This allows pricing the derivative by calculating its expected value and subsequently discounting it by risk free rate to get present value. That is the fair price, otherwise there would be arbitrage opportunities and this violates assumptions made earlier.

Using boundary conditions \( f = \max(S - K, 0) \) for call and \( f = \max(K - S, 0) \) for put, when \( t = T \) to solve BSM differential equation European option pricing formulas can be derived:

\[
c = S_0 N(d_1) - Ke^{-rT}N(d_2)
\]

and

\[
p = Ke^{-rT}N(-d_2) - S_0 N(-d_1)
\]

where

\[
d_1 = \frac{\ln\left(\frac{S_0}{K}\right) + (r + \sigma^2/2)T}{\sigma\sqrt{T}}
\]

\[
d_2 = \frac{\ln\left(\frac{S_0}{K}\right) + (r - \sigma^2/2)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T}
\]

Where \( c \) - call option price, \( p \) – put option price, \( N(x) \) is the cumulative probability distribution function for standardized normal distribution, \( S_0 \) – is price of underlying asset at \( t_0 \), \( K \) - is strike price (price that investor need to pay for underlying asset if he decides to exercise it).

Lets take a closer look on these equations. Initial price of the underlying asset is known. Strike price is set up by a contract same as the time to maturity. Risk free rate continuously compounded can be obtained through local government bonds. Volatility \( \sigma \) can be estimated from historical data or accessed using more sophisticated tools like exponentially weighted moving average (EWMA), autoregressive conditional heteroscedasticity (ARCH) or generalized ARCH (GARCH) models. Analyzing these equations shows that the only unknown and dependent variables are \( c \) and \( p \). We cannot express any other parameter through \( c \) and \( p \), because \( S_0, K, r, T, \sigma \) are included in cumulative probability distribution.
function. In this respect we clearly see that BSM pricing equations for European call/put options imply one-way effect. This means that only underlying asset with its independent variables can affect price of option, not other way around. This means that in current paradigm there is no mathematical explanation behind the model of reverse effect between option and its underlying asset. This paper investigates whether option existence itself affects the price of the underlying asset. In connection to BSM it might mean that option existence might affect underlying asset price or volatility and that would affect theoretical pricing of option itself. Thus, if the research finds no evidence of option effect, then it would support BSM. However, if the research finds empirical evidence of effect, the consequences would be that BSM need mathematical amendments, because currently it does not take into account the reverse feedback effect of option on its underlying asset price.

3.8.3. Empirical evidence of feedback effect of option on underlying stock price.

Currently, there are no such theories that assume or explain possible feedback effect of the options on the underlying assets’ price. Notwithstanding empirical literature in this field has found controversial results. There are plenty of studies that conclude that options on stocks have effect on stock prices and shown in table 3:

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Name of study</th>
<th>Time Horizon</th>
<th>Sample size</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Klemkosky</td>
<td>1978</td>
<td>The impact of option expirations on stock prices</td>
<td>1975, 1976</td>
<td>19-46</td>
<td>Short term negative effect</td>
</tr>
<tr>
<td>Damodara and Lim</td>
<td>1990</td>
<td>The effects of option listing on the underlying stocks’ return processes</td>
<td>1973-1983</td>
<td>200</td>
<td>Permanent variance and faster stock adjustments</td>
</tr>
<tr>
<td>Detemple and Jorion</td>
<td>1990</td>
<td>Option Listing and Stock Returns An Empirical Analysis</td>
<td>1973-1986</td>
<td>300</td>
<td>Permanent positive effect on stock price which strengthens with time as markets becomes more complete</td>
</tr>
<tr>
<td>Cinar and Vu</td>
<td>1997</td>
<td>Evidence on The Effect of Option Expirations On Stock Prices</td>
<td>1979-1985</td>
<td>6</td>
<td>Short term effect, increased volatility, increased volatility of volume traded.</td>
</tr>
<tr>
<td>Xiaoyan Ni, Pearson, Poteshman</td>
<td>2005</td>
<td>Stock price clustering on option expiration dates</td>
<td>1996-2002</td>
<td>2,628</td>
<td>Short term effect and price clustering close to maturity dates</td>
</tr>
<tr>
<td>Pearson, Poteshman, White.</td>
<td>2007</td>
<td>Does Option Trading Have a Pervasive Impact on Underlying Stock Prices?</td>
<td>1990-2001</td>
<td>all equities options traded on CBOE</td>
<td>Permanent effect on stock price</td>
</tr>
<tr>
<td>Brian and Pearson</td>
<td>2010</td>
<td>The Price Impact of Large Hedging Trades</td>
<td>2001-2009</td>
<td>173</td>
<td>Short term effect on very liquid stocks</td>
</tr>
</tbody>
</table>
Table 3 Papers on option effect

After the introduction of options in 1973, the first pioneering works on option effects started to emerge. One of the first authors who found feedback effect was Klemkosky. In his article “The impact of option expirations on stock prices”, he studied the weekly continuous compounding returns adjusted for dividends and stock splits for 50 weeks in which there were 3 expiration periods. He utilized linear market model and estimated coefficients for all firms during total period of 44 weeks, which were non-expiration weeks. The same was conducted for 6 weeks, which surrounds expiration period. He estimated residual terms using coefficients, which shows risk-adjusted measure of return on security after removal of the general market effect. Then he compared the average residuals between these samples and found significant (7 out of 14 at 5% significance level and 10 out of 14 at 10% significance level) evidence of effect of options on price behavior on underlying stock. This effect is strongest during maturity week averaging to negative 1 percent. Taking into account four expiration periods during the year makes the stock to be exposed to this effect four times a year. This study explored only two weeks surrounding expiration date so its findings are showing only short-term effect.

Cinar and Vu in their work called “Evidence on The Effect of Option Expirations On Stock Prices” highlights the conflict of theory and empirical evidence. They state that: "Although there is no economic theory that suggests that option expirations affect the prices of the underlying stocks, several studies have found evidence that options influence the return and the volatility of the underlying stocks, especially around the option expiration date” (Cinar & Vu, 1987, p. 55). Although there is no theoretical explanation for possible effect, the authors suggest possible explanation to it. First of all, it is possible that traders who use options for hedging would sell the stock if the exercise price were above the stock price, because they expect that option will not be exercised. Hence it creates downward pressure on the price of stock. The same effect could arise if the exercise price is below the stock price. Call writers would sell the stock and buy back the option in order to save on transaction costs. The study was made to check for feedback effect. Data consists of S&P 100, S&P 500 and six individual stock returns from 1979 till 1985. The approach was same as for Klemkosky. Total return index for the week was used, but instead of week returns authors made five daily pairs (Monday-Tuesday, Tuesday-Wednesday, etc.). The results are as follows: index option expirations have no significant effect on returns of individual securities, stock option expirations have controversial results with significant positive returns for some shares while negative for other. Additional results for volume traded were: index options have no effect on six individual shares, while their own options affect volume traded significantly.

Next work by Conrad widened the time span of study to seven years. The author discovered the effect of option introduction on underlying share price. The event study was performed with event window of 30 days surrounding the introduction date and 100 days period before and after the event window studied for price effect. Conrad found excess returns of around two percent around introduction date. This effect seems to be permanent, as returns stay abnormally high at least thirty trading days after the introduction.
Another long-term study was prepared by Damodaran and Lim, study that examined returns of 200 stocks that had option on them. Their work focused on returns between 1973 1983. This study was conducted in a similar way as the one employed by Conrad, but periods were widened to 500 days prior and after event window, which was 20 days in this case. Main findings of Damodaran and Lim are that the return variance is much lower for stocks with options and price adjusts much faster to new information. Important assumptions that authors make about these results are that it could be because of additional information that option provides and because of decreased bid-ask spread due to increased market makers competition. These assumptions are supported by the fact of declining of noise term in return process. Noisiness of returns is reduced with introduction of option, which provides more information on stock and draws institutional attention to it.

This line of thought continues in article “Option Listing and Stock returns An Empirical Analysis” by Detemple and Jorion. Authors take bigger sample of 300 securities and time span from 1973 till 1986. One of the key ideas stated by the authors is that markets are incomplete, thus options as providers of additional information ads value to underlying stock. As markets become more complete this effect diminishes. The outcomes of study are significant increase in the price of security around listing dates (0.6% on listing day and 2.9% in two surrounding weeks) and reverse effect with option delisting, which was analyzed for the first time in their work. Additionally there is evidence of indirect cross effects of option listing on other shares and on market. Market value increases abnormally around listing dates. In order to isolate indirect effect authors construct industry indices, which are still an increase even without having optioned stocks in these indices. Once again authors found volatility decrease due to option listing. Last finding supports idea of incomplete markets, the effects fade away with time. Price and volatility effects are less significant in more recent periods.

Ho and Liu reexamined price behavior in their paper, because they wanted to see results for companies after 1980. Reason to have this time span is that majority of research used option listings prior to 1980, which were mostly large firms with only call options available on their shares. Thus it might create sample bias and eliminate put option effect on stock as alternative for short selling. Thus Ho and Liu focused on 331 shares between 1983 and 1990. One of the main ideas in the article is that option improves informational environment by providing additional trading opportunities to investors. Especially put options as substitutes to short sales. Authors found positive option effect on share prices 100 days prior to option introduction and reverse effect of negative returns 100 days after the introduction. This reversal effect is documented in the research for the first time. It supports researchers’ assumption about effect of put options as substitutes for short sales. Negative returns after introduction day might represent the process of implementation of negative private information in stock price. Positive effect on returns prior to introduction might be connected with overall improvement of information environment. There is rise in trading volume too, but no effect on return variance and systematic risk. Price effect seems to be permanent (at least for 100 days).

In more recent work “The Effect of Options on Stock Prices: 1973 to 1995” by Sorin M. Sorescu, author continues to develop the idea of option effect on underlying share. Referring to Ross (1976), the paper states that option derivative should affect prices of
underlying assets in incomplete markets in contrast to Black and Scholes (1973) view on options as redundant securities. Moreover, he refers to previous works that showed that trading non-redundant options in incomplete markets affects general equilibrium price. The author takes much wider time window from 1973 to 1995 with more than 2000 observations. This is the most extensive study this far. The results are somewhat confusing but in line with some previous works. Author breaks sample in two subsets ranging from 1973 to 1980 and 1980 to 1995. The former sub sample shows positive effect on returns while latter sub sample revealed negative abnormal returns related to option introductions. So the price effect is clear, however researcher struggles with fitting this results into theoretical background. Nonetheless it might be related to what was found in previous works by Ho and Liu (1997) with short sale explanation for abnormal negative returns or with Detemple and Jorion (1990) idea of markets getting more complete. Results before 1980 are consistent with Conrad (1989) results and results after 1980 are consistent with findings by Ho and Liu (1997). Additional explanations could be introduction of market index options, which became very popular among investors.

Ni, Pearson and Poteshman performed important research that shows option effect on price of underlying shares in their work “Stock price clustering on option expiration dates”. They examined newly available data from 1996 to 2002, which includes 4395 stocks that are optionable at least once during studied period, 80 expiration dates and 184 449 expiration-events. Roughly at any point in time horizon there is around 2500 optionable stocks. Firstly researchers explore weather stock price ends up near strike price comparing it with closing price for -10/+10 days to see weather there is higher probability of being near strike price on expiration date compared with non expiration period. There is significant z-statistics that shows that prices tend to cluster around strike price on expiration days compared to surrounding dates. Then authors check whether this clustering exists due to expiring option presence. They compare non-optionable sample with optionable sample and finds highly significant results that optionable stocks tends to cluster around strike price because of option exercise date compared with no such result with non-optionable stocks. In this respect one can assume that option causes price clustering around expiration dates. This assumption is supported by same test performed between stocks that were optionable initially, but became non-optionable during these six years. After becoming non-optionable clustering effect disappears. Then the authors calculate absolute difference values in order to show that clustering effect is related to expiration day, but not to the day of the week. These findings show straight effect of option expirations on price. Authors suggest that possible cause of this effect might be due to delta hedging portfolio rebalancing or option investors attempting to price manipulate the underlying stocks.

Next work is forthcoming, thus it can’t be determined whether the findings can be considered legitimate, but the authors are quite famous among option studies researchers. Pearson, Poteshman and White in their work “Does Option Trading Have a Pervasive Impact on Underlying Stock Prices?” found substantial effect of options on the underlying stock prices. They used data from Chicago Board Options Exchange for years from 1990 till 2001, Optionmetrics LLC and Ivy DB. They examined open interest and found the portion of it that relates to possible delta-hedgers (Market makers (MM) and proprietary traders) using net Gamma approach, since net Gamma of all in investors should be zero. This hint is done in order to find positions of market makers by having only open interest of
proprietary traders and public investors. This is based on assumption that authors believe that huge positions in options are held by MM. These positions are often reshuffled for hedging purposes and could affect the underlying price. The findings are that positions in options reduce share price volatility, which is statistically significant. Additionally hedge rebalancing is estimated to reshape the probability of daily stock returns. Therefore there is straight affect on price. Importance of this study is that it completes findings of previous work by Ni, Pearson and Poteshman (2005) in a sense that it is not binned to Friday expirations only, but shows effect for hedge rebalancing, which occur constantly.

Latest evidences are found in the forthcoming work “The Price Impact of Large Hedging Trades” of Brian and Pearson. The data used by the authors is structured equity products (SEP) such as SPARQS and STRIDES issued by Bank of America Merrill Lynch and Morgan Stanley. This SEPs are similar to options, they are equity linked notes that have a payoffs based on the underlying stock price, index or several stocks prices. At the maturity customer receives either a share or the cash equivalent of share price, which makes SEPs equivalent to covered call position. The only difference was that call premium was paid in coupon form and SEPs had face value like a bonds. Approach in this study resembles approaches in earlier works. The authors look at event window when SEPs are priced and issued and compare returns on underlying shares with returns of the same shares before. The important aspect of this paper is that SEPs are usually issued on very liquid and large shares, thus it excludes the effect of liquidity premium that option might provide to the share. Researchers found convincing and significant results on the effect of SEPs introductions on the underlying share prices. This effect is studied for 11 days after SEP introduction. During this time abnormal returns are revealed. Comparing returns on pricing day and eleven days after it with market returns results in significant t-statistics, which rejects hypothesis that market adjusted returns are equal to zero. This price effects are related to impact of trades in the underlying stocks, which are performed by SEP issuer in order to hedge its liabilities in SEPs (Brian & Pearson, 2005, p.23). This might be the mechanics of interaction and one way to effect equity markets through markets for derivatives. To conclude, this paper is valuable with its findings in two ways: It shows effect of SEPs on underlying shares returns and it adds one possible explanation for feedback effect of options. Options might affect underlying share price, when the issuer of option carries out trading in the underlying share, which has price effect on these shares, in order to hedge its liabilities.

Based on results presented above it can be assumed that there is feedback effect of options on stock prices and there is several ways how options can affect price of the underlying share.

3.9 Summary

The existence of mismatch between theory and practice is very common. The objective of what we have discussed so far was to demonstrate this mismatch between what is suggested by theory and the actual empirical results in some cases. Many theories such as EMH are based on several assumptions that actually don’t prove to be true in the real world. Hence, there are competing theories that strive to explain what the other theories are unable to explain. Had the markets been perfectly efficient and integrated, there would have been no
need for CLSs and option derivatives. However, the reality is far from perfect, markets are segmented and inefficient to varying degrees depending on where they are located and how developed they are. Theories discussed in this section, such as imperfect arbitrage, information asymmetry and equity home puzzle hypothesis, all show that the markets are not as ideal as one might assume. The persistence of price divergence in CLSs is an example of this market inefficiency. There would be no need for companies to sell their shares abroad, if the investors could domestically buy foreign shares with no additional cost or obstacles. Advantages and disadvantages of cross listing were discussed in this chapter and the advantages seem to outweigh the disadvantages, otherwise no company would choose to cross list their shares. However, as the globalization takes place and markets become more developed and integrated, it is getting easier for investors to invest abroad (1995). This could be the reason for significant slowdown and even decrease in number of CLSs in recent times Karolyi (2006). Options are considered to be redundant instruments in theory, thus having no effect on the stock price, with only one-way relationship in which the underlying stock price defining the price of the option. Yet again, the empirical results obtained from previous research papers that we have discussed in this chapter, concerning effect of options on the underlying stock price, disputes what is suggested by the theory. This should come as no surprise as there are many inefficiencies and paradoxes existing in the market, in line with what we have discussed earlier. Therefore we believe that there is a good reason to assume that options have an effect on stock price and it could be one of the factors causing the divergence in price between CLSs. This research topic deserves further investigation and analysis.

3.10 Theoretical model

![Figure 1](image)

The model shown in Figure 1 demonstrates the idea of our research. Basically options and price disparity both exist due to inefficient markets. Otherwise derivatives are redundant in efficient markets and there should be no price disparity. However options and derivatives are thought to make markets more efficient, thus it should affect price disparity, making it
more efficient in terms of market efficiency. In other words if option makes markets more efficient it should make price disparity smaller, moving it to the more efficient condition.
CHAPTER 4. PRACTICAL METHODOLOGY

In this chapter we illustrate and rationalize how the data was retrieved, sorted out and organized. First of all, selection of data sample and justifications for the selection is given. Moreover, detailed explanation of how the data was processed, filtered and transformed to make it suitable for statistical analysis is provided.

As it was discussed in previous chapters, there are empirical evidences of existence of price discrepancy between CLSs listed on different stock exchanges. Various explanations were provided to explain this phenomenon. There have been several previous researches investigating the effect of options on stock prices as well. However, there is no previous research paper that made a research on the relationship between CLSs and options derivative. Thus this research is first of its kind and there was no similar previous research we could refer to while conducting the research.

4.1. Data collection

Our empirical study needed to identify cross-listed stocks that serve as underlying assets for traded option. Thus we had to create our own database. Initial plan was to retrieve the data for the entire cross-listed stocks, or in other words, to use the entire population for our research. However the total number of CLSs is too large and makes it practically infeasible considering the manual option identification process and time limit of our research. Datastream assigns separate codes for CLSs and options belonging to the same companies, and the codes don't match with each other. This meant that there was no automatic way of identifying and downloading the data for CLSs with option on them. Hence, we had to check each company individually in order to identify the ones with option. Besides checking each company individually for options, we had to check all the stock exchanges the companies were cross-listed on individually because in some cases the companies had more than one options on it. This manual checking process ensured that we didn't miss out any option. However, the downside of this checking process was that it consumed a lot of time and would not have been possible with the entire population of CLSs. Therefore, we narrowed down our research data sample to one sector and chose "Technology and Hardware" companies for our research purpose. This category named technology and hardware companies is one of quite a few predefined categories given in DataStream. The categorization of the companies seemed a little bit debatable in our opinion since some of the companies in technology and hardware category could be argued to be software companies, or belong to two or more categories at the same time. Nonetheless, for our research purposes, we downloaded the category as it is. The reason for choosing this category was because we needed to choose a category that includes companies with active option on it. Our research purpose is to detect any effect of option on CLS prices, so it would defeat the whole purpose of our research if we were to choose a group of companies with no actively traded option on them. Big portion of the list of most actively traded option belonged to technology and hardware companies. In addition, TMT (Technology, Media & Telecommunications) are the most actively traded stocks, thus it is assumed to have higher concentration of option instruments and larger amount of available trade data. From a point of view of only technology and hardware category (as defined by
DataStream), our dataset could be treated as the entire population, but we consider it to be a sample and sum of all the CLSs as the population.

We have downloaded the data for 546 companies, all the companies included in technology and hardware category. The number of different stock exchanges the companies were cross-listed and ranged from minimum of 2 cross listings to maximum of 8 cross listings. This gave us a total sum of 1266 cross listings. While we were downloading the data from Datastream, we used X (P#S)–U$ expression to make sure that all the prices were in the same currency of US dollars and for non-padding of the prices. DataStream uses historical currency rate for conversion, so the accuracy of the prices after conversion is no problem. Unless non-padding is applied, DataStream gives the most recent available data as the price for the days when there were no trades. This creates a problem since price differences between different exchanges are used in our research and the differences falsely become extremely large due to this. We solve this problem by applying non-padding and the prices when there is no trade are given as NA instead of latest previous price data.

Regression model in our research utilizes dummy variable, number of cross listings and market index as independent variables. Presence and absence of options is our dummy variable. As mentioned earlier, the number of cross listings for companies in our data sample ranges from 2 to 8, and it will be used as an independent variable. Third independent variable is DataStream industry index. Based on the company, DataStream provides the relevant industry index for that particular company. To make sure that the indexes are comparable and consistent, all industry indexes were converted into the same currency, namely US dollars, from their own local currencies. X (FII)–U$ command was used for conversion. It should capture local market sentiment of stock price. Fourth variable MSCI world index shall incorporate global market sentiment. These two indexes should complement each other. Local DS industry index accounts for local market sentiment while MSCI world for global economy sentiment. Trading volume is also included, since actively traded shares might represent liquidity premium compared to less liquid stocks. The last variable to include is trailing earnings per share. We included it in order to account for shocks, which happen to stock prices on earnings announcements days. In theory stock on two exchanges should react exactly the same, thus price should rise or fall by same amount. Any deviation in reaction in between this exchanges are due to market inefficiencies. These variables were included in attempt to exclude all possible market specific effects on price disparity. Additional goal was to increase the goodness of fit, because using just three dummy variables would result in extremely low goodness of fit.

Our time horizon is between 3st of January 2011(1st and 2nd are holidays) and 31st of March 2014. The selected horizon excludes the period during which the financial crisis effects were most severe. In addition, concept of long versus short in panel data was taken into consideration to select the appropriate time horizon. A short panel data in our case would be when the number of companies is large but the time horizon is short. A long panel data is when the number of companies is small but the time horizon is long. Short panel data is associated with Type I error and long panel data is associated with Type II error. Hence, researchers should be aware of these errors caused by mismatch between cross sectional and times series dimensions. Therefore, time horizon that would yield around 1000 observations (size of cross sectional data) was needed. Initially, time horizon between
2010 and 2014 was selected, giving 1106 time series data per company (there are no trade during weekends). Unfortunately, it was not possible but due to technical limitation. Data needed to be organized into a long list to be in a format accepted by the statistical software and the format required 1 150 000 rows. Maximum number of rows allowed in MS Excel is 1 048 576. Instead time horizon from the beginning of 2011 was selected and resulted in 846 000 rows. What's more, we encountered other technical problems due to our large dataset size, such as lack of processing power and memory, resulting in crashes during our processing of the data. This demonstrates that we would have had other problems such as technical difficulties while processing the data if we had selected all the CLSs as our dataset. Due to the nature of our data, which is called panel data, meaning cross-sectional and time series at the same time, the dataset size becomes quite large even when the number of companies are not that large. All in all, we were able to overcome the obstacles with collection and believe the collected data is appropriate for the research.

4.2. Data preparation.

In order to have the data ready for analysis using statistical software, first the data was examined for errors caused by DataStream. For example, there were instances where a stock price suddenly went from $8 to $3000, and obviously it’s an error in the data. Such errors of extremely large sudden changes were replaced with not available (NA).

Price differences of the same stock on different stock exchanges were calculated for all companies to be used as the dependent variable in our regression model. The differences were calculated for each different number of cross listings separately. When it comes to companies cross-listed on 2 stock exchanges, the calculation is straightforward with directly taking the differences. However, for companies that are cross-listed on more than 2 stock exchanges, all possible combinations were taken into consideration to be able to calculate the differences. For example, if a company is listed on 3 different stock exchanges and the exchanges are A, B and C, then there can 3 different combinations of possible stock price differences, namely A-B, A-C, B-C. The number of possible different combinations increases as the number of cross listing increases, with up to 28 different possible price difference combinations for companies listed on 8 different stock exchanges. Absolute values of the differences were taken in order to remove the effects of data order; in other words, there would be no difference between A-B and B-A. Furthermore, we sorted out all the data in a format that can be accepted by the statistical software and made a database by linking all the data together.

Dummy variables were assigned to the stock prices so that price differences between exchanges with options as well as exchanges with no options could be identified. Specifically, when calculating the price differences of the same stock, 0 was assigned to the prices on exchanges that did not have options and 1 was assigned to the prices on exchanges that did have options. Then taking the same combinations as the calculation of differences summed up these assigned dummies. Since the combinations used for calculating the differences and the dummies are identical, the differences were directly linked to their corresponding dummy variables. Sums of dummy variables have the following three different outcomes:

0 - denotes that the difference is between two exchanges that have no options
1 - denotes that the difference is between one exchange with options and one exchange with no options
2 - denotes that both of the exchanges have options

We have assumed that sums equal to 2 are assumed to be as the same as sums equal to 0 because in this case both of the exchanges have options, both situations are outside the context of our research. To explain it more elaborately, taking the price difference of two exchanges with options and price difference of two exchanges without options shall be essentially the same because the two exchanges are the same in terms of options. In our research, existence of options on one exchange and absence of options on the other one is of interest. If this is in fact the case, all the 2s can be replaced with 0s to be able to use 0s and 1s as our dummy variables. To test this assumption ANOVA test was employed.

Comparison of Difference in the prices on different exchanges for the same stock by Number of optioned stocks used in calculating Dif(0,1,2) (Bonferroni)

<table>
<thead>
<tr>
<th>Row Mean-Col Mean</th>
<th>0</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.090284</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.000</td>
<td>-0.130395</td>
</tr>
<tr>
<td>-0.130395</td>
<td></td>
<td>-0.220679</td>
</tr>
<tr>
<td>2</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

To determine whether an extra dummy variable was necessary, ANOVA test was used to serve as a hint and point to the right direction. Oneway command reports one-way analysis of variance (ANOVA) models and Bonferroni multiple comparison-test is conducted. Results are shown as a matrix at the end. -.130395 is the difference between existence of 0 options and existence of 2 options. Hence, 0.07491797 - .20531343 = -.130395, difference between the means is equal the value calculated for comparison of difference. The number 0.000 underneath -.130395 denotes that the result is significant at 0.000% level. Therefore, arriving at a conclusion that a separate dummy is required for differences calculated from two exchanges each having options. Variance for the difference with 2 options decreases down to .1104006, a result consistent with previous research papers suggesting that existence of options reduces variance.

The process described above could be rather complex, thus a graphical illustration is provided to ensure that the readers fully understand the process. The picture shown below is a stylized version of the actual data, but should be sufficient for illustrating the process.
In this hypothetical example, a company cross-listed on 4 different stock exchanges is considered. The company has options on two of the four stock exchanges it is listed on, namely SE1 and SE2. The other two stock exchanges have no options. Since there are 4 different exchanges the company is listed on, the total number of difference combinations is $3 + 2 + 1 = 6$, readers can see the exact combinations in the image. Absolute values are taken for all the calculated differences to assess the differences fairly and accurately. At the end of each column, there is an option dummy corresponding to the particular stock exchange. When calculating the dummies for the differences, it has the same combinations as the calculation of the differences, but instead of taking difference, the sum is calculated. For example, the dummy related to SE1-SE2 is calculated to be 1+1 = 2 since SE1 and SE2 both have options on them. On the other hand, dummy for SE3-SE4 would be equal to 0 because SE3 and SE4 both have no options. All other dummies would be equal to 1 because the rest of the combinations consist of dual stock exchanges where one of the exchanges have options but the other one doesn’t have options.

<table>
<thead>
<tr>
<th>Date yyyy-mm-dd</th>
<th>SE 1</th>
<th>SE 2</th>
<th>SE 3</th>
<th>SE 4</th>
<th>SE (1; 2)</th>
<th>SE (1; 3)</th>
<th>SE (1; 4)</th>
<th>SE (2; 3)</th>
<th>SE (2; 4)</th>
<th>SE (3; 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dummy variable</td>
<td>D1: 1</td>
<td>D2: 1</td>
<td>D3: 0</td>
<td>D4: 0</td>
<td>D1+D2: 2</td>
<td>D1+D3: 1</td>
<td>D1+D4: 1</td>
<td>D2+D3: 1</td>
<td>D2+D4: 1</td>
<td>D3+D4: 0</td>
</tr>
</tbody>
</table>

Table 4 Data illustration

4.3 Hypothesis and tests employed.

There is a wide range of statistical methods available for panel data starting from the simplest ones such as “pooled“ ordinary least squares to the advanced ones such as seemingly unrelated regression models and multi dimensional three way fixed/random models that are extremely complex. Current paper uses several techniques in attempt to get the most from the data and in order to fully answer the research question.

Estimation process starts with pooled OLS, the standard regression technique for panel data. It is the simplest approach for dealing with panel data (Brooks, 2008, p.488). Pooled OLS estimates a single equation for the entire dataset, which is stacked in a single column for regression and contains all cross-sectional and time-series observations. The same applies to the regressors. Then the parameters are estimated using simple OLS approach. This simplicity comes at the cost of an assumption that the average values of the variables and their relationship between each other are constant cross-sectional and over time (Brooks, 2008, p.488). In other words this regression expects constant intercept and slope regardless of the group and time period (Park, 2011, p.19). This approach ignores the comprehensive structure of panel data and decreases its statistical advantages. However, as it is simple and standard approach for panel data, we employed it in our research. It estimates how price disparity changes with number of options introduced, i.e. how price disparity changes on average from non-optioned exchanges to the case when one of the exchanges has option and to the case when both exchanges have option. It takes the form...
of:

\[ Dif_i = \alpha + \beta_1 \text{Option}_{it} + \beta_2 \text{Nocl}_{it} + \beta_3 \text{Indx}_{it} + \beta_4 \text{tv}_{it} + \beta_5 \text{eps}_{it} + \beta_6 \text{msci}_{it} + \varepsilon_{it} \]

The variables are explained below:

- **Dif** – is the difference in prices between two exchanges on the same stock;
- **Option** - is the number of optioned stocks used in calculating difference (0,1,2);
- **Nocl** – denotes the number of stock exchanges the company is listed on (2-8)
- **Indx** – local industry index;
- **tv** – difference in trading volume between the exchanges the company is listed on; **eps** – 12 month trailing earnings per share;
- **msci** - MSCI world stock index.

The intuitions behind these regressors are:

- **Option** – shows whether the number of option affect the price difference;
- **Nocl** – shows whether the difference is affected by the number of listings of a company;
- **Indx** – shows whether local market sentiment affects the difference in a sense that if one local market is bullish while the other one is bearish, the price disparity between them two might be bigger;
- **tv** – shows whether actively traded stocks and inactive stocks have a higher price gap compared to when both are actively or inactively traded;
- **eps** – denotes different impacts of quarterly earnings announcements on prices between exchanges;
- **msci** – should be the second composite completing the local market sentiment with global market sentiment.

Important thing to note here is that this model does not employ dummy variables compared to the rest of models. Instead it uses integer variable called ”Option”, which is taking integer values from 0 to 1, i.e. it takes values of 0, 1 and 2.

We included other control variables in order to increase the explanatory power of our models. They were chosen with regard to previous studies. For instance number of cross listings and trading volume are used as kind of liquidity premium proxy. Kadlec and McConnell (1994), Noronha et al. (1996), Smith and Sofianos (1997) Foerster and Karolyi (1998) (as cited in Pagano et al., 2002, p.2655-2656) claims that spread should decrease with cross listing. Hence additional cross listings might be regarded as addition to liquidity and the same reasoning is behind the choice of trading volume. Moreover, by economic supply-demand logic, we can assume that changes in trading volume on one exchange might drive price up or down on the same exchange depending on whether the interest for this share rises or falls. Market index and industry index are also important, because price on each exchange is highly correlated with corresponding index (Froot & Dabora, 1999, p.190). As a result, as index proxies, we employed local industry index and world MSCI world stock index. Local industry index accounts for local market sentiment, while world index accounts for global market conditions, which affects both exchanges. Prices change through market forces when companies announce their earnings. Even though Froot & Dabora (1999) logically showed that earnings per share should not affect price disparity, we
still included EPS as control variable, because they also assumed that earnings news might differently affect different markets. (Froot & Dabora, 1999, p.209-210). However we are not able to control for other factors, which were found in previous studies, because some of them are not quantifiable and some other factors require extensive data collection. Such factors are: holding cost, short sale constraint, level of access to the market, trading, funding costs, tax, accounting, regulation, governance (Gagnon & Karolyi, 2010, p.53); transaction costs, regulatory restriction cost, market environment (De Jong et al., 2009, p.495); Therefore we don’t expect our model to be 100% exhaustive explanation for price disparity.

The purpose of pooled regression is to estimate $\beta_1$. This coefficient explains how option affects price disparity. It can be interpreted as: introduction of option on a stock on one of its exchanges decrease/increase (based on sign of $\beta_1$) the price disparity between exchanges by $\beta_1$ amount. In order to state that one must be sure that $\beta_1$ is statistically different from zero, which is tested by hypothesis 1:

$$H_0: \beta_1 = 0$$
$$H_1: \beta_1 \neq 0$$

It is the standard null hypothesis. If null hypothesis is rejected, it means that the interpretation is true and there is effect of option on the price difference. If null hypothesis is not rejected then interpretation cannot be used, which means that there is no effect of option on the price difference.

In this pooled regression the hypothesis is:

$$H_0: \beta_1 = 0$$
$$H_1: \beta_1 \neq 0$$

It is standard Null hypothesis to see whether coefficient is significantly different from zero. Simple t-test is employed to test it. However pooled OLS must full 5 assumptions:

1) $E(\varepsilon_t) = 0$, error terms must have zero mean
2) $var(\varepsilon_t) = \sigma^2 < \infty$, variance of error terms is constant and finite
3) $cov(\varepsilon_i, \varepsilon_j) = 0$, there is no relationship between errors
4) $cov(\varepsilon_t, x_t) = 0$, error terms are linearly independent from corresponding independent variables
5) $\varepsilon_t \sim N(0, \sigma^2)$, error terms are normally distributed

In order for its estimators to be BLUE, which stands for:

Best – each estimator shall have minimum variance among other linear unbiased estimators.
Linear – estimators are linear, i.e. the equation consists of linear combinations of the random variables.
Unbiased – on average estimated coefficients will be equal their true values
Estimator – coefficients are estimators of the true values.
The nature of the data collected imposes heavy doubts on fulfillment the assumptions number 2 and 3, which means that there could be heteroskedasticity and autocorrelation in our data due to time dimension. In this respect two things could be done. First, if test for heteroskedasticity and autocorrelation shows that assumptions 2 and 3 are violated, then pooled OLS could be modified to include heteroskedasticity and autocorrelation consistent estimators in equation to adjust for violation (Brooks, 2008, p.132-171). The other method is to use different techniques, which rely on different assumptions.

Second approach employed is least squares dummy variable (LSDV) regression. It is an approach to estimate one-way fixed effect model (Brooks, 2008, p.491). It helps to eliminate disadvantages of Pooled OLS. Fixed effect models takes individual specific effect into consideration, which is based on an assumption that there are factors that affect dependent variable cross-sectionally, but remain constant over time. For example gender or company’s industry can be such a factor. In our case individual specific effect is the number of option that exists on the two exchanges used for calculating the price difference. It separates the whole dataset into three groups: both exchanges have no option on the underlying shares; one exchange has option on underlying share while other does not; both exchanges have option on underlying shares. This effect is constant over time and assumed to affect price disparity. Additionally it allows us to examine individual differences in intercepts for all three groups assuming that they have the same slopes. In addition, it allows us to weaken pooled OLS assumption that such effect cannot be correlated with other independent variables (Park, 2011, p.8). This approach involves transforming \textit{Option} into three dummy variables: \(d_0\), \(d_1\) and \(d_2\). 

\(d_0\) - is the dummy for the difference when the difference was calculated using prices from two exchanges that have no option on the stock.

\(d_1\) - is when one of the exchanges has option on the underlying stock while the other exchange has no option

Finally \(d_2\) is used to indicate when the difference is calculated using prices of exchanges both having option on it. Three slightly different fixed effect models are going to be used. Dummies remain the same for three slightly different fixed effect models, because we focus on the same groups with the same individual specific effect. In other words we examine effects, which are the same for all three models. The only difference is that we study them from different angles. The only thing is that we drop one of the dummies sometimes, but it is still there as basic intercept.

First fixed effect model is named LSDV Dev (stands for deviation) takes the form of:

\[
D_{it} = \alpha + \beta_1 d_{1it} + \beta_2 d_{2it} + \beta_3 Nocl_{it} + \beta_4 Indx_{it} + \beta_5 tv_{it} + \beta_6 eps_{it} + \beta_7 msci_{it} + \varepsilon_{it}
\]

In this case the \(d_0\) is dropped because of multicollinearity or so called dummy trap. The intercept represents \(d_0\) in this case. It was used as the baseline or reference point. The coefficients for other two dummies shows how far their estimated parameters are from the baseline, which is non optioned group in this case. Intuition behind is to show how the price difference for optioned groups on average differs from the non-optioned group.

**Hypothesis 2a:**
\[ H_0: \beta_1 = 0 \]
\[ H_1: \beta_1 \neq 0 \]
\[ H_0: \beta_2 = 0 \]
\[ H_1: \beta_2 \neq 0 \]

It can be tested using t-test. In case of rejection of null hypothesis, the conclusion would be that on average, the price disparity between exchanges where one exchange has option is lower/higher (based on sign of \( \beta_1 \)) by \( \beta_1 \) amount compared to the price disparity between non-optioned exchanges; on average, the price disparity between exchanges where one exchange has option is lower/higher (based on sign of \( \beta_2 \)) by \( \beta_2 \) amount compared to the price disparity between non-optioned exchanges. An additional hypothesis to be tested here is to see if optioned groups are statistically different from each other in terms of price disparity. It is checked with hypothesis 2b:

\[ H_0: \beta_1 = \beta_2 \]
\[ H_1: \beta_1 \neq \beta_2 \]

If this hypothesis is rejected, it means that on average, the optioned groups differ from non-optioned group by different amounts. In other words, optioned groups have different price disparities on average. This would serve as complimentary evidence for hypothesis 2 in a sense that having option on two exchanges changes price disparity by different amount than when only one exchange has option.

Next, true coefficients fixed effects model are estimated using second modification of LDTV. It is named “LSDV True” and it includes all dummies but suppresses the constant term from the equation. It means that there is no general intercept for the model, but dummy coefficients represent the true coefficients (intercepts) for each group. These coefficients display the average price disparity for each group. In this case the form of regression is:

\[
Dif_t = \beta_0 d0_{it} + \beta_1 d1_{it} + \beta_2 d2_{it} + \beta_3 Nocl_{it} + \beta_4 Indx_{it} + \beta_5 tv_{it} + \beta_6 eps_{it} + \beta_7 msci_{it} + \varepsilon_{it}
\]

Beta coefficients represent average price disparity for each group in this case. If each group has different price disparity, then one can assume that option affects it. This statement is true if beta coefficients are significantly different from zero, which is tested with Hypothesis 3a:

\[ H_0: \beta_0 = 0 \]
\[ H_1: \beta_0 \neq 0 \]
\[ H_0: \beta_1 = 0 \]
\[ H_1: \beta_1 \neq 0 \]
\[ H_0: \beta_2 = 0 \]
\[ H_1: \beta_2 \neq 0 \]

If null hypothesis are rejected, then it means that each group on average has price disparity
equal to the corresponding coefficient. Additionally, it is needed to test whether these coefficients are statistically different from each other to state that each group has their own distinct price disparity, on average, compared to the other groups. This is tested with hypothesis 3b:

\[ H_0: \beta_1 = \beta_2 = \beta_3 \]
\[ H_1: \beta_1 \neq \beta_2 \neq \beta_3 \]

It is tested with F test. If we reject null hypothesis, then the conclusion would be that the price disparity, on average, is different for all groups, which means that option has an effect on the price disparity. If we fail to reject the null hypothesis, then it would mean that the price disparity, on average, does not change between groups, which means that option does not affect the price disparity.

The intuition here is that if these coefficients are statistically significant from zero and if they are different from each other, it demonstrates evidence that option has an effect on price disparity. Moreover, it serves as the benchmark for first LDTV Dev as a cross-check because \( \beta_1 \) and \( \beta_2 \) coefficients must be equal to the sum of corresponding coefficients from the LDTV Dev plus intercept, which should be equal to \( \beta_0 \). It is assumed that \( \beta_0 \) shall have the highest difference, \( \beta_1 \) medium and \( \beta_2 \) the lowest from all three. This goes hand in hand with the theory that suggests option reduces volatility or the underlying stock price (Damodaran & Lim, 1990; Pearson et al., 2007), assuming that this effect spreads to other exchanges where the stock is listed. Additionally, it could be due to faster price adjustment (Damodaran & Lim, 1990; Ni et al., 2005) resulting in lower price disparity. \( R^2 \) of this model is misleading and it is incorrect and inflated, because the X matrix does not have a column vector of 1s since the constant was excluded from the equation. Consequently this results into wrong sum of squares of the model and total. (Uyar & Erdem, 1990, p.298) Nevertheless, other estimates should still be correct.

Last modification of LSDV is named LSDV Zero. It includes all dummies and the constant term with restriction that the total sum of all dummy parameters must be zero. It takes the form of:

\[
D_{if} = \alpha + \beta_0 d_{0it} + \beta_1 d_{1it} + \beta_2 d_{2it} + \beta_3 Nocl_{it} + \beta_4 Indx_{it} + \beta_5 tv_{it} + \beta_6 eps_{it} + \beta_7 msci_{it} + \epsilon_{it} \quad \text{subject to} \quad \beta_0 + \beta_1 + \beta_2 + \beta_3 = 0
\]

This restriction results into slightly different interpretations of dummy parameters and intercept. With this constraint, the intercept represents the average of individual group intercepts. Dummy coefficients are regarded as the deviations of the group intercept from the average intercept for all groups. In other words it shows how far away their actual parameters are from the average group effect (Suits, 1984, p.178). Beta coefficients in this case show how far the price disparities effect, on average, from the overall price disparity of CLS. These coefficients must be statistically different from zero in order to assert that the price disparities of groups are different from the CLS disparity on average. We test it with Hypothesis 4:
It is tested with t test. If we reject the null hypothesis, then it is possible to state that each group has their own price disparity, which is different from the overall CLS price disparity. Therefore, the option has an effect on the price disparity comparing based on the price disparity of all the companies in our sample. If we fail to reject the null hypothesis, then it means that, on average, the price difference of each group is same as the price disparity of all CLS stocks.

Chapter 5 Empirical findings, discussion and analysis

This chapter is the quantitative and statistical part of the research. Various statistical tools and methods are employed to analyze the data and finally give answer to the question of whether there is an effect of options or not. Basic as well as more advanced statistical techniques such as random and fixed effects were used. The different statistical techniques were compared with each other to come to overall comprehensive results to the research question.

5.1. Descriptive statistics

The results shown below provide a summary of the data. It is divided into three sub sections of companies with no options, with one option and with two options. N stands for number of observations, and mean denotes the average of all the observations. Standard deviation (S.D.) shows the amount of dispersion around its expected value or mean. Min and Max represent the smallest and the largest values. Median or 50th percentile (mdn) is the value in the middle of all the observations when all observations are ranked from the lowest to the highest. If there are even number of observations, then the average of the two values in middle is taken as median. 0.25 and 0.75 stand for 25th and 75th percentiles, in other words, 25% and 75% of the observations could be found below each respective value. Table 5, Table 6 and Table 7 refer to 0 option, 1 option and 2 options, respectively.

```
univar Dif Noel INDX, by(Option) vlabel
-> Option=0
------------- Quantiles -------------
   Variable n   Mean  S.D.  Min  .25  Mdn  .75   Max
-----------------------------------------------------------------------------------
     Dif  374044  0.21  0.47  0.00  0.02  0.07  0.21  24.89
```
Table 5 Option 0

The three independent variables in our analysis are Difference, Number of cross listings and Index. This group has the most number of observations because most of the data consist of companies with 0 options. Mean price difference in this case is 0.21 and standard deviation is 0.47. The minimum difference is 0, but the maximum difference is 24.89, which is quite large. Nevertheless, considering the number of 374044 total observations, this is not too surprising. On average the companies are cross-listed on approximately 3 stock exchanges. Since the range is predetermined to be between 2 and 8, the minimum number of cross listing is 2 and the maximum is 8. Index has rather large standard deviation compared to its mean, thus the differences between the minimum, median and maximum values are very large as well.

Table 6 Option 1

Compared to companies with 0 options, this group has smaller number of observations in total. Mean and standard deviation values are larger than 0 option group. This is assumed to be due to increased price difference between a listing without options and a listing with options. Minimum and maximum values remain pretty much the same as the previous group. Number of cross listing increases to almost 4 on average, which shows that the stocks with option on it are likely to be cross-listed on higher number of stock exchanges. When it comes to Index, unlike the previous group, mean and standard deviation are basically equal with each other.
The last group concerns the companies with 2 options and as expected, the smallest group. There are only 7828 observations of differences in total with a mean of 0.07 and 0.11. Standard deviation is much smaller in this case. This is line with findings of previous research papers suggesting smaller standard deviation caused by existence of options. The max price difference is 2.14 for this group, which is much smaller than the other two categories.

5.2. Regression results.

**Hypothesis 1:**

According to estimated coefficients, ceteris paribus, increase in option by 1 unit (additional optioned stock in difference (up to 2)), decreases the price difference by almost 2.6 cents. The result is statistically different from zero at 0.001 level of significance. Thus it is the first evidence of option effect.

**Hypothesis 2a:**

According to the results, the average price difference for non-optioned group (represented by constant here) is 15 cents. Further, you can see that the price difference when one of the underlying shares is optioned (represented by \( d_1 \) dummy) differs from the group when both exchanges non-optioned by -0.0122 on average. In other words, on average, the price disparity between exchanges where one exchange has option is lower by 1 cent compared to the price disparity between non-optioned exchanges, and the price disparity between exchanges where both exchanges are optioned is lower by almost 9 cents compared to the price disparity between non-optioned exchanges on average. These results are highly significant. Constant or intercept here is the average price difference for non-optioned stock is 15 cents. Based on this result of 15 cents, the average price differences for optioned groups can be calculated. Average price difference between exchanges where one of the exchanges has option is 0.1515802-0.0122198=0.1393604, or almost 14 cents. Average price difference between exchanges where both exchanges are optioned is 0.1515802-0.0881266=0.0634536, or 6 cents. It is evident that all three groups have quite different
price disparity on average. This is the second evidence of option effect on the price disparity.

**Hypothesis 2b**

\[ H_0: \beta_1 = \beta_2 - F \text{ test} = 129.03, \text{ corresponding P value} = 0.0000 \text{ therefore } H_0 \text{ is strongly rejected. Hence, on average, optioned groups differ from non-optioned group by different amounts. In other words, optioned groups have different price disparities.} \]

**Hypothesis 3a**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T stat</th>
<th>P-value</th>
<th>[95% Conf. Interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>d0</td>
<td>0.1515802</td>
<td>0.0134677</td>
<td>11.26</td>
<td>0.0000</td>
<td>0.1251839 - 0.1779765</td>
</tr>
<tr>
<td>d1</td>
<td>0.1393603</td>
<td>0.0134111</td>
<td>10.39</td>
<td>0.0000</td>
<td>0.1130748 - 0.1656459</td>
</tr>
<tr>
<td>d2</td>
<td>0.0634536</td>
<td>0.0148361</td>
<td>4.28</td>
<td>0.0000</td>
<td>0.0343751 - 0.0925321</td>
</tr>
</tbody>
</table>

It is worth to remind that for these regression coefficients for d0, d1 and d2 represents group intercepts. Thus the average price disparity for non-optioned group is 15 cents, when one exchange is optioned and the other one is not, then the difference is 13.93 cents, and when both stocks are optioned it is 6.345 cents. The values are almost the same as the calculated intercepts in previous model with slight difference, which might be there due to rounding. Obviously, these groups have different price disparities on average, but we need to test whether they are statistically different from each other.

**Hypothesis 3b**

\[ H_0: \beta_1 = \beta_2 = \beta_3 - F \text{ test} = 83.99, \text{ corresponding P value} = 0.0000 \text{ therefore } H_0 \text{ is strongly rejected. Thus each group has statistically different price disparity. This is the third evidence of option effect.} \]

**Hypothesis 4**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T stat</th>
<th>P-value</th>
<th>[95% Conf. Interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>d0</td>
<td>0.0053147</td>
<td>0.0015303</td>
<td>3.47</td>
<td>0.0000</td>
<td>0.0023152 - 0.0083141</td>
</tr>
<tr>
<td>d1</td>
<td>-0.0053147</td>
<td>0.0015303</td>
<td>-3.47</td>
<td>0.0000</td>
<td>-0.0083141 - -0.0023152</td>
</tr>
<tr>
<td>Constant</td>
<td>0.1442239</td>
<td>0.013583</td>
<td>10.8</td>
<td>0.0000</td>
<td>0.118042 - 0.1704059</td>
</tr>
</tbody>
</table>

Unfortunately d2 was dropped due to multicollinearity. We reject the hull hypothesis. Hence each group has their own price disparity, which is different from the overall CLS price disparity. Therefore, the option has an effect on price disparity based on price disparities of all cross-listed companies in our sample. Although, d0 and d1 have the same absolute number, they differ in sign, thus they lie on the opposite sides from the overall group mean. Therefore, based on the price disparity of all cross-listed companies in our sample, option has an effect on price disparity, which is the fourth evidence.

**5.3 Summary table**
This section represents the results of the regressions and f statistics once again in one table in order to allow the readers to have more insights in data and to be able to compare the models. This is shown in table 8 below. Raw STATA outputs for ANOVA and regressions can be found in Appendix B. The table includes the estimated coefficients for all variables, standard errors for this coefficients, goodness-of-fit measures (F test, SSE, R²), number of observations used, degrees of freedom, sum of squares of model and model sum of squares of residuals. Asterisks indicate significance levels: *** p<0.001, ** p<0.01, * p<0.05.

<table>
<thead>
<tr>
<th></th>
<th>Pooled</th>
<th>LSDV Dev</th>
<th>LSDV True</th>
<th>LSDV Zero</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nocl</td>
<td>-0.0263***</td>
<td>-0.0258***</td>
<td>-0.0258***</td>
<td>-0.0268***</td>
</tr>
<tr>
<td></td>
<td>[0.000805]</td>
<td>[0.000808]</td>
<td>[0.000808]</td>
<td>[0.000803]</td>
</tr>
<tr>
<td></td>
<td>-7.19e-07</td>
<td>-7.19e-06</td>
<td>-7.30e-06</td>
<td></td>
</tr>
<tr>
<td>Index</td>
<td>-7.60e-06***</td>
<td>06***</td>
<td>-7.19e-06***</td>
<td>06***</td>
</tr>
<tr>
<td></td>
<td>[6.28e-07]</td>
<td>[6.30e-07]</td>
<td>[6.30e-07]</td>
<td>[6.30e-07]</td>
</tr>
<tr>
<td>tv</td>
<td>1.84e-07*</td>
<td>1.46e-07</td>
<td>1.46e-07</td>
<td>3.95e-08</td>
</tr>
<tr>
<td></td>
<td>[7.49e-08]</td>
<td>[7.51e-08]</td>
<td>[7.51e-08]</td>
<td>[7.46e-08]</td>
</tr>
<tr>
<td>eps</td>
<td>0.0760***</td>
<td>0.0759***</td>
<td>0.0759***</td>
<td>0.0760***</td>
</tr>
<tr>
<td></td>
<td>[0.000239]</td>
<td>[0.000240]</td>
<td>[0.000240]</td>
<td>[0.000239]</td>
</tr>
<tr>
<td></td>
<td>5.20e-05</td>
<td>5.20e-05</td>
<td>5.20e-05</td>
<td>5.37e-05</td>
</tr>
<tr>
<td>msci</td>
<td>5.19e-05***</td>
<td>05***</td>
<td>5.20e-05***</td>
<td>5.37e-05***</td>
</tr>
<tr>
<td></td>
<td>[9.42e-06]</td>
<td>[9.42e-06]</td>
<td>[9.42e-06]</td>
<td>[9.42e-06]</td>
</tr>
<tr>
<td>Option</td>
<td>-0.0259***</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td></td>
<td>[0.00256]</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>d0</td>
<td>.</td>
<td>.</td>
<td>0.152***</td>
<td>0.00533***</td>
</tr>
<tr>
<td></td>
<td>.</td>
<td>.</td>
<td>[0.0135]</td>
<td>[0.00153]</td>
</tr>
<tr>
<td>d1</td>
<td>.</td>
<td>-0.0122***</td>
<td>0.139***</td>
<td>-0.00531***</td>
</tr>
<tr>
<td></td>
<td>.</td>
<td>[0.00306]</td>
<td>[0.0134]</td>
<td>[0.00153]</td>
</tr>
<tr>
<td>d2</td>
<td>.</td>
<td>-0.0881***</td>
<td>0.0635***</td>
<td>.</td>
</tr>
<tr>
<td></td>
<td>.</td>
<td>[0.00681]</td>
<td>[0.0148]</td>
<td>.</td>
</tr>
<tr>
<td>Constant</td>
<td>0.159***</td>
<td>0.152***</td>
<td>.</td>
<td>0.144***</td>
</tr>
<tr>
<td></td>
<td>[0.0134]</td>
<td>[0.0135]</td>
<td>.</td>
<td>[0.0134]</td>
</tr>
<tr>
<td>Observations</td>
<td>153,777</td>
<td>153,777</td>
<td>153,777</td>
<td>153,777</td>
</tr>
<tr>
<td>F-test</td>
<td>16921</td>
<td>14519</td>
<td>16128</td>
<td>16896</td>
</tr>
<tr>
<td>Degrees of freedom</td>
<td>153770</td>
<td>153769</td>
<td>153769</td>
<td>153770</td>
</tr>
<tr>
<td>SSM (Model)</td>
<td>31295</td>
<td>31315</td>
<td>39754</td>
<td></td>
</tr>
<tr>
<td>SEE (error/residual)</td>
<td>47398</td>
<td>47377</td>
<td>47377</td>
<td>.</td>
</tr>
<tr>
<td>Root MSE (SEE)</td>
<td>0.555</td>
<td>0.555</td>
<td>0.555</td>
<td>0.555</td>
</tr>
<tr>
<td>R²</td>
<td>0.398</td>
<td>0.398</td>
<td>0.456</td>
<td>.</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.398</td>
<td>0.398</td>
<td>0.456</td>
<td>.</td>
</tr>
<tr>
<td>N</td>
<td>153,777</td>
<td>153,777</td>
<td>153,777</td>
<td>153,777</td>
</tr>
</tbody>
</table>

Standard errors in brackets *** p<0.001, ** p<0.01, * p<0.05

50
Let us have a closer look at table 8. It is quite complex on its own, so we are going to explain it by guiding the reader through it. The columns are four models, which were used in this research. They are explained in chapter 4 and section 4.3. Just to slightly refresh reader’s familiarity with them, short explanations of what these models are provided. Pooled - pooled ordinary leased squares (OLS) model, which estimates how price disparity changes with number of options introduced (from non optioned stocks to the case where one of the exchanges has option and to the case where both exchanges have options). It does not have dummy variables, but uses integer variable option (0,1,2) instead. It is used in order to see how the existence of option on one exchange affects price disparity. LSDV Dev - fixed effect model, which estimates the difference in price between optioned (when single or both exchanges has optioned stock) stocks compared to price disparity between non-optioned stocks. The aim of this model is to observe difference in price disparity between non-optioned group and optioned groups. LSDV True - fixed effect model, which estimates the average price disparity for all three groups. Which means that it shows average price disparity for non-optioned group, group with 1 option and group with 2 options. LSDV zero – fixed effect model that shows how each group differs in terms of price disparity from the overall mean of all three groups. This regression’s goal is to show whether groups differ from the overall population.

The rows are represented by 3 sections, which are separated with lines. First section is control factors, which were used in models and were explained in section 4.3. They determine the slope of regression line. Reader can interpret them as follows:

Nocl (number of cross listings): Price disparity between any two cross listings decreases by around 2.6 cents (in all four models) when company lists its shares on a new exchange. Standard error (in a brackets) is so small that it can hardly alter this number by 0.08 cents. These findings are connected to Merton’s “shadow cost” of incomplete information (Merton 1987, p.491). When firm lists its shares on an additional exchange, it increases investor base, thus it decreases incomplete information. From this respective, we may assume that increased investor base can result in more information available about the company, hence the price disparity drops, because the information asymmetry between exchanges decreases. Another aspect of this is the additional liquidity for investors and reduced cost of capital (Merton 1987, p.500). Company might decide to cross-list elsewhere assuming that undervalued shares (lower price) on one exchange will go up closer to shares which are fairly valued on other exchanges.

Index (local industry index) and msci (MSCI world index): Both of these estimates have very small values around -0.00000719 and 0.000052. So for every increase in indexes for 100 base points or 1 unit price disparity decreases by -0.000719 cents (local industry) and increases by 0.0052 cents (world index), or perhaps it should be said that this effect is negligibly small. This means that both indexes do not affect price disparity. However, it does not go against the previous study by Froot and Dabora (1999), which stated that prices on each exchange are highly correlated with the corresponding index (Froot and Dabora, 1999, p.190). What this study can add to their study is that both indexes affect all cross-
listings in the same manner by the same amount; therefore price disparity remains the same. Although these results are statistically significant at 0.1%, they do not have any economic value, because they are way too small.

Tv (trading volume): All four model estimates are very small numbers ranging from 0.00000395 to 0.0000146 cents. Important thing here is that these numbers are statistically insignificant, or indistinguishable from zero in other words. From this perspective, traders in search of arbitrage opportunities cannot rely on stocks that are actively traded on one exchange, but are less active on the other.

EPS (earnings per share): All four models estimated quite big impact of EPS on price disparity. For each dollar increase in EPS, price disparity tends to increase by around 7.59 cents. These results are statistically significant at 0.1%. However, this does sound illogical because stockholders on both exchanges are entitled for same cash flows arising from earnings. Nevertheless, this finding supports Froot and Dabora (1999), assumption that earnings news might be perceived differently on different exchanges. It seems that this difference in perception of the same information results in increased price disparity. As for companies, this might mean that they better stick to their anticipated profit forecasts, in order to avoid mispricing on their shares. Traders on the other hand, can anticipate rise in arbitrage opportunities if the company deviates from its forecasts on profits. The arbitrage may occur if the investors on one exchange positively overreact to earnings announcement, while stockholders on the other exchange do not believe in this news. Hence trader can short sell overvalued stocks on one exchange and buy the same stocks on the exchange where the investors are skeptical. Theoretically, they are dealing with the same assets entitled to the same payoffs, but are mispriced. Therefore this spread between overvalued price and undervalued price can be earned.

Option: This is the most important estimate from the first section, which is related to our research topic. Only pooled OLS model has it, because other models transforms this variable into dummies, in order to separate the groups. The result is -0.0259, which means that introduction of option on stock on one of the exchanges would result in 2.59 cents decrease in price disparity. These results are statistically significant at 0.1%. This is the main evidence of option effect on stock price. This result is in line with assumptions made in previous studies by Damodaran and Lim(1990); Detemple and Jorion(1990); Ho and Liu(1997). The assumption was that the existence of option instrument improves information environment and adds more useful information about the underlying stock to investors, therefore decreasing possible price asymmetry between exchanges. Fall in information asymmetry results in fairer pricing of stock. Hence, undervalued or overvalued stocks tend to move closer to their fair price. This leads to decrease in price disparity and in the perfect case scenario; it would lead to complete convergence of the prices between exchanges. Introduction of the option on any exchange would help company to get fairer price for its stocks and would improve information available about its stock. As for traders there is double edge effect.

On the one hand, traders would have more information about stock through option. For instance, they can try to forecast volatility in the near future for the underlying stock and market sentiment using implied volatility. Implied volatility can serve as anticipated
volatility of a stock for a period of option’s life. This is possible because option markets are considered superior compared to stock markets information wise. (Chen & Lu, 2013, p.6; Jin et al., 2012, p.5-6) Thus traders have much more possibilities for arbitrage using information available about stock with option. Exploiting this arbitrage would result in better pricing of assets. On the other hand option markets are also much more attractive for insider traders, because it can help them to dodge trade restrictions and laws since they are not trading stocks directly (Chen & Lu, 2013, p.6; Jin et al., 2012, p.5-6). This creates quite the opposite effect. Insider trader having information that no one else has can use it in order to create profits for himself at the cost of the market. Even though pricing would still improve with existence of option, the informational environment would suffer with presence of insider trading. The rest of the market participants would trade at informational disadvantage, which is unfair. Nevertheless, option existence bounded with wise insider trading laws would help many traders and enrich their trading strategies with new information.

Second section represents the most important estimates of this paper. These are the dummy estimates for three groups of price differences. Let us remind the reader what they are: d0 – represents the price differences which were calculated between exchanges which had no options on the underlying stocks; d1 – represents price differences when one exchange had option on the underlying stock while the other one didn’t have option; d2 – represents price differences between exchanges when both had options on the underlying stock; constant is the intercept estimate of the model. This section represents intercepts or difference between intercepts for three groups. This section is discussed in a column (model by model) manner.

Pooled OLS has constant estimate of 0.159. This means that on average price disparity between exchanges is almost 16 cents. By taking into account the value of 2.59 cents from the previous section, we can conclude that according to pooled OLS model, the average price disparity would decrease from 15.9 to 15.9-2.59=13.31 cents if one of the exchanges has option and to 15.9-2.59*2=10.72 cents if both exchanges have options. Practical implementation and relation to previous studies have been already discussed above. These results are statistically significant at 0.1%.

LSDV Dev estimates are: Constant = 0.152; d1 = -0.0122; d2 = -0.0881. Perhaps some readers might remember that we had to drop out d0, due to multicollinearity trap. This regression was employed with the purpose of estimating price disparity for non-optioned group and estimating difference between this group and optioned groups. Our research aimed to show how optioned groups differ from non-optioned one. The constant term represents intercept, which is the estimated average price disparity for non-optioned group. Coefficients for d1 and d2 show how optioned groups differ from average price disparity of non-optioned group. Therefore according to the model, estimated average price disparity between exchanges with no options is 15.2 cents, which is close to pooled OLS estimation. Group with option on one of the exchanges differs from it by -1.22 cents, or we can say that it is lower by 1.22 cents. Consequently we can calculate average price disparity for single option group and it is 15.2-1.22=13.98 cents. Similarly average price disparity for group with options on both exchanges differs from non-optioned group by -8.81 cents, so it is 15.2-8.81= 6.39 cents. These results are statistically significant at 0.1%. First two estimates are pretty close to the previous model estimates.
The main difference is between the groups, which contain price differences between exchanges where both exchanges have options on the underlying stocks. In LSDV Dev model this difference is smaller compared to pooled OLS model. This is a stronger evidence to support the idea that option existence affects price disparity. In case where both exchanges are optioned price disparity is much smaller than in the case where only one exchange has option. This result is in support of previous works by Damodaran and Lim(1990); Detemple and Jorion(1990); Ho and Liu(1997) as it was with pooled OLS. However, this model reveals it in much more clear manner. We observe dramatic decrease in the price disparity compared to pooled OLS result. Furthermore this decline is not the same as the group with single option. Thus with additional number of option, this effect becomes much stronger.

When option was introduced on the second exchange, which previously had no options while first one had, the information environment significantly improved and price disparity is more than halved. Based on this result, we can say that option does affect price of CLS. For example when both of the exchanges had no options, prices differed by 15.2 cents on average. After option was introduced on one of the exchanges prices had to move closer to each other by 1.22 cents (or one price had to move closer to the other one by the same amount). Subsequently, when option is introduced on the second exchange, which previously had no option, prices had to converge by 8.81 cents. If there were no option effect on the underlying stock price, then the price disparity would have remained the same as it was before introductions of options. What implications this might have? In regards to companies, we can say that the existence of options on exchanges where the company is listed implies that its stocks are better priced and are closer to the fair price. This cuts possible arbitrage opportunities and brings together two different prices on the same asset.

Traders can profit from these results as well. For instance, if there is an announcement about option introduction on a stock, traders can check whether this stock has other cross-listings with existing options. If there are other listings with options on them, then traders can anticipate price movements after the introduction. Since both prices has to come closer to each other, trader can short sell higher valued stock on one exchange and buy same stock with lower price on the other exchange. Following the introduction, it is either that shorted/sold stock would decrease in value or bought stock would increase in value or both. In any case trader would make profit based on the spread of this price change.

LSDV true. This model does not have a constant term. Instead it has three different intercepts for each group. Since only one out of three dummy variables can have value of 1 at the same time, each coefficient can be regarded as intercept for the corresponding group. This model estimated coefficients are: 0.152 - for non-optioned group; 0.139 – for group with single option; 0.0635 – for group with two options. This means that on average price disparity is equal to 15.2 cents - for non-optioned group; 13.9 cents for the group with single option; 6.35 cents – for the group with two options. These results are statistically significant at 0.1%. Results are very close to the ones that were calculated in previous paragraph. The goal of this regression is to demonstrate that all three groups have different intercepts. Conclusions here are the same as mentioned in abovementioned paragraph.
Again the groups with two options have the smallest estimated average price disparity. This is second strong evidence of option effect on the price.

LSDV zero. This model is in place in order to see whether the group means differ significantly from the overall mean of the sample. In other words, it shows us whether these groups are unique on their own or not, and distinguishable from the overall sample. D2 was dropped due to dummy trap. Constant estimate is equal to 0.144. This means that average price disparity for sample of non-optioned group and single option group is 14.4 cents. D0 estimate is 0.00531, thus non-optioned group has a slightly bigger (0.531 cent) price disparity than the sample. D1 estimate is -0.00531, so it has slightly lower (0.531 cent) price disparity than the sample. These results are statistically significant at 0.1%, so we can state that the groups significantly deviate from the overall mean. Implied that each of them forms their own subsample. This gives us the third evidence of option effect on stock price. If there were no effect, the group means wouldn’t have deviated from the overall sample by a significant amount.

Third section represents statistical properties of four estimated models. Total number of observations used in models is 153 777. It differs from initial amount of 846 000, due to NAs (not available). We decided that we would use only those observations that had full data on them in order to get the most accurate results. All observations that had some gaps in data were excluded. For instance, for some difference, if any of the listed independent variables (i.e. trading volume) was not available, then these observations were excluded from the model. We assume that 153 777 observations is big enough and solid dataset, because there is always a balance between many much and too few observations. If the number of observations were too small, it would lead to inaccurate estimates with low p values. On the other hand if the dataset is too big, then the p-values would skyrocket and all the results would be significantly different from zero.

F-test is used to compare pooled OLS with fixed effect models. This parameter will help us to decide which model fits the data better. First one is F-test and it is one of the goodness-of-fit measures (Park, 2011, p.22) and we can compare models. Firstly, we use f test in order to test whether all of our dummies from LSDV Dev are zero. We received F (3,153769) = 94.44 with p-value of zero. Thus we can reject the null hypothesis and state that fixed effect presented. Additionally we test pooled OLS against LSDV Dev using ftest command in Stata and again we receive a very high value F (1,153769) = 65.71 with zero p value, therefore we could conclude that LSDV Dev fits data better than pooled OLS. The same applies to LSDV True with value F (2, 153769) = 8281.34. Based on these we can conclude that LSDV models are better than pooled OLS model. Thus its estimates are more accurate since regression line is better fitted.

Degrees of freedom can be considered as the number of pieces of supplementary information beyond the minimum requirement. (Brooks, 2008, p.488). Hence the more degrees of freedom, the better it is. In this case pooled OLS has the highest number compared to LSDV Dev and LSDV true, so it is superior from this point of view. SSM is Sum of Squares for Model and the lower the better. It the lower sum of squares for model the better line is fitted. Pooled OLS is a bit more attractive in this point as well. The high SSM for LSDV True occurs due to surpass of intercept, thus we force regression line to go
through group intercepts. SEE stands for standard error of the estimate. This parameter shows the degree to which observations deviate from the regression line, it reflects the accuracy of the prediction and the lower it is the better it is. In this case LSDV models are superior over pooled OLS. Thus the accuracy of LSDV models is better. MSE or Root MSE stands for root mean square error. It is sample variance of the residuals of the model. In other words it is another measurement of accuracy. The more precise the model is, the less error it has, thus resulting into smaller error sum of squares and smaller MSE is preferable. All four models have the same MSE, so they are equivalent in terms of MSE. R squared is a measure that shows how much variation in dependent variable is explained by the model. Basically it tells us how good our model can explain the dependent variable, in terms of percentage. Adjusted R squared is a modification of the original R squared, in order to take into account the fact that by adding many new explanatory variables, one can raise the r square (Brooks, 2008, p.106-112). The higher the R square, the better it is. In our case, pooled OLS and LSDV Dev have the same value. They can explain almost 40% of variation in the price disparity. LSDV True has a higher value of 45.6%, but it is a wrong number. It is inflated because we surpassed intercept in that model, thus we cannot rely on this number. (Park, 2011, p.26) N is the number of observations listed again.

5.4 Analysis

First of all, let us first refresh the research question before going into the analysis. The research question is: Does the existence of option affect prices of CLSs? In order to answer it, pooled regression and least squares dummy variables regressions were conducted. Intuition behind them is that if on average three groups of CLS disparities differ from each other, one can conclude that option has effect on CLS disparities. Now let us think what is a price disparity and how option can affect it. Price disparity was calculated using two prices on different exchanges. Thus if one of these exchanges has option, then this option affects price disparity through price of stock on corresponding exchange. To put it simply, if there is a price disparity between exchange A and exchange B, and exchange A has option, this option can affect price disparity between A and B only through affecting the price on exchange A. The same logic applies when both exchanges are optioned. As a consequence, if there is evidence of option effect on price disparity one can conclude that such effects exist due to option effect on the price, therefore option effect on the price exists. What evidence do we have that answers this question? From testing hypothesis 1 we know that number of options affects the average price disparity by 2.6 cents. Hypothesis 2a tells us that that on average, if one exchange is optioned, then the price disparity decreases by 1 cent and if both stocks are optioned, then the price disparity declines by almost 9 cents. Furthermore, we know that these changes in price disparity are significantly different from zero and different from each other, according to hypothesis 2b. Another finding of this study is that the price difference decreases on average from 15 cents for non-optioned exchanges, to 13.93 cents when one of the exchanges has option and to 6 cents when both exchanges are optioned. In this respect we can say clearly see that price difference shrinks dramatically with additional option. Lastly, all of the groups are substantially different from overall sample of CLS disparities. All these results give us a strong evidence to conclude that option affects price disparity and thus affects price.
In terms of the connection between theories mentioned and results, we can infer several conclusions based on our results. They are in line with what we have discussed in the theoretical methodology chapter, in particular EMH and weak, semi-strong and strong forms associated with this hypothesis. Our results support the argument that EMH does not hold, at least in its strong form as it was mentioned in theory (Fama, 1970, p.383). Otherwise, this effect wouldn’t have existed and the results of this research should have been the opposite of what the results infer statistically. However, the results don’t deny EMH in its entirety and weak and semi-strong forms could still hold. On the other hand, the results support the theories in contradiction to EMH (especially the strong form), theories such as imperfect arbitrage, information asymmetry and prospect theory that suggest market inefficiencies and anomalies to explain the phenomenon contradicting EMH. Option makes price disparity smaller and markets more efficient, because it might deliver some additional information to investors. Hence, we cannot claim that all public information is already reflected in price. Therefore investor and portfolio managers can get some additional insights about stock behavior and amend their stock picking and portfolio management. (Bodie et al., 2011, p.351). In regard to Arbitrage Pricing Theory, option decreases the arbitrage opportunity amount and brings prices between exchanges closer together. This makes markets more efficient and eliminates arbitrage opportunities. (Bodie et al., 2011, p.324)

Speaking about Black Scholes Merton Model (Black and Scholes, 1973) in the theory chapter we have made some anticipations. Now we can say that our results highlights that BSM model does not fully explain reality around option instruments. In its current form, the model does not account for feedback effect of existence of option.

Linking the results to figure 1, where we made a depiction that price disparity and options are two consequences of inefficient markets. We made an assumption that options should increase efficiency of markets. According to the results obtained, we can see that without options price disparity is 15 cents on average, when one exchange is optioned price disparity declines to 14 cents and when both stocks are optioned price disparity shrinks further to 6.4 cents. Obviously that it is in line with figure 1. Options do make markets more efficient and reduces price disparity.

Current results are in line with some of the previous works. We cannot determine whether option increases or decreases the price of the stock, thus we cannot compare results with Klemkosky (1978) who found negative effect on price; Conrad(1989) who found permanent price increase; Detemple and Jorion (1990) who documented permanent price increase; and Sorescu (2000) with negative effect. The only thing that this research has in common to these previous works is that option does affect underlying asset price, even though the results cannot determine the direction of the effect. Current paper reinforces the results of Damodaran and Lim(1990), which found lower variance and faster stock adjustments. Lower price disparity shall result in lower variance for prices. What’s more, news and market shocks are reflected faster in the price, because daily price disparities are lower for optioned groups on average. The results of our research is the opposite of Cinar and Vu(1987). Cinar and Vu documented higher volatility, which is not found in this study.
In conclusion, the results reinforce and support the conclusion and arguments made in the theoretical summary section, where we discussed the mismatch between theory and empirical results in practice and the possible explanations for it. Cross listing is a result of market inefficiency and incomplete integration and would not have existed in the absence of barriers and cost associated with it. The same goes for option instrument and option should have no effect on the underlying asset, but the empirical results suggest there is indeed an effect of option on the underlying asset. Our results support this view of option effect on stock prices and extend the research to separate specific area of cross-listed stocks. As we have made clear already in our theoretical chapter, option effect and cross listing both would not exist in a perfectly efficient and integrated market. However we have observed that option through its effect on price, makes the market more efficient and reduces price disparity between exchanges.

Analyzing the model we can see that it explains 40% of price disparities. This number would have been less than 1%, if we had included only dummies. Therefore, we believe that the appropriate control variables were included. As you can see, the first and the last models have one more degree of freedom, but it is not of high importance because the total number of observations is high for each model. Moreover, previous worries about pooled OLS look to be incorrect. It has the same sum of error terms as others. Overall goodness of fit around 40%, as we consider it, more or less acceptable.
6. Conclusion and quality criteria

6.1. Conclusions

*Based on the statistical analysis and discussions, the entire paper is concluded in this section. In addition, further research suggestions are provided and the chapter closes with an assessment of the quality of the results and research.*

As has been stressed before, our research is unique by being the first of its kind. In order to determine whether the existence of option instruments has an effect on the price discrepancy of CLSs, statistical methods such as pooled OLS, LSDV, fixed effect model and random effect model were deployed. Statistically significant evidence of effect of option on the price disparity was found based on the statistical results obtained from the tests. In other words, the main conclusion of the paper is that there is indeed an effect of option on the price discrepancy of CLSs, which is a completely new insight with potential important implications. The result fulfills our research purpose of bringing together and connecting the research fields of cross listing and option effect. As well as, fulfilling the purpose of carrying out a kind of research that has never been done before. By bringing together these two areas of research, we were able to obtain statistically significant results that link the price discrepancy of cross-listed stocks with existence of option. In order to ensure the robustness of our result, four different statistical techniques were used and the results of these models are all in line with each other, all pointing to the existence of option effect on the underlying asset, thus we believe the legitimacy of our result is strong.

The results would have contributed a lot both academically and practically even if we had not found any option effect. However, this is a more exciting and interesting result that has even more contribution in our opinion. The results contribute to both of the fields of option instrument research and cross listing research. In terms of academic contribution, the conclusion supports the argument that options affect stock prices in general. Moreover, the results support the theory that introduction of option reduces price volatility in stock prices, as you could see how the price difference became smaller with more option. Thanks to these results, one more factor that could explain the price discrepancy between cross-listed stocks is discovered and added into the research field of CLS. This is rather significant because there are few popular established reasons among researchers for explaining the price discrepancy associated with cross listing such as transaction cost but option is never considered. However, it can’t solely explain the price discrepancy and other independent variables with potentially high explanatory power such as tax structure and media coverage could not be included in the regression. Another academic contribution could be the research purpose itself. As has been mentioned before as the potential reason for why there is no prior research on this topic is because academics who conduct research on option and cross listing are very field specific and it’s not often for them to cross over to other research areas. This research could give an incentive to these researchers to conduct more studies that combine different research fields and make them realize that its potentially an interesting topic that is not explored at all. Nonetheless current paper provides evidence against strong form of EMH and in support of APT.
When it comes to practical contribution, this would help arbitrageurs to better understand the arbitrage opportunities related to cross-listed stocks with option. By better understanding what is really affecting the price difference, since the results found that there is an effect, the ones looking for arbitrage opportunities would be able to make more informed decisions. In case this results in more arbitrage opportunities, then the market would become more efficient due to increased arbitrage activities. Arbitrage activities are supposed to bring back the market back to its equilibrium or efficient state, but then again this is not guaranteed considering what was discussed about imperfect arbitrage in the theory chapter. Nonetheless, assuming the results do result in increased arbitrage, then the entire society would benefit from it because more efficient market would be the result of it. Practical example of such arbitrage could be announcement of introduction of option on one of the exchanges. An arbitrageur can then check whether this stock has options on other exchanges. If the price on optioned exchange is higher/lower, one can assume that the price on non-optioned exchanges will move to the direction of optioned exchange price, therefore one can buy/short sell the stock to make profit after option introduction. Additional practical contribution is that, as discussed before, option reflects additional information to stock price. In this respect, simple investor can be sure that stock is priced much closer to fair price if it has option on it. Even if the stock does not have option on it on investor’s exchange, according to our research, the investor can use the same optioned stock from another exchange as a benchmark, in order to see whether the stock that he wants to buy is priced fairly. In other words, in case an investor wants to buy a stock, but it is not optioned on his exchange. Then the investor sees that the same stock on another exchange is optioned and has higher/lower price there. This indicates to the investor whether the stock is undervalued/overvalued on his exchange. With this in mind he can invest more wisely. A complimentary finding is related to volatility assumption. Investor who follows buy and hold strategy can be sure that volatility of optioned stock is lower, therefore their portfolio of investments will have the same return at lower volatility if the investor is able to buy from several exchanges, therefore we hope to benefit portfolio managers too with this result. On the contrary, since most traders make profits from highly volatile stocks, they must focus on non-optioned exchanges, because that is the place with the highest concentration of volatility.

6.2. Further research

Further research to suggest would be to overcome the weaknesses in our research and include more independent variables that could explain the price discrepancy of CLSs. This would lead to more accurate description of the causal relationship between the price discrepancy and the independent variables, as well as enabling researchers to more precisely determine the extent to which each factor affects the price discrepancy. We believe including control variables such as media coverage would increase the explanatory power of the regression model substantially, but we couldn’t include it since the data is difficult to obtain and was out of question for us. Furthermore, instead of comparing time series data in a cross sectional manner, other researchers could take a different approach and compare the period prior to options introduction to the period subsequent to options introduction. This would help the research deeper understanding of the option introduction effect instead of observing the price discrepancy subsequent to option introduction and
enable researchers to precisely estimate the effect of option introduction. There are previous research similar to this but not on cross-listed stocks.

In addition, researchers could make this research more complete by analyzing the entire population. Unfortunately, for reasons stated before, we were unable to use the entire population of cross-listed stocks with option even though that was our initial intention. However, considering the practical difficulties of this research, at least using the same methods as us, using the entire population would probably be very difficult. Therefore, other researchers could use different categories of companies and check whether the results still hold valid. The category used in this research is based on Datastream categorization system, so different categories based on different criteria could be used other research to make a study on a specific type of companies. Although we didn’t intentionally choose a sample consisting of companies headquartered in specific geographic area or market, the sample of companies in our chosen category ended up being mostly the US and European markets. Hence, other researchers could choose a sample in other geographic area and markets.

6.3. Quality criteria

6.3.1. Reliability

Reliability is asks the question of whether the measures employed in a study are consistent and stable or not. In other words, it is concerned with whether the results would remain the same in case the study is done repeatedly (Bryman & Bell, 2007, p.40). There is no vague or controversial measurement concept such as IQ used in our research, so the subjectivity level and the degree of fluctuation are very low. Data downloaded from DataStream can be considered stable over time and the results of this study shall remain stable as long as the statistical inference itself is error free.

6.3.2. Replication

Replication is somewhat similar to reliability and refers to the possibility of replicating a particular research. First of all, the study must be replicable, meaning the procedures for conducting the research has to be explained thoroughly enough to enable replication (Bryman & Bell, 2007, p.41). Relevant concepts and theories, as well as data collection, processing and analysis part of this research are explained in detail. In addition, some other useful information such as terminology definition and statistical software commands are given as appendixes. The information provided is deemed more than adequate to replicate the study.

6.3.3. Validity

According to (Bryman & Bell, 2012, p. 47), the most important criterion in research is validity. There are several different types of validity but as a whole, objective of validity is to ensure the integrity of the conclusions of a research. The main subcategories of validity are measurement validity, internal validity, external validity and ecological validity (Bryman & Bell, 2012, p.47). Measurement validity is fundamentally the same as reliability
and particularly important for quantitative researches such as this one. It is concerned with whether the measure actually measures what it is supposed to measure to a satisfactory level.

The definition given by (Bryman & Bell, 2012, p.47) for internal validity states that it’s a matter of whether a conclusion which involves a causal relationship between two or more variables holds water. Put differently, it’s an issue of causality, and internal validity is strong when the change in the dependent variable is mostly caused by the change in the independent variable and not by other confounding factors (Ryan et al., 2002, p.122). When there is a change in the dependent variable and if the independent variable changes along with it, then it’s hard to determine which one is causing the change in the other one and thus internal validity would be weak. In this respect, internal validity problem related to this research ought to be non-existent. As mentioned earlier, the aim of this research is not to measure how strong the causal relationship or provide detailed explanation to the causal link, but to just detect any kind of effect. Additionally, in our case, it is obvious that the dependent variable shall cause have no or minimal effect on independent variable. Otherwise, it would be the same as saying that price discrepancy between prices of cross-listed stocks causes stocks to have options.

External validity is about whether it is possible to generalize the results of a study can be generalized beyond the specific research context (Bryman & Bell, 2012, p.47). Generalizability or external validity could be might not be very strong in this case since our research sample mostly consists of companies originating from the US and western Europe, listed on stock exchanges in the developed markets. Majority of the rest of the world has not as developed and efficient financial markets. The time horizon selected in this research excludes the crisis period. During financial crisis times markets behave much more volatile and thus there’s a good chance the results might differ depending on different time periods. Moreover, the results are based on a sample constituted by a specific category of companies, many of which have actively traded options. Extending the sample to a larger number of companies with less active or no options could change the results as well. Therefore, it would difficult to claim that the results have strong external validity.
Reference list:


Itô, Kiyosi; Nisio, Makiko. (1964). On stationary solutions of a stochastic differential equation. *Journal of Mathematics of Kyoto University* 4, no. 1, 1—75


Appendix A:

List of Stata code used in the research

clear all
set more off
use /Volumes/Elements/CLS_research/DATA_DO_NOT_ENTER/OMG_WTH/madness/no_hope/panel_monster.dta

* Set dataset as panel data
xtset $ID $Date

* Get rid of any interim variables that were stored in dataset previously
. keep ID Date Dif Dum1 Dum2 Nocl INDX Option tv eps msci

* Assign short description to each variable

. label variable Dif "Difference in the prices on different exchanges for the same stock"

. label variable Dum1 "Dummy variable for Dif(one of exchanges are optioned = 1, 0 otherwise)"

. label variable Dum2 "Dummy variable for Dif(both exchanges are optioned = 1, 0 otherwise)"

. label variable Nocl "Numer of Cross-Listings of the stock(from 2 to 8)"

. label variable INDX "Relevant country industry index(Datastream provided)"

. label variable Option "Number of optioned stocks used in calculating Dif(0,1,2)"

. label variable tv "Difference in the volume traded on different exchanges for the same stock"

. label variable eps "Trailing earnings per share"

. label variable msci "MSCI World Index"

* Produce a table with all descriptions

describe Dif Dum1 Dum2 Nocl INDX Option tv eps msci

* Download univar package that was written by John R. Gleason and appears in the Stata Technical Bulletin #51
findit univar

* Produce descriptive statistic tables
  . univar Dif Nocl INDX tv eps msci, by(Option) vlabel
  . xtsum Dif Nocl INDX tv eps msci

*ANOVA test for group means
  . oneway Dif Option, bonferroni tabulate

//////////////////////////////////////////////////////////////////////////////////////

* Modeling part starts here

* Pooled OLS
  . regress Dif Option Nocl INDX tv eps msci
  est store m1
  outreg2 using Table.xls, replace ctitle(Pooled) nor2 coefast se label bracket e(F, df_r, mss, rss, rmse, r2, r2_a, N) alpha(0.001, 0.01, 0.05) symbol(***, **, *)

* LSDV part

* Assign option group dummies
  . gen d0=(Option==0)
  . gen d1=(Option==1)
  . gen d2=(Option==2)

* LSDV_deviation_from_d0 (dropping one dummy since it serves as baseline)
  . regress Dif d1 d2 Nocl INDX tv eps msci
  est store m2
  outreg2 using Table.xls, append ctitle(LSDV Dev) nor2 coefast se label bracket e(F, df_r, mss, rss, rmse, r2, r2_a, N) alpha(0.001, 0.01, 0.05) symbol(***, **, *)
*LSDV_true_intercept(all dummies are included but constant term is removed from equation)

. regress Dif d0-d2 Nocl INDX tv eps msci, noc
est store m3
outreg2 using Table.xls, append ctitle(LSDV True) nor2 coefast se label bracket e(F, df_r, mss, rss, rmse, r2, r2_a, N) alpha(0.001, 0.01, 0.05) symbol(***, **, *)

*LSDV_zero_sum(LSDV regression with restriction on dummy parameters. Their total must be zero)

. constraint define 1 d0 + d1 + d2 = 0
. cnsreg Dif d0-d2 Nocl INDX tv eps msci, constraint(1)
est store m4
outreg2 using Table.xls, append ctitle(LSDV Zero) nor2 coefast se label bracket e(F, df_r, mss, rss, rmse, r2, r2_a, N) alpha(0.001, 0.01, 0.05) symbol(***, **, *)

*Fixed-effect model

. areg Dif Nocl INDX tv eps msci, absorb(Option)
est store f1

*Random-effect model

. xtreg Dif d0-d2 Nocl INDX tv eps msci, re i(Date) theta
est store r1

*Hausman Test

. hausman f1 r1

*This test is no in the paper because we assumed clustering of data on companies level, market level and country level, therefore in the presence of clustered data Hausman test does not hold
Appendix B:

List of statistical tests and results

*ANOVA test for group means

. oneway Dif Option, bonferroni tabulate

<table>
<thead>
<tr>
<th>Number of optioned stocks used in calculating Dif(0,1,2)</th>
<th>Summary of Difference in the prices on different exchanges for the same stock</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>0</td>
<td>0.20531343</td>
</tr>
<tr>
<td>1</td>
<td>0.29559734</td>
</tr>
<tr>
<td>2</td>
<td>0.07491797</td>
</tr>
<tr>
<td>Total</td>
<td>0.22326818</td>
</tr>
</tbody>
</table>

Analysis of Variance

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Prob &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>862.606441</td>
<td>2</td>
<td>431.30322</td>
<td>1558.48</td>
<td>0.0000</td>
</tr>
<tr>
<td>Within groups</td>
<td>135819.952</td>
<td>490776</td>
<td>.276745301</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>136682.558</td>
<td>490779</td>
<td>.278501804</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Bartlett's test for equal variances: chi2(2) = 4.4e+04  Prob>chi2 = 0.000

Comparison of Difference in the prices on different exchanges for the same stock by Number of optioned stocks used in calculating Dif(0,1,2) (Bonferroni)

<table>
<thead>
<tr>
<th>Row Mean- Col Mean</th>
<th>Freq.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>.090284</td>
</tr>
<tr>
<td>2</td>
<td>-.130395</td>
</tr>
</tbody>
</table>
. * Pooled OLS
. * regress Dif Option Nocl INDX tv eps msci

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>Number of obs = 153777</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>31294.6314</td>
<td>6</td>
<td>5215.77191</td>
<td>F( 6,153770) = 16921.29</td>
</tr>
<tr>
<td>Residual</td>
<td>47397.6403153770</td>
<td>.308237239</td>
<td></td>
<td>Prob &gt; F = 0.0000</td>
</tr>
<tr>
<td>Total</td>
<td>78692.2717153770</td>
<td>.511733117</td>
<td></td>
<td>R-squared = 0.3977</td>
</tr>
</tbody>
</table>

| Dif     | Coef.   | Std. Err. | t     | P>|t| | [95% Conf. Interval] |
|---------|---------|-----------|-------|-------|----------------------|
| Option  | -.025864 | .0025581  | -10.11 | 0.000 | -.0308778 -.0208501  |
| Nocl    | -.0262742 | .0008054  | -32.62 | 0.000 | -.0278528 -.0246955  |
| INDX    | -7.60e-06 | 6.28e-07  | -12.10 | 0.000 | -8.83e-06 -6.37e-06  |
| tv      | 1.84e-07  | 7.49e-08  | 2.46   | 0.014 | 3.74e-08  3.31e-07   |
| eps     | .0760121  | .0002393  | 317.68 | 0.000 | .0755432  .0764811   |
| msci    | .0000519  | 9.42e-06  | 317.68 | 0.000 | .0000335  .0000704   |
| _cons   | .1589012  | .0134402  | 11.82  | 0.000 | .1251839  .1779765   |

. * LSDV_deviation_from_d0(dropping one dummy since it serves as baseline)
. * regress Dif d1 d2 Nocl INDX tv eps msci

<table>
<thead>
<tr>
<th>Source</th>
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<th>df</th>
<th>MS</th>
<th>Number of obs = 153777</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>31314.8759</td>
<td>7</td>
<td>4473.55371</td>
<td>F( 7,153769) = 14519.45</td>
</tr>
<tr>
<td>Residual</td>
<td>47377.3958153769</td>
<td>.308107589</td>
<td></td>
<td>R-squared = 0.3979</td>
</tr>
<tr>
<td>Total</td>
<td>78692.2717153770</td>
<td>.511733117</td>
<td></td>
<td>Root MSE = 0.55507</td>
</tr>
</tbody>
</table>

| Dif     | Coef.   | Std. Err. | t     | P>|t| | [95% Conf. Interval] |
|---------|---------|-----------|-------|-------|----------------------|
| d1      | -.0122198 | .0030618  | -3.99 | 0.000 | -.0182208 -.0062188  |
| d2      | -.0081266 | .0068065  | -12.95| 0.000 | -.1014671 -.074786   |
| Nocl    | -.0257511 | .0008079  | -31.88| 0.000 | -.0273345 -.0241677  |
| INDX    | -7.19e-06 | 6.30e-07  | -11.42| 0.000 | -8.42e-06 -5.96e-06  |
| tv      | 1.46e-07  | 7.55e-08  | 1.94  | 0.052 | -1.45e-09  2.93e-07  |
| eps     | .0759028  | .0002393  | 317.68| 0.000 | .0755432  .0764811   |
| msci    | .0000519  | 9.42e-06  | 317.68| 0.000 | .0000335  .0000704   |
| _cons   | .1589012  | .0134402  | 11.82 | 0.000 | .1251839  .1779765   |
. *LSDV_true_intercept(all dummies are included but constant term is removed from equation)
.  . regress Dif d0-d2 Nocl INDX tv eps msci, noc

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>Number of obs = 153777</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>39753.7009</td>
<td>8</td>
<td>4969.21261</td>
<td>F( 8,153769) = 16128.17</td>
</tr>
<tr>
<td>Residual</td>
<td>47377.3958</td>
<td>153769</td>
<td>.308107589</td>
<td>Prob &gt; F = 0.0000</td>
</tr>
<tr>
<td>Total</td>
<td>87131.0966</td>
<td>153777</td>
<td>.566606818</td>
<td>R-squared = 0.4563</td>
</tr>
</tbody>
</table>

Dif Coef. Std. Err. t P>|t| [95% Conf. Interval]

d0  .1515882  .0134677  11.26  0.000  .12151839  .179765

d1  .1393603  .0134111  10.39  0.000  .1130748  .1656459

d2  .0634536  .014361  4.28  0.000  .0343751  .0925321

Nocl  -.0257511  .0008079  -31.88  0.000  -.0273345  -.0241677
INDX  -.0719e-06  .014361  -11.42  0.000  -.842e-06  -.596e-06

tv  1.46e-07  .014361  4.28  0.000  -.145e-09  2.93e-07

eps  .0760334  .0002395  316.79  0.000  .0754332  .0763724

msci  .0000537  .0002395  9.42e-06  0.000  .0000352  .0000722

. *LSDV_zero_sum(LSDV regression with restriction on dummy parameters. Their total must be zero)
. constraint define 1 d0 + d1 + d2 = 0

. cnsreg Dif d0-d2 Nocl INDX tv eps msci, constraint(1)

Constrained linear regression Number of obs = 153777
F( 6, 153770) = 16896.36
Prob > F = 0.0000
Root MSE = 0.5554

( 1) d0 + d1 + o.d2 = 0

Dif Coef. Std. Err. t P>|t| [95% Conf. Interval]

 d0  .1442239  .0133583  10.80  0.000  .118042  .1704059

d1  .1393603  .0134111  10.39  0.000  .1130748  .1656459

d2  .0634536  .0134677  4.28  0.000  .0343751  .0925321

Nocl  -.0257511  .0008079  -33.41  0.000  -.0284203  -.0221677
INDX  -.0719e-06  .013461  -11.42  0.000  -.842e-06  -.596e-06

tv  1.46e-07  .013461  4.28  0.000  -.145e-09  2.93e-07

eps  .0759028  .0002395  316.79  0.000  .0754332  .0763724

msci  .0000537  .0002395  9.42e-06  0.000  .0000352  .0000722

_cons  .0000537  .0002395  9.42e-06  0.000  .0000352  .0000722

Root MSE = 0.5550
Adj R-squared = 0.4562

. fixed-effect model
. areg Dif Nocl INDX tv eps msci, absorb(Option)

Linear regression, absorbing indicators
Number of obs = 153777
F( 5, 153769) = 20178.41
Prob > F = 0.0000
R-squared = 0.3979
Adj R-squared = 0.3979
Root MSE = 0.5551

|     | Coef. | Std. Err. |      t  |    P>|t|    | [95% Conf. Interval] |
|-----|-------|-----------|--------|--------|---------------------|
| Dif |       |           |        |        |                     |
| Nocl| -0.02575111 | 0.0008079 | -31.88 | 0.000  | -0.0273345, -0.0241677 |
| INDX| -7.19e-05  | 6.30e-07  | -11.42 | 0.000  | -8.42e-06, -5.96e-06  |
| tv  | 1.46e-07   | 7.51e-08  | 1.94   | 0.052  | -1.45e-09, 2.93e-07   |
| eps | 0.0759028  | 0.0002396 | 316.79 | 0.000  | 0.0754332, 0.0763724  |
| msci| 0.0000528  | 9.42e-06  | 5.53   | 0.000  | 0.0000336, 0.0000705  |
| _cons| 0.1412532  | 0.0133532 | 10.58  | 0.000  | 0.1150812, 0.1674253  |

Option
F(2, 153769) = 83.987  0.000  (3 categories)

. est store f1
. *Random-effect model
.  . xtreg Dif d0-d2 Nocl INDX tv eps msci, re i(Date) theta
warning: existing panel variable is not Date
note: d2 omitted because of collinearity

Random-effects GLS regression                   Number of obs      =  153777
Group variable: Date                             Number of groups   =    838

R-sq: within  = 0.3995                           Obs per group: min =     6
             between = 0.4603                       avg = 183.5
             overall = 0.3979                       max = 288

corr(u_i, X) = 0 (assumed)                      Wald chi2(7) = 102132.26

                     min      5%       median        95%      max
theta               0.0317  0.3712  0.4280  0.4700  0.5116

                      Coef.     Std. Err.     z     P>|z|     [95% Conf. Interval]
Dif     d0     .086027     .0067723   12.70   0.000     .0727535    .0993006
     d1     .074941     .0066465   11.28   0.000     .0619142    .0879679
     d2     0 (omitted)
     Nocl   -.0254005     .0008056  -31.53   0.000     -.0269794   -.0238215
     INDX    -7.12e-06     6.27e-07  -11.35   0.000     -.8.35e-06   -.5.89e-06
     tv     8.02e-08     7.51e-08    1.07   0.285    -6.70e-08    2.27e-07
     eps     .0758483     .0002388  317.56   0.000     .0753802    .0763165
     msci   .0000502     .0000165    3.04   0.002     .0000178    .0000826
     _cons   .0651142     .0238181    2.73   0.006     .0184316    .1117968

sigma_u     .05811243
sigma_e     .55198661
rho     .0109621   (fraction of variance due to u_i)

. est store r1
### Coefficients

<table>
<thead>
<tr>
<th></th>
<th>(b)</th>
<th>(B)</th>
<th>(b-B)</th>
<th>sqrt(diag(V_b-V_B))</th>
</tr>
</thead>
<tbody>
<tr>
<td>f1</td>
<td>-.0257511</td>
<td>-.0254005</td>
<td>-.0003506</td>
<td>.0000604</td>
</tr>
<tr>
<td>INDX</td>
<td>-7.19e-06</td>
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<td>-7.01e-08</td>
<td>5.70e-08</td>
</tr>
<tr>
<td>tv</td>
<td>1.46e-07</td>
<td>8.02e-08</td>
<td>6.55e-08</td>
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<tr>
<td>eps</td>
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<td>.000019</td>
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<tr>
<td>msci</td>
<td>.000052</td>
<td>.0000502</td>
<td>1.80e-06</td>
<td>..</td>
</tr>
</tbody>
</table>

**B = inconsistent under Ha, efficient under Ho; obtained from xtreg**

**b = consistent under Ho and Ha; obtained from areg**

Test:  Ho: difference in coefficients not systematic

\[
\text{chi2}(4) = (b-B)'[(V_b-V_B)^{-1}](b-B) = 36.83
\]

\[
\text{Prob}>\text{chi2} = 0.0000
\]

(V_b-V_B is not positive definite)