TESTING PREDICTIONS FROM SELF DETERMINATION THEORY USING PROGRAMME FOR INTERNATIONAL STUDENT ASSESSMENT (PISA) 2012 DATA FOR MATHEMATICS LEARNING

by

ARİF BÖYÜKSOLAK

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APPROVED BY:

Assist. Prof. Fatih Çağlayan Mercan .....
(Thesis Supervisor)

Assoc. Prof. Zeynep Gürel .....

Assist. Prof. Bengü Börkan .....

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Dedicated to my wife

for all her love and support

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ABSTRACT

TESTING PREDICTIONS FROM SELF DETERMINATION THEORY USING PROGRAMME FOR INTERNATIONAL STUDENT ASSESSMENT (PISA) 2012 DATA FOR MATHEMATICS LEARNING

The main aim of the study was to test the predictions of SDT in the sample of PISA 2012 for mathematics learning domain. In this study, data for SDT related variables were obtained from the data supplied by PISA 2012 study. Mathematics autonomy, mathematics competence and relatedness to school were expected to predict mathematics intrinsic and extrinsic motivations significantly and positively in the total sample of PISA 2012 (N= 485490). The relationships between variables were transformed in to SEM. Moreover, cultural invariance of the effects of the basic psychological needs on types of mathematics motivation was tested in the nine countries (Finland, Japan, Lithuania, Russia, Thailand, Spain, UK, Turkey, and Brazil) which were selected from nine different cultural clusters in WVM 6 (N= 93659). MG-CFA and MG-SEM were used to test the cultural invariance.The proposed model fit the data in the total sample of PISA 2012. Except for the relationships between relatedness to school and mathematics intrinsic motivation, all of the relationships between basic psychological needs and types of mathematics motivation were significant. Although there is a differences in the significance of the relationships of relatedness to school for Thailand and Spain with respect to other countries, the difference were not statistically significant and an empirical evidence for the cultural invariance of the effects of basic psychological needs was provided by the results. As a result, except for the relationship between mathematics intrinsic motivation and relatedness to school, all of the predictions of SDT were consistent with the results obtained by this study.

ÖZET

ÖZ BELİRLEME KURAMINDAN ÖNGÖRÜLERİN ULUSLARARASI ÖĞRENCİ DEĞERLENDİRME PROGRAMININ (PISA) 2012 MATEMATİK ÖĞRENME VERİSİNDE TEST EDİLMESİ

Bu çalışmanın temel amacı, PISA 2012 örneklemi üzerinde Öz Belirleme Kuramının (ÖBK) tahminlerini matematik öğrenme alanında test etmektir. Bu çalışmada, ÖBK ile ilişkisi olan değişkenlerin verisi PISA 2012 tarafından tedarik edilen verilerden elde edilmiştir. Matematik özerkliğin, matematik yeterliğin ve okula aidiyetliğin bütün PISA 2012 örneklemi içinde (N= 485490) içsel ve dışsal matematik motivasyonunu pozitif ve anlamlı olarak açıklanması beklenmiştir. Bu değişkenlerin ilişkileri yapısal eşitlik modeline dönüştürülmüştür. Ek olarak, temel psikolojik ihtiyaçların matematik motivasyon çeşitleri üzerindeki etkisinin kütürel değişmezliği WVM 6' daki dokuz farklı kültürden seçilen dokuz ülke (Finlandiya, Japonya, Litvanya, Rusya, Tayland, İspanya, İngiltere, Türkiye, Brezilya) için test edilmiştir(N= 93659). Kültürel değişmezliği test etmek içik çoklu grup doğrulayıcı faktör analizi ve çoklu grup yapısal eşitlik modeli kullanılmıştır.Çalışmada önerilen model PISA 2012' deki tüm örneklem için uygun bulunmuştur. Okula aidiyet ile içsel matematik motivasyonu haricinde, temel psikolojik ihtiyaçlar ve matematik motivasyon çeşitleri arasındaki tüm ilişkiler anlamlı bulunmuştur. Okula aidiyetin ilişkilerinin önemi Tayland ve İspanya için diğer ülkelerden farklı olsada, bu fark istatistiksel olarak anlamlı değildir. Şonuç olarak, okula aidiyet ve içsel matematik motivasyonun ilişkisi haricinde, ÖBK'nın tahminlerinin tamamı bu çalışmadan elde edilen sonuçlar ile tutarlıdır.

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LIST OF SYMBOLS

df	Degrees of Freedom
N	Number
p	Level of Significance
R^2	Variance
β	Regression Coefficient
χ^2	Chi-Square
Δ	Difference

LIST OF ACRONYMS/ABBREVIATIONS

AU	Autonomy
BPNT	Basic Psychological Needs Theory
CET	Cognitive Evaluation Theory
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CI	Confidence Interval
COT	Causality Orientation Theory
Cov	Covariance
EPC	Expected Parameter Change
EX	Extrinsic Motivation
IM	Intrinsic Motivation
MG-CFA	Multi Group Confirmatory Factor Analysis
MG-SEM	Multi Group Structural Equation Model
OECD	Organisation for Economic Co-operation and Development
OIT	Organismic Integration Theory
PISA	Programme for International Student Assessment
RMSEA	Root Mean Square Error of Approximation
SB	Self Belonging
SC	Competence
SDT	Self Determination Theory
SE	Standardized Error
SEM	Structural Equation Model
SEPC	Standardized Expected Parameter Change
SRMR	Standardized Root Mean Square Residual
TLI	Tucker-Levis Index
TPB	Theory of Planned Behavior
UK	United Kingdom
WVM	World Values Map

WVS	World Values Survey
Sβ	Standardized Regression Coefficient

1. INTRODUCTION

Motivation is a massive theoretical construct which explains a set of characteristics of behavior. Motivation is generally defined as a reason for stimulation of behavior. Some of these characteristics are as follow: Motivation is the reason to determine the direction of behavior, repetition of the behavior, desire for the behavior, and the need for the behavior (Ellliot and Covington, 2001). There have been two types of studies that form the background in studying motivation. First, there are process theories which practice on the progress of motivation. For instance, a reward or a punishment leads to representation of certain behaviors (Skinner, 1948) because of rationality of human beings. Some of the process theories are Skinners' reinforcement theory, expectancy value theory, and goal-setting theory. Second, content theories investigate what motivates people. For example, satisfying certain needs motivates people according to Maslow's (1943) hierarchy of needs. In the same direction with Maslow's theory, there have been content theories such as, Alderfers's Theory of Existence, Relatedness and Growth (ERG), Self-Determination Theory (SDT), and Herzberg's Two Factor Theory (Golembiewski, 2000). What motivates people and how the motivation process works are the primary questions to understand motivation.

Among these perspectives, SDT was chosen for the current study. SDT is a part of content theories, and it is relatively new when it is compared to others. According to SDT, source of motivation includes three basic psychological needs which are autonomy, competence, and relatedness. These needs are related to well-being or being fully functioning (Ryan and Deci, 2000). These psychological needs have different effects on different types of motivation. In SDT, three types of motivation are considered. They are called amotivation, extrinsic motivation and intrinsic motivation. These motivation types are identified with the amount of satisfied psychological needs. The behavior becomes more permanent and internalized from amotivation to intrinsic motivation. SDT has started with the Ryan and Deci's research in 1970s and is composed of four mini theories fundamentally (Ryan and Deci 2002). Accord-

ing to a sub-theory of SDT (Basic Psychological Needs Theory), these indicators are culturally invariant. SDT tends to explain the effects of social factors on intrinsic motivation with Cognitive Evalution Theory (Deci, 1975). Organismic Integration Theory (Deci and Ryan, 1985b) predicts a continuum in extrinsic motivation. The effects of individual differences of human beings on motivation are studied under the name of Causality Orientation Theory (Deci and Ryan, 1985a).

Motivation theories have a crucial role in education and there is no need to say anything about the importance of education. Because students cannot be internally motivated towards every subject area, teachers must be aware of creating the motivating environment. Although, teachers can help for improvement of students' intrinsic motivation, motivating students extrinsically can sometimes be an option for teachers. Because intrinsic motivation is a long lasting process compared to extrinsic motivation which can also be helpful depending on the subject area, students' current motivation type, and time. Moreover, they can gradually regulate the environment of students from amotivated to intrinsic motivated. Current trend in education is developing intrinsic motivation, because it gives much responsibility and control to students (student centered education) (Ormrod, 2012). Moreover, it is possible to increase students' mathematics motivation because teacher intervention for students mathemeics motivation was found beneficial by researches (Middleton and Spanias, 1999).

Students' mathematics motivation is decreasing after first few years of education (Rohrkemper and Bershon 1984; Nakamura 1988; Dossey *et al.*, 1988). Students' current mathematical motivation can be predicted by their teacher to find out and develop the students' mathematic motivation. In addition, there have been a few studies in the field of source of mathematics motivation. Although, a better way of predicting mathematic motivation is discrimination of internal and external motivation (Goodchild, 2001; Middleton and Spanias, 1999), most of the studies were inadequate in defining mathematics motivation (Wæge, 2009). According to recent reviews on mathematics motivation (Wæge, 2009; Hannula 2006; Evans and Wedege,

2004), there are few empirical researches on mathematic motivation with all needs and types of motivation in SDT.

In this study, predictions of SDT are tested in order to investigate mathematics motivation scale of the PISA 2012 data with the help of structural equation model which is recommended by the literature. PISA 2012 students' questionnaire data were chosen because of two main reasons. Firstly, mathematics motivation variables of PISA 2012 were based mainly on self-determination theory (OECD 2013). Secondly, PISA is an international program which has been conducted to compare nations' educational systems and their success. Cultural invariance assumption of the basic psychological needs can also be tested by the data PISA supports. In this study, cultural division of the nations is decided from WVS's cultural map (2015). From these analyses, probable difference in structural models of students' motivation can be identified.

2. LITERATURE REVIEW

International assessments are important for comparison of the nations' educational policies (OECD, 2013), therefore achievement scores of students in Programme for International Student Assessment (PISA) have been a contemporary issue. Especially, mathematics achievement scores of students in PISA have had a great impact on educational policies of participating nations (Kamens and McNeely, 2010; Breakspear, 2012; Grek, 2009). In order to adapt to the mathematics skills of the new age, some of the participating nations have already changed their mathematics curriculum in the direction of mathematics literacy defined by PISA because of their unsatisfactory scores in the past international assessments. These nations are Great Britain (BBC, 2014), Turkey (Anıl *et al.*, 2015), Ireland (Kırwan, 2015), Unites States, Germany, Australia, Italy, and France (Froese-Germain, 2010). Obviously, the changes in the mathematics curriculums were made in order to increase the achievement scores of students in PISA mathematics assessment (Breakspear, 2012). According to Breakspear (2012), both The Organization for Economic Co-operation and Development (OECD) and non-OECD countries participated in PISA have started to change their curriculum since 2003. These nations set and revised their mathematics curriculum standards in the direction of mathematics literacy defined by PISA. PISA describes the mathematical literacy as follows (OECD, 2013; p.25):

> "Mathematical literacy is an individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to recognize the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged and reflective citizens."

There are three main constructs which have important effects on the increasing success of mathematics. These are cognitive ability, motivation and emotions (Schiefele and Csikszentmihayli, 1995). In the past, in the studies about mathematics, cognitive ability overshadowed the effects of motivation on mathematics achievement.

Old reviews mentioned that, achievement in mathematics greatly depended on cognitive ability of students, whereas motivational factors were less important (Reynold and Walberg, 1991; Steinkamp and Maehr, 1983). In this age, motivation in mathematics also becomes important for mathematics performance of students because of the change in definition of mathematics performance (Schiefele and Csikszentmihalyi, 1995). Four facts are considered to understand the effects of motivational factors are held constant (Schneider and Bös, 1985). First of all, the variance in mathematics achievement can be explained by the cognitive ability that reduces dramatically when motivational factors are held constant (Schneider and Bös, 1985). Although intelligence is known as the most important factor for academic achievement, motivation predicts school performance variance that cannot be explained by intelligence (Steinmayr and Spinanth, 2009). Motivation also estimates the social behavior in school and affective domain of learning (Steinmayr, and Spinanth, 2009). For example, students who have autonomous motivation represent positive emotion in classroom, enjoyment of academic work, and satisfaction in school (Vallerand *et al.*, 1989). Second, motivational factors have indirect and complicated relation with mathematics achievement, which leads to underestimation of the effects of mathematics motivation (Schneider and Bös, 1985; Meece *et al.*, 1990). Third, mathematics motivation is important for mathematics related skills which are prominent in these days. Learning mathematics with problem solving, creativity, and deep comprehension is possible with the help of mathematics motivation (Csikszentmihalyi, 1988; McLoad, 1990). For example, a student can come up with a creative solution if she or he is dissatisfied with some common knowledge on a mathematics topic. However, this is not the case for every dissatisfaction. Students need to have enough autonomy and motivation in order to come up wih a new and creative solution (Csikszentmihalyi 2014). Lastly, there is a decreasing trend in both high school students' mathematics interests (mathematics intrinsic motivation) and mathematics performance (Jones, 1988; Reynolds and Walberg, 1992). Moreover, empirical studies investigating the relation between mathematics performance and mathematics motivation support that, there is a positive correlation between these variables (Gottfried, 1985; Lyold and Barenblatt, 1984; Haywood and Burke, 1977). Jones (1988) proposes that, schools facilitating students'

mathematics interest (mathematics intrinsic motivation) can overcome the problem of students' mathematics performance. Therefore, mathematics motivation should be taken into consideration for complete understanding of mathematics achievement. Moreover, motivation is not only a predictor of academic achievement but also an important outcome for education (Nancy, 1992). For example, National Council of Teachers Mathematics (NCTM) states that, motivation is important to change the nature of learning mathematics in schools. In this respect, NCTM (1989, p.2) considers two out of five goals; learning to value mathematics and becoming confident in students' ability to do mathematics.

Mathematics motivation can be improved by teachers' appropriate interventions and motivation integrated instructional designs. Mathematics motivation is a contextual level motivation which means it is only valid in certain domain of life such as mathematics classes (Ryan and Deci, 2002). Therefore, teachers need to stimulate the mathematics motivational behaviors of students with classroom activities and their own attitudes towards students. Actually, teachers can stimulate it. According to Middleton and Spanias (1999), consistency in generalizable amount of studies' conclusions marks the benefits of teachers' intervention for students' mathematics motivation. Trainings based on Attribution Theory (a motivational theory) help teachers improve the students' mathematics motivation (Williams, 1993); however even trained teachers in this field could fail to design a whole instruction that promotes their students' mathematics motivation (Fennema and Peterson, 1984; 1985). Therefore, determination of appropriate intervention by the teacher is a difficult task. The main problem behind the determination of appropriate intervention is that teachers feel the deficiency of knowledge about the source of mathematics motivation to measure students' current motivational regulations. According to Middleton (1995), a teacher who predicts her students' current mathematics motivational regulation better can manage her instructions according to her students' motivational anticipations. Furthermore, although effects of motivation on achievement scores have been validated over and over again (Mata *et al.*, 2012; Tsao, 2014; Steinmayr, and Spinath, 2009; Durmaz, and Akkuş, 2016; Spinath *et al.*, 2006; Steinfield, 2002, Valas and Sovik,

1993), European countries (except for Austria and Finland) did not pay enough attention to motivation in their curriculum (Eurydice, 2011, p.12). For example, in Turkish secondary school mathematics curriculum (TTKB, 2013), there are only two sentences about mathematics motivation. The first one is that mathematics motivation is a self-regulated behavior for students (TTKB, 2013, p.12) and the second one is that teachers must consider the students' mathematics motivation level to be able to discuss the depth of the topics (TTKB, 2013, p.4). In fact, this phenomenon is not a simple ignorance. A motivation integrated instructional design which is demanded by generalizable amount students were not constructed up until now (Wæge, 2009) because there is not enough and appropriate study about students' source of mathematics motivation. It means that, most of the studies look for motivational outcomes, and studies about students' sources of mathematics motivation generally worked with predetermined aspects (Wæge, 2009). The studies about mathematic motivation generally do not distinguish the motivation as intrinsic and extrinsic motivation. Therefore, a relatively new theory must be considered in order to work with students' sources of mathematics motivation.

Motivation is a comprehensive and an everlasting issue. There have been different aspects of it. Most of the psychologists and educators have a consensus on some outcomes of the motivated behaviors. Motivation arouses and promotes behavior, gives direction and goal to a behavior, increases the persistence of behavior, determines the consciousness of behavior (Wlodkowski, 1984). However, the sources of motivation have been studied from different perspectives in history. First of all, Alfred Adler's (1938) Individual Psychological Theory states that each individual was born with a motivation towards socialization. People endeavor for superiority to overcome others and themselves. This struggle drives the motivation (Marx and Tombaugh, 1967). Maslow describes several needs in the hierarchical model. In this model, the needs must be satisfied step by step to sustain motivation (Maslow, 1943). There are five steps from lowest to highest: physiological needs, safety needs, love needs, esteem needs and self-actualization needs. According to Skinner's point of view, inner processes can be ignored and motivation is measured by reinforcement history (Skin-

ner, 1948). Expectancy Value Theory posits that, there are certain expectancies and values which are interdependent to predict motivational outcomes (Eccles, 1983). In this regard, "expectancy" is one's belief about his/her ability to accomplish a task and "value" is perceived importance, joy or usefulness of a task. Bandura's theory expresses self-efficacy as a factor for motivation (Bandura, 1997).

Besides the sources of motivation, types of motivation are another research area related to the source of motivation. Internal and external locus of control are the key factors of types of motivation. The main difference between internal and external locus of control is that; while internal locus of control is determined by inner sense of self, external locus of control is determined by environmental factors independent from self. Inherent interest and enjoyment are an example of internal locus of control. Ego satisfaction and others' beliefs about one are instances for external locus of control (deCharms, 1984). In accordance with these locus of control types, there are three types of motivation. First, intrinsic motivation is described as doing an activity for exploration, inherent satisfaction and enjoyment (Coon and Mitterer, 2000). It means that the activity reinforced in –and- on itself (Hagger and Chatzisarantis, 2007). Second extrinsic motivation is considered as; performing an activity for external rewards. These rewards can be psychological, avoidance from punishment and seeking praise, or physical like expecting money, medal or good conduct abatement (Hagger and Chatzisarantis, 2007). The last one is amotivation which is complete lack of motivation.

This study is based on Self Determination Theory to consider sources of mathematics motivation, because it supports the differentiation of the types of motivation and culturally invariant sources of motivation. There are three reasons why SDT was chosen for this study. First of all, according to declaration of OECD (2013), Self Determination and Expectancy Value Theories are basis for their motivation constructs. The motivation theory that was chosen to be used by PISA is important because this study analyzes the PISA 2012 data and regards mathematical literacy definition of PISA as important for revising the most of the nations' mathematics

curriculum in this day and age. Secondly, there is a suggestion to use SDT in literature to measure students' sources of mathematics motivation. Wæge (2009) suggests that, self-determination theory is one of the best motivation theories explaining mathematics motivation, because it considers both types and sources of motivation in a well-developed structure. Thirdly, SDT model is better than the developmental model to predict motivation (Faye and Sharpe, 2008). According to Faye and Sharpe (2008), while basic psychological needs mediate between intimacy, identity, and motivation in SDT model, intimacy and identity mediate between basic psychological needs and motivation in developmental model. Self-determination theory is a relatively new theory on motivation, which explains motivation by three psychological needs. The theory considers intrinsic and extrinsic motivation through the satisfaction level of three psychological needs which are autonomy, competence and relatedness. The empirical research about self-determination theory started in early 1970s (Deci, 1971), and SDT became an empirical theory in 1980s. There has been an increase in the amount of research about self-determination theory in domains such as sport, work, health care, education psychotherapy and religion (Ryan and Deci, 2000).

2.1. Self Determination Theory

SDT presents a continuum model for motivation. According to SDT, psychological needs are more powerful factors than physiological needs for motivational regulations of people. In addition, these needs have to be cultural and age invariant because psychological needs stem from human nature, and they are universally innate requirements (Ryan and Deci, 2002). This definitions of SDT adequately restrict the list of psychological needs. Therefore, there are only three psychological needs which are autonomy, competence and relatedness (Deci, 1975). Autonomy can be considered as the degree of one's will, responsibility and choice for their own behaviors. DeCharms (1984) asserts that, personal control and taking responsibility for their own learning enhance the motivation. Wang and Peverly (1986) found that autonomous learners are active and independent in their learning process in a way that students can change the goals of learning with regard to their own interest and needs, and by identifying

and formulating their own goals. Similarly, motivation is intrinsic in students for the following cases: learning for their own sake instead of the rewards given for success (Deci and Ryan, 1985b), focusing on learning outcomes instead of performance outcomes (Dweck, 1986), and understanding the importance of their efforts in determining the success and overcoming failures (Wang and Palinscar, 1989). Autonomy is one of the key factors for motivation and must be satisfied to make learner responsible, independent, and free to choose.

Competence is referred as the degree of feeling to express and exercise one's own skills from encountering opportunities. White (1959) states that people have inborn need for competence. It is desired for effective and competent interaction with environment. For example, newborns represent curiosity and exploratory behaviors (White, 1959). These behaviors stem from the need for competence (White, 1959). Need for competence is the need to feel confident and effective in an action, moreover it leads to seek for harder challenges to improve related skills. For example, sense of achievement for a hard task, and willingness for being excellent in a hard task are related to the need for competence.

Relatedness is concerned with the sense of security, which flourishes from being cared by others and caring for others. It means that belongingness is a feeling of becoming a part of the community. Relatedness has also adaptive advantages, because one can connect and share experiences with significant others. Relatedness is inherently satisfactory factor for one, since it is an evolved psychological need (Ryan, 1995). For example, according to Ryan (1991, 1993), if young mammals have a background of secure attachment and self-belongingness to caregivers, they exhibit intrinsically motivated behaviors. Relatedness is also significant for human begins to be motivated intrinsically (Ryan and Niemiec, 2009).

SDT is a combination of mini theories. This study is composed of four of these mini theories of SDT that explain the different aspects of motivation (Ryan and Deci, 2002). All these minor theories are related to the effects of basic psychological needs on

motivation and its mechanism. Namely, these sub theories are Cognitive Evaluation Theory (CET) (Deci, 1975), Organismic Integration Theory (OIT) (Deci and Ryan 1985b), Causality Orientation Theory (COT) (Deci and Ryan 1985a), Basic Psychological Needs Theory (BPNT) (Ryan and Deci, 2000). CET (Deci, 1975) represents the effect of social context on intrinsic motivation by means of psychological needs. OIT (Deci and Ryan 1985b) expresses extrinsic motivation as a continuum and transitions between levels in this continuum. According to OIT, extrinsic motivation is a continuum depending on the level of satisfaction of the needs. COT (Deci and Ryan 1985a) asserts that, individual differences lead to a change in motivational orientation for an activity. BPNT (Ryan and Deci, 2000) asserts that autonomy, competence and relatedness are responsible for being fully functioning, and all of the needs are both cultural and age invariant.

2.1.1. Cognitive Evaluation Theory

CET describes the effects of social context on intrinsic motivation. The effects of social context are possible with the help of two cognitive processes .These cognitive processes create the distinction between extrinsic and intrinsic motivation (Ryan and Deci, 2002, p.10). Perceived causality is one of the two cognitive processes and it means that the causes are perceived by the participant to do an activity. For instance, offering tangible rewards or supplying verbal rewards can be counted as two different causes to perform a task (Kruglanski *et al.*, 1971); because offering tangible rewards -such as money- undermine the intrinsic motivation, whereas supplying verbal rewards can enhance it (Deci *et al.*, 1999). Perceived causality changes with the autonomy social context offers. A tangible reward activity shifts the perception towards an external motivation because of the absence of autonomy in the subsistence of tangible rewards. Furthermore, verbal rewards can enhance intrinsic motivation, if people feels competent enough. It means that, there is an interaction between perceived causality and perceived competence (Ryan and Deci, 2002, p.12). Perceived competence changes with the level of challenge offered by the contextual events. Difference in the competence level of an activity leads to difference in motivational regulations of

participants. When participants of an activity feel competent enough to overcome the challenge; the increase in the level of challenge enhances the intrinsic motivation, and the decrease in the level of challenge is responsible for undermining the intrinsic motivation (Ryan and Deci, 2002, p.12).

According CET (Deci, 1975), there are three fundamental social contexts which can support or hinder the intrinsic motivation. These are autonomy supportive (informational), controlling or amotivating contextual factors, and each corresponds to a different type of motivation (Ryan and Deci, 2002, p.9). Moreover, an autonomy supportive contextual event which can be possible with non-instrumental participation to the event is responsible for intrinsic motivation. Controlling contextual events lead to external motivation, which is controlled by a factor apart from one's basic psychological needs (Ryan and Deci, 2002, p.12). Perceived causality and competence are determined by the effects of informational and controlling characteristics of social context. The difference between the controlling contextual events and informational (autonomy supportive) contextual events is that controlling contextual events have factors which pushes the participants instrumentally to complete the task, instead of supporting the free engagement towards the task. Apart from perceived competence and perceived causality (autonomy), relatedness in a social context is another factor that effects the intrinsic motivation. Research shows that, although children are engaged in an activity with an interest, the presence of an unknown adult prevents children from motivating intrinsically (Anderson *et al.*, 1976). Need satisfaction for relatedness is only important for interpersonal activities, while competence and autonomy is crucial for all kinds of activities (Deci and Ryan, 2000). Therefore, competence and autonomy have closer relationship with intrinsic motivation than relatedness.

Although all kinds of contextual events have an important effect on intrinsic motivation, the effects of the interpersonal climate are more determinant than others to undermine or enhance intrinsic motivation. For example, a verbal praise can undermine the intrinsic motivation too, when it is given in a pressuring climate. In this kind of climate, one can perceive the verbal praise as a controlling factor. In the

same way, when tangible rewards are presented in a non-evaluative climate, they do not undermine the intrinsic motivation (Reeve and Deci, 1996). Moreover, if one has an overarching external motivation such as ego, then he is somehow independent from social context. For instance, people who are involved in an activity to satisfy his/her ego can be independent from the social context. Although the context is informational (autonomy supportive), intrinsic motivation can be undermined; because self-worth prevents people from the autonomous involvement for a task (Plant and Ryan, 1985).

According to CET (Deci, 1975), satisfaction of perceived causality (perceived autonomy), perceived competence, and relatedness positively affect intrinsic motivation, therefore students with a high degree of autonomy, competence and relatedness are intrinsically motivated. The prediction of CET is utilized for determining the direction of regression coefficients between basic psychological needs and intrinsic motivation variables in PISA 2012. Therefore, three mathematics related basic psychological needs have positive regression coefficient for predicting mathematics intrinsic motivation to test the assumptions of SDT in this study.

2.1.2. Organismic Integration Theory

Unlike CET, OIT focuses on extrinsic motivation. Activities that are not found interesting, challenging or pleasing cannot be experienced intrinsically. According to an old fashioned view (deCharms 1968), extrinsic motivation is negatively related to intrinsic motivation. However, OIT assumes that intrinsic and extrinsic motivation are not a part of a dichotomy, they are ranged in a continuum. Moreover, autonomously extrinsic motivation is possible. According to Active Organismic Theory (Schafer, 1968), people tend to work for transformation of an external regulation into a self-regulation. It means that people tend to develop autonomy to do an uninteresting activity. Initially, an uninteresting activity makes participants externally regulated, but it can be internalized with the help of support for basic psychological needs. The level of internalization is based on the given degree of autonomy support to do an externally regulated activity. Thus, there are different degrees of extrinsic

motivation flourishing from different level of autonomy (Ryan and Deci, 2002, p.18). Internalization is a process that assimilates the external regulations into self, however this process does not end up with intrinsic motivation (Ryan and Deci, 2009, p.62). Internalization and impairment are only possible between the levels of extrinsic motivation, because perceived external locus of control is still effective on the participants of an activity. Therefore, amotivation, extrinsic motivation and intrinsic motivation are considered as different constructs, and they cannot be collected under the same title.

DeCharms (1968) explains extrinsic motivation as non-autonomous form of motivation (antithetical to self-determination), but SDT posits (Ryan and Deci, 2002) that autonomously extrinsic motivation is possible. Following example can make the situation clear. With the help of a verbal reward, a girl can do her homework to understand lesson well instead of doing it to avoid punishment. Less autonomous form of extrinsic motivation is also possible. A boy who does his homework because of the feel of shame, has less autonomous extrinsic motivation than her. Most probably, he avoids the shame of being punished in a crowd. It means that, punishment controls him more than her. However, both students are still externally motivated, because controlling effects of punishment continues. Students are intrinsically motivated only when they have free choice and are given equal chance not to do it. Therefore, there are different degrees in extrinsic motivation. Figure 2.1 shows the self-determination continuum.

To start with, amotivation is not a part of extrinsic motivation. Amotivation means unwillingness towards an activity or participating in an activity passively because of the lack of motivation. There are reasons for becoming amotivated. First, one may not trust that he will succeed in the activity. These people can have self-esteem problems (Crocker and Major, 1989) or learned helplessness (Seligman, 1975). Second, they may not feel competent enough for an activity or they may not perceive competence to do an activity (Deci, 1975). Third, they may not value the activity itself or outcome of it (Ryan, 1995). Thus, amotivation can be stated as lack

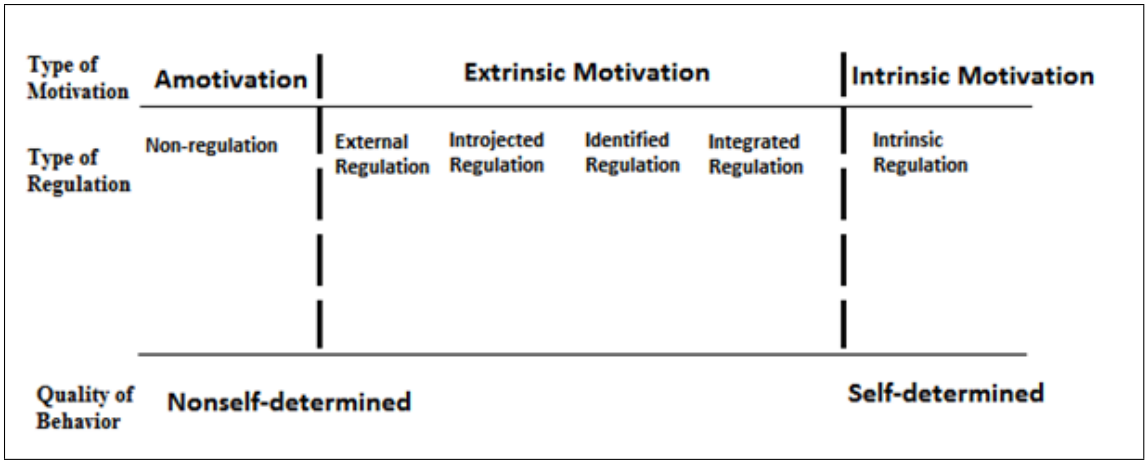

Figure 2.1. Continuum of extrinsic motivation in Self Determination Theory (Ryan and Deci,2000, p.16)

of autonomy and it is at the left-hand side of Figure 2.1 which is complete lack of motivation.

External regulation is the first level of the extrinsic motivation, and it is the least autonomous form of extrinsic motivation. In this type, external sources regulate the individuals' motivation. External regulations of motivation are the main focus for Skinner's operant conditioning (Skinner, 1948). Although Skinner uses an animal, it is a good example of external regulation. Because animals do not have values or the need for verbal rewards, their motivation can be regulated only externally to do an uninteresting activity. Doing activities to avoid punishment or to obtain a reward leads to external regulation of motivation, because the behavior results from an absolute external factor.

Introjected regulation is the second level of the continuum in extrinsic motivation because it includes an external regulation created by and on one's self. The best example can be stated as shame. Although shame is not a physical punishment directed from others, it can regulate the individual's behaviors and motivation. When an individual does an activity to avoid the sense of shame, s/he has introjected reg-

ulation. It is introjected regulation of external motivation because one's own feelings about others' thoughts or beliefs regulating his motivation. It is quite under the control of subject compared to external regulation. It means that a person regulates her activity because of her thought about others. This is an unconscious way of regulation. In the same way, doing activity to attain ego or feeling worthy can be a sign of introjected regulation.

Regulation through identification (Deci and Ryan, 1985b), can be referred as autonomous external regulation. It is a conscious way to regulate motivation. The difference between introjected regulation and regulation through identification is the source of the thoughts triggering to do an activity. For example, a child who does homework in order to feel the worth given by the teacher as a result of a properly done homework is an example of introjected regulation. A child who claims she does homework to understand the lesson well, is an instance of regulation through identification (Deci and Ryan, 1985b, p.137). Thus, it is at the third place in internalization continuum which is more internalized than introjected regulation. The key point of the regulation through identification is true self-regulation. A person with regulation through identification pays attention to values, outcomes and regulations instead of significant others. Moreover, it is why children do not internalize all the beliefs and regulations of others, and integrate some by themselves.

Integrated regulation is the most autonomous form of external regulation. Integrated regulation of external motivation is only possible after a person develops identification by defining his/her personal values, goals and needs. Then, regulations can become integrated regulations with the help of environmental conditions (Deci and Ryan, 1985b, p.148). Integrated regulation shows similarity with intrinsic motivation with respect to self-control (Ryan and Deci, 2002, p18). The difference between integrated regulation and intrinsic motivation is that while people with intrinsic motivation act for inherent interest and enjoyment, people with integrated regulation act to achieve personally important outcomes. Although integrated regulation is found at the right-hand side of the Figure 2.1. Integrated regulation is still instrumental. It

is still in the range of external motivation because the need for achievement to obtain personally important outcomes controls one.

These four steps of OIT are not a developmental process, and one does not really need to progress each stage of internalization. A person can be at any point in this continuum depending on his prior experience and the level of the support from the environment. These regulations are internalized with the ego and cognitive development (Ryan and Deci, 2002). Integrated regulation can be seen in children as they are raised. As time passes, ego and cognitive development increase (Piaget, 1971), therefore more internalized type of regulations are created (Deci and Ryan, 1991). These regulation styles are intercorrelated with autonomy (Ryan and Connell, 1989). Autonomously motivated behaviors lead to improvement in self-control, effective performance, social relationship, and well-being (Ryan and Deci, 2002, p.19).

Extrinsically motivated people do not really attempt to do the activity, unless the activity offers a desired outcome because of lack of inherent interest. Relatedness has an active role in internalization of such behavior. Promotion of integrated regulation is mostly possible by significant others and confirmation from a group, therefore relatedness has crucial role for integration. People, who have significant others, can regulate their activity in order to be appreciated by them or feel worthy in their eyes. Ryan *et al.* (1994) state that, children who are cared by their teacher and family internalize positive school behaviors. Relatedness is a key factor to promote internalization progress; however a full internalization is not possible without perceived competence and autonomy. Perceived competence make the progress easier (Ryan and Deci, 2002, p.19; Deci *et al.*, 1994). Autonomy helps people to reach higher levels in external motivation continuum (Ryan and Deci, 2002, p.20). Moreover, autonomy supplies persistence over time for internalized behavior (William and Deci, 1996).

Based on the assumptions of OIT, there are two consequences to be considered by this study. At first, three mathematics related basic psychological needs in PISA 2012 have positive regression coefficient for predicting mathematics extrinsic motivation

defined by PISA 2012. Second, extrinsic and intrinsic motivation for mathematics are two different constructs which are differentiated by locus of control.

2.1.3. Causality Orientation Theory

COT relates motivation with individual differences (Deci and Ryan 1985a). They found that, personality offers different degrees of motivational orientation which also shows parallelism with basic psychological needs. The types of orientations are autonomous orientation, controlled orientation and impersonal orientation as shown in Figure 2.2.

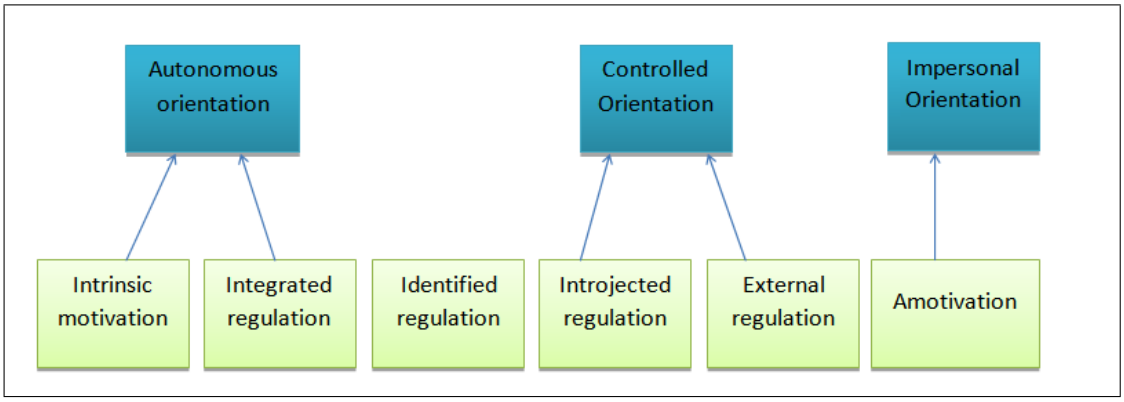

Figure 2.2. Motivational orientations

To some degree, people can have all of these orientations. Autonomous orientation symbolizes behaving together with inherent interest and self-developed values. Controlled orientation includes behaving according to values that are not developed by themselves, such as acting according to others' expectation instead of their own will. Impersonal orientation involves behaving unintentionally and concentrating on absence of signs. Figure 2.2 shows the relation between orientation styles and self-determination continuum according to OIT.

Deci and Ryan (1985a) also examined the characteristics of these personalities. Autonomy orientation is related to self-actualization, self-esteem and indicators of

well-being. Controlled orientation is related to public self-consciousness, intrinsic insecurity and insufficient level of self-esteem. Impersonal orientation is related to self-derogation, low self-esteem and depression.

The central point in the autonomy orientation is choice. When one takes an equal chance on doing or avoiding an activity, she makes a choice freely , and this choice stems from an integrated sense of self (Deci and Ryan, 1985b, p.154). Therefore, choice needs to be deliberate. People generally make a decision instead of choice by considering its outcomes. People make a choice when they can join an activity for no reason except for the fact that they feel like it. Because the choice implies a free will, it is different than a decision. A truly chosen behavior has to be dispensable because a person who cannot give an equal chance to not doing it, make a decision rather than a choice. The flexibility of the decision for behaving is important for choice. Therefore, autonomously oriented people are flexible in their choices, and it is not important that the choice is deliberate or conscious.

Control orientation is concerned with a behavioral controller. A behavioral controller can create a pressure or a distracter which prevents one from experiencing free choice. The consequences of controlling behaviors are generally ego satisfaction for success and shame or guilt for failure. The main point about a controlled behavior is that, it can stem from both a rebellion against the controlling factor or a conformance with the controlling factor. Behaviorally controlled person is external to his integrated sense of self. For example, a student who claims that he is free to choose a profession in arts because his parents are pressuring him to choose engineering. The student does not make a free choice, so it is a control orientation. Similarly, a student who contemplates on future career plan with family and decides to study engineering, also represents a control orientation. Thus, control orientation means to decide by responding controlling factors, instead of being flexible in decision process. In this example, the student's rebellion or accommodation undermines the intrinsic motivation (Deci and Ryan, 1985b).

Impersonal orientation means being not competent enough to overcome challenges. Impersonally oriented person does not have a structure to overcome internal and external forces. S/he believes that there is no relation between a behavior and its outcomes. Then, s/he cannot master the environment and control the external and internal forces. These people develop a sense of helplessness (Selingman, 1975). Autonomously oriented people have the flexibility in internal forces and external forces. Control oriented people have the inflexibility in internal forces and external forces, while impersonal oriented people don't have any structure to overcome these forces. For example, a child who is rewarded, punished and ignored for the same kind of behaviors or continually punished for his behaviors, cannot develop a structure for dealing with these forces and cannot master the environment. Such an environment is amotivating and provides the child with loss of self-control. Then, the child either tends to avoid or be reluctant for any activity, therefore he develops impersonal orientation.

According to Ryan and Deci (1985b), locus of causality is a key factor for COT. They clearly state that perceived locus of causality and locus of control are two different constructs, however they are together for understanding of autonomous behavior. While locus of causality determines the behavioral orientations of people, locus of control explains the type of control for one's behaviors. However, Ryan and Deci distinguished perceived locus of causality from Rotter's definition on locus of control. In the past, Rotter (1954) asserted that there are two types of locus of control which are internal and external locus of control. However, Rotter's differentiation was not enough for explaining all the situations in SDT, because SDT considers the autonomy in a continuum while Rotter (1954) defined it as a point. Therefore, internal locus of control did not guarantee the self-determining behaviors in Rotter's differentiation, he ignored the fact that the possibility of internalized types of external behaviors. Then, Deci and Ryan (1985b, p.210) differentiate the locus of causality and locus of control with an explanation like that:

> "Self-determination involves choice, and people may choose to take control or to give up control. The basic intrinsic need is not to be in control of situations or of outcomes; it is to choose, to be self-determining with respect to situations or outcomes."

Connell (1985) redesigns the types of locus of control in an autonomy continuum as internal, powerful others and unknown. In Connell's differentiation (1985), internal, powerful others, and unknown locus of control respectively corresponds to the intrinsic, extrinsic, and impersonal behaviors. With the help of Connell's research (1985), Ryan and Connell (1989) are able to measure the integrated, introjected and external type of behaviors. PISA 2012 utilizes the Connell's locus of control differentiation in order to measure perceived locus of control for success in mathematics.

OECD report that (2013, p.185) perceived control for success in mathematics scale of PISA 2012 is measured under locus of control construct to enable testing theory of planned behavior (Ajzen, 1991).Theory Planned Behavior (TPB) asserts that perceived control has dual interpretation: perceived capacity and perceived autonomy (Fishbein and Ajzen, 2010; Ajzen, 2002). In that respect, if behavioral performance depends on one's own volition, it determines perceived autonomy.

Although, PISA 2012 motivation scales depend on SDT, there are not any specific indication of autonomy measuring items depending on COT, hence SDT. Actually, PISA 2012 is able to measure autonomy over perceived control scores because OECD (2013) declares that perceived control scale depends on TPB. The definition of perceived autonomy given by both COT and TPB are very similar to each other, however definition of perceived control varies between COT and TPB. According to COT (Deci and Ryan, 1985b), there is a difference between perceived autonomy and Rotter's (1954) definition of perceived control, however there is not a contradiction with TPB's definition of perceived control. Perceived control means both perceived autonomy and perceived capacity in TPB, unlike COT because COT takes an old perspective on perceived control into consideration. It means that TPB's perceived control definition includes also autonomy COT defines which depends on free choice

(Yzer, 2012). Furthermore, Patrick, Skinner, and Connell (1993) state that, there is a large overlap between variance explained by perceived autonomy and perceived control for predicting autonomous behaviors. Paulhus (1983) also states that, a domain specific perceived control scale predicts autonomous behaviors powerfully. Therefore, perceived autonomy scores measured over perceived control scores in PISA 2012 for this study with the help of COT and TPB.

2.1.4. Basic Psychological Needs Theory

BPNT (Ryan and Deci, 2000; 2002) proposes that when the psychological needs are satisfied, well-being is promoted i.e. greater work performance, less perceived stress, fewer turnover intentions (Gagne *et al.*, 2015). When they are thwarted, the result is negative motivational outcomes. Well-being has recently been researched by Ryan and Deci (2001) and there are two different aspects of the well-being research. The first is related to happiness, whereas the second is concerned with being optimal functioning and growth (called as eudaimonic aspects). Autonomy, competence and relatedness have been researched in the context of eudaimonic well-being. Because autonomy, competence and relatedness are related directly to vitality, psychological flexibility and deep inner sense of self (Ryan and Deci, 2002, p.27), people can function in an effective way in a social environment that supports the basic psychological needs. Deci and Flaste (1995) drew an analogy to explain the importance of the need satisfaction;

> "If you put an avocado pit in a pot of earth it will probably grow into a tree, because it is in the nature of avocados to do that . . . [But for that to occur] they need sun; they need water; and they need the right temperatures. Those elements do not make trees grow, but they are the nutriments that the developing avocados need, that are necessary in order for the avocados to do what they do naturally" (p. 98).

As the example explains, human beings have innate and life-long tendencies for satisfying basic psychological needs in order to do what they do naturally, which is giving motivational content to life (Deci and Ryan, 2000). According to Ryan *et al.* (2013),

eudaimonic living is an intrinsically motivated organism which pursues intrinsic goals, behaves autonomously, acts with a sense of awareness, and behaves in the direction of the basic psychological needs' satisfaction. Need for autonomy, competence and relatedness are universal, because these are innate psychological needs. Although they are culture, age and gender invariant (Deci and Ryan, 2008), the way of needs' satisfaction can change across these groups because of cultural values and goals. It means that, whatever the way of needs' satisfaction is, they are still basic psychological needs for all groups and satisfaction of autonomy, competence and relatedness is required. Moreover, Chirkov (2012) states that, the priority of the needs can change according to being in a collectivist or individualist culture. Deci and Ryan (2008) state that, the needs can also interchange the position in priority. Therefore, these basic psychological needs are universally prerequisite regardless of their priority and the way of their satisfaction for enhancement and impairment of motivation for one. Therefore, this study utilizes the BPNT predictions for mathematics motivation variables in PISA 2012 to look for an evidence for supporting cultural invariance of the basic psychological needs. The direction of the regression coefficients was determined by the CET (Deci, 1975), and OIT (Deci and Ryan, 1985b)

2.1.5. Hierarchical Model of Self Determination Theory

To explain complex hierarchical model more effectively, investigating a case about the motivational regulations of a student can be helpful. In this example, there is a student who is successful in academic and social life. Although he does physics, arts, literature, and music for his enjoyment and satisfaction of inherent interest, he fails in mathematics. He will have an exam for university entrance at the end of the year. In the school, he has a mathematics teacher who gives the instructions on how to solve questions. His mathematics teacher is a controlling man and he never lets anyone solve questions in a different way than he does. The student feels that he is compelled to solve questions in the direction of his teacher's wishes. Moreover activities in the class lack competence and opportunities of choice. Certainly, he does not like mathematics at all, and his family is never satisfied with his

performance. Then, his school counselor decides to change his lesson program from mathematics weighted program to social science weighted program for trial. One day, he and his friends from new class decide to play a mathematics related computer game for enjoyment. In that game, there is not a teacher who gives instructions to him. He is excited during the game, because he solves mathematics related questions with his own thinking process. He makes the highest score among friends in a social network which also includes his school counselor. His shining performance is seen by the school counselor. The counselor talks to his family about it. Then, family finds a new mathematics teacher for him. The new teacher encourages him to make his own decisions in mathematics problems and lessons. This is always what he wants to do in the lessons, and he starts to experience the pleasure. Then, he finds himself enjoying more in the lessons and exams. After a certain period of time, his teacher gives him a chance to take the university entrance exam which he has already intended to take as a student from mathematics weighted program. Then, it made him anxious to take exam in mathematics weighted form because of his past experience. His teacher does not push him to take the exam for students in mathematics weighted program; instead he says that, "you don't need to take a mathematics weighted exam, your family can handle the situation". This talk takes a great burden from his shoulders and he decides to take mathematics weighted exam anyway. When he goes to have a last talk to his coach, he says that "go and solve questions in your own way". This autonomy support makes him encouraged to think free. At the end of the day, he solves almost all questions in the mathematics part. While they are leaving from the exam place, his school counselor, family and classmates give greetings for him. Solving most of the questions make him happy although he does not know the exam result, yet. At the end of the day, he continues to play mathematics related computer games in his room, because he is really satisfied with his ability to solve the questions in the mathematics exam and his own performance (Vallerand and Ratelle, 2002).

From the example above, several motivational features can be derived. First of all, motivation construct has a complex structure. To explain the complexity, there is a need for different levels in generality, because his motivation can change in different

life domains and there is not a unitary conclusion for his motivational behaviors. These levels are global, contextual and situational. Individuals tend to develop a general (global) motivational orientation to respond the environment (Vallerand and Ratelle, 2002, p.45), so the global level is the most stable form of motivation among levels of generality (Hodgins and Deci, 1999). The student has intrinsic motivation towards school, social life and many other contexts, because he involves in activities in most of the life domains for his enjoyment and satisfaction of inherent interest. Context for generality levels can be described as "distinct sphere of human activity" (Emmons, 1995). That is to say, he has intrinsically global motivation because of engaging in activities for enjoyment in most of the life domains. He has extrinsic contextual motivation towards mathematics; because he feels compulsory to solve questions, he lacks competence and autonomy, and he has controlling factor (mathematics teacher) for his behaviors only in mathematics lesson. He has contextual external motivation despite his intrinsically motivated personality in global level. The situational level can be determined as the least stable motivational generality level, because it can interact with environmental changes reflexively. It also explains that, why people participate in an activity for a certain instant of time (Vallerand and Ratelle, 2002, p.46). Before the exam, he is intrinsically motivated at situational level to take exam in mathematics weighted form.

Social factors can result in a change in motivation in any generality level. Social factors include not only human factors but also nonhuman factors (Deci and Ryan, 1985b; Vallerand, 1997). School environment is a nonhuman factor which also has an impact on academic motivation. According to CET (Deci, 1975), the effect of social factors on motivation are mediated by perception of psychological needs (autonomy, competence, relatedness). Moreover, there is a corresponding generality level of social factors for each level in generality of motivation. For example, a teacher can be a contextual social factor because she can affect her students' contextual level motivation with her attitudes in lessons. In the same way, a rebel can be a situational social factor, because people react and experience immediately opportunity of choice. These examples show that others can have a significant impact on people's motiva-

tion. His previous teacher was controlling enough to make him externally motivated. His new teacher gives opportunities for experiencing choice (autonomy support) and competence.

Another feature of the generality levels in motivation is bottom up and top down effect. A generality level in motivation affects the next lower level. That is to say, global motivation has greater impact on contextual motivation than situational motivation. It is expected that, globally and intrinsically motivated person is also intrinsically motivated in different life context. A path way analyses revealed that, obese patients' global motivation determines the contextual motivation towards treatment (William *et al.*, 1996). Moreover, repeatedly participating in an activity which enhances intrinsic motivation at situational level and facing with its beneficial outcomes leads to development of contextual intrinsic motivation. This fact is called as recursive effect. In the same way, negative recursive effect is also possible which enables the transformation of extrinsic motivation from situational level to contextual level. Several studies show that bottom up effect and top down effects are possible between two nearest level in that hierarchy (Guay *et al.*, 2000).

Although a social factor which is in an irrelevant level of generality has an effect on motivational regulations of one with the help of top-down and bottom up effects in hierarchical model, a social factor which is in a corresponding level of generality is the main factor in affecting one's motivational regulations. Thus, mathematics teachers are the best candidates for regulating the student's mathematics motivation, because they are in the same level of generality which is contextual level. With the help of hierarchical model, motivation integrated mathematics instruction plan (non-human contextual level factor) and mathematics teachers' appropriate interventions (human contextual level factor) can be effective on students' motivation. This study fills a gap in the literature of sources of mathematics motivation suggested by Wæge (2009) in order to help for development of motivation integrated mathematics instruction plan and mathematics teachers appropriate interventions for students motivation.

2.2. Related Studies

There are some studies which examine the effects of competence, autonomy, and relatedness on students' mathematic motivation, however these studies do not consider these needs as a part of SDT. Rohrkemper and Bershon (1984), conducted a study which has the purpose of finding out development of students' mathematics motivation. They report that most of the students start to show a decrease in self-concept (competence) towards mathematics as early as third grade. A decrease in competence leads to decrease in students' persistence in difficult tasks, hence intrinsic motivation. Another study puts intrinsic motivation and competence in a regression analysis to predict mathematics motivation (Spinath *et al.*, 2006). When intrinsic motivation and competence were entered simultaneously, the results show that only competence was a significant predictor for mathematics achievement. When intrinsic motivation was entered solely, intrinsic motivation was also a significant predictor for mathematics achievement. Also Nakamura (1988) argues that, while high achievers in mathematics try to show their best for hard challenges, low achievers tend to choose challenges below their ability level. The high achievers attempt questions with intrinsic motivation, while the low achievers tend to avoid anxiety and stress. According to Stipek *et al.* (1998), when teachers create autonomy environment (giving opportunities to choose their own behaviors), students tend to feel less anxiety and put their best performance. When teachers create a controlling environment (giving reward or punishment for students' behaviors), students attribute anxiety for failures. Teachers' autonomy support creates a better psychological environment (Stipek *et al.*,1998). Steinfeld (2002) conducted a study on the effects of students' relatedness on mathematics motivation and mathematics achievements. He analyzed the data with correlation and regression methods. The results show that, there was no significant relation between relatedness and mathematics motivation. Moreover, there was also no significant relationship between relatedness and mathematics quantitative achievement. There was only significant indirect inverse relationship between relatedness and mathematics quantitative achievement.

According to recent reviews on mathematics motivation (Wæge, 2009, Hannula 2006, Evans and Wedege, 2004), there are few empirical researches on mathematic motivation with all needs and types of motivation in SDT. Durmaz and Akkuş (2016) conducted a research on the relationship between all of the basic psychological needs on mathematics motivational regulations and mathematics anxiety with respect to SDT. They found that there is a negative correlation between basic psychological needs and mathematics anxiety. According to them, especially an increase in autonomy has significantly estimates an increase in basic psychological needs and decrease in mathematics anxiety. They concluded that, autonomously supported students feel less anxiety, and teachers should reconsider their instructions in accordance with SDT. Research designed by Durmaz and Akkuş (2016) includes 4 types of motivational regulations which are intrinsic motivation, identified regulation, introjected regulation and external regulation. The results of the study show that, all of the basic psychological needs are positively correlated with all types of motivation considered by the study. Moreover, all regression coefficients between all basic psychological needs and all types of motivation considered by the study are positive, except the regression coefficient between autonomy and identified regulation. Valas and Sovik (1993) conducted a study about the relationships between variables that are mathematics teachers' controlling strategies (teachers' autonomy support) for students' intrinsic motivation, students' mathematics achievement, and students' mathematics competence. The data from the students have been analyzed by using path analysis. The study was designed as longitudinal study which collects data throughout a year to investigate the effect of treatments' persistence (teaching strategies). They concluded that, teachers' autonomy support significantly affects the students' mathematics competence, and students' mathematics competence significantly affect the students' mathematics intrinsic motivation. Students' mathematics intrinsic motivation also significantly affect the mathematics achievement. To sum up, students' competence and students' intrinsic motivation could be developed by appropriate SDT integrated teaching strategies (Valas and Sovik, 1993). Moreover, Zhou *et al.* (2009) investigate the autonomy and control motivation in mathematics learning domain with a cross cultural sample. They analyze the relationship between interest, perceived competence, perceived

choice (autonomy), autonomous motivation (intrinsic) and control (extrinsic) motivation in rural Chinese schools. They found that, autonomy is a significant factor for intrinsic motivation in the collectivist culture (rural Chinese schools) as much as individualist cultures. All three factors are positively related with intrinsic motivation. Competence has a significant positive relation with extrinsic motivation. Zhou *et al.* (2009) also investigate the effects of autonomy support on rural Chinese students' extrinsic motivation. They found that, autonomy support for the students has also positively related to the control motivation. Jang *et al.* (2009) conduct a study which investigates the relationships between Korean students' basic psychological needs for mathematics and four outcomes for mathematics learning (achievement, engagement, intrinsic motivation, proneness to the negative effects). They found that, relatedness was not a significant factor for mathematics intrinsic motivation while mathematics autonomy and mathematics competence were a significant factor for mathematics intrinsic motivation. Moreover, they separate the students into two groups with respect to their endorsement of collectivism. The results showed that, all basic psychological needs were culturally invariant for predicting intrinsic motivation and relatedness was still non-significant for both of the groups.

In the light of the studies on SDT and mathematics motivation, both students' mathematics competence and students' mathematics autonomy can be supported by only teachers, because mathematics motivation is a contextual level motivation according to hierarchical model (Valerand and Ratelle, 2002) and it is only valid in the school context. Therefore, a study on sources of mathematic motivation can be beneficial for the development of motivation integrated instruction plan and determination of appropriate interventions by teachers. The cultural adaptation of the SDT integrated instruction plan is possible with the help of cultural invariance of the basic psychological needs.

2.3. Differentiation of Cultures

Cultural invariance of the effects of autonomy on motivation has dominated the literature when it is compared to the rest of the basic psychological needs. Autonomy is popular in the literature because there is a belief that the need for autonomy is only valid for western individualist culture. Contrary to literature in mathematics motivation, all basic psychological needs are included in cultural invariance measurement in this study as BNPT predicts. Moreover CET asserts that, extrinsic motivation is not a dichotomy rather it is a continuum depending on the level of students' autonomy satisfaction. Therefore, division of cultures according to two ends of autonomy (collectivist vs individualist or western vs eastern) is inadequate to measure cultural invariance of the basic psychological needs. Therefore, this study considers the cultures in a wider variety than studies in the literature.

Worlds Values Map 6 (WVS, 2015) which analyses the cultures in depth, was used to differentiate cultures in study. World Values Map 6 not only covers the time interval from 2010 to 2014 but also includes an empirical separation of cultures. According to World Values Map 6, the differentiation of the cultures greatly (%70) depends on traditional/secular- rational and survival/self-expression values (WVS, 2015).

Traditional/secular-rational values represent the cultural dependencies on religion. Most of the variables differentiating the cultures which are ranged from family relations to national pride, depend on this variable (WVS, 2015).Self-expression values mostly depend on cultures with surpassing wealth after the industrialism period. Survival values are demonstrated in cultures which have not guaranteed the survival. The shift of priority from survival to self-expression values create a big gap between cultures (WVS, 2015). The Figure 2.3 shows the world values map. In this research, only some of the countries (Figure 2.3) are chosen among PISA 2012 countries. The main reason behind choosing looped countries in Figure 2.3 is that, they were relatively placed in the middle of their cultural region in the map (WVS, 2015) therefore their representative power for their cultures is better than the others in their cultural clus-

ter (WVS, 2015). Finland, Japan, Lithuania, Russia, Thailand, Spain, Great Britain, Turkey, and Brazil were chosen for this study to test cultural invariance of the basic psychological needs.

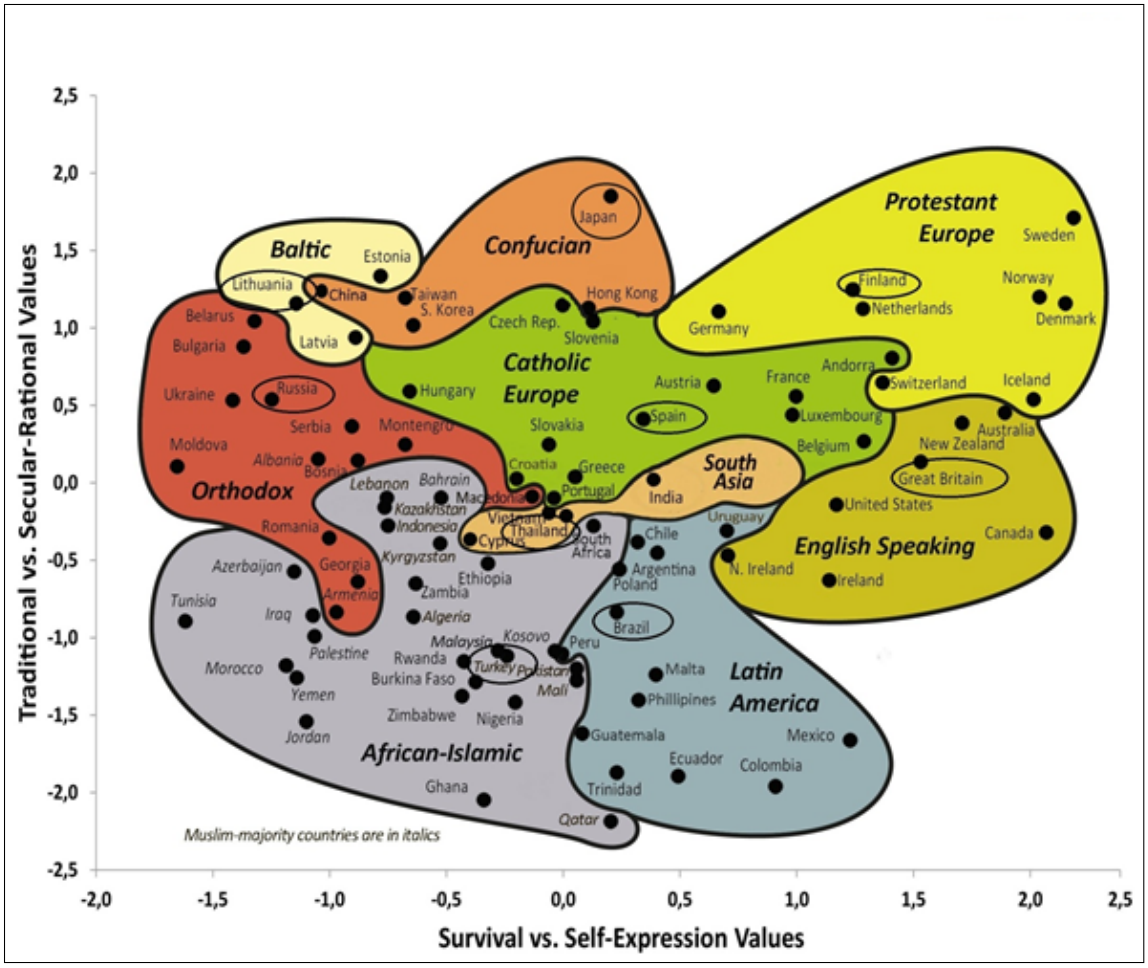

Figure 2.3. World Values Map 6, (WVS, 2015)

3. SIGNIFICANCE OF THE STUDY

Research shows that, students' motivation towards mathematics affects students' mathematics achievement, attitudes towards mathematics, and mathematics related feelings (anxiety, enjoyment) (Mata *et al.*, 2012; Tsao, 2014; Steinmayr and Spinath, 2009; Durmaz and Akkuş, 2016). Lepper (1988) specified several benefits of motivation such as increase in time spent on a task, invulnerability towards failure, search for detailed comprehension, risk taking, attempt to solve problems creatively, choice on difficult tasks, focus on deeper and efficient learning strategies, participation in an activity for their own interest and enjoyment. Motivation for learning mathematics is an important issue, because mathematics motivation decreases gradually after first few years of education (Rohrkemper and Bershon 1984; Nakamura 1988; Dossey *et al.*, 1988). According to hierarchical model in SDT (Ryan and Deci, 2002), there are three generality level of motivation, and mathematics motivation is a contextual level motivation. Mathematics lessons are the main context for developing mathematics motivation. Although there are top-down and bottom-up effects between generality levels of motivation, a contextual level social factor has the greatest effect on a contextual level motivation (Valerand and Ratelle, 2002). Therefore, mathematics motivation depends greatly on students' mathematics teachers. Inference about the effectiveness of teachers' interventions for students' mathematics motivation springs from hierarchical model. Thus, an instructional design promoting mathematics motivation and teachers' appropriate interventions for students' mathematics motivation can help students for maintaining their motivation (Wæge, 2009; William, 1993). However, determination of intervention type is not an easy task for teachers, because they need to predict students' current motivational regulations (Fennema and Peterson, 1984). Motivational regulations can be measured by the sources of motivation, therefore source of mathematics motivation must be identified to develop mathematics motivation. Although there are several studies on mathematics motivation, there are few studies on the source of students' mathematics motivation in consideration of types of motivation. Sources of mathematics motivations and their regression coeffi-

cients for predicting types of mathematics motivation may be beneficial for teachers. With the help of the explanations derived from the SDT in this study, mathematics teachers may use the regression coefficients to determine the type of interventions developing the students' mathematics motivation and experts can benefit from the regression coefficients for a new motivation integrated instructional design. Moreover, this study supports further validity of SDT on mathematics education.

This study considers SDT as a basis of the students' mathematics motivation. SDT proposes (Ryan and Deci, 2002) that; basic psychological needs (autonomy, competence, and relatedness) predict intrinsic and extrinsic mathematics motivation. There are some reviews mentioned (Wæge, 2009; Hannula 2006; Evans and Wedege, 2004), there is a limited number of empirical studies utilizing sources of mathematics motivation in SDT for students (Valas and Sovik, 1993; Durmaz, and Akkuş, 2016; Zhou textitet al., 2009). Therefore, current study can help to establish further validity of SDT on mathematics motivation.

BPNT which is a part of SDT asserts that, basic psychological needs are culture invariant (Ryan and Deci, 2002). That is to say, autonomy, competence and relatedness are important predictors of motivation for all cultures. In the literature, there are some studies about cultural invariance of self-determination theory including two or three nations, but none of these study is related to mathematics motivation (Hayamizu, 1997; Ryan and Cornell, 1989; Yamauchi and Tanaka, 1998; Chirkov, and Ryan, 2001; Deci *et al.*, 2001). There has already been an international study which uses the SDT for their mathematics motivation scales which is utilized in this study to test cultural invariance of basic psychological needs for mathematics. The name of the study is Program for International Student Assessment 2012 (PISA 2012). PISA 2012 supports a complete and cost free dataset of their studies. In addition, the data were collected from 65 countries (OECD, 2013). Wide variety of cultures in PISA 2012 enables to investigate cultural invariance of SDT. Determining the priority of the basic psychological needs for each nation helps to compare and contrast students' motivation in different nations. The way to find the answer may be applying the

data into the Structural Equation Modeling (SEM) because of complex theoretical structure of motivation. SEM provides a better way for empirical examination of SDT by involving both measurement and structural model in one analysis (Hair et al, 2010). In addition, SEM provides to measure invariance between two or more groups, therefore this study also tests the invariance of basic psychological needs in SDT to contribute literature with the help of SEM.

To sum up, there are two purposes of this study. The first purpose of this study is determining the regression coefficients between variables which are chosen from the PISA 2012 by using SEM. These variables are: autonomy, competence, relatedness, intrinsic, and extrinsic motivation. The second purpose of this study is testing cultural invariance of the structure of relationships for the variables in SDT among selected countries from PISA 2012 data. Therefore, this study is significant to establish further validity of SDT on mathematics education. Results of the analysis in this study can also be used for predicting students' mathematics motivation to take advantage of motivation related positive outcomes.

4. STATEMENT OF PROBLEMS

The main purpose of this study is to test predictions of self- determination theory (SDT) that explain the students' mathematics motivation by using related PISA 2012 scales. This study takes four sub theories of SDT into consideration to develop and test the model (Figure 4.1).

CET states (Deci, 1975) that, there are two cognitive processes to investigate the effects of contextual events on intrinsic motivation. These are perceived causality and perceived competence. Events which are responsible for a change in perceived causality are in a continuum of autonomy. They can either undermine or enhance intrinsic motivation depending on their degree of autonomy. An increase in the degree autonomy of the events results in an increase in intrinsic motivation. However, the effects of the events which prompt a change in perceived causality and perceived competence are only valid when one feels competent enough for the activity. Events changing perceived competence can also undermine or enhance intrinsic motivation. Although the need for autonomy and competence must be satisfied to be intrinsically motivated (Niemiec and Ryan, 2009), relatedness affects intrinsic motivation too. Studies have shown that, students who are ignored by unknown adults during an activity, show a low level of intrinsic motivation (Anderson *et al.*, 1976). Therefore CET theory states that, perceived causality (need for autonomy), perceived competence (need for competence), and relatedness are important psychological needs to enhance or undermine intrinsic motivation. While events satisfying basic psychological needs enhance intrinsic motivation, events preventing satisfaction of basic psychological needs undermine intrinsic motivation. Therefore, the model prepared for this study estimates positive regression coefficients between basic psychological needs and intrinsic motivation.

OIT (Deci and Ryan 1985b) clarifies the steps of internalization and levels of external motivation. Unlike other theories, SDT regards external motivation as a continuum with four different levels. These levels are differentiated by the degree of

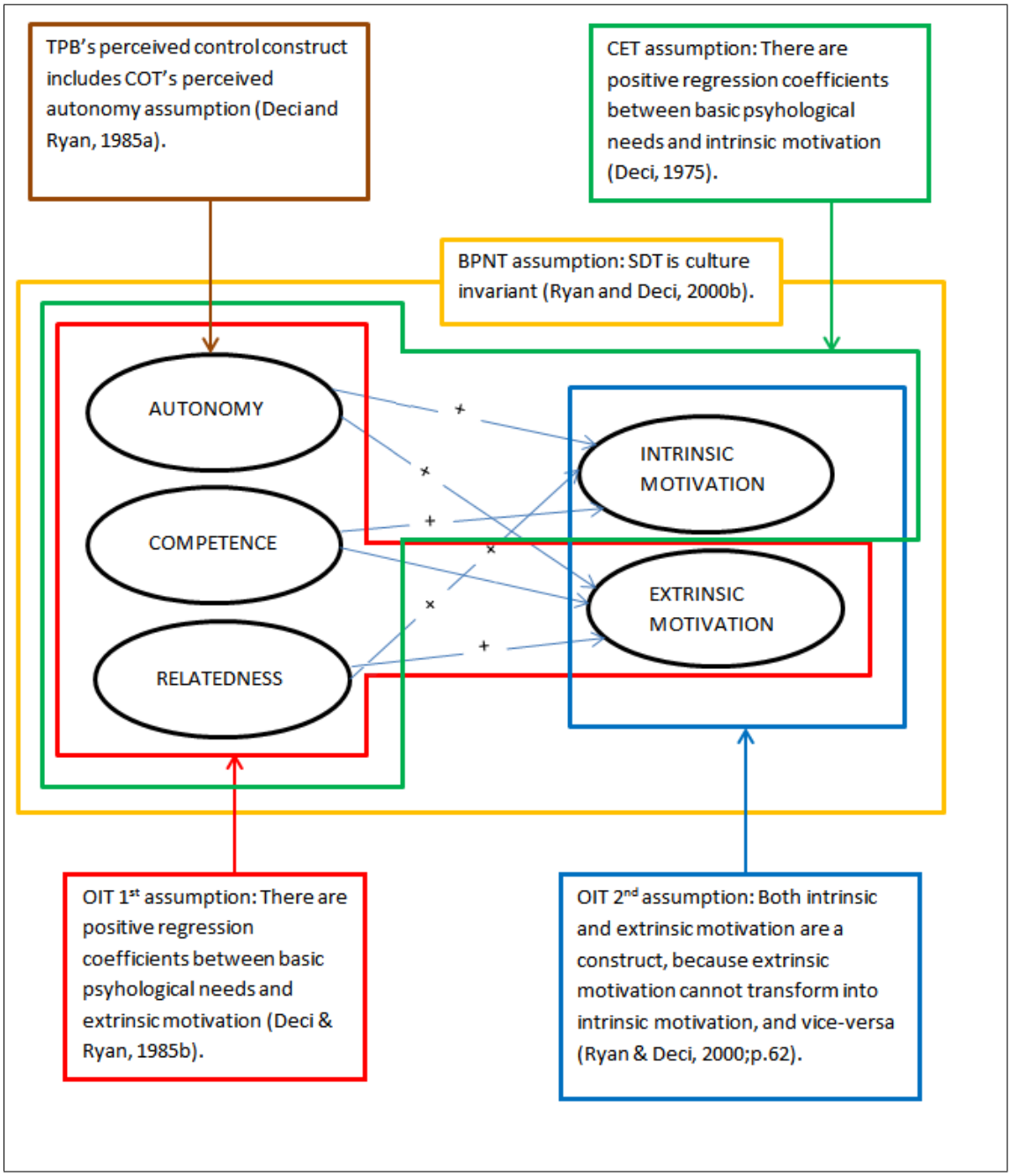

Figure 4.1. Model and assumptions of the sub theories

autonomy. Although levels of external motivation are decided by the degree of self-determined behavior (autonomy) (Sartawi *et al.*, 2012), competence and relatedness are also important in the internalization process of external motivation. Internalization process means the assimilation of external regulations into self. No matter how much they are internalized, they cannot be transformed into intrinsic motivation (Ryan and Deci, 2000, p.62), because they are still controlled externally. OIT (Deci and Ryan, 1985b) asserts that, whether intrinsic motivation is undermined or extrinsic motivation is internalized, they do not transform each other. Therefore, OIT (Deci and Ryan, 1985b) presents continuum for only external motivation. The model prepared for this study estimates positive regression coefficients between basic psychological needs and extrinsic motivation. Moreover, intrinsic and extrinsic motivation are taken into consideration as two different constructs, because of lack of transition between them.

COT (Deci and Ryan, 1985a) states that, personal differences have a significant determining role while people are behaving and experiencing an activity. According to COT (Deci and Ryan, 1985a), there are three types of motivational orientation (autonomy orientation, control orientation, and impersonal orientation) which are differentiated by the locus of causality. Personal differences affect the motivational orientations of people, because locus of causality changes with the personality and lifelong experiences. Locus of control can also be interpreted as the combination of perceived autonomy and perceived capacity in theory of planned behavior (Yzer, 2012; Ajzen, 2002; Fishbein and Ajzen, 2010). Perceived autonomy and perceived control are two different constructs with respect to SDT, because definition of perceive control in SDT is different than TPB. However, both of the theories explain perceive autonomy in a very similar way. Definition of perceived control in TPB is important because PISA 2012 measures autonomy under TPB. COT is utilized to create a link between these theories' definition of perceived autonomy. In this study, locus of control subscale of PISA 2012 is sorted by the help of COT in order to find out mathematics autonomy level of the students. Process of perceived autonomy items' selection is discussed more under the title of "4.1 Variables and Operational Definitions".

According to BPNT (Ryan and Deci, 2000), autonomy, competence and relatedness are basic psychological needs for an individual to be fully functioning. In addition, these needs are both culture and age invariant (Ryan and Deci, 2000). Chirkov (2012) states a contradiction about cultural invariance of BPNT. Eastern cultures are known as collectivist while western cultures are known as individualist, so people in eastern cultures give less importance to autonomy (Chirkov, 2012). However, there has already been a declaration about the confusion on cultural invariance of BPNT. Deci and Ryan (2008) assert that, although the needs can interchange the position in priority from a culture to another, they are still significant for all cultures. In addition, the methods for satisfying the needs may change across cultures. In the past PISA surveys, some of the motivation sub-scales (self-efficacy and self-concept scores) were not nationally invariant over mathematics learning outcomes (OECD, 2013, p.186). In PISA 2012, there is a new attempt to measure invariance of the mathematics self-concept, self-belongingness towards school, mathematics interest and instrumental motivation for mathematics (OECD, 2013, p.190). It is obvious that, except for perceived control for success in mathematics scores, the variables listed by OECD (2013) signs a need for a measurement invariance analysis of self-determination theory. Age invariance is not included in this study because of PISA's equal cognitive development policy therefore this study only uses BPNT's cultural invariance estimation.

To sum up, the goal of the study is determining students' mathematics motivation sources, and their weighted coefficients for the types of mathematics motivation with respect to SDT. Moreover, this study attempts to explain cultural invariance of the mathematics motivation's sources with respect to BPNT. For this purpose, PISA 2012 data were analyzed by structural equation model.

4.1. Variables and Operational Definitions

The variables analyzed in the study were perceived control for success in mathematics, mathematics self-concept, self-belongingness towards school, mathematics interest, and instrumental motivation for mathematics. According to OECD report

(2013), PISA 2012 motivation measurement depends on Self Determination Theory.

There is not a scale called as "autonomy" in PISA 2012 students' questionnaire. "Autonomy" is measured over items' scores of students' perceived control for success in mathematics in PISA 2012 students' questionnaire because PISA 2012 perceived control scale depends on Theory of Planned Behavior (OECD, 2013, p.185). TPB asserts that, there are two aspects of perceived control which are perceived capacity and perceived autonomy (Yzer, 2012; Ajzen, 2002; Fishbein and Ajzen, 2010). Perceived autonomy is defined by Yzer (2012, p.105) for TPB as:

> "Perceived autonomy is the degree to which people feel that behavioral performance is of their own volition. Autonomy items thus need to include a reference to control over behavioral performance (e.g., Whether or not I inject insulin twice a day is up to me)"

Initial analysis on perceived control scale of PISA 2012 shows that, this scale has at least two factors for six items measuring it (PC1= .655, PC2= .511, PC3 = -.002, PC4=. 040, PC5= .537, PC6= .301, and PC stems for perceived control). When highly loaded items are examined, they represent a great similarity with Yzer's statement (e.g., whether or not I do well in mathematics is completely up to me). Three out of six items are responsible for measuring the internal locus of control which can be differentiated by the structure of questions that includes reference to self. Thus, the questions referencing self are included in the model under the name of autonomy. Items measuring external (powerful others) locus of control and lack of (unknown) locus control has less than three questions. They are excluded from analysis because they lack sense of self (Yzer, 2012; Connell, 1985). Following example is to explain the selection process of autonomy items. Let us take these items that are "If I wanted to, I could do well in mathematics" and "If I had different teachers, I would try harder in mathematics" to tackle with measuring autonomy (OECD, 2013). A girl who is in agreement with the first statement represents an autonomous behavior. She is aware of that she has an option to choose on her own to take control over success. Moreover, she gives an equal chance to her choices; because she is also in agreement with that

she would be successful in mathematics. Therefore she does not consider the things that prevent her from success as an external factor. There can be two reasons for a girl in disagreement with the first statement. First, she may not believe that she has an option for herself to take control over success for learning mathematics. This situation can easily be considered as that she behaves non-autonomously because of lack of conviction on her choice. Second, she may believe that although she wanted to take control over success, she would fail in mathematics. According to Deci and Ryan (1985b, p.154), when one gives an equal chance to doing or avoiding an activity, she makes a true choice and this choice stems from an integrated sense of self. Then this situation means that she has a belief in a controlling factor (ie. intelligence) to become successful in mathematics. Therefore she does not give an equal chance to her choices for success in mathematics. Autonomy cannot be measured over the second statement that is "If I had different teachers, I would try harder in mathematics" because there is not a clue about students' integrated sense of self for perceived control over success in mathematics. Students who choose self and in what degree they choose self in items of perceived control scale in PISA 2012 is utilized to measure autonomy behavior of students in SDT. Therefore, items which were coded by this study as "PC1" for item "a","PC2" for item "b", and "PC5" for item "e" were chosen because they include reference to self. Items which do not include reference to self were excluded from the whole analysis.

In this study, "Competence" is defined as students' mathematics self-concept scores on PISA 2012 students' questionnaire. According to OECD (2013), mathematics self-concept construct were the students' response about their perceived competence in mathematics.

"Relatedness" is defined as students' self-belongingness towards school scores on PISA 2012 students' questionnaire, because sense of belongingness is synonym for relatedness. Sense belonging to school measure of PISA 2012 includes nine items. First six items of the sense of belonging to school measure were adapted from school engagement scale of PISA 2003. The last three items were added for the first time by

PISA 2012. The last three questions were deleted from the whole analysis because of three reasons. The first reason was that, these questions were not measure the sense of belonging to school construct. According to OECD report (2013,p.43):

> "In 2012, as in 2003, PISA asked students to report whether they "strongly agree", "agree", "disagree" or "strongly disagree" that they feel like an outsider or left out of things, that they make friends easily, that they feel like they belong, that they feel awkward and out of place, that other students seem to like them, or that they feel lonely. For the first time, PISA 2012 asked students to evaluate their happiness at, and satisfaction with, school and to reflect on whether their school environment approaches their idea of an ideal situation"

Therefore, these questions which are named by PISA as "g", "h" and "i" were intended to measure happiness and satisfaction. This study is only interested with sense of belonging to school, hence the last three questions were deleted from whole analysis. Second reason was that, there is a scale which is Satisfaction with Life Scale (SWLS) includes very similar questions with the last three questions deleted by this study (Diener *et al.*, 1985). This scale only assesses the satisfaction which is not a sub-domain for sense of belonging. Difference between the questions added by PISA 2012 to sense of belonging to school measure and questions of SWLS is the replacement of the words "my school" and "my life". Especially, these two questions of SWLS can be named as synonyms for the PISA questions, which are "The conditions of my life are excellent" and "I am satisfied with my life". The last reason was that, Principle Component Analysis were conducted by this study in order to investigate the factor structure and item loads of the sense of belonging construct. Results showed that, two factor model is the most preferable model for explaining the variance in the sense of belonging measure with the nine items assessed by PISA 2012. Moreover, there is a clear separation between first six items and last three items of PISA 2012 sense of belonging to school measure. The last three questions' items loads for the second factor are respectively ".169", "0" and "0". All of the first six questions' item loads for first factor are smaller than ".30". Furthermore, Cronbach's alpha reliability score of sense of belonging to school measure is the worst score among all scales in PISA 2012. The problem behind low reliability of the sense of belonging to school scale may

be the last three questions which are irrelevant with sense of belonging construct.

"Intrinsic motivation" is defined as students' mathematics interest scores on PISA 2012 students' questionnaire, because OECD states (2013) that intrinsic motivation index constructed in four questions which is named as mathematics interest.

"Extrinsic motivation" is defined as students' instrumental motivation for mathematics scores on PISA 2012 students' questionnaire.

4.2. Research Questions

The research focuses on four main questions. These questions basically look for predictions of Self Determination Theory. According to SDT, there are three psychological needs which predict the intrinsic and extrinsic motivation. In the light of the information about SDT, the research questions are;

- Do the PISA 2012 data fit the self determination model explaining relationship between the latent variables: mathematics intrinsic motivation, mathematics extrinsic motivation, mathematics autonomy, mathematics competence and relatedness towards school?
- Is the structure of relationships predicted among the latent variables: mathematics autonomy, relatedness towards school, mathematics competence, mathematics intrinsic, and mathematics extrinsic motivation simultaneously conserved for Finland, Japan, Lithuania, Russia, Thailand, Spain, Great Britain, Turkey, and Brazil?

4.3. Null Hypothesis

- PISA 2012 data do not significantly fit the self determination model explaining relationship between the latent variables: mathematics intrinsic motivation, mathematics extrinsic motivation, mathematics autonomy, mathematics com-

petence and relatedness towards school?

- The structure of relationships predicted among the latent variables: mathematics autonomy, relatedness towards school, mathematics competence, mathematics intrinsic, and mathematics extrinsic motivation is not simultaneously conserved for Finland, Japan, Lithuania, Russia, Thailand, Spain, Great Britain, Turkey, and Brazil?

5. METHODS

5.1. Participants

In this study, there were two sets of analyses. For the first set of analysis (total group analysis), this study included 65 countries with 31 OECD and 34 non-OECD member countries. The number of participating students from 65 countries was 512.363 with over 95% participation rate. 512.363 were chosen to represent 21.591.068 students (target population). After 5% exclusion rate, there were 485.490 total participating students with 245.064 (50,5%) female, 240.426 (49,5%) male (OECD, 2014) (Appendix A) for the number of participating students for each country). For the second set of analysis (cultural invariance analysis), the current study included nine countries with 5 OECD countries and 4 non-OECD countries. There were 93659 total participants with 47567 (50,8%) female, and 46092 (49,2%) male. Students, who were aged between 15 years and 3 months, and 16 years and 2 months, were selected (OECD, 2014). The major challenge of PISA 2012 team was to guarantee international comparability of national target population. Students who are in the same grade level in different countries, can differ in age because of their nation's educational policies. Therefore they may have different cognitive development level. To ensure comparability of nations, PISA 2012 team used the age-based sampling. Regardless of being full-time or part-time, all educational institutions named as schools in PISA 2012 although some of them even did not have semesters. Students who are not legally registered to a school, were not included in target population. PISA 2012 also includes resident attending schools in a foreign country. These schools were placed in the target population of the school's original country.

5.1.1. Sampling Techniques of PISA 2012

Choosing schools that can have 15 years old students was the first part of the sampling. Then, two-stage stratified sampling is mostly used among countries. Ex-

plicit and implicit stratification sampling was used by PISA 2012. Explicit stratification sampling includes various school sampling frames. For example, region or state based stratification for a country is an explicit sampling. Implicit stratification sampling consists of unique selection of each school in explicit stratification. For example, the variables for implicit stratification could be minority composition of schools, type of schools, and degree of urbanization. There are 38 explicit strata which includes 12 region and 4 school program types for Turkey in PISA 2012. Each region has more than one program type. Implicit strata includes 18 school types, 3 gender composition types, 2 urbanization types and 2 funding types. Probability proportional to size sampling was used for determination of the schools from strata. Probability proportional to size sampling starts with a calculation which is the number of schools in the data pool over number of schools PISA 2012 needs. The proportion is multiplied by a random number which determines the identity number in the data pool for the first school. Then by adding the proportion, identity numbers of the other schools were calculated. Then, rest of identity number of schools were calculated by summation of the proportion and identity number of the last selected school. Most of the countries chose their own eligible sample schools, and report the list of 15 years old students to the PISA consortium. 35 students for each school were chosen from the list for survey. A student who participate in the original and follow up study was determined as a participant.

PISA 2012 team permitted countries to exclude 5% of the target population because of several reasons. For example, geographical accessibility of schools, language proficiency of students, and functional or intellectual disabilities of students were some of these reasons. Overestimation of scores was an issue because of these exclusions. PISA 2012 team fixed the problem by dropping 0.5 point for each 1% exclusion (OECD, 2014).

5.2. Instrument

PISA 2012 assesses the five domains of education which are mathematics, reading, science, finance, and problem solving literacies. PISA uses the term literacy to cover broader concepts of knowledge and skills, and students' active cognitive processes (OECD, 2013). The main assessment includes mathematics, science and reading literacies questions. Problem solving and financial literacies are optional for countries, because of technical issues. PISA 2012 team also prepares a questionnaire for students' background to obtain information about their nations' educational systems, and to investigate the reason behind success. The name of the survey is student, school and parent context questionnaire. The questionnaire consists of 3 parts: the school questionnaire, the student questionnaire, and the parent questionnaire. There are also two additional questionnaires about students' background, which are educational career questionnaire for students and student's access to information and communication technologies questionnaire (OECD, 2013).

All variables in the study are chosen from the student questionnaire. This questionnaire has seven sub-domains (OECD, 2013).

- Students' characteristics and educational career
- Family context and home resources
- Learning mathematics
- Experience with different kinds of mathematics problem at school
- Mathematic experiences
- Classroom and school climate
- Problem solving experiences

Five measures are selected for the present study. Four of them are chosen from the learning mathematics sub-domain of the student questionnaire. One of the variables is chosen from classroom and school climate sub-domain of the student questionnaire. Namely these variables are: mathematics interest, instrumental motivation for

mathematics, mathematics self-concept, perceived control of success in mathematics, sense of belonging to school (OECD, 2013). There are also three variables which are used for descriptive purposes. Those are students' identity number, students' nations, and students' gender. All of these five measures include four points Likert type scales. The points for perceived control for success in mathematics, mathematics self-concept, sense of belonging to school, mathematics interest, and instrumental motivation for mathematics are "Strongly agree", "Agree", "Disagree", and "Strongly disagree". In the coding process, PISA scores "1"for "Strongly agree", "2" for "Agree", "3" for "Disagree", "4" for "Strongly disagree". This study uses reverse coding procedure of PISA 2012, therefore an increase in the score means increase in the construct measured. Table 5.1 shows the variables' name in the current study, definitions of variables on PISA 2012, and number of items measuring each variable (OECD, 2013). Items measuring each variable were shown in Table 5.2,Table 5.3, Table 5.4, Table 5.5, and Table 5.6.

Table 5.1. Definitions of variables in PISA 2012

	Variables	**Number of Items Included in This Study**	**Definitions on PISA 2012 Students' Questionnaire**	**Number of Items in PISA 2012**
Types of Motivation	Extrinsic Motivation	4	Instrumental Motivation for Mathematics	4
	Intrinsic Motivation	4	Mathematics Interest	4
Basic Needs of Motivation	Autonomy	3	Students' Perceived Control	6
	Competence	5	Students' Self-Concept	5
	Relatedness	6	Students' Self-Belonging	9

Table 5.2. Intrinsic motivation

	Items	**Item ID**	**Coding**
a)	I enjoy reading about mathematics.	ST29Q01	Normal
b)	I look forward to my mathematics lesson.	ST29Q03	Normal
c)	I do mathematics because I enjoy it.	ST29Q04	Normal
d)	I am interested in the things I learn in mathematics.	ST29Q06	Normal

Table 5.3. Extrinsic motivation

	Items	**Item ID**	**Coding**
a)	Making an effort in mathematics is worth it because it will help me in the work that I want to do later on.	ST29Q01	Normal
b)	Learning mathematics is worthwhile for me because it will improve my career <prospects, chances >*	ST29Q05	Normal
c)	Mathematics is an important subject for me because I need it for what I want to study later on.	ST29Q07	Normal
d)	I will learn many things in mathematics that will help me get a job	ST29Q06	Normal

*is adapted to the national context by the participating country.

The questions have been developed by an international committee of educational research institutions contracted by OECD. Several small scale pilots, a field trial with 1000 students, and several commentary meetings with emissary of all countries have been administered. Technical quality of survey, cultural appropriateness, and interest level of 15 years old students are the most important criteria for selecting the sets of materials (OECD, 2013). OECD (2013) reports the each scales reliability coefficients, except for mathematics perceived control for success. Cronbach's alpha scores of the

scales are shown in the Figure 5.7.

Table 5.4. Competence

	Items	**Item ID**	**Coding**
a)	I am not just good at mathematics.	ST42Q02	Reverse
b)	I get good <grades>* in mathematics.	ST42Q04	Normal
c)	I learn mathematics quickly.	ST42Q06	Normal
d)	I have always believed that mathematics is one of my best subjects.	ST42Q07	Normal
e)	In my mathematics class, I understand even the most difficult	ST42Q09	Normal

*is adapted to the national context by the participating country

Table 5.5. Autonomy

	Items	**Item ID**	**Coding**
a)*	If I put enough effort I can success in mathematics.	ST43Q01	Normal
b)*	Whether or not I do well in mathematics is completely up to me.	ST43Q02	Normal
c)	Family demands or other problems prevent me from putting a lot of time into my mathematics work.	ST43Q03	Reverse
d)	If I had different teachers, I would try harder in mathematics.	ST43Q04	Reverse
e)*	If I wanted to, I could do well in mathematics.	ST43Q05	Normal
f)	I do badly in mathematics whether or not I study for my exams.	ST43Q06	Reverse

* shows autonomy measuring items and c,d,f are excluded

Table 5.6. Relatedness

	Items	**Item ID**	**Coding**
a)	I feel like an outsider (or left out of things) at school.	ST87Q01	Reverse
b)	I make friends easily at school.	ST87Q02	Normal
c)	I feel like I belong at school.	ST87Q03	Normal
d)	I feel awkward and out of place in my school.	ST87Q04	Reverse
e)	Other students seem to like me.	ST87Q05	Normal
f)	I feel lonely at school.	ST87Q06	Reverse
g)	I feel happy at school.	ST87Q07	Normal
h)	Things are ideal in my school.	ST87Q08	Normal
i)	I am satisfied with my school.	ST87Q09	Normal

Table 5.7. Reliability of variables

	OECD	**NON-OECD**
Intrinsic Motivation	.89	.88
Extrinsic Motivation	.89	.87
Autonomy	.98*	.98*
Competence	.89	.83
Relatedness	.40	.53

* is calculated by this study

5.3. Data Collection

In sampling section great details about sample and sampling method has been discussed. Pisa data collection starts with determining the roles of personnel. School selection is made by an international contractor, but in some cases PISA consortium determines the schools for certain nations because of fairness. The cases which are

chosen by PISA team, determined from past PISA experiences. International contractor sends the list of sample school to National centers. School administers send the list of eligible students to the National centers. National Project Managers uses a computer program to choose students (OECD, 2014).

PISA uses the rotated design for booklets to implement the survey. This design allows increase in content coverage without extending the allocated time. There are three rotated forms. All includes the same demographic questions for all students and a rotated part. Multi-level item response model were applied to check test continuity of survey because of fragmentation. Despite the difficulties in logistic, cost and assignment process of rotated forms, the survey was applied with great success. Each booklet has two of the three rotated forms. The design of the booklets is shown in Table 5.8 (OECD, 2014).

Table 5.8. Booklets

Clusters	**From A**	**Form B**	**Form C**
Question sets	Demographic part (8 minutes)		
	Q1 (11 minutes)	Q3 (11 minutes)	Q2 (11 minutes)
	Q2 (11 minutes)	Q1 (11 minutes)	Q3 (11 minutes)

There are certain criteria for the rotation of questions. Items for a construct don't split, and these questions placed in the same set. The sets have the same quantity in completion time, words, and the performance correlation with constructs. Performance correlation with constructs is measured from field trials. First question set (Q1) includes attitudes towards mathematics and problem solving situational judgments. Second question set (Q2) consists of questions related to school climate, attitudes towards school and mathematics anxiety. Third question set (Q3) contains questions about the opportunities to learn and learning strategies (OECD, 2014).

Source version of all booklets in two languages (French and English) was given to National Project Managers (NPM). The test items and units are sent to NPM be-

fore the implementation day with sufficiently enough time for translation. NPMs are instructed about the assembling translation and social adaptation process of booklets. The translated materials designed in the same way with the source copy with respect to layout. NPMs submit the translated material and a form including national adaptations to get feedback from international contractor. Then, NPMs edit the document and submit it for the second time for verification of the material. International contractor designs the arrangements of the booklets by clusters. Then the materials are packed and shipped to the test administrator or school (OECD, 2014).

The students' questionnaire was applied to students after reading assessment, and it takes 35 minutes to complete. Determining the completion time for students' questionnaire depends on experiences gained from the past PISA assessments. Time plan of the whole implementation of the survey is shown in the Table 6.9 (OECD, 2014).

Table 5.9. Timeline of implementation

Activity	**Time**
Distributing the materials and reading the general directions	10-15 minutes
The test booklet	1 hour
Break 1	<5 minutes
The test booklet	1 hour
Break 2	15 minutes
The students questionnaire	35 minutes
Collecting the materials and ending the session	5 minutes
Total	3 hours 15 minutes

After the implementation period, the test administrator directly sends small pieces of data to the system for the security of data while transporting. When all booklets arrive at the National Center, coding process starts. In the students ques-

tionnaire there is no need for coding process because it is multiple choice response item. A questionnaire form and tracking form are used to collect the data hence the data is directly entered to a computer program which does not allow interventions on the data later on. The quality of data is under the responsibility of NPMs. The quality of data is checked by the program too. Before the data is sent to the international contractors, sampled school and session reports must be submitted to the program. Data cleaning report and procedure, and data quality report must be supplied with submission of data (OECD, 2014).

5.4. Data Analysis

5.4.1. Dataset

In this study, PISA 2012 data released by OECD were used. Data were directly taken from PISA's official website. PISA serves the full and cost free data. Missing values must be considered carefully for the health of covariance matrix created by the structural equation model. There are three different main methods to handle missing variables (Honaker *et al.*, 2015). First method is pairwise deletions, in which the variable of the participants is deleted if any of the variable's item is missing. Second method is list wise deletion, which deletes the whole data collected from the participants with any missing items. Third method is data imputation. Compared to list wise deletion method, data imputation reduces biases and increases efficiency (Honaker *et al.*, 2015). Moreover, data imputation protects the selected demographic information's mean scores among its groups (Honaker *et al.*, 2015). According to Gelman and Hill (2006), the model using data imputation is only as good as the initial model. It means that data imputation does not harm or contribute to the structural equation model. Data imputation was chosen from these alternatives in this study, and it is applied to Amelia II (Honaker *et al.*, 2015) package developed in R program. Amelia II generates values with the help of a complex algorithm. In this study, nations of participants were used in algorithm to predict trends in data and generate values for missing ones. Both ordinal and nominal variables were entered the

function. Data imputation and standardization of the data were applied respectively with the help of a statistical tool, R-studio. Data are analyzed by the same statistical tool too.

5.4.2. Structural Equation Model

In literature, SDT is generally analyzed with SEM, (Deci *et al.*, 2001; Barbeu *et al.*, 2009; Jang *et al.*, 2009; Ciani *et al.*, 2011; Ntoumanis *et al.*, 2012) because SDT has a complex structure to analyze with other statistical methods. SEM is able to analyze more advanced theoretical models with the help of measuring interactions among variables (Schumacker, and Lomax, 2004) so it is essential to analyze multiple relationships at a single point. Other techniques can analyze multiple dependent variables or/and multiple independent variables, but all have the limitation of analyzing only a single relationship in a single point. SEM can investigate several dependence relationships simultaneously, therefore SEM is beneficial in theory testing. In a theory, while a variable is a dependent variable for some constructs, it could be an independent variable for others. Except for SEM, other techniques cannot assess these relationships in one technique (Hair *et al.*, 2014). Moreover, SEM involves also greater recognition of validity and reliability of observed scores (Schumacker and Lomax, 2004). That is to say, structural equation model is fruitful method, if there are enough participants. To conduct a SEM analysis, the sample size of the study is an important issue. Estimating the latent variables needs large sample sizes (Kline, 2011), and more than 200 sample is considered as a large sample (Hair *et al.*, 2014).

In this study, relationships between variables were investigated with the help of SEM analysis. SEM gives certain names to variables to specify the variables' position in the model. First, measured variables are the data collected from various data collection methods. Latent (unobserved) variables are estimated (Klein, 2011) with the help of consistency of measured variables. Decrease in the number of measured constructs reduces the measurement error and improves the statistical estimation. Because it reduces the measurement error; instead of measuring directly, using la-

tent variables are beneficial. Exogenous and endogenous variables are respectively considered as independent and dependent variables (Klein, 2011). Several types of relationships can be listed in SEM. These relationships are; a construct and a measured variable relationship, a construct and multiple measured variable relationships, dependence relationship between two constructs and correlational relationship between constructs. These relationships, variables and constructs are shown in a single visual model (Figure 5.1). In this figure small rectangular boxes are measured variables. Circular boxes are latent variables (constructs). Single headed arrows are dependence relationship. Multi headed arrow is correlational relationship (Hair *et al.*, 2014).

There were two sets of analyses in order to test the predictions of SDT, which were conducted on variables in PISA 2012 students' questionnaire data. First sets of analyses were transformed into SEM. Then, SEM analysis was conducted with roboust maximum likelihood estimator with the help of "lavaan.survey" package in R (Oberski, 2014), which is the corrected version of lavaan package (Rosseel, 2012). In this study, sample stratified in two stages were used, hence students in the sample do not have equal chances to be selected. Two-stage stratification method is a kind of proportionality sampling. Oberski (2014) suggests that, all kinds of SEM analysis on complex survey designs should be done by lavaan.survey package. Therefore, this study uses standardized students' weight with lavaan.survey package in order to supply unbiased estimates of the parameters (Oberski, 2014). SEM is composed of two models that are structural and measurement model. Both models are multivariate techniques. Measurement model includes factor analysis of variables and structural model consists of multiple regression analysis.

5.4.2.1. Measurement Model. Generally in SEM, variables and their relationships with each other are derived from theories, instead of using explanatory factor analysis. Then, measurement model helps to show how much the model fits the data. Initially, all participants from all nations in PISA 2012 dataset were included to measure that, how much the prediction of SDT fits the variables' data in PISA 2012

students' questionnaire. For this reason, the appropriateness of model was assessed by confirmatory factor analysis (measurement model). In order to measure the appropriateness, dependence relationships were removed and correlational relationships were placed between all variables (Hair *et al.*, 2014). Confirmatory factor analysis generates fit indices to measure appropriateness which is calculated by the relationships between the correspondences of observed matrix and estimated covariance matrix. This study used two kinds of goodness-of-fit indices and two kinds of badness-of-fit indices for measurement and structural models. The goodness-of-fit indices were TLI (Tucker-Lewis index) and CFI (comparative fit index). The badness-of-fit indices were RMSEA (Root Mean Square Error or Approximation) and SRMR (standardized root mean square residual). Significant cut-off values of the indices are; SRMR<.08, RMSEA<.06, CFI>.95, TLI>.95 (Brown, 2006). The study did not consider the chi-square value, because chi-square value is sample size dependent. The current study has a massive sample size (485.000) that changes chi-square dramatically (Brown, 2006). Therefore, measurement model derived from the predictions of self-determination theory is shown in the Figure 5.1. In this study, abbreviations used in this study are "AU" for autonomy, "SC" for competence, "SB" for relatedness, "IM" for intrinsic motivation, "EX" for extrinsic motivation.

5.4.2.2. Structural Model. After measurement model was conducted, structural model was applied to the same dataset. Structural model represents series of different but interdependent multiple regression equations (Hair *et al.*, 2014). The results of the structural model give the regression coefficients between endogenous and exogenous variables. While creating structural model, dependence relationships between the variables were placed. The structural model of the current study is represented in Figure 5.2.

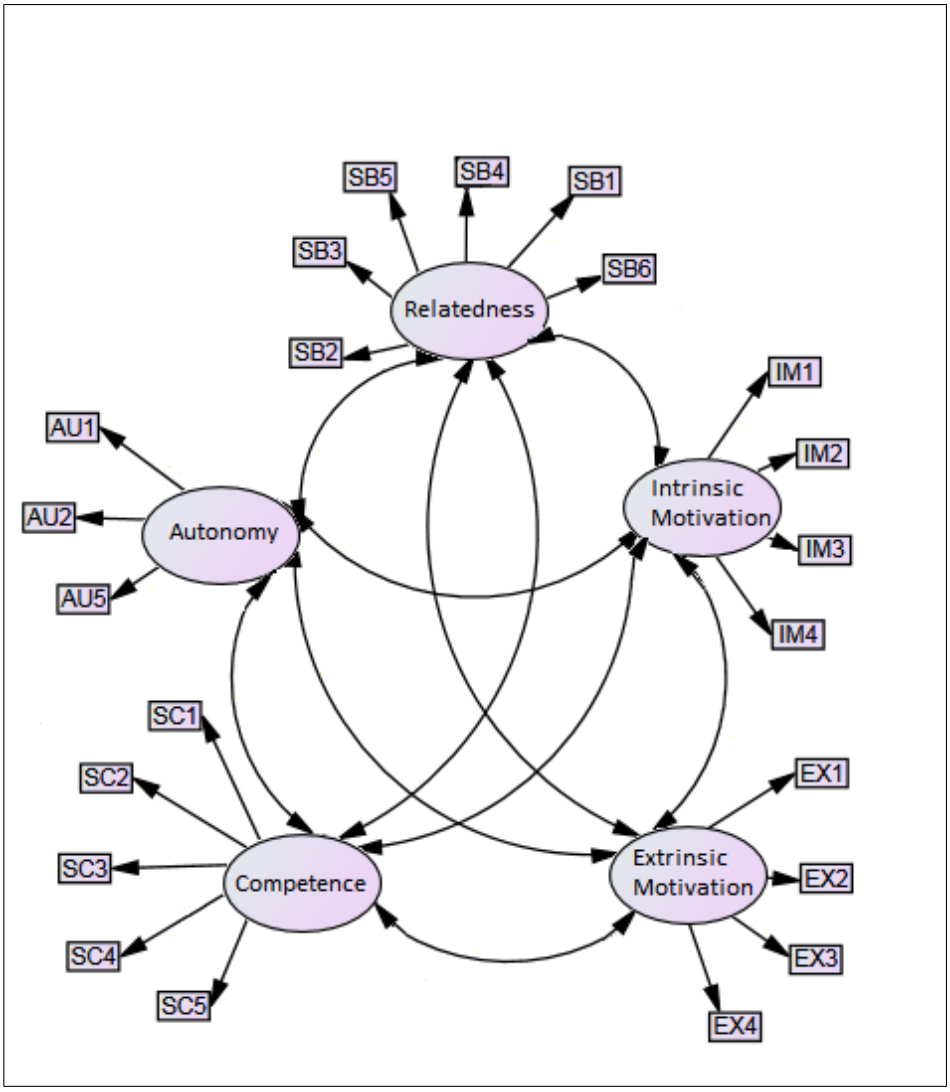

Figure 5.1. CFA model

5.4.3. Cultural Invariance Analysis

In the second set of analysis, invariant analysis was used for comparing structure of the relationships (significance of the variables' relationships and direction of the relationships between the variables). In this study, cultural invariance is compared to regression coefficients of nations in certain cultures. Nine countries were selected to measure cultural invariance in basic psychological needs. These countries were Finland, Japan, Lithuania, Russia, Thailand, Spain, Great Britain, Turkey, and Brazil. The reason of choosing these specific countries is that each individual country has the

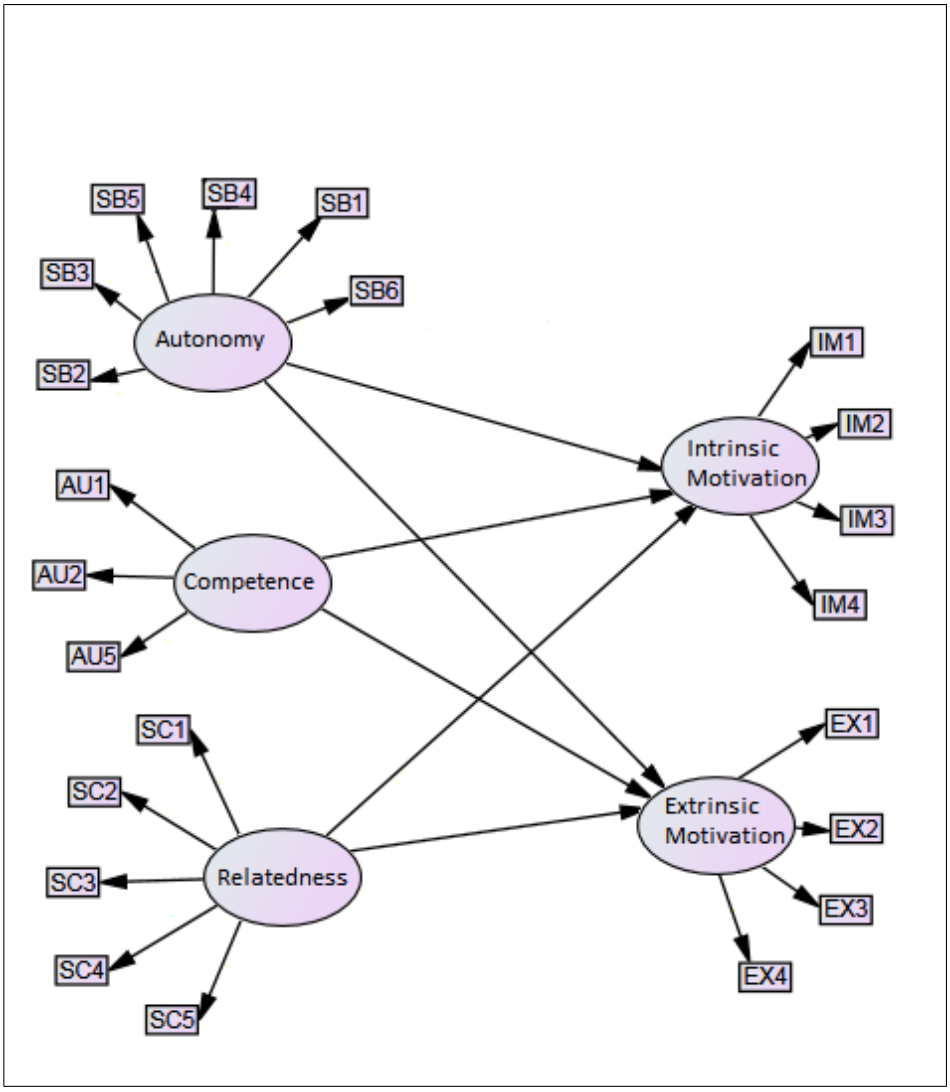

Figure 5.2. SEM model

best representative power for their culture (WVS, 2015). Before starting the cultural invariance analysis, this study investigates whether the model fits for each country separately (Kline, 2011).

There are four models for measuring invariance in this study. These four models can be collected under two sections. The first section which is Multi Group Confirmatory Factor Analysis (MG-CFA) includes configural and weak invariance models. Configural and weak invariance models are the nested models applied under confirmatory factor analysis (CFA). When there is no constraint on the values of CFA,

the model is called as configural model (Kline, 2011). This model is a prerequisite model in order to test any invariance. It also gives an idea about the structures of the factors. A well fitted configural model means that the numbers and structure of observed items measuring the factors are invariant across cultures (Gunnell, *et al.*, 2012). Secondly, weak invariance model means that items' factor loadings are constrained to be equal across groups. The difference between fit indices of configural and weak invariance model were measured in order to test weak invariance model (Cheung and Rensvold, 2002). Not exceeding the critical values of the difference in fit indices between these models means that configural and weak invariance model is equivalent and weak invariance model was supported (Kline, 2011). Difference in CFI value is generally used for comparison of the nested models, when chi-square difference test is inadequate (Kline, 2011). Chi-square measurement strongly depends on sample size (Kline, 2011) therefore chi-square difference test was ignored in this study. When the ΔCFI values between weak and configural model exceeds the critical value (ΔCFI $<0.01^{**}$, ΔTFI$<0.01^{**}$, ΔRMSEA$<0.015^{**}$, ΔSRMR$<0.03^{**}$), the null hypothesis is failed to reject (Cheung and Rensvold, 2002).Thus, the variables are not invariant across cultures. Moreover, weak invariance model supports a strong evidence for comparing different cultures' structural relationships which is between factors (Gunnell, *et al.*, 2012). However, this model does not ensure that, the mean scores of the factors become comparable. The current study assumes that the measured groups are equivalent with respect to structure of the relationships. Although there are more steps in MG-CFA, this study does not include rest of the analysis because of BPNT assumption that the mean scores of the factors in the model can be differentiated among cultures. Therefore, analysis in the MG-CFA is enough to pass Multi Group Structural Equation Model (MG-SEM) analysis.

MG-SEM analysis includes two models. These are called as model 3 and model 4. These nested models are tested by the difference of the fit indices just like between configural and weak invariance model (Cheung *et al.*, 2006). Model 3 is a model that has the same constraints with weak invariance model however correlational relationships in weak invariance model are replaced with structural relationships determined

by SDT for model 3. Model 3 is supported when the difference of fit indices between weak invariance and model 3 does not exceed the same critical values used in configural and weak invariance model (Cheung *et al.*, 2006). Supporting model 3 gives the path coefficients of weak invariance model. Model 4 differs from model 3 with an additional constraints on path coefficients to be equal across the groups for checking the invariance of them. It is also tested in the same way which looks for the difference in the fit indices. To support model 4, the difference between model 4 and model 3 is regarded by the same critical values used in configural and weak invariance model (Cheung *et al.*, 2006). Supporting model 4 means that path coefficients are invariant across cultures.

6. RESULTS

In this study, there are two kinds of analysis which are named as total group and cultural invariance analyses.

6.1. Total Group Analysis

In order to analyze total group, SEM analysis which composes measurement and structural models was used. Both of the analyses were assessed on total sample size of PISA 2012.

6.1.1. Results of Measurement Model in Total Group Analysis

6.1.1.1. Initial Analysis. This model is applied in order to detect the measurement deficiencies, therefore all variables are included except for "AU3","AU4","AU6" ,"SB7", "SB8", "SB9" because of theoretical reasons. CFA with mathematics autonomy, mathematics competence, relatedness to school, mathematics intrinsic motivation, and mathematics extrinsic motivation fit the total sample data acceptably (χ^2 (265, N= 485490)=55.074,409, CFI=.902, TLI=.889, RMSEA=.021 (90% CI= .021-.022), SRMR =.047), however there are some problematic items in relatedness to school scale.OECD (2013) has already stated that, reliability of items' scores for relatedness to school is low. Initial CFA for total group analysis shows the problematic items which are coded as "SB1", "SB4" and "SB6" in this study.

According to Hair et al. (2014), these items can be excluded from whole analysis, because items with lower than .5 factor load are candidates for deletion, however, the great majority of the papers in the literature suggest to investigate problem in wording of the questions (Brown, 2006; Byrne, 1993; Byrne, 2010). According to Byrne (2010, p.202) and Brown (2006, p.157), items which are reversely worded or similarly worded, can create problems in the case of confirmatory factor analysis of

a latent variable in a likert type scale. Because reverse-worded and similarly worded items can be close to the meaning of an other item, the variance of this kinds of items are explained by a common external cause which is not the latent factor. Correlated errors must be accounted when there is problem with reverse-worded and similarly worded items. Checking modification indices and EPC (expected parameter change) values are generally used for attainment of the correlated observed items (Brown, 2006, p.157). Therefore, three correlations were placed between "SB1","SB4" and "SB6" and because they have relatively large value of EPC and modification indices. The rest of the modification indices are ranged from 15946 to 235 and the rest of the EPC values are ranged from .157 to 0. The important modification indices and standardized EPC values are given in the Table 6.1.

Table 6.1. Modification indices and expected parameter change values

Name of the Items Correlated	**Modification Indices**	**SEPC**
SB1 and SB4	55950	.300
SB4 and SB6	61193	.312
SB1 and SB6	68061	.330

Brown (2006) shows an evidence with regard to EPC values and significance of the χ^2 difference test between initial (correlations are freed) and latter (correlations are set) models. Firstly, items needed correlation modification more than others are evidenced by the standardized EPC values with respect to suggestion given by Brown (2006, p.161). However,χ^2 test has a vulnerable test when confirmatory factor analysis included large sample size. Therefore, scaled χ^2 difference test with improved approximation for social sciences and large samples were used (Satorra and Bentler, 2001). However, the scaled χ^2 difference test could not be conducted on robust models' results of lavaan.survey package because anova function developed by R were set to use lavaan results. Therefore, lavaan results was used in order to apply the difference test. The scaled χ^2 difference test results were shown in the Table 6.2.

Table 6.2. Scaled χ^2 Difference Test

Items Correlation in Models	χ^2	**df**	$\Delta\chi^2$	**Δdf**	**Significance**	**Compared Models**
a)no correlation	328497	265				
b)SB1 and SB4	268957	264	3213	1	p<.001	a and b
c)SB1 and SB4 SB4 and SB6	230879	263	3714	1	p<.001	b and c
d)SB1 and SB4 SB4 and SB6 SB1 and SB6	150815	262	7398	1	p<.001	c and d

Futhermore, difference in fit indices of the robust models derived by Lavaan.survey package in R were shown in the Table 6.3.

Table 6.3. Difference in fit indices of the robust models

Items Correlation in Models	**ΔCFI**	**ΔTLI**	**ΔRSMEA**	**ΔSRMR**	**Compared Models**
a)no correlation					
b)SB1 and SB4	.017	.019	.002	.004	a and b
c)SB1 and SB4 SB4 and SB6	.012	.013	.002	.003	b and c
d)SB1 and SB4 SB4 and SB6 SB1 and SB6	.023	.027	.003	.007	c and d

Moreover, Brown (2006) and Byrne (2010) suggest to look for the similarity in the meanings of items.Therefore an evidence for the similarity of the questions are supplied in the Table 6.4.

Table 6.4. Questions of correlated items

Items	**Questions**	**Name of the Correlated Items**
SB1)	I feel like an outsider (or left out of things) at school.	SB4 and SB6
SB4)	I feel awkward and out of place in my school.	SB1 and SB6
SB6)	I feel lonely at school.	SB1 and SB4

Therefore, three correlations were added between the questions of "SB1","SB4" and "SB6" , because they are reverse-worded items. Moreover, there are several words which are very similar in the meanings ("lonely","out of place", and "outsider") or same.Therfore, Item loads of "SB1","SB4" and "SB6" decreased when the correlational relationships were added to the model (Table 6.5). Furthermore, questions which have such close meanings can lose their original meanings in period of translation for cultural adaptation.

6.1.1.2. Measurement Model. After addition of correlations between "SB1", "SB4" and "SB6", CFA is applied to the model in order to test measurement model. CFA based on Figure 6.1 fit the total sample data well (χ^2 (196, N=485490) =14.019,034, CFI=.972, TLI=.967, RMSEA=.012 (90% CI=012-.012), SRMR=.028). CFA model is shown in Figure 6.1. All paths in the Figure 6.1 are statistically significant (p<.001). Table 6.6 shows the unstandardized covariances and their standardized errors.

6.1.2. Results of the Structural Model in the Total Group Analysis

SEM is applied to the data in order to test the structural model. SEM based on Figure 6.2 fit the data well (χ^2 (196, N=485490)=14.019,030, CFI=.972, TLI=.967, RMSEA=.012 (90% C.I.=.012-.012), SRMR=.028). SEM is shown in the Figure 6.2. Except for self-belonging to school and intrinsic motivation (β=.003, p=.46), all paths are statistically significant (p<.001). Unstandardized and standardized path

Table 6.5. Standardized item loads of total group's initial model

		ITEM LOADS
Autonomy	**AU1**	.670
	AU2	.527
	AU3	.546
Competence	**SC1**	.569
	SC2	.645
	SC3	.716
	SC4	.737
	SC5	.648
Relatedness	**SB1**	.327
	SB2	.587
	SB3	.568
	SB4	.319
	SB5	.500
	SB6	.351
Intrinsic Motivation	**IM1**	.675
	IM2	.729
	IM3	.774
	IM4	.730
Extrinsic Motivation	**EX1**	.715
	EX2	.721
	EX3	.738
	EX4	.707

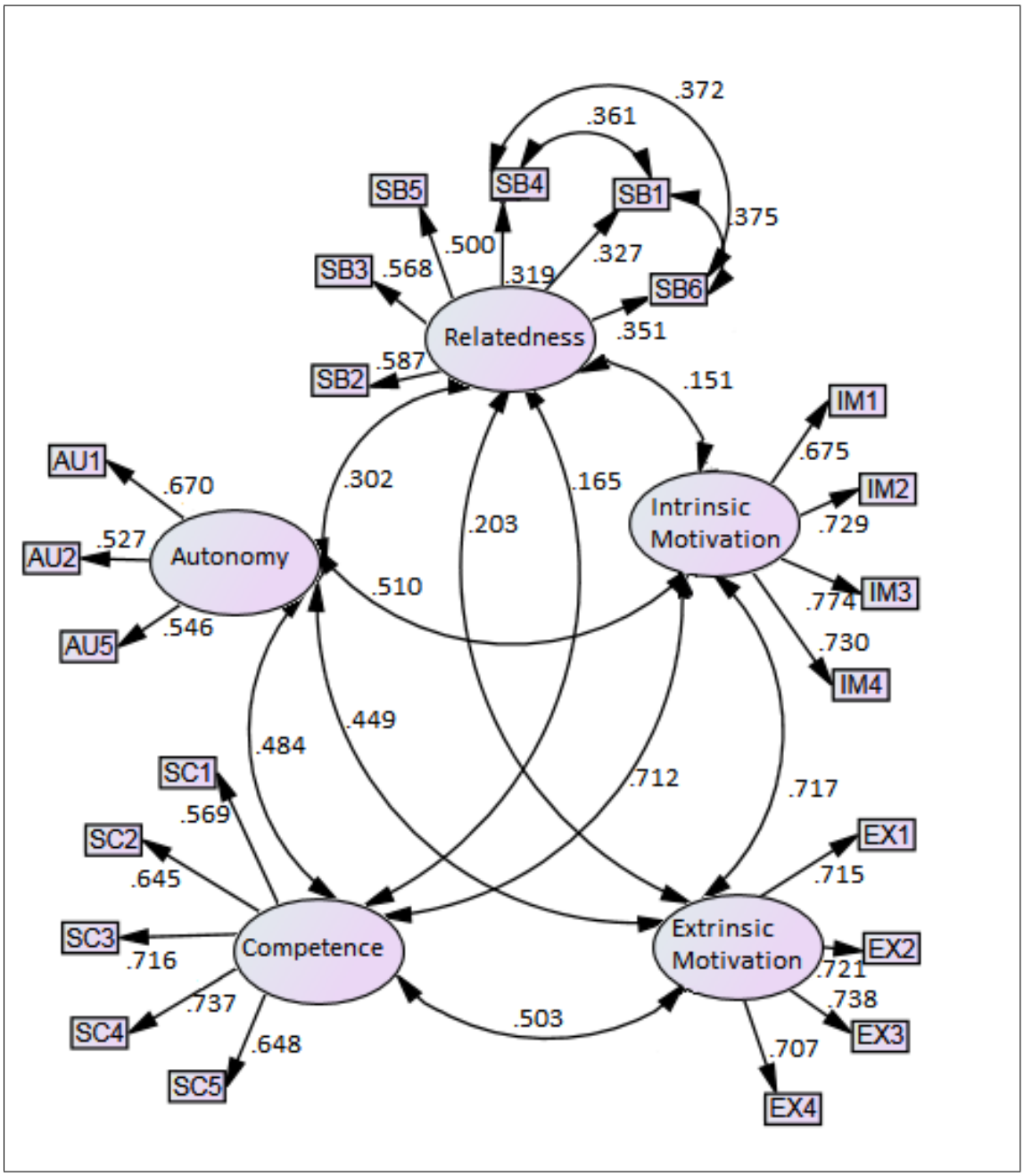

Figure 6.1. Standardized item loads and covariances of total group CFA

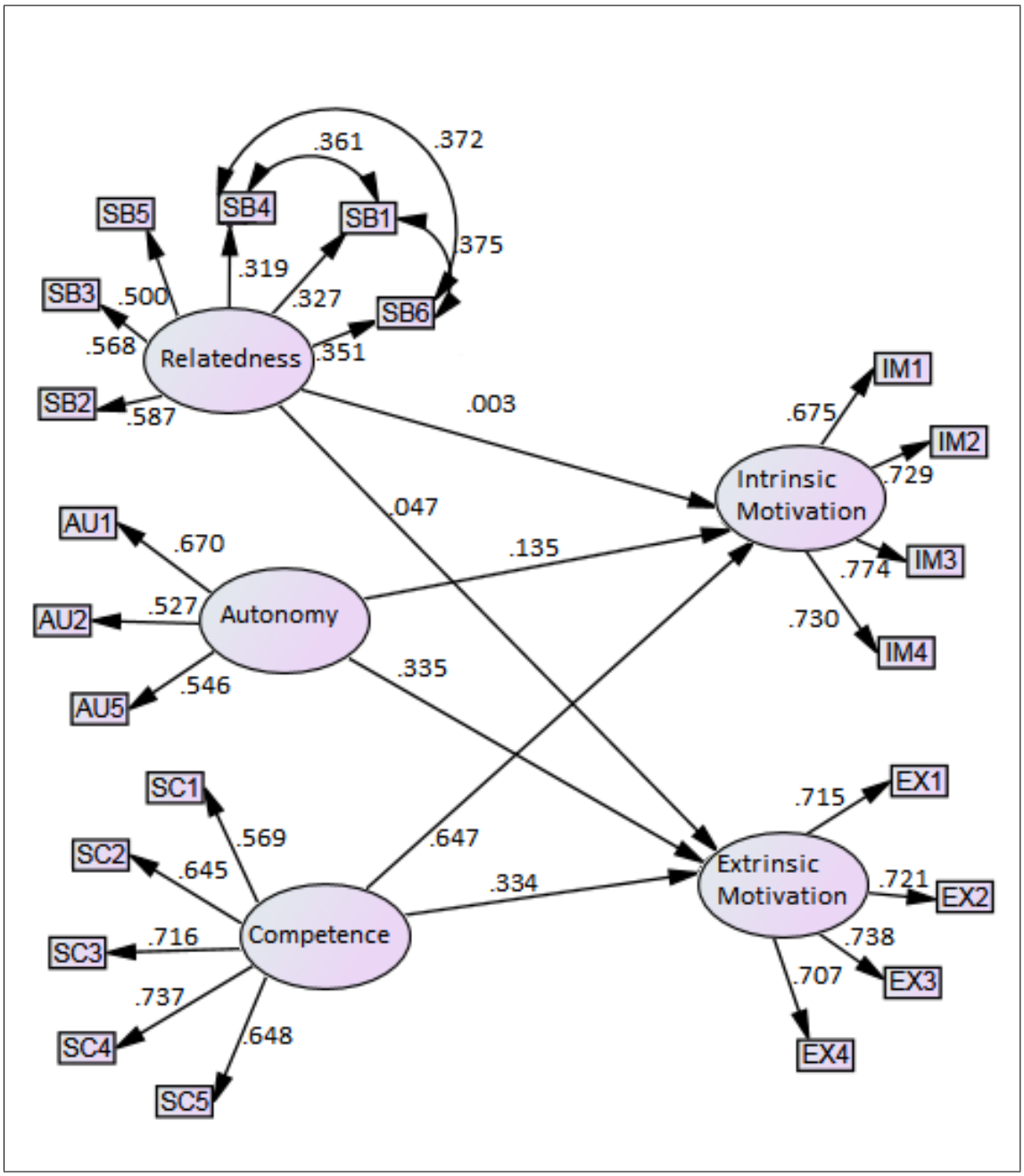

Figure 6.2. Standardized item loads and regression coefficients of total group SEM

Table 6.6. Unstandardized covariances between variables of total group CFA

	AU		**SC**		**SB**		**IM**		**EX**	
	Cov	**SE**	**Cov**	**SE**	**Cov**	**SE**	**Cov**	**SE**	**Cov**	**SE**
AU	1	0	.178	.002	.064	.002	.198	.003	.236	.003
SC			1	0	.030	.001	.266	.002	.197	.002
SB					1	0	.033	.001	.046	.001
IM							1	0	.337	.003
EX									1	0

coefficients ,and their standardized errors are shown in the Table 6.7.

Table 6.7. Results of total group SEM

	AU			**SC**			**SB**		
	β	**SE**	**S**β	β	**SE**	**S**β	β	**SE**	**S**β
IM	.137	.006	.135	.774	.008	.647	.004	.005	.003
EX	.356	.007	.335	.419	.007	.334	.057	.006	.047

According to suggestion given by Hair *et al.* (2014), items residuals and their R^2 values were checked. None of the residuals of items are bigger than |2.5|, therefore there are not outliers. Moreover none of the R^2 is greater than 1, hence there is not ant problematic case in the model. Total explained variance for intrinsic motivation needs were 52% (R^2) with respect to Wright's Rule (1934). Total explained variance for extrinsic motivation were 35% (R^2). Uniquely explained variance by relatedness to school were 0% (R^2) for intrinsic motivation and .2% (R^2) for extrinsic motivation. Uniquely explained variance by mathematics autonomy were 2% (R^2) for intrinsic motivation and 12% (R^2) for extrinsic motivation. Uniquely explained variance by mathematics competence were 42% (R^2) for intrinsic motivation and 11% (R^2) for

extrinsic motivation. The rest of the explained variance stems from the correlations among basic psychological needs.

6.2. Cultural Invariance Analysis

In this study, nine different cultures are selected with respect to WVM 6 (WVS, 2015). In order to operationalize cultures, one country were selected from each cultural clusters.Although the words ,*culture* and *country*, have different meanings, they can be used interchangeably in this study. Therefore, both of the words are used in the meaning of culture. Table 6.8 shows sample size of countries and corresponding culture for each country.

Table 6.8. Countries and cultures

Countries	**Name of the Culture in WVM 6**	**N**
Brazil	Latin America	19204
Finland	Protestant Europe	8829
Japan	Confucian	6351
Lithuania	Baltic	4618
Russia	Orthodox	5231
Spain	Catholic Europe	25313
Thailand	South Asia	6606
Turkey	African-Islamic	4848
UK	English Speaking	12659

At first, CFA model is applied for each country separately. A well-fitting CFA model for each group separately is prerequisite to test an invariance (Byrne, 2008, p.876). Then, MG-CFA and MG-SEM models are applied to the data as suggested in the literature (Cheung *et al.*, 2006). Groups are simultaneously entered into MG-CFA and MG-SEM. There are two nested models for each multi group analysis. MG-CFA

which includes configural (model 1) and weak (model 2) invariance models is tested for cultural invariance of the structure of the SDT. Metric invariance for MG-CFA which is applied to test cultural invariance of the means was not included in this study. BPNT (Deci and Ryan, 2008) posits that, the magnitude of the need for autonomy, competence and relatedness can change across cultures, therefore the theory does not predict cultural invariance among means of the needs. In this study, MG-CFA is applied to ensure the comparability of the cultures with respect to their regression coefficients (Davidov *et al.*, 2012, p.566). MG-SEM has two steps which are called as model 3 and model 4. In model 3, regression coefficients of the weak invariance model is determined by applying constraints on factor loadings in SEM. Then, applying additional constraints on path coefficients creates model 4. The difference between model 3 and model 4 gives information about cultural invariance of the path coefficients.

6.2.1. Separate Group CFA

Model fit well for all of the cultures separately. CFI, TLI, RMSEA and SRMR values for each country are shown in Table 6.9.

Table 6.9. Fit indices of CFA for each country

Countries	χ^2	**df**	**RMSEA**	**SRMR**	**CFI**	**TLI**
Brazil	1.849,815	196	.021	.029	.965	.959
Finland	999,314	196	.022	.026	.979	.975
Japan	1.011,092	196	.026	.024	.979	.975
Lithuania	949,960	196	.029	.030	.973	.968
Russia	752,136	196	.023	.026	.976	.971
Spain	1.527,157	196	.016	.024	.976	.971
Thailand	873,248	196	.023	.029	.964	.958
Turkey	854,381	196	.028	.026	.977	.972
United Kingdom	915,617	196	.017	.025	.977	.973

A well fitting CFA model for each country is established therefore an analysis for cultural invariance can be conducted on these countries.

6.2.2. Multi-Group CFA

Configural (model 1) and weak (model 2) invariance models are tested for the cultural invariance of the structure of SDT. Configural model fit well the data in the sample which includes nine different cultures (χ^2 (1764, N=93659)=10.460,854, CFI=.974, TLI=.969, RMSEA=.022 (90% CI=.021-.022), SRMR=.026). Configural model is a baseline model for measurement of any invariance because there are not any constraints in this model. This model is used for comparison with the weak invariance model. Therefore, results obtained from a well fitting configural model is that, weak invariance model can be applied to the model in order to test the difference between models. All factor loadings are constrained to be equal in weak invariance model. When there is no significant difference between weak and configural invariance models' fit indices, an evidence to check invariance of path coefficients is supplied. Weak invariance model fit well the data (χ^2 (1900, N=93659)=11.683,579, CFI=.971, TLI=.968, RMSEA=.022 (90% CI=.022-.023), SRMR=.031). The difference between weak invariance model and configural invariance model was not significant (ΔCFI=.003, ΔTLI= .001, ΔRMSEA=.001, ΔSRMR=.005) with respect to the cut off values recommended by Cheung and Rensvold (2002).Structure of the SDT's latent variables (factors) are found to be invariant across culture.

Multi-group SEM analyses are applied in order to test invariance of the path coefficients. For model 3, all of the factor loadings were set to be equal and the data of the cultures were simultaneously entered to SEM analysis. Therefore, model 3 was applied to determine the path coefficients of weak invariance model (model 2). Both models (model 3 and model 2) have constraints only on factor loadings. Moreover they have same measurement model because Lavaan package in R-studio automatically places covariance between unpredicted latent variables. Therefore, fits of the models are identical to each other, model 3 fit well the data (χ^2 (1900, N=93659)=11.683,575,

CFI=.971, TLI=.968, RMSEA=.022 (90% CI=.022-.023), SRMR=.031). All path coefficients of autonomy and competence were significant (p<.001). Except for Thailand (p<.001), all path coefficients between relatedness and intrinsic motivation are non-significant. Except for Spain, all path coefficients between relatedness and extrinsic motivation are significant (p<.05). The path coefficients between exogenous and endogenous variables for model 3 are shown in Table 6.10.

Table 6.10. Path coefficients of model 3

		Autonomy			**Competence**			**Relatedness**		
		β	**SE**	**S**β	β	**SE**	**S**β	β	**SE**	**S**β
Brazil	**Intrinsic Motivation**	.165	.016	.174	.642	.014	.643	.024	.022	.014
Spain		.089	.017	.099	.628	.014	.681	.007	.019	.004
Finland		.124	.017	.139	.592	.016	.648	.008	.026	.005
U.K.		.138	.022	.135	.652	.019	.645	.028	.027	.016
Japan		.111	.017	.123	657	.017	.649	.042	.026	.026
Lithuania		.102	.018	.112	.686	.018	.682	.019	.036	.010
Russia		.073	.021	.083	.664	.019	.664	.047	.028	.030
Thailand		.135	.024	.138	.669	.021	.630	.136	.035	.078
Turkey		.133	.018	.146	.719	.019	.688	.007	.031	.004
Brazil	**Extrinsic Motivation**	.391	.022	.363	.350	.017	.309	.073	.031	.039
Spain		.318	.025	.283	.406	.019	.353	.024	.029	.011
Finland		.365	.025	.363	.313	.021	.304	.132	.037	.068
U.K.		.373	.030	.341	.299	.023	.276	.149	.037	.080
Japan		.285	.023	.249	.454	.022	.354	.148	.036	.072
Lithuania		.378	.025	.359	.361	.023	.311	.154	.046	.072
Russia		.326	.030	.282	.444	.028	.339	.123	.043	.061
Thailand		.394	.029	.372	.362	.025	.315	.164	.042	.087
Turkey		.305	.022	.308	.449	.025	.395	.081	.038	.042

All path coefficients are constrained to be equal in model 4 in order to check the invariance of path coefficients. Model 4 fit well the data (χ^2 (1948, N=93659) =11.918,452, CFI=.970, TLI=.968, RMSEA=.022 (90% CI=.022-.022), SRMR=.032). The difference between model 3 and model 4 was not significant (ΔCFI=.001, ΔTLI=.000, ΔRMSEA=.000, ΔSRMR= .001) with respect to cut off values recommended by Cheung and Rensvold (2002). Therefore, path coefficients between basic psychological needs for mathematics and types of mathematics motivation were culturally invariant. All path coefficients are statistically significant (p<.01). The path coefficients between exogenous and endogenous variables for model 4 are shown in Table 6.11.

Table 6.11. Path coefficients of model 4

		Autonomy			**Competence**			**Relatedness**		
		β	**SE**	**S**β	β	**SE**	**S**β	β	**SE**	**S**β
Brazil	**Intrinsic Motivation**	.119	.007	.128	.639	.008	.653	.025	.009	.015
Spain		.119	.007	.129	.639	.008	.676	.025	.009	.014
Finland		.119	.007	.129	.639	.008	.675	.025	.009	.014
U.K.		.119	.007	.118	.639	.008	.643	.025	.009	.014
Japan		.119	.007	.131	.639	.008	.637	.025	.009	.015
Lithuania		.119	.007	.133	.639	.008	.649	.025	.009	.014
Russia		.119	.007	.134	.639	.008	.639	.025	.009	.016
Thailand		.119	.007	.126	.621	.008	.653	.025	.009	.014
Turkey		.119	.007	.135	.639	.008	.648	.025	.009	.014
Brazil	**Extrinsic Motivation**	.350	.010	.328	.370	.008	.329	.093	.013	.049
Spain		.350	.010	.310	.370	.008	.319	.093	.013	.044
Finland		.350	.010	.342	.370	.008	.352	.093	.013	.047
U.K.		.350	.010	.315	.370	.008	.337	.093	.013	.049
Japan		.350	.010	.307	.370	.008	.292	.093	.013	.045
Lithuania		.350	.010	.338	.370	.008	.324	.093	.013	.044
Russia		.350	.010	.308	.370	.008	.288	.093	.013	.046
Thailand		.350	.010	.339	.370	.008	.329	.093	.013	.050
Turkey		.350	.010	.355	.370	.008	.333	.093	.013	.048

7. DISCUSSION

7.1. Discussion for Total Group Analyses

7.1.1. Intrinsic Motivation

In this study, predictions of SDT were tested in the total sample of PISA 2012. According to SDT, basic psychological needs (autonomy, competence, and relatedness) positively predict the intrinsic motivation. Therefore, mathematics related basic psychological needs would be expected to predict mathematics intrinsic motivation positively. Results show that, although mathematics autonomy (β=.135, p<.001) and mathematics competence (β=.647, p<.001) significantly and positively predicted the mathematics intrinsic motivation, relatedness to school (β=.003, p=.460) was non-significant for predicting mathematics intrinsic motivation. Moreover, mathematics competence was relatively more significant predictor than mathematics autonomy for mathematics intrinsic motivation. These findings are consistent with the literature whereas they are partially consistent with SDT. According to Bandura (1986), competence is the only predictor of intrinsic motivation. SDT opposes Bandura with an argument that, satisfaction of the need for competence can enhance intrinsic motivation however it must be accompanied by the need for autonomy in order to experience the intrinsic motivation (Ryan and Deci, 2002, p.11; Fisher, 1978; Ryan, 1982). CET which is a sub theory of SDT asserts that, feeling of competence must be supported by the feeling of autonomy in order to enhance intrinsic motivation (Ryan and Deci, 2000, p.58). Findings about relatedness in this study contradict with the SDT predictions. Although relatedness is not one of the main predictors for intrinsic motivation in CET, Ryan and Deci states that relatedness is still a significant predictor for intrinsic motivation. It means that, the effect of relatedness on intrinsic motivation is not considered as important as the effect of autonomy and competence (Niemiec and Ryan, 2009; Ryan and Deci, 2002; 2000; Aunola *et al.*, 2016).Therefore, results obtained from this study for total sample of PISA 2012 were partially consistent with

the predictions of SDT. Mathematics competence and mathematics autonomy were significant factors for predicting mathematics intrinsic motivation while relatedness to school was not significant factor for mathematics intrinsic motivation.

Predictors of intrinsic motivation have been studied in various educational domains. A great majority of these studies found that both autonomy and competence were significant predictors of intrinsic motivation (Jang *et al.*, 2009). Moreover, most of the prior research was consistent with the findings that competence is a more important predictor than autonomy for intrinsic motivation (Sheldon and Filak, 2008; Jang *et al.*, 2009; Painter, 2011, Ryan 1982). Painter (2011), stated that competence (β=.75) was the main predictor for intrinsic motivation in science, and autonomy (β=.07) was also significant intrinsic motivation in science.

Studies in mathematics learning domain are also consistent with findings in this research. In this study, the gap between the magnitude of the regression coefficients of autonomy (β=.135) and competence (β=.647) for predicting intrinsic motivation were found relatively larger than the findings in the literature. It means that, the effects of mathematics competence was found bigger than the effects of mathematics autonomy on mathematics intrinsic motivation . Zhou *et al.*, (2009) conducted a regression analysis in order to find out the predictors mathematics intrinsic motivation. They found that, perceived competence and perceived choice (autonomy) were significant predictors of mathematics intrinsic motivation. Moreover, competence (β=.58) was a more important predictor than autonomy (β=.38) for mathematics intrinsic motivation in rural Chinese students. Durmaz and Akkuş (2016) also conduct a regression analysis between basic psychological needs and types of mathematics motivation. They found that, competence (β=.35) was the main predictor for mathematics intrinsic motivation among basic psychological needs. Aunola *et al.* (2013) were analyzed the relationships between mathematics intrinsic motivation and basic psychological needs by SEM. The results showed that, all of the basic psychological needs contributed for mathematics intrinsic motivation uniquely. Competence (β=.26) is the most important predictor for mathematics intrinsic motivation. Autonomy is the sec-

ond most important for predicting mathematics intrinsic motivation (β=.17). Jang *et al.* (2009) were investigated the effects of basic psychological needs on four mathematics outcome (achievement, intrinsic motivation, proneness to negative affects and engagement) with Korean students. The results of the study showed that, both competence (β=.55) and autonomy (β=.32) were important predictors of mathematics intrinsic motivation.

Relatedness as a predictor of intrinsic motivation is discussed separately in this study, because findings about effects of relatedness conflicted by predictions of SDT. According to CET relatedness is not a necessary factor for intrinsic motivation however it must be still significant for attainment of intrinsic motivation. On the other hand, most of the empirical studies did not find supporting evidence for the effect of relatedness on intrinsic motivation (Jang *et al.*, 2009; Steinfield, 2002) or they did not consider relatedness as a factor for intrinsic motivation at all (Zhou *et al.*, 2009; Painter, 2011). Relatedness did not have a significant effect on intrinsic motivation in high school students (Jang *et al.*, 2009, p.658; Steinfield, 2002, p.17). For mathematics context, students' perceptions of relatedness change when they are transferred from middle school to high school. Steinfield (2002) states that, adolescence period of children leads to change in the perception of relatedness. Moreover, relatedness was more effective on students who achieve low, drop out school or develop learned helplessness (Werner and Smith, 1982). Therefore, relatedness plays a role for internalization of a behavior which is initially amotivated or externally regulated (lowest level in external motivation)(Ryan and Deci, 2000). Furthermore, Zhou *et al.* (2009) investigated the effects of basic psychological needs for mathematics motivation. They did not consider relatedness as a factor for intrinsic motivation because of the lack of support from literature and theoretical background of intrinsic motivation. In a similar way, Painter (2011) also conducted a research with science students, which investigated the effects of autonomy and competence for students' intrinsic motivation. Durmaz and Akkuş (2016) found that, relatedness had an important effect on mathematics intrinsic motivation which is also higher than the effect of autonomy. They conducted the study in a small city for a school. Results obtained about relatedness from such

an environment may be problematic because high conservative environment includes within many types of social relationships which can be confused with relatedness, such as respect (Jang *e*t al., 2002, 658).

Based on the findings of this study and Wright's rules for explained variance calculation (1934), majority of the mathematics intrinsic motivation was explained by the mathematics competence (R^2=41.8%). Mathematics autonomy was also a significant predictor for explaining mathematics intrinsic motivation however it explained very low variance for mathematics intrinsic motivation (R^2=2%). Mathematics relatedness was not a significant predictor for mathematics intrinsic motivation. In mathematics learning domain, findings of this study strongly suggest that mathematics teachers of intrinsically motivated students should consider competence for their lessons and measurement of students' intrinsic motivation. They should keep in mind that, student must be competent enough for mathematics activities for enhancement of mathematics intrinsic motivation. Moreover, mathematics activities must be challenging enough for intrinsically motivated students in order to avoid impairment of intrinsic motivation. Furthermore, students' feelings of autonomy must be supported during the mathematics activities. Mathematics teachers can feature students' mathematics autonomy by increasing students' choice opportunities during the activities. For example, mathematics teachers can state different strategies for solution of a question instead of demonstration of a strategy for the question, and expected to choose one.

7.1.2. Extrinsic Motivation

According to SDT, basic psychological needs are positive predictors of extrinsic motivation (Deci and Ryan, 1985b). Therefore, mathematics autonomy, mathematics competence and relatedness to school would be expected to be positive predictors of mathematics extrinsic motivation. Results obtained from total sample in PISA 2012 show that, each of the basic psychological needs was a significant positive predictor of the mathematics extrinsic motivation. Mathematics autonomy (β=.335, p<.001)

and mathematics competence (β=.334, p<.001) equally and positively predicts the extrinsic motivation. Relatedness to school (β=.047, p<.001) was also significant predictor of mathematics extrinsic motivation however it had relatively low effects on extrinsic motivation.

According to SDT, extrinsic motivation is not negatively related with intrinsic motivation (Ryan and Deci, 2000, p.15). In order to avoid a misunderstanding about the increase in the scores of extrinsic motivation, understanding of internalization is important. PISA 2012 assessed the extrinsic motivation depending on SDT (OECD, 2013). Moreover, questions in the mathematics extrinsic motivation scale includes self-valued extrinsic motivation questions. Therefore, an increase in the scores of extrinsic motivation means more internalized regulation of the mathematics extrinsic motivation. Durmaz and Akkuş (2016) also used same strategy for assessing the types of regulations in the extrinsic motivation.

Findings for extrinsic motivation in this study were consistent with both empirical studies and SDT. According to SDT, extrinsic motivation includes four kinds of motivational regulations which are differentiated by the degree of autonomy. Therefore, autonomy is the most important predictor for the enhancement of extrinsic motivation. Competence and relatedness are also important predictors for enhancement of extrinsic motivation. According to Ryan and Deci (2000, p.19), students which are not competent enough for an activity will find an excuse to evade the activity. Moreover, relatedness is also important for promoting extrinsic motivation. Students who do not initially perceive an inherent interest or desired outcome for doing an activity need a significant other for enchantment of extrinsic motivation (Ryan and Deci, 2000). Therefore, relatedness is more effective on students who are externally regulated (lowest level of extrinsic motivation) or amotivated. Competence and autonomy enable to reach more internalized form of extrinsic motivation for students (Ryan and Deci, 2000). Therefore, one could expect comparable regression coefficients for relatedness and competence. While significance and priority of the basic psychological needs' effects were consistent with the SDT, effect sizes of the basic psychological

needs are somehow different than SDT. In this study, relatedness was found less effective than expected for students' mathematics extrinsic motivation. According to Huff (2009), using relatedness to teacher for predicting the motivation makes more sense than using relatedness to school. Because PISA 2012 did not assess relatedness to teacher, this study only included relatedness to school.

The effects on basic psychological needs on intrinsic motivation dominate the literature about SDT in education context. Extrinsic motivation is mostly studied in health context (Vlachopoulos *et al.*, 2010; Edmunds *et al.*, 2006; Gourlan *et al.*, 2013) and there are some studies in education context (Ciani *et al.*, 2011; Lam *et al.*, 2010).There few numbers of studies which study with the effects of basic psychological needs and extrinsic motivation in mathematics education context (Durmaz and Akkuş, 2016; Zhou *et al.*, 2009). Research conducted by Ciani *et al.* (2011) investigated the relationships between achievement goals, enhancement of extrinsic motivation and basic psychological needs in teacher candidates. They found that, autonomy (β=.26) was the most important predictor for enhancement of extrinsic motivation and relatedness (β=.23) was the second in importance. Effect of competence was the smallest for enhancement of extrinsic motivation (β=.02). They also reported that, the effect of competence on students' extrinsic motivation was lower than expected because of the low reliability of the competence scale. Lam *et al.* (2010) conducted a study which investigated the schools' basic psychological supports for teachers' motivational regulations. They separated the motivational regulations of teachers' into five levels. The priority of the basic psychological needs for four out of five motivational regulations was the same as the findings in this study. Zhou *et al.* (2009) looked for the effect of mathematics competence and mathematics autonomy support on mathematics control (extrinsic) motivation in the sample of Chinese college students. They reported that autonomy (β=.47) was the most significant predictor for enhancement of control motivation. Competence (β=.25) was also a significant predictor for enhancement of extrinsic motivation. They did not measure the students' relatedness. On the other hand, Durmaz and Akkuş (2016) found that, teacher relatedness was the most important predictor of mathematics extrinsic motivation for students in the sample of

Turkish university. Mathematics competence was the second most significant predictor for mathematics extrinsic motivation. The interesting result of the research was autonomy. They found that, autonomy was not a statistically significant predictor for mathematics extrinsic motivation. They reported that, SDT brings autonomy up front and the results could not be explained by these findings. Therefore, they tried to explain the results in a hypothetical way that, autonomy and competence are not supported by Turkish teachers because they generally use traditional methods for teaching. They also stated that, traditional methods for teaching mathematics do not give much chances to support autonomy and competence. However, it does not mean that students do not need for autonomy and competence. A researcher interested with SDT keeps in mind that students' need for autonomy, competence and relatedness does not have to be the same across cultures but it has to be significant for all cultures (Deci and Ryan, 2008).

Based on the findings of this study and Wright's (1934) rules for explained variance calculation, variance in the mathematics extrinsic motivation was explained mostly by the mathematics competence (R^2=11.1) and mathematics autonomy (R^2= 11.2) among the basic psychological needs. Relatedness to school was also significant predictor for mathematics extrinsic motivation however it explained very low variance in mathematics extrinsic motivation (R^2= .2%). There could be two reasons for low explained variance by relatedness. First, relatedness is mostly significant for students who are amotivated or externally regulated (lowest level in extrinsic motivation)(Werner and Smith, 1982). PISA 2012 does not distinguish the levels of extrinsic motivation in SDT although the scale depended on SDT. Therefore, this study considers the high scores of extrinsic motivation as more internalized, and low scores of extrinsic motivation as less internalized. A study including low levels of extrinsic motivation cannot be conducted with PISA 2012 dataset. That is to say, the effect of relatedness to school may have been suppressed by the high levels in mathematics extrinsic motivation. Second, PISA 2012 did not include a scale for relatedness to teacher. Relatedness to teacher can supply a more effective measurement for SDT (Huff, 2009).

Mathematics autonomy was found as an important effect for internalization of the extrinsic motivation. Therefore, mathematics teachers who have students with less internalized extrinsic motivation can more frequently give choice opportunities during the classroom activities. Moreover, the effect of competence was found nearly same with the effect of autonomy for mathematics extrinsic motivation. Therefore, mathematics teachers should also consider the competence level of the classroom activities carefully. Relatedness to school was found as a significant factor for the mathematics extrinsic motivation. Suggestion for relatedness to school given by this study depends on theoretical background because of low explained variance by the variable in this study. Mathematics teachers should also take relatedness to school into consideration because it is expected to be more effective when students are amotivated or externally regulated (the lowest level in extrinsic motivation). Therefore, teachers who have students at risk group for mathematics learning can scheduled school activities for special days like Pi-day (Huff, 2009).

7.2. Discussion for Cultural Invariance Analyses

According to BPNT (Deci and Ryan 1985a), basic psychological needs are innate and lifelong factors for one's motivation. SDT states that, basic psychological needs are both age and culture invariant. In this study, age invariance cannot be assessed because sample of PISA 2012 includes students in the same age group. PISA 2012 suggested conducting studies on cultural invariance of some of the scales (OECD, 2013, p.190). Therefore, PISA 2012 intended to maintain measurement invariance of the scales like self-belonging to school, mathematics interest, instrumental motivation for mathematics and mathematics self-concept (OECD, 2013, p.190). According to BPNT, one feels the necessity of all basic psychological needs independent from her culture in order to be motivated although strength of the needs can change among different cultures (Deci and Ryan, 2008). Hence, cultural invariance of path coefficients between basic psychological needs for mathematics and types of mathematics motivations was tested. In order to operationalize culture, nine different countries from different cultures with respect to WVS (2015) were selected among PISA 2012 coun-

tries. Those are Brazil, Spain, United Kingdom, Thailand, Lithuania, Japan, Turkey, Finland and Russia. Then, a dataset including these nine countries was constructed to test the cultural invariance.

In this study, four models were used to test cultural invariance. These models are in a hierarchy that, support for the former one enables to test following one. Firstly, model 1 (configural model) was supported by results (χ^2 (1764, N=93659)=10.460,854, CFI=.974, TLI=.969, RMSEA=.022 (90% CI=.021-.022), SRMR=.026). Therefore, first step for testing the predictions of BPNT in mathematics learning domain were supported. It is important to attain support for model 1 because model 1 supplies a strong evidence for conclusions that perception of variables' meaning did not differentiate among cultures and meanings of the variables were not affected by the translational errors (Vlachopoulos *et al.*, 2010, p.407). As a second, model 2 (weak invariance model) is also supported by the results (ΔCFI=.003, ΔTLI=.001, ΔRMSEA=.001, ΔSRMR=.005). In this study, support for the model 2 supplies a strong evidence for the conclusion that number and structure of factors for types of mathematics motivation and basic psychological needs measured in mathematics learning domain were not influenced by the cultural differences. Moreover, structural relationships of these variables (regression coefficients) become comparable with the help of support for model 2 (Cheung *et al.*, 2006). Third, model 3 (structural equation model with equal factor loadings) was supported by the results. Model 2 and model 3 were identical to each other because degrees of freedom and number of relationships were same in these models. Moreover, lavaan.survey package in R uses the same function for CFA and SEM. According to creator of the package (Oberski, 2014), the difference between the functions of CFA and SEM does not include a meaningful information. Moreover, the difference between the formulas for CFA and SEM creates a negligible difference in the results. Support for model 3 gave the regression coefficients between basic psychological needs for mathematics and types of mathematics motivations for each country under constraints on equal factor loadings. Standardized regression coefficients of the countries in model 3 and total group SEM are shown in the Table 7.1. In Table 7.1 non-significant values were shown in bold font. Except for values shown

in the bold font, all parameters were significant (p<.05). Although actual results for the cultural invariance of all path coefficients were obtained by the model 4, model 3 was also important to compare the different countries regression coefficients.

Table 7.1. Standardized path coefficients for total group model and countries in model 3

	Intrinsic Motivation			**Extrinsic Motivation**		
	AU	**SC**	**SB**	**AU**	**SC**	**SB**
Total	.135	.647	**.003**	.335	.334	.047
Brazil	.174	.643	**.014**	.363	.309	.039
Spain	.099	.681	**.004**	.283	.353	**.011**
Finland	.139	.648	**.005**	.363	.304	.068
U.K.	.135	.645	**.016**	.341	.276	.080
Japan	.123	.649	**.026**	.249	.354	.072
Lithuania	.112	.682	**.010**	.359	.311	.072
Russia	.083	.664	**.030**	.282	.339	.061
Thailand	.138	.630	.078	.372	.315	.087
Turkey	.146	.688	**.004**	.308	.395	.042

CET states that, one needs to be competent enough in order to reach intrinsic motivation, and then autonomy leads to an increase in intrinsic motivation (Ryan and Deci, 2000). Predictions of SDT for intrinsic motivation were partially consistent with the results obtained from the nine different countries. Predictions about autonomy and competence for intrinsic mathematics motivation were consistent with the findings for all of the nine countries. Results showed that, mathematics competence was more important than mathematics autonomy and relatedness to school for predicting intrinsic motivation in all of the nine countries. Moreover, OIT states that (Deci and Ryan 1985b), autonomy and competence are especially important for students to reach high levels of autonomous extrinsic motivation. Predictions of OIT were consistent with the results obtained from the nine countries. Nine different countries' regression coefficients of mathematics autonomy and mathematics competence were

equally significant for predicting extrinsic mathematics motivation. Therefore, all of the predictions of SDT for mathematics autonomy and mathematics competence were supported also for nine different countries by the results of this study. It can be seen in Table 7.1 that, nine countries' regression coefficients between (1) autonomy and intrinsic motivation, (2) competence and intrinsic motivation, (3) autonomy and extrinsic motivation, and (4) competence and extrinsic motivation were close to each other in mathematics learning domain. Moreover, these regression coefficients were also close to regression coefficients for total group SEM. Results obtained for these regression coefficients were consistent with the findings in the literature. Zhou *et al.* (2009) stated that, mathematics autonomy and competence were a significant factor for mathematics intrinsic motivation in rural Chinese students (a collectivist culture) as much as it is significant for western cultures (individualist). Jang *et al.* (2009) conducted a study which tests the cultural invariance of mathematics related basic psychological needs and mathematics positive outcomes (intrinsic motivation, achievement, proneness/invulnerability to negative effect) within Korean students. Korean students were divided in two groups which included the students with high or low endorsement in collectivist cultures' values. They report that, relatedness was not a significant factor for intrinsic motivation in both groups. Moreover, there was not a significant difference between the groups' regression coefficients between mathematics related basic psychological needs and mathematics intrinsic motivation.

Moreover, CET (Deci, 1975) predicts that relatedness is also a significant factor for intrinsic motivation however its strength is lower than autonomy and competence for intrinsic motivation. Relatedness was found as a non-significant factor for intrinsic motivation in eight countries. Relatedness was only significant in Thailand for predicting intrinsic motivation. Therefore, the prediction about relatedness in SDT was only supported for Thailand. In total group analysis, relatedness to school was found non-significant for predicting mathematics intrinsic motivation. Except for Thailand, eight countries' regression coefficients between relatedness to school and mathematics intrinsic motivation were also close to each other and non-significant in model 3. Although the path coefficient was significant for Thai students in PISA 2012, relatedness

to school scores of Thai students only explained .5% of the variance in mathematics intrinsic motivation. Therefore, cultural invariance for path coefficients between nine different countries relatedness to school scores and mathematics intrinsic motivation scores can still be maintained by model 4. A study conducted on Thai students including relatedness belief of students or predictions of SDT was not found in the literature, hence there was not any empirical evidence to state cultural difference for the Thai students' relatedness to school in the past. Therefore, findings about the regression coefficient of Thailand cannot be supported by the literature. The effects of relatedness to school on mathematics intrinsic motivation ought to be studied in Thailand.

OIT asserts that, relatedness is also a significant factor for extrinsic motivation. Effect of relatedness is more important for the internalization of extrinsic motivation of students who have low level of autonomous extrinsic motivation initially. Eight countries' regression coefficients between relatedness and extrinsic motivation were also significant. However, the regression coefficient between relatedness and extrinsic motivation were not significant for only Spain, which is inconsistent with the prediction of SDT. In total group analysis, relatedness to school was found significant for predicting extrinsic motivation. Except for Spain, eight countries' regression coefficients between relatedness to school and extrinsic motivation were close to each other and significant in model 3 ($p<.05$). It seems like that (Table 7.1), regression coefficient for Spain between relatedness to school and mathematics extrinsic motivation were also close enough to other countries' regression coefficients, however it was non-significant for Spanish students. The significance of these countries' path coefficients between relatedness to school and mathematics intrinsic motivation was statistically tested by model 4. In the literature, there was not any study about the students' relatedness to school conducted in Spain. The effects of relatedness to school on mathematics extrinsic motivation ought to be studied in Spain.

Why Thailand and Spain are different in regression coefficients of relatedness? Firstly, the significance of the regression coefficient may spring from the scale used

for these countries in the PISA 2012. PISA may not have completely measured what SDT meant by relatedness. Indeed, SDT predicts the cultural invariance of overall relatedness which is more comprehensive construct than relatedness to school. Relatedness score which is measured over relatedness to parents, teachers and school can be more meaningful to test the predictions of SDT (Huff, 2009). The association of these related but different constructs may lead to an increase or a decrease in the value for significance. For example, Thai students may associate relatedness to school with relatedness to teacher. Therefore, the regression coefficient between relatedness to school and mathematics intrinsic motivation may become significant for Thailand. Moreover, an item or items in the scale may be little more convenient for Thai students or less convenient for Spanish students than students in other countries. Second, there may be an actual cultural difference for Thai and Spanish students' belief about relatedness to school. However, it seems like that (Table 7.1) the nine countries' regression coefficients between relatedness to school and types of mathematics motivation were close enough with each other. Model 4 can help to assess the difference between path coefficients are significant or not.

Model 4 was also supported by the results (ΔCFI=.001, ΔTLI=.000, ΔRMSEA= .000, ΔSRMR= .001). A support for model 4 means that, nine countries path coefficients between basic psychological needs and mathematics motivation were culturally invariant. Therefore, predictions of BPNT were consistent with the findings in this study. Although, Thailand and Spain were different for the significance of the regression coefficients of relatedness school scale in model 3, the difference between these countries and rest of the countries were not significant. Nine countries' all path coefficients between basic psychological needs and types of motivation in mathematics learning domain successfully converged to the new path coefficients which is close for each country (Table 7.2). All of the path coefficients were significant in Table 7.2 ($p<.01$).

While Thailand's regression coefficient of relatedness and intrinsic motivation was significant in model 3, all regression coefficients of relatedness and intrinsic mo-

tivation became significant in model 4. The reason for the change in the significance of the regression coefficient was the constraints on path coefficients which decreases the standardized errors for regression coefficients by forcing them to be equal (Bollen, 1989, p.126). All of regression coefficients of relatedness and intrinsic motivation in model 4 were statistically significant however they were not significant practically. Russia had the biggest regression coefficients of relatedness and intrinsic motivation (β=.016) and it only explained .02% of the variance with respect to Wright's (1934) rule in the intrinsic motivation. The significance of the regression coefficients in this study were calculated by the unstandardized regression coefficient over standardized error. Therefore, the significance of the regression coefficients becomes more vulnerable when the regression coefficients are small. Therefore, there was not such a problem for other regression coefficients.

Table 7.2. Standardized path coefficients for total group model and countries in model 4

	Intrinsic Motivation			**Extrinsic Motivation**		
	AU	**SC**	**SB**	**AU**	**SC**	**SB**
Total	.135	.647	.003	.335	.334	.047
Brazil	.128	.653	.015	.328	.329	.049
Spain	.129	.676	.014	.310	.319	.044
Finland	.129	.675	.014	.342	.352	.047
U.K.	.118	.643	.014	.315	.337	.049
Japan	.131	.637	.015	.307	.292	.045
Lithuania	.133	.649	.014	.338	.324	.044
Russia	.134	.639	.016	.308	.288	.046
Thailand	.126	.653	.014	.339	.329	.050
Turkey	.135	.648	.014	.355	.333	.048

Regression coefficients in model 4 were close to the regression coefficients calculated in the Total group analysis which included 65 countries. It means that, none of the nine countries can be differentiated from 65 countries. Moreover, these regres-

sion coefficients were also close to the regression coefficients in model 3. Therefore, regression coefficients of basic psychological needs for mathematics and types of mathematics motivation in the nine countries which were selected from different cultural background with respect to WVS (2015) were culturally invariant as predicted by BPNT. Although there were studies which investigated the cultural invariance of the effects of BNPT, none of these studies tested the cultural invariance of the regression coefficients (Zhou *et al.*, 2009; Jang *et al.*, 2009). On the other hand, SDT predicts a significant but small regression coefficient between relatedness and intrinsic motivation. This prediction was not supported by this study. Although relatedness to school scale in PISA 2012 may be unable to measure the relatedness construct mentioned by SDT, SDT may also need a revision for intrinsic motivation. Most of the studies in the literature did not found relatedness as a significant predictor for intrinsic motivation.

Therefore, several suggestions for mathematics teachers can be stated by the results of cultural invariance analysis in this study. First of all, mathematics teachers must significantly consider the competence of the classroom activities, because mathematics competence was practically and statistically significant for both types of mathematics motivation. According to Bandura (1986), competence is the most important need for students' motivation. The results show that, mathematics competence was the leading factor for predicting student mathematics motivation and its internalization. However, the results also showed that mathematics autonomy contributed the internalization of the motivation as much as competence contributed. Therefore, SDT supplies more comprehensive understanding for mathematics motivation. Second, mathematics teachers especially in a multicultural school might not need to care about the cultural differences in order to satisfy students' basic psychological needs in mathematics learning domain. They should consider the motivational regulations of students for mathematics instead of their culture, because the effects of basic psychological needs can change in accordance with students' initial motivational regulations in mathematics learning domain.

7.3. Limitations of the Study

Relatedness to school and mathematics extrinsic motivation scales might be considered as the most important limitations in this study. Huff (2009) states that, relatedness explained by SDT includes relatedness to school, relatedness to teacher and relatedness to the parents constructs. However, relatedness to school construct was only eligible variable in PISA 2012 to measure relatedness. According to SDT (Ryan and Deci, 1985b), extrinsic motivation has four different levels which is differentiated by the degree of autonomy. Mathematics extrinsic motivation was measured over a single scale. Although there are many study which uses a single scale for extrinsic motivation (Ciani *et al.*, 2011; Lam *et al.*, 2010 ;Zhou *et al.*, 2009), it would be better to measure them in four different scales.

The difficulty of the measurement of a psychological process with self-report likert scale might be referred to as another limitation in this study. Self-report likert scales are practical to assess hundreds of people. Paulhus (1984) stated that, participants were mostly likely to choose socially desirable responses when self-report likert scales were used. Moreover, self-report likert scales were invulnerable for assessing psychological process because participants might not have enough information about the psychological construct to assess themselves .

This study only included PISA 2012 data which is cross-sectional, therefore time dependent changes in mathematics motivation cannot be tested and discussed. Hence, using cross-sectional data can be considered as an other limitation for this study.

7.4. Suggestions for the Further Studies

The results of this study indicated the importance of the Self Determination Theory in mathematics learning domain. Further researches might be concentrated on using different scales will greatly contributed the literature in this area.

Practical implications of the findings in this study might be studied. Especially, a research in experimental design conducted to measure the effects of mathematics related basic psychological needs on types of mathematics motivation will contribute to the literature of mathematics motivation. Furthermore, There is need for conducting qualitative studies in order to comprehend the reason for the effects of mathematics basic psychological needs on types of mathematics motivation .

Moreover, the effects of the need for relatedness to school on types of mathematics motivation should be especially studied in Thailand and Spain which were exceptional cases for this study.

Furthermore, it is suggested that the model proposed by this study should be investigated with different samples and datasets. Moreover, a longitudinal study with the model proposed by this study could be conducted to investigate time dependent changes in mathematics motivation.

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APPENDIX A: NUMBER OF PARTICIPANTS FOR EACH COUNTRY IN PISA 2012

Table A.1. Number of participants for each country in PISA 2012

Countries	**Frequency**	**Percent**
Albania	4743	1.0
United Arab Emirates	11500	2.4
Argentina	5908	1.2
Australia	14481	3.0
Austria	4755	1.0
Belgium	8597	1.8
Bulgaria	5282	1.1
Brazil	19204	4.0
Canada	21544	4.4
Switzerland	11229	2.3
Chile	6856	1.4
Colombia	9073	1.9
Costa Rica	4602	.9
Czech Republic	5327	1.1
Germany	5001	1.0
Denmark	7481	1.5
Spain	25313	5.2
Estonia	4779	1.0

Table A.1. Number of participants for each country in PISA 2012 (cont.)

Countries	**Frequency**	**Percent**
Finland	8829	1.8
France	4613	1.0
United Kingdom	12659	2.6
Greece	5125	1.1
Hong Kong-China	4670	1.0
Croatia	5008	1.0
Hungary	4810	1.0
Indonesia	5622	1.2
Ireland	5016	1.0
Iceland	3508	.7
Israel	5055	1.0
Italy	31073	6.4
Jordan	7038	1.4
Japan	6351	1.3
Kazakhstan	5808	1.2
Korea	5033	1.0
Liechtenstein	293	.1
Lithuania	4618	1.0
Luxembourg	5258	1.1
Latvia	4306	.9
Macao-China	5335	1.1
Mexico	33806	7.0
Montenegro	4744	1.0
Malaysia	5197	1.1

Table A.1. Number of participants for each country in PISA 2012 (cont.)

Countries	**Frequency**	**Percent**
Netherlands	4460	.9
Norway	4686	1.0
New Zealand	4291	.9
Peru	6035	1.2
Poland	4607	.9
Portugal	5722	1.2
Qatar	10966	2.3
Shanghai-China	5177	1.1
Perm (Russian Federation)	1761	.4
Florida (USA)	1896	.4
Connecticut (USA)	1697	.3
Massachusetts (USA)	1723	.4
Romania	5074	1.0
Russian Federation	5231	1.1
Singapore	5546	1.1
Serbia	4684	1.0
Slovak Republic	4678	1.0
Slovenia	5911	1.2
Sweden	4736	1.0
Chinese Taipei	6046	1.2
Thailand	4407	.9
Tunisia	4407	.9
Turkey	4848	1.0
Uruguay	5315	1.1
United States of America	4978	1.0
Vietnam	4959	1.0