

**DEMOGRAPHIC AND DEVELOPMENT INDICATORS ON
NANO-AWARENESS DIVIDE: FROM MACRO ANALYSIS OF
NANOTECHNOLOGY POLICY TO MICRO ANALYSIS OF THAI
CONSTRUCTION WORKFORCE**

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DEMOGRAPHIC AND DEVELOPMENT INDICATORS ON NANO-AWARENESS DIVIDE: FROM MACRO ANALYSIS OF NANOTECHNOLOGY POLICY TO MICRO ANALYSIS OF THE THAI CONSTRUCTION WORKFORCE

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ABSTRACT

This study served two main objectives: 1) to examine the relationship between demographic and development indicators and nanopolicy at international level; and 2) to examine the influence factors on knowledge, awareness and adaptation regarding construction nanoproduct usage among Thai construction workers. A quantitative approach was employed to provide relationship analysis at the macro and micro level. At the macro level, data from the Population Reference Bureau (PRB) 2007 and UNFPA database were analyzed to find the existing nanopolicy at international level, while micro data was obtained by questionnaire survey of 1,148 workers from the central, north and northeast parts of Thailand from May to August 2009.

The unit of this research analysis was the construction workforce. The psychological model, the Unified Theories and Use of Acceptance Theory (UTATU) model, is employed to measure technology adoption. The results from regression with dummy dependent variable estimation confirmed existing nano-divide at international level through demographic and development indicators. Micro analysis results pointed out the existence of a nano-divide in knowledge, awareness and adaptation of construction nanoproducts usage by demographic and social characteristics of the individuals. The influence of network, work position, and communication generated different outcomes on knowledge, awareness and adaptation, divided among samples. Recommendations are to increase awareness through provision of knowledge to all workforces, especially to labor in large firms through one-way and two-way communication.

The findings can expand existing policy formation to emphasize knowledge distribution among Thai construction workers. This will mitigate knowledge and awareness inequity as well as increase social intelligence among the construction workforce who are faced with possible health and environmental impacts from variables like nanoparticles.

KEY WORDS: DEMOGRAPHIC AND DEVELOPMENT INDICATORS/ NANO DIVIDE /AWARENESS /THAI CONSTRUCTION WORKFORCE

180 Pages

ตัวชี้วัดทางประชากร การพัฒนาและการแบ่งแยกความตระหนักด้านนาโนเทคโนโลยี: จากการวิเคราะห์ระดับมหภาคของนโยบายด้านนาโนเทคโนโลยีสู่การวิเคราะห์ระดับจุลภาคในแรงงานก่อสร้างไทย

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บทคัดย่อ

วัตถุประสงค์ของการศึกษานี้จำแนกเป็นสองส่วนได้แก่ 1) ตรวจสอบความสัมพันธ์ระหว่างปัจจัยทางประชากรและตัวชี้วัดระดับการพัฒนาของประเทศที่มีต่อนโยบายทางด้านนาโนเทคโนโลยีในระดับมหภาค และ 2) ตรวจสอบปัจจัยที่มีอิทธิพลต่อความไม่เสมอภาคด้านความรู้ ความตระหนักและการยอมรับในสินค้าวัสดุก่อสร้างที่ใช้เทคโนโลยีนาโนในกลุ่มก่อสร้างโครงการที่พักอาศัย การวิจัยเชิงปริมาณนี้ใช้การวิเคราะห์ข้อมูลดัชนีการพัฒนามองของ Population Reference Bureau (PRB) ปี 2550 และฐานข้อมูลของกองทุนประชากรแห่งสหประชาชาติ (UNFPA) เพื่อตรวจสอบความสัมพันธ์กับความไม่เท่าเทียมในการมีนโยบายระดับประเทศในด้านการพัฒนาเทคโนโลยีในขณะที่การวิเคราะห์ระดับจุลภาคใช้ข้อมูลจากการเก็บแบบสอบถามแรงงานในอุตสาหกรรมก่อสร้าง 1,055 ราย กระจายในกรุงเทพฯและปริมณฑล ภาคกลาง ภาคเหนือและภาคอีสาน ระหว่างเดือนพฤษภาคมถึงเดือนสิงหาคม 2552

โดยในระดับจุลภาคกำหนดให้แรงงานบุคคลเป็นหน่วยของการวิจัยครั้งนี้ และใช้กรอบแนวคิดตามแบบจำลองทางจิตวิทยา Unified Theories and Use of Acceptance Theory (UTATU) ในการวัดระดับการยอมรับนวัตกรรม ผลการวิเคราะห์พหุคูณโลจิสติกยืนยันความสัมพันธ์ของความไม่เท่าเทียมในการมีนโยบายระดับประเทศในด้านการพัฒนาเทคโนโลยีผ่านปัจจัยทางประชากรและตัวชี้วัดระดับการพัฒนาของแต่ละประเทศ เช่นเดียวกับผลการวิเคราะห์ระดับจุลภาคที่ชี้ว่าความไม่เท่าเทียมกันในด้านความรู้ ความตระหนักและการยอมรับในสินค้าวัสดุก่อสร้างที่ใช้เทคโนโลยีนาโนปรากฏว่ามีความสัมพันธ์กับปัจจัยทางประชากรและสังคมรายบุคคล อิทธิพลของเครือข่าย ตำแหน่งงาน ช่องทางการสื่อสารก่อให้เกิดความแตกต่างด้านความไม่เท่าเทียมกันในด้านความรู้ ความตระหนักและการยอมรับในสินค้าวัสดุก่อสร้างที่ใช้เทคโนโลยีนาโน

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LIST OF ABBRIVIATION

APEC	Asia-Pacific Economic Cooperation
ASTM	The American Standard of Testing and Measure
CRT	Criterion Reference Test
DOI	Diffusion of Innovation
EPA	The Environmental Protection Agency, United State of America
ETC Group	the Action Group on Erosion, Technology, and Concentration, Winnipeg, Canada
ETUC	The European Trade Union Confederation
GDP	Gross Domestic Product
GMOs	Genetic Modification Organisms
GNI, PPP	Gross National Income, purchasing power parity
IDT	Innovation Diffusion Theory
ISO	International Organization Standardization
LFS	Labour Force Survey, by NSO
MDGs	Millennium Development Goals
NANOTEC	National Nanotechnology Center, Ministry of Science and Technology, Thailand
NESDB	National Economic and Social Development Board, Office of Prime Minister, Thailand
NSO	National Statistical Office, Ministry of Information and Communication Technology, Thailand
PRB	Population Reference Bureau
REACH	Registration Evaluation and Authorization of Chemicals
ROS	Reactive Oxygen Species
SCT	Social Cognitive Theory
SI	Social Influence

LIST OF ABBRIVIATION (cont.)

TAM	Theory of Acceptance Model
TPB	Theory of Plan Behavior
TRA	Theory of Reason Action
UNESCO	United Nation Educational, Scientific and Cultural Organization
UNFPA	United Nation Population Found
UNIDO	United Nation Industrial Developments Organization
UNISDR	United Nation International Strategy for Disaster Reduction
UTAUT	Unified Theory of Acceptance and Use of Technology model

CHAPTER I

INTRODUCTION

1.1 Problem statement and justification

Since the discovery and utilization of fire before 400,000 B.C., this very first technology does not only mean to convenience and safety providing for human environment but also lights up the limited vision after dust (James, 1989; Crump, 2001). Later in the renaissance era, diversified technologies were invented into both tangibles and intangibles such as materials, engines and knowledge etc. to reciprocate the original purpose as same as fire was used to be. As technologies crossing through a meaning of expediency to inevitability compared with others, for example, previous steam engine was used to replace coach that it extended the limit of migration or vaccination is a technology to reduce a mortality rate from pandemic during the late industrial revolution. However the relationship between technology and demographic aspect had still not obvious perception until there was Malthus-Boserup regime where some scholars accepted that population growth is limited by resources as capacity for food production is a major constraint of growth (Malthus, 1798). However, Boserup followers considered that technological change in the last 100 years had brought about extended food production to reveal other relationships between population and technological changes (Boserup, 1981). For Neo-Malthus followers, technological change is a major factor for productivity growth that counters the Malthusian concept about constant technology on the productivity limitation (Boserup, 1981; Simon, 1981; Kremer, 1993). These sampled the effect from technology change to population dynamic especially in Europe. Recently with information technology, the word globalization was introduced to hobnails the relationship between technology and population's behavior especially in popular consumption world.

Practically, world society is evolving from Information economy into Molecular economy that Nanotechnology, Biotechnology and Material science are playing the main role on knowledge-driven growth (UNESCO, 2006; United Nation, 2007; NESDB, 2008). Therefore, high expectation about the benefit from these technologies sometime blinds the other side of coin especially the threat from unknown condition of novel properties from manmade technology like nanomaterials. Theoretically, nanotechnology could generate a new opportunity to cure cancer and even any infectious diseases while there are fears about unknown harmful effects of those manmade materials, therefore, many scholars started to investigate the cost and benefit of nanomaterials and products focusing on health, environment and ethic.

In 2003, there was a debate between Two Canadian institutes about the possible impacts of nanotechnology among developing countries. The Joint Centre for Bioethics, University of Toronto mentioned on the potential benefit of nanotechnology on developing world (Court et al., 2004; Salamanca-Buentello et al., 2005). Whereas the nanotechnology divide was raised by the Action Group on Erosion, Technology and Concentration (ETC Group) in Winnipeg arguing that nanotechnology will increase the gap of development between rich and poor countries through political and socioeconomic conditions (ETC-Group, 2003; Schummer, 2007). Besides, in 2005, the United Nations Industrial Development Organization (UNIDO) launched an international conference while UNESCO also established expert group as an international stakeholders for ongoing discussion about nanotechnology dividing topic (North-South dialogue, 2005, UNESCO, 2005). According to the Asia Pacific Nano Forum 2004 on the societal impact of nanotechnology, most Asia Pacific countries have launched policy support but still lack of public awareness (Asia Pacific Nano Forum, 2004). Many studies have been conducted around the world about the social concerns on nanotechnology development and there is still a lack of explanation on social perception of nanotechnology as most countries have low public and industry awareness on benefits and risk of nanomaterials (Sheetz et al., 2005; Fujita, 2006). Normally, most scholars who have published their research on the social dimensions of nanotechnology perception are scientists so they need social science knowledge to understand the influential factors of public opinion and decision making on

nanotechnology (Scheufele and Lewenstein, 2005). Some studies also reveal that the unknown human health and environmental impacts are a bigger concern for scientists than for the public because most who are involved with nanotechnology activities have more understanding of risks as well as benefits than the public which relies on media and also have low nanotechnological understanding (Scheufele, 2008).

According to a study of Salamanca-Buentello et al. (2005), nanotechnology could help Millennium Development Goals (MDGs) achievement especially for construction development. However, there is a doubt about the difference of demographic and socioeconomic backgrounds of each nation on how nanotechnologies can contribute the development equity especially in construction sector where a gap between technology-based and labor-based intensities strongly appeared in both developed and developing worlds. In 2006, European Commission conducted survey research and forecasted that there will be more than 30 percent of nanomaterials such as Silver, Titanium dioxide, Carbon nanotube, etc. widely used within 2010 especially in buildings, road and bridge (Mann, 2006). The study of possibility on construction workers exposed to potential engineered nanoparticles in Italy revealed a warning about occupational health of construction workers who have higher probability to expose the ultrafine materials (Bocconi et al., 2008). With great expectation, many scientists hope that nanomaterials would integrate with bulk materials like cement, wood, plastic, etc to create novel function like anti-bacterial, anti-scratch, stainless, etc. However, possible nanotoxicological impacts on human health and environmental quality are still under investigated by many scholars. For example, a study of Adam and colleague (2006) found the eco-toxicity of nano TiO₂, SiO₂ and ZnO (which are common ingredient in many present construction products) to reactive oxygen species (ROS) like bacteria and mammal (Adam et al, 2006). Some nanoparticles like TiO₂ can also be acute lethality effect and oxidation damage to ROS like aquatic animals (Wolfrum et al, 2002; Long et al, 2006; Blaise et al., 2008). Such clinical research brings about the some concerned about both local and international agencies to established international standard and regulation to control about how to apply the nanomaterials in consumer products as well as occupational health such as Environmental Protection Agency (EPA), National Institute of Occupational Safety

and Health (NIOSH), British Standard Institute (BSI), etc. launch the risk assessment procedure, regulation and safety guideline for occupational health on nanomaterials application in workplace. For example, Canadian government announced that the import of nanomaterials and application more than 1 gram must report to state government for life cycle assessment operation toward safety issue.

At present, there are already more than 5 years where nanoproducts are available in Thai construction market and widely applied without clear knowledge on their certain harmful effect to user's health and environment. For Thailand, the concerned agencies such as National Nanotechnology Center (NANOTEC), Ministry of Science and Technology also launched risk network program on health and environmental quality toward nanotechnology application. Due to this is an emerging issue in Thai society, so there is not yet existing guideline established about how to surveillance and assess the possible health impacts on workers who may potentially expose to release nanoparticles during work operation especially construction workforce. As study of Lee and colleague (2009) raises a concerned of potential environmental and human health impacts of nanomaterials used in the construction industry such as respiratory damage and skin inflammation while there are some gaps of understanding how risk from dose and exposure to them have still not fully understood not only acute toxicity and mortality but also chronic exposure and impact on behaviour of organism (Lee et al, 2009). Moreover, an important area of risk assessment from the EPA and DuPont's Nano Risk Framework is the understanding of how worker exposure to risk products (nanoproducts) such as level of usage, awareness for protection and storage and how people gain information about risk products (source of information) which brings about the further management (DuPont, 2009) for example, if the knowledge and awareness divide was proved among public then proper information should provide through the right source of information to reduce inequity of risk mitigation on health impacts from nanomaterials as already conflict happen on the rights of equity information of nanoproducts for Northern European workers was raised and demonstrated to the European Trade Union Confederation in Brussels (ETUC, 2008). Therefore, it is a reasonable to examine how much level of knowledge, awareness and adaptation divide (have and don't have)

of construction nanoproducts usage among construction workforce. Lacking of the benchmark data about level of knowledge and awareness on nanoproducts usage is an obstacle for further implementation for public understanding on health and environmental protection from unintended particle released of nanoproducts using.

To achieve such goal, this study examines the divide into two levels as macro analysis of nanotechnology divide at policy level. Even without nanotechnology development, our world will continue to grow the development divided as a sample between rich and poor countries but many scholars still hope that nanotechnology could narrow the divide gap of development by providing new alternative solution such as cheaper water purification, more solar energy harvesting, more effective fertilization, etc. if the public in developing countries is well-informed on such technology otherwise the gap may accelerated increase (Sheetz et al, 2005). On the present nanotechnology racing, developed countries dominate the technology advance by allocating budget in both government and private sector like IT that finally attracts to well educated workers from developing countries like a case of United States of America and India on software industry. This industry makes some Indian city like Bangalore being an IT colony for US software market while the poor Indians still struggle from other under developing conditions such as metallic toxic like lead in hardware left from computer manufacturing. For nanotechnology, it may probably follow the case of IT if concerned agencies ignore on this emerging technology. To examine the condition of technology divide at macro level, it needs to employ the development indicators and carefully analyzes about the relationship between those development indicators such as demographic and socio-economic which represent the development status of a countries and allow the comparison among all nations on the emerging nanotechnology indicator which represented by using of term “nanotechnology policy” (UNFPA, 1997; Maclurcan, 2005). After examining of nano divide at national level which gives the inequity development among nations then the focusing at micro level (individual) about the existing divide on knowledge, awareness and adaptation of nanotechnology through the experience on using of construction nanoproducts will be conducted. Therefore, this study aims to take two steps. First this study will examine the effects of socio-demographic development and economic

development indicators such as Infant Mortality Rate (IMR), Total Fertility Rate (TFR), percent of urban population, etc. on nanotechnology policy at the international level. Second, endogenous factors of population responses on technological change, especially in labor-intensive sectors like the construction industry, though awareness and adoption of measurements on nanomaterials application will be examined through the social cognitive model, Unified Theories of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003; Kripanont, 2007), and focus on the role of social influence factors on industrial concerns such as material technological changes like nanomaterials. Due to many scholars are trying to find out the critical issues of nanomaterials in social dimension and polarize problems about nanomaterials application and public opinion, the misunderstanding of nanotechnology application and knowledge about it could generate mistrust between public and policy makers as well as entrepreneurs and labourers as some case of GMOs, nuclear power plant, and industrial estate promotion. Therefore, this study will reveal the relationship between socio-demographic factors that could be considered as development indicators on technological policy like nanotechnology as explained by the Boserupian concept and also investigate the potential influential factors for public awareness and adoption on nanomaterials especially for construction workers who face risk in nanomaterials application. This study would be expected to bear comparison with the survey of nanotechnology and construction industry of European Commission 2006. Additional investigation of the awareness and adoption of Thai construction sector of nanotechnology should provide better policy implications and regulations on labor issues.

1.2 Research questions

1. At macro analysis, are demographic and socio-economic indicators having a significant relationship on nanotechnology policy divide?
2. What are the influential factors on awareness and adaptation of nanoproducts usage in construction work among construction workers?

3. Does social influence factor have a significant relationship to the increasing of awareness on unknown risk and adaptation of nanoproducts usage in construction work among construction workers?

1.3 Research objectives

1. To investigate the relationship of demographic and socio-economic factors on nanotechnology that could confirm the inequity of technology divided at international level.
2. To identify influential factors on awareness of unknown risk and adaptation of nanoproducts usage in construction work among construction workers.
3. To examine the relationship of social influence to the increasing of awareness and adoption of nanomaterials in construction work among stakeholders such as construction workers and entrepreneurs.

1.4 Study contributions

Boserupian perspectives on inequality development through technology transmissions in agricultural technology such as food supply development are influential and many followers replicate such studies. This study will replicate Boserupian perspective through material technology development and explores the distribution of technology transmission through the links between socio-demographic factors and development indicators and nanotechnology policy application with respect to Millennium Development Goal's global partnership of development goals (UN, 2007). The aim is to reveal what the impacts of nanotechnology will be on the Thai construction industry through the lens of stakeholders. The findings from this research will also explore what information channels construction workers can access as well as what are the influential factors on awareness and adoption. This study is based on the Cognitive Miser Model and UTAUT model which assumes that making decisions based on little information is in fact making rational sense (Fiske and Taylor, 1991). Also, this study will examine the influence of social factors by adjusting the UTAUT model to examine the Thai construction industry under the concept of Social

Hierarchical Levels. Finally, this study aims to enhance situation awareness as a part of social intelligence by investigating the potential factors on raising awareness of nanomaterials in Thai construction sector which could be compared with the same issue in other countries to contribute solving problem on raising public awareness through a pilot case study of the Thai construction industry. The benefit of this research result will also generate the expected solution to reduce ethical conflict on nanotechnology as knowledge and awareness divide.

1.5 Limitation of the study

Even though nanotechnology is an emerging field especially for social science, but similar survey research has been conducted on the level of knowledge and awareness in public as the result in United State and Japan shown that public still lack of knowledge and awareness about what is nanotechnology (Sheetz et al, 2005; Scheufele and Lewenstein, 2005; Takemura, 2008). Previous survey showed the overall low level of knowledge and awareness about nanotechnology among general public and recommended that it is not fair for those who remain unclear about what is nanotechnology to support this emerging field and it seems that who have little or nothing about nanotechnology will made up their mind to against this technology like in Belgium Labor Union. This study will focus more details on construction workforce as mention by previous studies in United State and Japan. However, there are limitation should be described as

1. As same as other previous study about public perception on nanotechnology, this study also treats that all respondents have no variation on their knowledge background due to nanotechnology is accepted as the new emerging technology in society. However, the questionnaire is intended to study the fundamental rights of labor on risk information accessibility from nanoproducts which were strongly mentioned by European Union that workers who have potentially exposure to products that contain with engineered nanomaterials as present must be regulated by International Organization for Standardization (ISO) and American Society for Testing and Measurement (ASTM) and a kind of chemical hazardous materials (under ISO/TS

27687 and ASTM E2456) should be declared to those worker (ETUC, 2008). However, this study can not vividly point out health impact from nanoproducts usage owing to research method limitation as the researcher can not do blood check for investigating a relationship between harmful dose, period of exposure and possible health impact from nanoproducts usage among the workers.

1.6 Term of definition

Development indicators mean the indicators applied for measuring the development of demographic and socioeconomic conditions at international level according to Population Reference Bureau (PRB) 2007.

Macro analysis means the analysis from macro level that analyzed the relationship of demographic, socioeconomic and nanopolicy indicators from PRB 2007 and in micro level analyzing relationship between awareness of nanotechnology (nano awareness divide) and construction workforce data gained from survey.

Nano-awareness divide means “aware or unaware” about some nanoproducts which samples of this study had been exposing to. The extent of common knowledge about disaster risks, the factors that lead to disasters and the actions that can be taken individually and collectively to reduce exposure and vulnerability to hazards.

Nano-knowledge divide means “knowing or don’t know” about some nanoproducts which samples of this study had been exposing to.

Nano-adaptation divide means “adapted to use or don’t adapted to use” about some nanoproducts which samples of this study. It’s concept employ the definition of “adaptation” that attitude of the adjustment human in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (UNISDR, 2009).

Nanotechnology is a technology relating to create and manipulate materials or system in a range between 1 and 100 nanometer under precise controlling (Booker and Boysen, 2005). Moreover, the creation must perform novel properties of the materials or system towards the benefit of socio-economic aspect (Teparkum, 2008).

Thai construction labor force means workforce in Thai construction sector covering entrepreneurs, architects, engineers, technicians, craftsmen and construction labor.

Nanoproducts means products such as cement, paint, wood, adhesive, plastic, contained materials that have been engineered and claimed that they are nanoproducts by commerce and advertisement. Moreover, this study defines meaning according to the definition of nanotechnology that products must perform “novel properties” such as anti-bacterial, stainless, UV protection, etc.

Social intelligence means the ability of individual to understand and manage to interact with other person that brings about the adaptability toward social change (Thorndike, 1920). Similar to social learning theory, social intelligence hypothesis still be under investigate about it term as new word in social cognitive science. However, this study extend the original meaning of Thorndike’s definition of social intelligence through the study of Albrecht’s model of “situation awareness” by giving the mean of “awareness” as public awareness that is “the process of informing the general population, increasing level of consciousness about risks and how people can act to reduce their exposure” (UNISDR, 2009).

Norm means pattern of behaviour in a particular group, community, or culture, accepted as normal and to which an individual is accepted to conform. Social Norms are the rules for how people should act in a given group or society. Any behavior that is outside these norms is considered abnormal (Lewis, 1969; Hume, 1978). Therefore, norm of construction workforce in this study was defined that pattern of workforce behavior who accepted to use the construction materials according to standard or industrial regulation which are formed by peer organizations like ISO, Thai Industrial Standard where indicated the qualified materials must be used to served social achievement.

Social network means a tie that made by individual (or organization) focus on similar interest such as friendship, kinship, relationship of belief, etc (Freeman, 2006). This study defined social network of construction sectors as “construction network” where is a place of individual who practice in the area of construction sector such as engineer, foreman, labor, etc. They have the same common of interest on construction technology and system use and tied together by sharing of information within organization and interplay with their construction society.

Communication (media) means a source of information that man can learn about their social and environmental change (Bandura, 1977). According to Bandura’s Social Learning Theory, this research adapted original concept of human learning from media to examine whether communication (media or source of information) influence of construction workforce’s knowledge, awareness and adaptation on construction nanoproducts or not.

CHAPTER II

LITERATURE REVIEW

Even nanotechnology is an upcoming technology that few scholars recognized but concerned scholars forecasted that it will be a disruptive technology which affects life in the 21st century. In social science, this technology is the newest arrival one that needs to discover the overwhelming gaps under social context. Through this study, finding is aimed to explain the pattern of knowledge transferring and awareness rising among Thai construction workforce that correlates with the new impact technology.

This chapter explores the existing theoretical and empirical knowledge that contributes to the understanding of knowledge transferring, awareness rising and nanotechnology. The chapter begins with brief overview of the historical relationship between demographic and technology change through Malthusian-Boserupian era. The explanation the meaning of nano-divided and it relates to inequity among the one who has or not has. Background of concerns is still debatable among agencies on the impacts of this technology on human health and environment. The existing policy and recommendation at both international and domestic level on probability risk from expose to nanomaterials was also presented. Existing theories and concept of social intelligences and how to measure behaviour outputs on technology change through the Unified Theories of Accepted and Use of Technology (UTAUT) model. The relationship between socio-demographic characteristic of construction workforce and knowledge transferring that relates with awareness rising is mainly conceptualized based on the empirical research evidence. The aim of this review is to identify the existing knowledge as well as theoretical and empirical research gaps that need to be explored in order to deepen understanding of the subject. The conceptual framework in this study was designed into 2 level as macro analysis that examine the existing of nanopolicy divided at international level and micro analysis that examine the existing

of knowledge-awareness divide among Thai construction workforce. For micro level the framework was developed from UTAUT model by considering multiple factors associated with the demographic, social characteristic on knowledge and awareness of nanoproducts in construction industry. It considers social factors that affect construction workforce in forms of hierarchical influence such as education level, work position, size of firms, etc. Research hypotheses are then proposed based on the literature.

2.1 Malthusian-Boserupian and Technological changes

Under the Malthusian method, the population size and growth depends on the food supply and agricultural method (Malthus, 1798). Malthus argued that population will always tend to overrun the growth of food production, causing famine, war and illness. In the Malthusian perspective, food supply can only increase by the arithmetic ratio, while population increases in geometric ratio. That is to say, some positive checks like the death rate from war and famine will constrain the growth of population, while some preventive checks like decreasing of the birth rate from abortion, infanticide and birth control also limit the increase of the entire population. However, some scholars point out that Malthus also argued the important of technological influences on food production and wage level of labor (Daly, 1971; Galor and Weil, 2000). Malthus's viewpoint on labor class was that the increase of income per head of population will also bring about the increase of labor supply through higher fertility, while most evidence has shown the inverse effect occurring in the relationship between income and fertility in the post industrial period (Daly, 1971; Mallick and Ghani, 2005).

Through the lens of human capital development as productivity enhancement, education plays an important role in human capital accumulation as it directly affects increasing of wages. When the wage increases as labor skill increases, the minimum subsistence also increases due to the better facilities which can be accessed by the majority of the population through the educational system.

Infrastructure will also be developed by innovators who mostly reside in the dense area such as cities (Kremer, 1993; Klasen and Nestmann, 2005). Another explanation of technological effect on fertility decline is Davis's Multiphasic Response Theory (1963). Davis explains the population's response to development as economic induction. New machines can help to reduce manpower as the improvement of the literacy rate has a positive impact on the rate of growth of labor productivity so there is less demand for higher reproduction as people enjoy their economic opportunity as well as seeing burden from having a lot of children. This has been a cause of fertility decline in industrial countries like Japan (Davis, 1963; Prskawetz et al., 1999).

Boserup stated the doctrine that argued Malthusian views on technological effect, as "necessity is the mother of invention", as, under pressure, people will find out ways to increase the productivity of food by increasing workforce, machinery, fertilizer, etc. so that the limits of population growth can be extended by technology improvement on their subsistent food demand (Boserup, 1981). Her thesis and work on agriculture technology and population dynamics emphasized that people are problem solvers who will never give up under any constraint and will try to find the way out for problems so with these conditions the fluidity of resource carrying capacity would exist through technological development for better gathering. For nonagricultural technology such as war, health and transportation, this directly effects population changes through fertility, mortality and migration. From primitive to industrial societies, Boserupians also stated that technology development has positive increase along with the population size and density where the urban craftsmen are easier to find than in remote and low density rural areas. Due to those craftsmen's needs to serve their customers problem on equipments to accelerate their productivity as well as dense productivity there is always a need for high skilled labor for mass operations like irrigation and mass transportation system (Boserup, 1976; Weisdorf, 2003). Besides human capital and technological development is always parallel to income increasing as farmers in agricultural to industrial transition societies such as Japan, Taiwan and South Korea favor to support their children on education attainment rather than being only farmers as they are (Oshima, 1983).

For neo-economist scholars, Galor and Weil (2000) about the population transition of Western Europe mentioned that there are three-stage of transition. The first stage is Malthusian, the next is post-Malthusian and the last is Modern. In the early stage technological development is very slow, as there is a positive increase for both income and population. In the post-Malthusian period, the income rate is accelerated with the relationship between growth of income and population (Mallick and Ghani, 2005). The standard of living also increases as income increases. As health and wellbeing improve the mortality rate decreases, while constant fertility rate occurs and net increase in population is positive. By the end of the 1800s in Western Europe, the population growth rate started to fall while it was a time of rapid technological improvement that left a consequence of rapid increasing of income. A reason at this final stage of transition is the increased rate of return to human capital as the literacy rate accelerated as it influenced the family's decision to substitute quality for quantity of children (Galor and Weil, 2000; Mallick and Ghani, 2005).

Both Malthusian and Boserupian adherents may be correct because they base their ideas on different views. Malthus refers his concept on the limitation of environmental perspective while Boserup refers her model on the phenomenon of cultural and technological development (Kermer, 1993). However, the non-agricultural technology likes material development Both Boserupians and Neoclassical Economists make a common assumption, namely, the substitutability of factors of production which try to explain the natural limits of carrying capacity that may consider in terms of today's sustainable development.

2.2 Nanotechnology divide, development indicators and unknown risks

2.2.1 Nanotechnology divide

Most rich countries where commonly measured by per capita gross domestic product (GDP) can always own every advanced technologies that benefit to

their socioeconomic conditions and now the nanotechnology also called molecular manufacturing is a coming technology that seems to serve those who have high purchasing power than others. This uneven development has been raised in 2003 and still being hot potato among international organization in the ethical aspect of how one can “have or not have” this tiny technology towards the Right based approach. In 2003, the polarized of nanotechnology development between rich and poor worlds was raised by the Joint Centre for Bioethics from University of Toronto which mentioned that nanotechnology could have potential benefit to reduce the development gaps between developed and developing world (Court et al., 2004; Salamanca-Buentello et al., 2005). In remote areas where indigenous people rarely to access to better medical service, early disease diagnosis can be promised by nanoliter system (Lap-on-a-chip) that helps to detect infectious diseases such as malaria, HIVs, Dengue fever, etc. at the early state and reduce the mortality while some nano sensor can help to detect chronic illness such as hypertension, diabetes, cancer, etc. as well (Appendix A) (Salamanca-Buentello et al., 2005). However, the Action Group on Erosion, Technology and Concentration (ETC Group) in Winnipeg disputed that nanotechnology will increase the gap of development between rich and poor countries though political and socioeconomic condition (ETC-Group, 2003; Schummer, 2007). ETC-Group mentioned that nano divide will follow previous digital divide and genomic divide that increase the development gaps between industrialized and developing countries. Later in 2005, the United Nations Industrial Development Organization (UNIDO) launched an international conference as UNESCO also established expert group that bring international stakeholders for ongoing discussion about technological dividing topic like nanotechnology (North-South dialogue, 2005, UNESCO, 2005).

In 2003, there are 10 developing countries that are categorized as front-runners of nanotechnology development and Thailand is in the middle range of the global nano race at the moment. There is no doubt about potential impacts of nanomaterials on Thai economic development. Also, the Asian Pacific Nano Forum and UN Millennium Development Goals stated that nanotechnology raises hopes of quality of life improvement (Ramón Compañó and Hullmann, 2002; Salamanca-Buentello et al., 2005; Maclurcan, 2005; NESDB, 2008). However, there is huge gap

between government support, implementation and public awareness of new emerging technology.

2.2.2 Nanotechnology policy

A policy is typically described as a deliberate play of action to guide decisions and achieve rational outcome. This term may also apply to government, private sector organizations and groups, and individuals. Broadly, importance of policies is intended to avoid some negative effect that has been noticed in the organization, or to seek some positive benefit. A broad “science and technology policy (S&T policy)” means the guiding principles and rules that is in order to develop the science and technology and the relationship between them of a country or region, and even a department in a certain period of history and strategic objectives (Jianhua et al, 2008). The philosophy of technology policy is based on confidence in its own excellence and ability to reach an even higher level of development (Szanto, 1996). The guiding principle of rationale for S&T policy was involved with intellectual property protection for industrial research and development (R&D) such as human capital resource development (academic and training) in order to overcome the limitation of development as well as other “hard” technologies like infrastructure and facilitating tools (Jacobs and De Man, 1996). For specific S&T policy like nanotechnology, it is a type of public policy that engaged responsible agencies to promote and develop on research, diffusion on benefit technology while minimizes the negative effect on socio-economic development of nation (Macnaghten, 2005). Therefore, the international agencies like the Organization for Economic Co-operation and Development (OECD) announced the policy on establish the Working Party on Nanotechnology (WPN) in 2007 under the Committee on Scientific and Technological Policy (CSTP) to advise on emerging policy-relevant issues in science, technology and innovation related to the responsible development and use of nanotechnology and cooperate with the OECD Chemicals Committee Working Party on Manufactured Nanomaterials in 2006 where is working on international cooperation in health-related and environmental safety-related aspects of manufactured nanomaterials. According to world wide nanotechnology policy reviewing from 364 governmental agencies (58

nations) that the rank of policy issue on nanoscience and nanotechnology development are shown in figure 2.1 below.

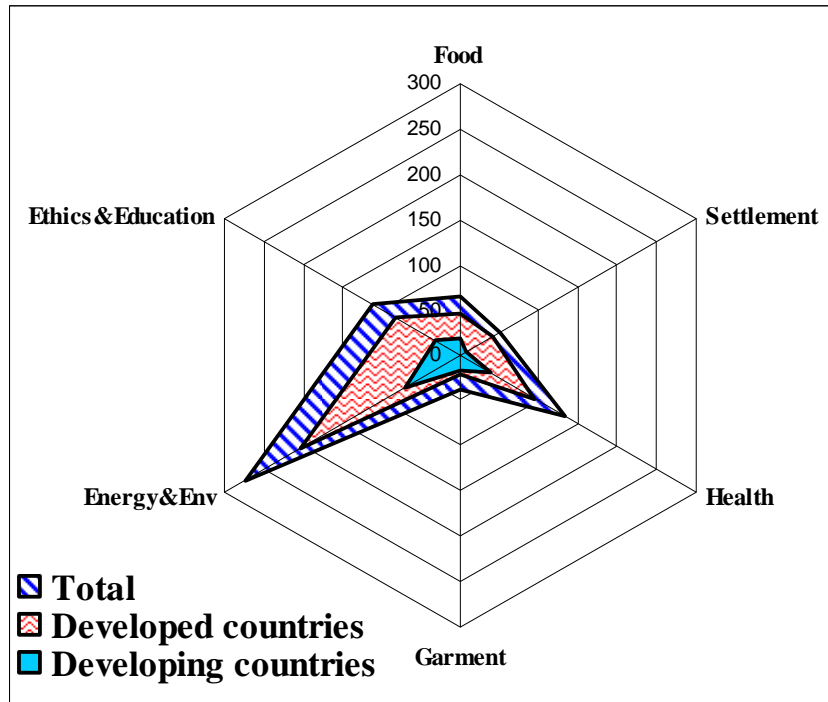


Figure 2.1 Comparison of national nanotechnology policy world wide

As the above figure shows that most existing nanotechnology policies are prioritized focusing on energy and environmental research and development such as energy saving batteries and devices, fuel cell, data memory, ecotoxicity detector, etc. while health, ethic and education was also under consideration among both developed and developing countries.

In 2008, the European Commission launched REACH regulations on chemicals and nanomaterials which European labour unions in Belgium were against because they consider that nanomaterials and products should declare their ingredients clearly, especially in regards to human health and environmental impacts. (ETUC, 2008). The European Trade Union Confederation (ETUC) has also requested some training, more information, and regulation to promote awareness among labourers in the logistic sector. Some laboratory studies have revealed that there is the possibility that malignant brain tumors can develop from nano-particles inhalation like the

Buckminster Fullerene (Bucky ball-C₆₀) shown in animal testing. In another nanotoxicity case in USA, the Environmental Protection Agency (EPA) announced the withdrawal of about 60 silver nanoproducts due to uncertainty about their role in human health and environmental contamination. Many scholars conducted research towards toxicological impacts of nanomaterials as some evidences warned that nanoparticles may be more toxic than larger particles of the same substance because their larger surface area and high ratio of particle number to mass that can be more absorbed into contacted surface than its bulk size (Lam et al., 2004; Gurr et al., 2005).

2.2.3 Risk concern on nanoparticles and nanoproducts

Risk can be defined as “expose” multiplying by “hazard” and many studies try to investigate engineered nanoparticle’s toxic effect on living organism and environment. However, there are few studies started to examine the risk of expose to engineered nanoparticles. Some possibilities of nanoparticles shown are dermal, inhalation and oral absorption as they have potential accumulation and cause damaging on living organism’s DNA (Monteiro-Riviere and Rayman-Rasmussen, 2006). A study of nano Zinc Oxide (ZnO) particle of Lim and colleague (Lim et al, 2009) show nano ZnO particle leads to cell membrane damage and oxidative DNA damage among Reactive Oxygen Species (ROS) as caused of cytotoxicity in human lung epithelial cells as well (Lee et al, 2009). Even many study of impacts on human health and environment effects from nanoparticle still under processed. There is also needed to classified each nanoparticle because each nanoparticle in different shape and size will produce difference effects on living organism as a sample of nano Silica Dioxide (SiO₂) which common used in ceramic industry and Titanium Dioxide (TiO₂) which available in construction nanoproducts like painting and coating are also suspected cause pulmonary impairment and function change and later damage in human lung than leads to a kind of carcinogen (Lim et al, 2009). Even still needs more strong evidence to confirmed cause of human health damage from nanoparticles from available products but to reduce possible health impacts as “precautionary principle” was also considered as alternative, the regulation are already launched by many well known organizations i.e. Environmental Pollution Agency (EPA), ISO and ASTM,

etc. while most public in both developed and developing countries still have little information about how nanoproducts can effect their life (Scheufele and Lewenstein, 2005; Sheetz et al., 2005).

Another question is about “how labor can aware and apply nanomaterials even they do not know or having less knowledge on the materials. According to the report of the Royal Society and The Royal Academy of Engineering, there is possible nanomaterials that can be left behind if we don’t manage them properly and those left behind particles could accumulate in ecosystem and later through food chain (The Royal Society and The Royal Academy of Engineering, 2004). By the way, risk controlling and assessing should be applied with nanomaterials application due to those nanoparticle can be considered as a chemical particle which has potential accumulation to human cellular and micro organism through ecosystem (figure 2.2) (National Institute for Resources and Environment, 2004).

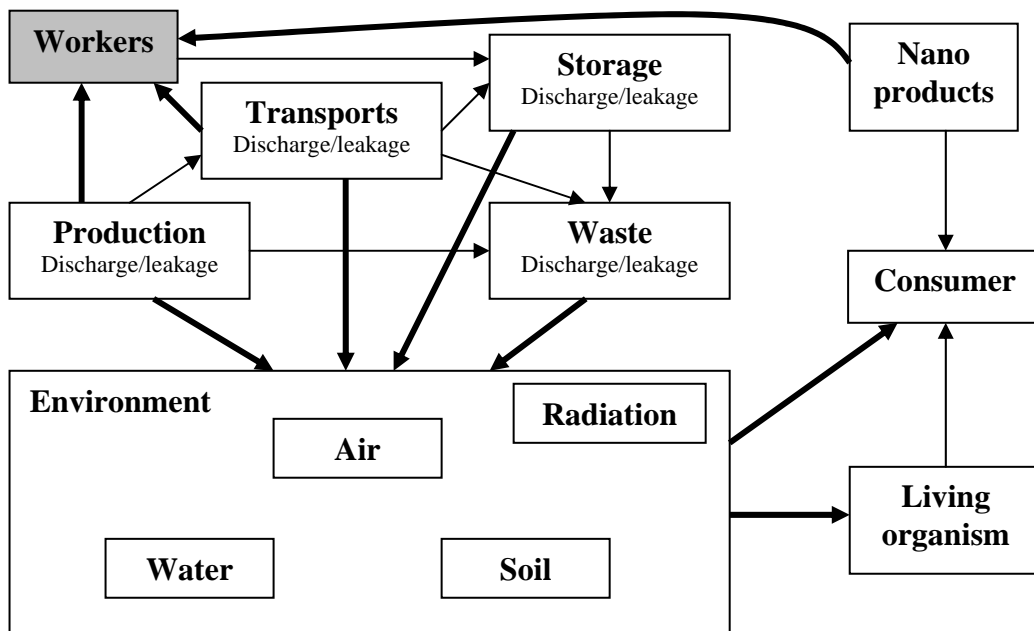


Figure 2.2 Some possible exposure routes for nanoparticles and nanotubes based on current and potential future applications (National Institute for Resources and Environment, 2004)

Unfortunately National Nanotechnology Center (NANOTEC), Ministry of Science and Technology who takes responsible for nanotechnology development has not yet established the clearing house system for nanoproducts provided in Thai market. But the centre only informed that there are more than 100 nano construction products at present. However, construction industry is not prioritized in National Nanotechnology Roadmap. It means that this sector might not be much paid attention among concerned authorities (figure 2.3) (NANOTEC, 2003).

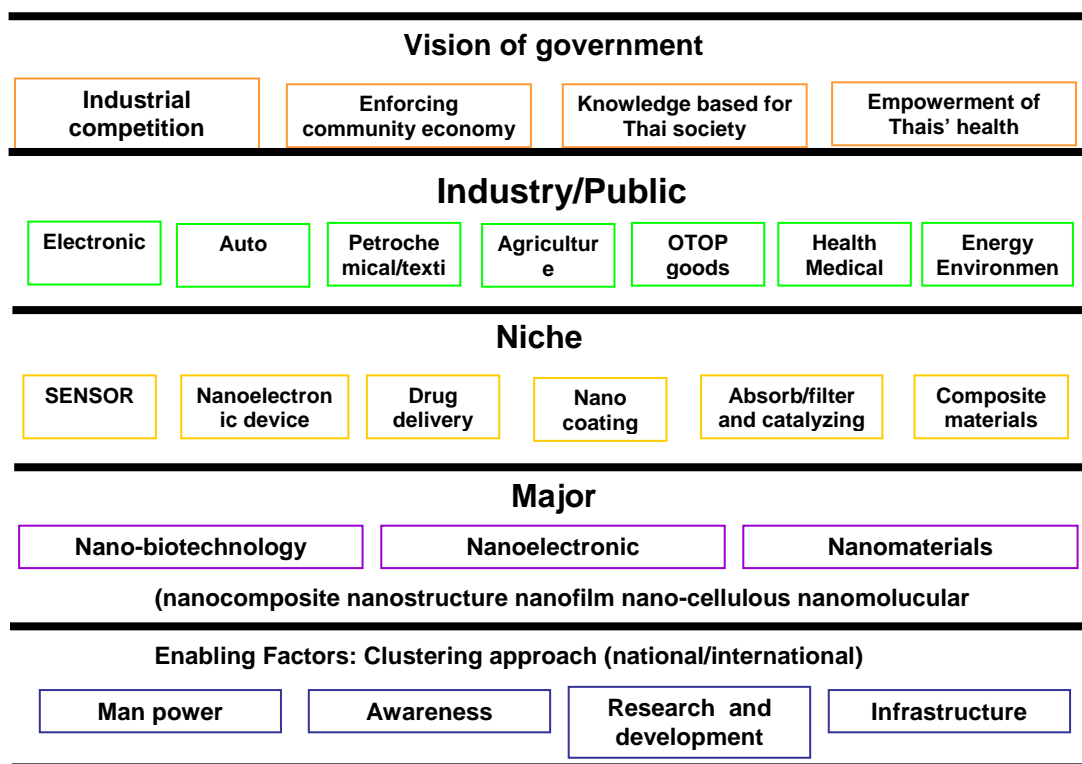


Figure 2.3 Framework Strategies for Thailand Nanotechnology Development 2004 – 2013 (NANOTEC, 2003)

Awareness is an importance factor in Thai Nanotechnology Development plan, therefore, this study tries to examine how to increase awareness especially among the vulnerable people like construction workers who are working closely with new materials today.

This study also intends to examine the risk exposure of construction workforce who may use construction nanoproducts without risk awareness on health and environmental impacts from unintended releasing. Moreover expected finding could help to understand what are communication channels of workforce who expose to risk of nanoproducts usage? since it will help to increase their knowledge and awareness of construction nanoproducts usage through policy recommendation and understand existing adaptation of usage among experienced workforce who already applied construction nanoproducts in overall picture. Therefore, this study area will fall in part of risk communication at shadow area in figure 2.3 below.

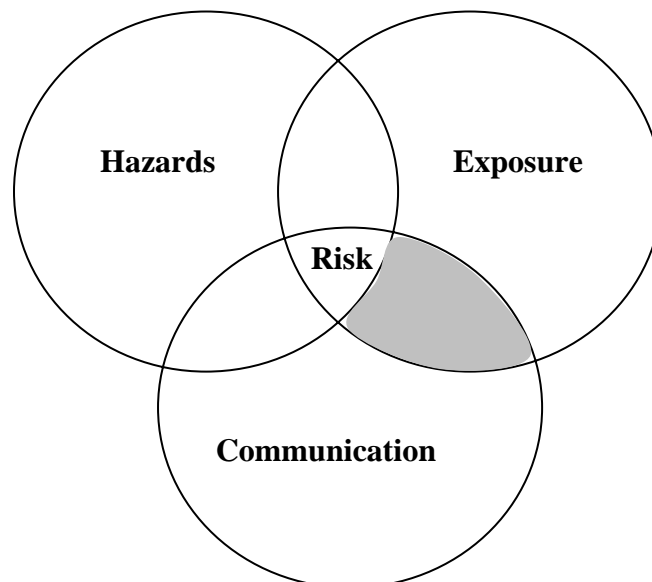


Figure 2.4 Nano Risk Communication extracted from Nano Risk Framework Assessment (adapted from DuPont, 2009)

2.3 Urbanization and Thai construction workforce

Urbanization growth is associated with construction material consumption increased in developing countries. The urban population and economic development need infrastructure investment that consumes materials like concrete, wood, plastic, etc. to construct power plants for electricity supply, irrigation, transportation and housing. Bangkok is a Mega-city in South East Asian where dense of construction and urban sprawl has been emerged for more than 30 years ago. Presently Bangkok

construction is still in the process of Mega project such as extended new town nearby the new Bangkok International Airport, sky link train, condominiums, etc. to serve Bangkokian. Therefore, most big construction firms reside their headquarters in Bangkok and periphery. Obviously, Thai construction workforces are mostly unskilled workers (68.7%) who have completed only class 6 by average. (table 2.1) (figure 2.4) (NSO, 2006).

Table 2.1 Age, gender and year of education of Thai construction workers 1997-2000

Construction	1997		1998		1999		2000		Average	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
age	34.4	11.5	34.8	11.2	35.2	11.0	35.6	11.3	35.0	11.2
gender (male = 1, female = 0)	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4
year of education	5.7	3.2	6.0	3.1	6.1	3.4	6.1	3.2	6.0	3.2
N	2,066,646		1,452,437		1,418,730		1,381,851		1,579,916	

Source: calculated from NSO, 2006

Majority construction workforces are male and have mean age at 35 years old. After economic crisis in 1997, the number of technician and craftsmen sharply decline from 600,000 in 1997 to about 200,000 in 2000 which explain the crisis of construction market during such a period.

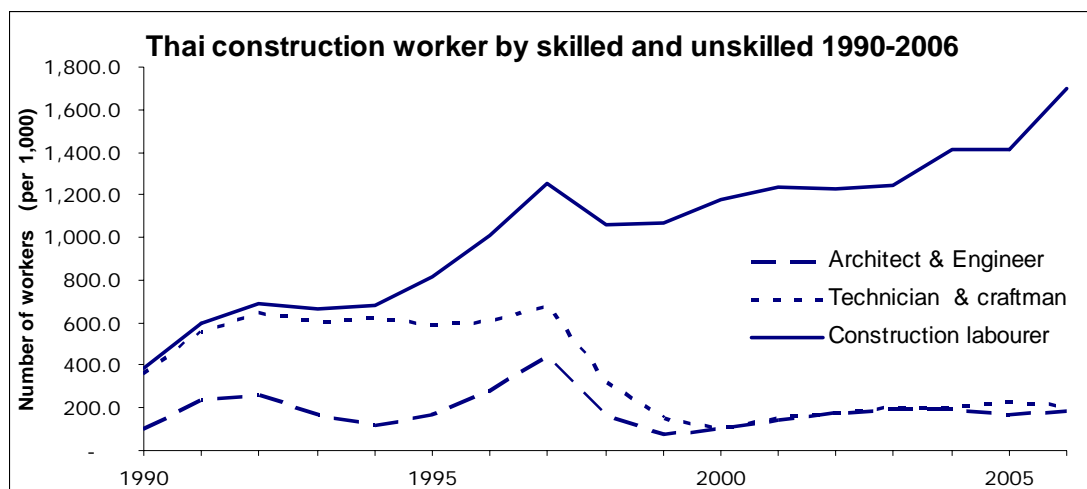


Figure 2.5 Thai construction worker classified by skill level between 1990 and 2006 (calculated from Labor Force Survey, 1990-2006)

It is interesting to examine that how about 2,000,000 construction workforces adapt and prepare themselves for new construction products as nanomaterials. Especially, examination the relationship between the nano awareness divide (known or unknown) among low literacy workforces in construction firms and the information divide through the firms themselves will help to explain the situation of technology divide in this industrial sector. This study would also employ the method of Technological Transfers from previous Psychological theories which used to be clarified the relationship between human perception and technology.

2.4 Social Cognitive Theory and Awareness measurement

Based on social learning methodology towards technology application, Miller and Dollard (1941) proposed the theory of social learning. Later, Bandura and Walters (1963) broadened the social learning theory with the principles of observational learning and vicarious reinforcement. In 1977, Bandura provided his concept of self-efficacy, while he refuted the traditional learning theory for understanding learning. The social cognitive theory (1986) provided by Albert Bandura helps to explain how people acquire and maintain certain behavioural patterns (Bandura, 1963). It indicated that personal cognitive (awareness and adoption) can be viewed as the product of dynamic interplays between environment and behaviour. For example, common people mostly follow and believe what the majority believes or social norms. In another case, children will imitate what they see. Bandura's experimental always plays with two terms 1) cognitive (awareness) and 2) imitation (adoption).

Another interesting theory is the Law of Imitation (1904) that was introduced by Gabriel Tarde (Bruno Latour), a French sociologist, who had a great debate concerning the nature of sociology and its relation to other sciences with Emile Durkheim (Bruno Karsenti) at the Ecole des Hautes Etudes Sociales in 1903. He proposed the concept of imitation to explain how personal imitation was influenced by environment. This is exemplified by: 1) people imitating others. If crime begins as a fashion, it later can become a custom" 2) the inferior usually imitating the superior

and; 3) the newer fashion displacing the older one. He was the first to draw an S-shaped curve to explain the diffusion process which was later influential in Everette M. Roger’s Diffusion of Innovation (DOI) theory (Roger, 1995).

According to social psychologists and technologist, there are many theories and models which have been introduced to explain how entrepreneurs and customer accept the new technology. Information technology is an example of disruptive innovation. For instance, the demise of the traditional typewriter in favour of the computer has effects on a secretary’s occupation and she or he needs to adapt. These theories are shown in table 2.2.

Table 2.2 Prominent theories of Social psychologist and technologists on Technology acceptance

Theory or model	Originated Author (s)	Year
Innovation Diffusion Theory (IDT)	Lazarsfeld et al;	1949
Theory of Reason Action (TRA)	Fishbein	1967
Theory of Plan Behavior (TPB)	Ajzen	1985
Theory of Acceptance Model (TAM)	Davis	1986
Social Cognitive Theory (SCT)	Bandura	1986
Unified Theory of Acceptance and Use of Technology (UTAUT) model	Venkatesh et al,	2003

Obviously, social psychologists and technologists have tried to examine the relationship between society and individuals and technological change in various ways from Innovation Diffusion Theory (IDT) to Unified Theory of Acceptance and Use of Technology (UTAUT) models which combine all the strongest points of Social psychologists and Technologists to explain the individual response to technology change (Appendix C) (Kripanont, 2007). In addition, Venkatesh (2003) compared IDT, TRA, TPB, TAM and SCT as he found these models can explain between 17% and 53% of usage behavior. For example, TAM when including gender variable can increase variance explained by 52% compared to approximately 35% in cross-

sectional test of all. Therefore, Venkatesh (2003) introduced UTAUT model which is combined all models and it can explain behavior intention and usage of technology as highest power (adjust R^2 was 69%) (Venkatesh, 2003; Kripanont, 2007). The UTAUT use direct determinants of user acceptance and usage behaviour such as performance expectancy, effort expectancy, social influence, and facilitating conditions. The key moderators in the model are age, gender, voluntariness of use and experience (see Appendix B).

Under the umbrella of Social Cognitive Theory on how to measure awareness from technology change, this study would employ demographic characteristic as introduced by UTAUT model such as age, gender include voluntariness of use and experience of individual to examine the awareness on technological change like nanotechnology application in construction products which would be help to explain the level of different among Thai construction workforce who may facing with uncertainty risk of expose to ultra fine particles as mention by some scholars.

2.5 Conceptual Framework

2.5.1 Macro determinants on nanotechnology policy

Neo-Malthusianism challenged the limitations of the Malthusian perspective on food supply by investigating technologies of food production (Lipton, 1989; Ruttan, 2002; Hirschman, 2004). Boserupian scholars also tried, through population studies, to extend understanding why some technology fails to be transmitted in some societies (Boserup, 1976; Roumasset and Smith, 1981; Weisdorf, 2003). This study will again examine the influence of technology in the way that Boserupians and neo-Malthusians did in agricultural technology but concentrated on the application of sociological method to examine the development indicators such as demographic and socioeconomic index on nanotechnology policy. The study aims to explore nanotechnology applications on policy support distribution though the links of development indicators at the international level. Therefore, demographic indicators

such as mid-year population, birth rate, death rate, net migration and growth rates which represent the relationship between population size and technological will be looked at for their implications for decision making in policy on nanotechnology (Enrlich, 1986; Klasen and Nestmann, 2005).

Societies which have some health development indicators such as Infant Mortality Rate (IMR) and Total Fertility Rate (TFR) at low levels are normally developed countries. It will be pointed out that those societies have high levels of development because most industrial societies generally have low levels of IMR and TFR. Both indicators can be used to explore policy-related implications of technology advances such as nanotechnology.

Where there are better economic and public health systems, life expectancy at birth (e_0) is high in both sexes. The percentage of married women who use contraception is also higher than in developing areas. Therefore, these indicators will be examined to reveal their associations with nanotechnology policy. Quality of labor supply is also considered in this study to check whether nanotechnology policy could be a substitute for the labor supply, especially for those labor forces aged between 15-49 years old who living with HIV/AIDs. The other development indicators such as percentage of under weight under 5 year-old children related to level of development. Gross National Product (GNP) will be counted as economic development (Kuznets, 1967; Boserup, 1981). Most developed nation consumes higher energy than less developed ones. This will be measured through Carbon Dioxide emission as higher emissions mean higher levels of development. Most developed countries will have high density of population when compared with other developing nations. However, this may not always be true, as the cases of the United States and China show, but at least it can indicate the level of development according to Boserupian viewpoints on the relationship between population density and technology invention (Klasen and Nestmann, 2005).

For sociology study, macro analysis on technology policy from demographic factors has been recommended as a potential methodology for contextual analysis

(Mason et al., 1983). In socio-demographic studies, fertility and economic indicators like TFR and GNP have been examined for their macro influences on the micro level (Entwisle et al., 1986). This study used the multilevel analysis method to investigate the relationship between population factors and decision making on development policy.

2.5.2 Micro determinants on nanomaterials recognition

Survey on Nanotechnology in European construction industry indicated that Nanotechnology will have effects on construction industry within 10-15 years so the conceptual framework for this study will investigate the effect of nanomaterials awareness on existing construction workers who will get direct effects in the form of possible structural change from material technology implications in the future. Even, there are rarely nanomaterials implications that declare themselves as nanomaterials in Thai construction market but it still can classify other non-declaring of nanomaterials by their characteristic and new efficiency as it could be recognized by comparing with other traditional materials. As previously mentioned, forums such as the APEC Nano Forum 2004 about the increasing public awareness and industrial impact are urgently needed. With the UTAUT model, the researcher is using such a model adjusted for this research conceptual framework (Figure 2.5) as follows.

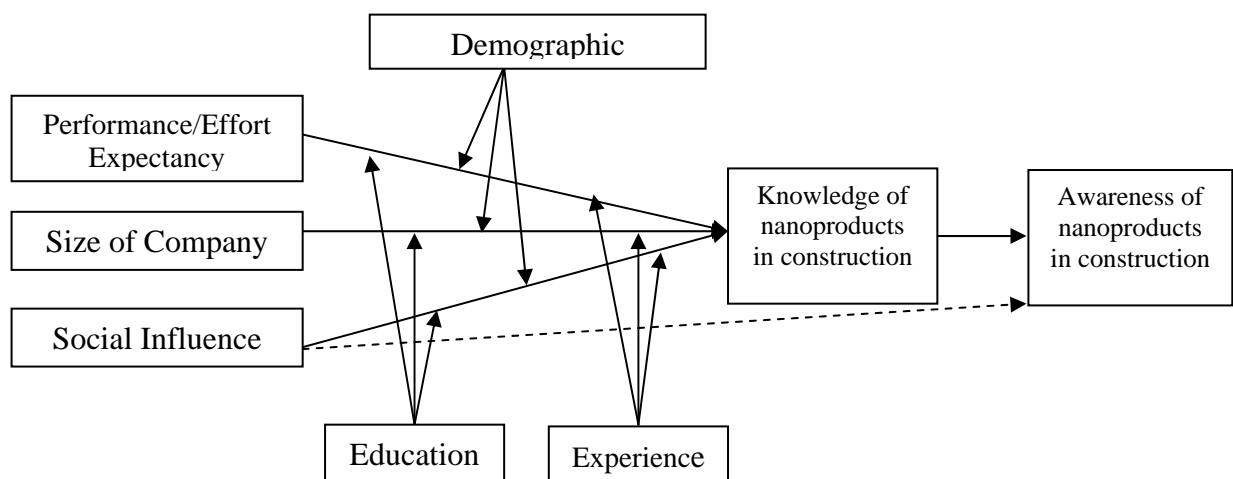


Figure 2.6 Conceptual Framework for exploring knowledge and awareness of nanoproducts

Performance/Effort expectancy has significant correlation to behavior intention of technology use. Davis, Bagozzi and Warshaw (1989) and Kripanont (2007) revealed that performance and effort expectancy increases explanatory power of the model in predicting user behavior towards technology adoption for IT. Study of variables of performance/effort expectancy that will be conducted in this research is expected to provide benefits for nanomaterials in construction work, advantage of nanomaterials usage as saving cost, availability of nanomaterials, etc.

Social influence is represented as a subjective norm in many theories (Venkatesh et al., 2003) including the TRA and TPB. Social influence directly influences technology awareness and adoption of individual and firm. As Venkatesh et al (2003) stated social influence involve, *“The degree to which an individual perceives that other important persons believe he or she should use the system”* (Venkatesh et al. 2003: 451). The TAM model mentioned that social influence as social network has rather positive effects on behavior intention of technology usage (Taylor and Todd, 1995). Gullkvist (2003) showed that technology adoption in e-accounting has a positive correlation to the size of company as well as on trust in technology application through network awareness. In contrast, a number of researchers have found that social influence (SI) has no significant effect on behaviour intention (Dishaw & Strong 1999). Some articles have suggested both non-significant and significant effects of SI (System Information) toward intention because they studied in different conditions and generated inconsistent results of SI on behavior intention (Kripanont, 2007).

Educational level has been investigated as a factor/predictor in the study related to factors that influenced adoption and use of technology. For example, Zakaria (2001) indicated that only highest educational level was a significant predictor and contributed significantly to the variance of Information Technology Implementation. However, a study of Mahmood (2001) suggested that the factor of education level had a substantial effect on IT usage but the magnitude of the effect was lower than other factors which were the perceptions of the user (perceived usefulness and perceived ease of use) and organizational support. Nevertheless, the education level seemed to

have an impact on the influence of determinants toward technology acceptance in some way or another. It is in the sense that entrepreneurs and workers who have different levels of education may have different perceptions and thoughts relating to using nanomaterials. Thus, education will be investigated as a moderator, and it is expected to impact the influence of determinant toward awareness and adoption of technology. As manager and workers who have more education and experience with using previous technology such as Computer Aid Drafting (CAD), prefabrication system, logistic, etc., their education would have positive effect on technology awareness and adoption rather than technology infusion.

Age gender and experience will be examined in relation to awareness and adoption of nanomaterials in construction work as controlled variable given that most construction workers are young adult workers and mainly male (NSO, 2000). It is evident that gender, age, and experience significantly moderate the influence of the determinants on behaviour intention. For example, in accordance with the findings of Venkatesh et al. (2003) on adoption of internet usage behavior, it has been found that first the effect of performance expectancy (perceived usefulness) on behaviour intention was moderated by gender and age. Second the influence of effort expectancy (perceived ease of use) on behaviour intention was moderated by gender, age and experience. The last, the influence of social influence on behaviour intention was moderated by gender and age (Venkatesh et al., 2003; Kripanont, 2007). The finding of influential factors on awareness and adoption of nanomaterials in construction activities will provide information for awareness and adoption empowerment as a guideline for stakeholders towards human capital development and policy.

2.5.3 Hypotheses

The hypotheses of this research are classified into two levels as follows:

Socio-demographic and development indicators on nanotechnology application at international level

1. Socio-demographic and development indicators have a positive significant influence on nanotechnology application at the international level

Knowledge, Awareness and adaptation on unknown risks of construction nanoproducts usage among Thai construction workers

2. Social influence (norm, network and communication) has a positively significant influence on knowledge, awareness and adaptation on unknown risks of construction nanoproducts usage among Thai construction workers

2.6 Definition of key variables at micro analysis

As second portion of research question examined the determinants of demographic and social characteristic of Thai construction workforce about knowledge, awareness and adaptation on construction nanoproducts, it was important to summarize the key variables that extracted from literature reviewing as follow.

2.6.1 Effects of worker's age and gender on self-awareness and adaptation

Normally, worker who has age increase their ability of learning and adaptability slower than younger individuals especially if those new information different from their previous mastered (Colonia-Willner, 1998). Whenever senior workers have new task assignment that they need more time to understand and adapt to new tool and mission (Smith, 1996). Job experience may improve older worker's productivity but it may no longer effect when new skill is required. Moreover, Aging worker usually present the symptom of diminished physical that include lower sensory, or cognitive capability for operation (Porter et al, 2008: 1). In the past, several studies pointed out that educational level of female workers lower than male that brings about lower payment for female workers (Sanborn, 1964; Fuchs, 1971; Oaxaca, 1973). Traditionally, some eastern countries like Chinese family prefers to encourage higher education for son than daughter due to their willing of son take caring on their property while daughter usually was married out of their family. This existed inequity of education level also caused overall suppress on work promotion among female worker at all level. However, educational rate of Thai worker is only slightly different between male and female in present (NSO, 2008).

According to previous literatures about the effects of age and gender on worker's learning process work, this study explored the unique industry like construction that phenomenon of male dominated industry due to physical ability requirement as hard working while focus of age cohort difference related with worker's self-awareness on new information as nanoproducts. For worker in higher age cohort (40 years and over) may probably has lower knowledge, awareness and adaptability when compare with younger cohort (less than 40 years old). Therefore, it is interesting to investigate the correlation of knowledge and gender difference through educational system in terms of inequity on knowledge and awareness of construction nanoproducts that may explore the existing divided factors for future knowledge reinforcement on target group.

2.6.2 Worker's education, work position and experience considering on knowledge and awareness difference

Education and knowledge on new technology adaptation was studied by some scholars such as Oaxaca (1973) mentioned that worker who has higher skill and knowledge also has higher probability to be employed more than other as same as a study of Doms and his colleagues (1997) also shown that higher educated and experience with technology workers usually earned more wage than others (Oaxaca, 1973; Doms et al, 1997). For workers who have highest educational level, they generally have better ability to learn and adapt to skilled requirement than lower education one. Nevertheless, worker's position also plays some role on learning differentiate among workforce in the same firm (Zakaria, 2001; Mahmood, 2001). Experience is a base of learning process according to John Dewey's theory, the knowledge graining can be considered not only through formal process of learning such as education attainment but also through increasing of year experience (Dewey, 1938; Venkatesh et al, 2003).

As entrepreneurs and workers who have different levels of education, work position and experience may also have different knowledge, awareness even

adaptation on new technology like nanomaterials. Thus, education, work position and experience were examined in this research.

2.6.3 Size of firm and information accessibility of worker

For information accessibility, workers who were employed in bigger organization have higher opportunity to use various and complex devices (technology) when comparing with smaller firm (Venkatesh et al, 2003). Bigger companies in the same industry usually purchased updated technology to compete with their competitors and providing some training for their staffs. Consideration on knowledge gaining through channel of communication among workforce, it is found that probably two-way communication such as information from salesman and chatting with friend may draw attention among worker than one-way communication (television, radio, newspaper, etc.) due to information can be deeper discussed as clearer understanding can be made during communication.

2.6.4 Influence of social context (norm and network) on worker's knowledge

According to UTATU model, social network factor play a role as a subjective norm in many theories such as Theory of Reason Action (Fisbein, 1967), Theory of Plan Behavior (Ajzen, 1985), Theory of Acceptance Model (Davis, 1986), etc. These theories suggested that social influence is found as a direct determinant of behavioral intention. However, a number of researchers found that social influence (SI) has no significant effect on behaviour intention in some technology like information technology (Chau & Hu 2001; Davis 1989; Dishaw & Strong 1999; Mathieson 1991; Venkatesh & Morris 2000; Venkatesh et al. 2003). Reviewing from both significant and non significant effects from SI variable can found that because they studied in different conditions and generated inconsistent results. Therefore, social influence is used as a determinant for UTAUT model that also is expected to determine usage behaviour in terms of knowledge, awareness and adaptation on construction nanoproducs in this research. Social influence is defined in this study as:

“The degree to which an individual perceives that other important persons believe he or she should use the system” (Venkatesh et al. 2003, p. 451).

2.6.5 Performance/Effort expectancy as worker attitude on construction products

According to the concept of adoption of technology acceptance framework which was originated by Theory of Acceptance Model (TAM) (Davis, 1989) that proposed by Hu et al. (1999) and Chau and Hu (2002). Hu et al. (1999) pointed out that technology acceptance should be examined following three different contexts as individual, technological, and implementation. Individual's acceptance behaviour on technology is influenced by factors of difference in individual context which refers to the characteristics of individual end-users, the technological context which refer to the characteristics of the technology such as functionality and user-friendliness, among others, and the implementation context which to the user's professional environment (Chau and Hu, 2002). Chau and Hu's (2002) multi-contextual framework for performance/effort expectancy was adapted for this research because of its applicability to technology acceptance within both the public and private sectors. The proposed research will study the impact of the following factors on employees' attitudes toward technology acceptance motivation, usage intention, and actual usage as technology performance expectancy, technology effort expectancy and accessibility of technology (Venkatesh et al, 2003; Kripanont, 2007) which motivated by originated concept of TAM as follows: *“The degree to which a person believes that using a particular system would enhance his or her job performance”* (Davis 1989, p. 453).

2.6.6 Knowledge and awareness towards nanoproducts

Awareness in Situation Awareness (SA) theory is popularity in 1990s among simulation model of Aviation technology (Wiener, 1993). However, Endsley (1995) stated that SA is not only mean a state of knowledge but also the human responding to their surrounding environmental dynamic (Endsley, 1995). This proposed similar to the concept of Social Intelligence (Thorndike, 1920) about how

human respond to their social environment and interact with each other. Generally person may not get attention from common practice if there is no risk concerned. To dealing with risk awareness, a classical model is Haddon matrix which introduced by William Haddon Jr (1968). As prevent phase influence factors like prevent risk communication on unexpected health effects was first introduced as need for culture for knowledge and responding from public is a must. Moreover the identifying of the personal knowledge on risk exposure was a key on Haddon matrix of prevention public health emergency readiness and response (Barnett et al., 2005). The knowledge and awareness factor in Haddon matrix, situation awareness theory and Thorndike's social intelligence concept all pointed out that awareness is a natural human behaviour respond to the surrounding environment however there is not clear about how to measure it. Therefore, this research employed the educational evaluating method on knowledge measurement by giving the scoring system from questionnaire survey.

CHAPTER III

RESEARCH METHODOLOGY

3.1 Introduction

This study focuses on the dimension of macro analysis whether there is nanotechnology divide among nations or not through the examination of relationship between the demographic and socio economic indicators which represent level of development of countries and having of nanotechnology policy. This will help to describe the inequity of perspective on benefit and opportunity to access nanotechnology through nanotechnology policy formulation. Due to lack of nanotechnology policy will be an obstacle for public agency on funding for establishing of infrastructure, human resource and facilities to generate benefit from nanotechnology application. For those countries where have no nanotechnology policy, they may face difficulty to have benefit from this emerging technology and might be dependent on countries who own technologies mentioned by ETC-Group (ETC-Group, 2003; Schummer, 2007). After macro analysis was done, the micro analysis will be conducted to examine through similar approach of macro level for investigating any divide existed among Thai construction workforces especially a difference among skilled and unskilled labor. The study mainly focused on inequity knowledge, awareness and adaptation among workers which brings about health risk and environmental impacts which was mentioned by many international agencies such as EPA, NIOSH, Environmental Defend Fund, etc. (Environmental Defend Fund and DuPont, 2008; NIOSH, 2009).

Some scholar from previous studies of awareness measurement suggested that awareness and knowledge measurement require the followed approaches. First, it is important to measure what respondents know as well as what they do not know. This based on individual's knowledge rather than by guessing. For example,

respondents may hesitate about opinion providing on their less knowledge issues rather than admitting that they “don’t know”. This recommends that previous questions regarding knowledge are “a must” to classify the likelihood of uncertainty of individual’s knowledge (Bishop et al., 1980, Ciochetto and Haley, 2007). Therefore, the questionnaires employed the full filter question on individual’s knowledge about construction nanoproducts as detector and providing “don’t know” answer as well (Schuman and Presser, 1981; Sudman and Bradburn, 1982). This study will be classified into 2 steps. The first step is done through Content Analysis from documentary reviews and examinations of policy and implementation of nanotechnology development at international level to confirm the hypothesis on socio-demographic and development indicators of decision making support on nanotechnology policies. Second, because no research has been done on the topic of nanomaterials application in the construction industry, and consequently there is no available data so, this research will conduct a survey as pilot study as follows.

3.2 Data and Methods

To examine the relationship between socio-demographic and development parameters on nanotechnology policy application, the socio-demographic and development indicators such as TFR, IMR, GNP, etc. will be employed from population database resources such as Population Reference Bureau (PRB) 2007 and UNFPA database. However, there are possibilities of lack of data on some indicators on countries so the statistical smoothing method will be employed to eliminate these constraints. According to the PRB 2007, there are about 195 nations which are internationally recognized. However, in other sources there are about 240 states in the process of independence declaration. Therefore, this study will try to explore those states as well and see how development indicators can play a significant role in technology decision making like nanotechnology policy.

Given the limitation of data as such research has never been done before in Thailand, so pilot research will survey a cross section of data because there are no variables of “awareness of nanotechnology or nanoproducts” in any available data.

Stratified Random Sampling will be employed for this study because of its advantages of precision in regards to the specific population and unit of analysis being the “individual level” in which the population characteristic is classified by hierarchical level.

Because this research examines the relationship between construction workforce’s characteristic and social learning background on awareness and adoption towards nanomaterials using, it is necessary to explore the population size. The Labor Force Survey (LFS) round 1st to 4th (2008) which is selected to explore for population size, most seasonal migrant workers are construction workers who return after the harvesting period to the construction industry. The survey showed that there were about 2,265,267 persons in construction industry. However, target population in this research are person who work involved with construction material that focus only manager who has authority on purchasing decision, architect or engineer who assign material, foreman and craftsmen whose manipulate materials as same as construction labor who also expose material on site. While others such as administrative staffs are except. According to LFS 2008, the numbers of entrepreneurs, construction skilled and unskilled workers 8.9% in Bangkok, 13.4% in Southern, 20.7% in Northern, 20.7% in Central, and 33.5% in Northeastern, respectively (table 3.1 and table3.2) (NSO, 2006).

Table 3.1 Comparison numbers of entrepreneurs, construction skilled and unskilled workers among locations of Thailand in 2008

	Employer		Employee	
Bangkok	1.3	(29,900)	7.6	(171,867)
Central	2.6	(58,633)	22.0	(498,000)
Northern	1.8	(40,800)	18.9	(428,267)
Northeastern	1.8	(39,967)	31.7	(718,233)
Southern	1.2	(27,000)	11.2	(252,600)
Total	8.7	(196,300)	91.3	(2,068,967)

Source: Adjusted from Labor Force Survey 1st to 4th round, 2008, NSO

Obvious data showed that the number of construction workforce in Southern especially at employee level is less than other regions (about 11.2%). Moreover, most construction employee are Central and Northeastern workers due to

local southern people prefer to work as rubber farmer and fisherman than being construction workers for better paying. Therefore, this study sampling will except the data collection from Southern while concentration for Central and Northeastern part.

Table 3.2 Comparison numbers of entrepreneurs, construction skilled and unskilled workers among work position in 2008

	percent	number
Manager/Engineer	4.1	(87,063)
Foreman/Craftsman	9.5	(201,212)
Labor	86.4	(1,833,296)
Total	100.0	(2,121,571)

Source: Adjusted from Labor force survey 1st to 4th round, 2008, NSO

The percentage of entrepreneurs, architects and engineers, technicians, craftsmen and construction labourers can be classified as 10.8, 1.3, 2.6, 56.1 and 29.2, respectively (NSO, 2008). Besides, the expected sample representations are 100 entrepreneurs due to the adoption of technology in firm being mostly influenced by the owner or manager of the firm who is authorized on decision making towards technology adoption. However the technological compatibility according to Diffusion of Innovation Theory (Lazarsfeld et al., 1949; Rogers, 1995) will be examined through sub stratified level as architects and engineers, technicians, craftsmen and construction labourers which can also be classified as 13, 26, 561 and 292 persons, respectively as follows (Table 3.3 and 3.4).

Table 3.3 Proportionate sample representation for a hypothetical construction determiner and distribution

Entrepreneurs and Construction workers	Population Size (in hundred)	Percent	Expected Proportionate Sample Representation	Percent
Entrepreneurs	29.9	1.4	110	10
Architects & Engineers	57.1	2.7	110	10
Foreman & Craftsmen	201.2	9.5	550	50
Construction laborers	<u>1,833.2</u>	<u>86.4</u>	<u>330</u>	<u>30</u>
Total	2,121.4	100.0	1,100	100.0

However, numbers of architects, engineers and technicians are recognized as too small to achieve certain requisite margin of error (± 10 percent), thereby the resizing of expected proportionate samples is required to meet the threshold as the table below shows.

Table 3.4 Adjusted proportionate sample representation for a hypothetical construction determiner and distribution

Construction workforce	Expected Proportionate Sample Representation	Percent
Entrepreneurs	110	10.0
Architects & Engineers	110	10.0
Technicians	110	10.0
Craftsmen	528	48.0
Construction laborers	<u>242</u>	<u>22.0</u>
Total	1,100	100.0

An entrepreneur is a person who has graduated at least at the diploma level. Skilled and semi skilled workers such as engineers, architects, and technicians, are persons who have graduated at least at the diploma level. Division into three groups of workers mentioned above allows all workers to be selected equally. For example, a company which has 10-19 workers will be interviewed as 1 entrepreneur, 1 architect/engineer, 1 technician, 5 craftsmen and 2 construction laborers while one which has 100-199 workers will be interviewed as 10 entrepreneur, 10 architects/engineers, 10 technicians, 48 craftsmen and 22 construction laborers (see Appendix B).

3.3 Population and Sample

The examination of the influence of socio-demographic and development indicators on policy support of nanotechnology is assigned as the research objective so the first step will be conducted as macro analysis by using population and development indicators from various data source with respect to about 240 nations. This exploration will reveal the role of policy support of nanotechnology distribution in both developing and developed countries in the distribution and determinant of

population and development factors on policy making especially nanotechnology as the first part of study.

For next part of this study, due to lack of secondary data on nanomaterials and construction sector's awareness and adoption, this study will use purposive stratified random sampling. Given the target population's characteristic as individuals in hierarchical levels of occupation it will focus on individual workers who are unskilled workers facing technological change and then on administrative and management levels. The proportion used is shown in table 3. However, for bigger organizations of more than 20 workers, the proportion for sample size may increase by 2-3 times (see pie chart in appendix B). The questionnaire is designed to be classified as the following steps.

Step 1: Study areas are set covering Bangkok, central, northeastern and northern provinces. The southern provinces are not included as the study area due to the fact that construction workers in southern part mostly migrated from northeastern and northern parts of Thailand. Thus, data collection from southern construction workers might not provide finding differently from others. According to Social Cognitive theory (1904) and Diffusion of Innovation theory (1949), the size of firms influences individual behavior. Therefore, this study will select 30 small companies (companies which have between 10 and 19 workers), 40 medium companies (companies which have between 20 and 49 workers), 40 big companies (companies which have more than 49 workers).

Step 2: the questionnaires will be employed for data collection from following workers as 1 manager (who has completed higher than bachelor degree), 1 architect or engineer (who has completed a bachelor's degree), 1 foreman (who has completed a diploma), 5 craftsmen who have complete certificates), 2 construction labourers (who have graduated with less than certificate level). The surveying will distribute equally about 110 firms (1,100 samples) in Bangkok, Northeast Central and North represent Thai construction industry.

However, during the surveying between April and July 2009 that the data collection have been collected for 1,148 cases as additional cases were collected base on the missing and outlier cases consideration such as incomplete information filled in questionnaire, incomplete return number of questionnaires, irrelevant firms from random sampling, etc. Unfortunately, the data distribution can not equally distribute due to economic recess period, therefore, most construction operation only concentrated in some region as prioritized cases distribution is shown as followed table.

Table 3.5 Distribution of prior samples

Region	Frequency	Percent
Bangkok	558	48.6
Northeast	400	34.8
Central	20	1.7
North	170	14.8
Total	1,148	100.0

Moreover, there are some comments from thesis committees about size and type of firms where should not be consider for this research framework due to oversize and not relevant activities for expose to nanoproducts such as road and bridge construction or firm size over 300 workforces so the selection of samples focus only on firm who have higher chance to apply nanoproducts during construction which is housing construction. Thus, there are 93 cases (8.1%) have been drop as the result that the final sample size is 1,055 cases as present in the next below table.

Table 3.6 Distribution of finalized samples

Region	Frequency	Percent
Bangkok	465	44.1
Northeast	400	37.9
Central	20	1.9
North	170	16.1
Total	1,055	100.0

Table 3.7 Studied variable, definition, explanation of all variables in the analysis of the determinant that affect on awareness and adoption of nanomaterials in construction work

Variables	Definition	Scale of measurement
1. Dependent Variables		
1. Knowledge divide of construction nanoproducts	Categorical data 0 = Don't know 1 = Known	Nominal scale
2. Awareness divide of construction nanoproducts	Categorical data 0 = Accept 1 = Neglect	Nominal scale
3. Adaptation divide of construction nanoproducts	Categorical data 0 = Don't accepted 1 = Accepted	Nominal scale
2. Control Variables		
1. Age		
1.1 Age 15-29 years old	0 = Other age group. 1 = Age 15-29 years old	Dummy
1.2 Age 30 – 39 years old	0 = 0 = Other age group 1 = Age 30 – 39 years old	Dummy
1.3 Age 40 years and over	0 = Other age group 1 = Age 40 years and over	Dummy
2. Gender		
	Categorical data 0 = Female 1 = Male	Nominal scale
3. Education		
3.1 Less than certificate	0 = Other education level 1 = Less than certificate	Dummy
3.2 Certificate or equivalent	0 = Other education level 1 = Certificate or equivalent	Dummy
3.3 Diploma	0 = Other education level 1 = Diploma	Dummy
3.4 Bachelor and over	0 = Other education level 1 = Bachelor and over	Dummy

Table 3.7 Studied variable, definition, explanation of all variables in the analysis of the determinant that affect on awareness and adoption of nanomaterials in construction work (continue)

Variables	Definition	Scale of measurement
4. Religious	Categorical data 1 = Buddhism 2 = Christian 3 = Islam 4 = Other religious	Nominal scale
5. Position		
5.1 Construction labor	0 = Other work position 1 = Construction labor	Dummy
5.2 Craftsman	0 = Other work position 1 = Craftsman	Dummy
5.3 Foreman	0 = Other work position 1 = Foreman	Dummy
5.4 Architect/engineer	0 = Other work position 1 = Architect/engineer	Dummy
5.5 Manager/owner	0 = Other work position 1 = Manager/owner	Dummy
6. Experience		
6.1 have experience 0-5 years	0 = Other 1 = have experience 0-5 years	Dummy
6.2 have experience 6-10 years	0 = Other 1 = have experience 6-10 years	Dummy
6.3 have experience 11-15 years	0 = Other 1 = have experience 11-15 years	Dummy
6.4 have experience more than 15 years	0 = Other 1 = have experience more than 15 years	Dummy

Table 3.7 Studied variable, definition, explanation of all variables in the analysis of the determinant that affect on awareness and adoption of nanomaterials in construction work (continue)

Variables	Definition	Scale of measurement
7. Influence of norm	0 = Have no influence of norm 1 = Have influence of norm	Dummy
8. Influence of network	0 = Have no influence of network 1 = Have influence of network	Dummy
9. Performance/Effort expectancy		
9.1 Ease to use	Categorical data 0 = complicated 1 = easy	Nominal scale
9.2 Benefit		
9.2.1 Have attitude that recent products is poorer efficiency than previous	0 = Other 1 = Have attitude that recent products is poorer efficiency than previous	Dummy
9.2.2 Have attitude that recent products is same efficiency as previous	0 = Other 1 = Have attitude that recent products is same efficiency as previous	Dummy
9.2.3 Have attitude that recent products is better efficiency than previous	0 = Other 1 = Have attitude that recent products is better efficiency than previous	Dummy

Table 3.7 Studied variable, definition, explanation of all variables in the analysis of the determinant that affect on awareness and adoption of nanomaterials in construction work (continue)

<i>Variables</i>	Definition and explanation	Scale of measurement
9.4 Availability		
9.4.1 Have attitude that recent products is easier available than previous	0 = Other 1 = Have attitude that recent products is easier available than previous	Dummy
9.4.2 Have attitude that recent products is common available	0 = Other 1 = Have attitude that recent products is common available	Dummy
9.4.3 Have attitude that recent products is harder to access than previous	0 = Other 1 = Have attitude that recent products is harder to access than previous	Dummy
3. Independent Variables		
1. Source of Information		
1.1 Television	0 = Other source of information 1 = Television	Dummy
1.2 Radio	0 = Other source of information 1 = Radio	Dummy
1.3 Salesman	0 = Other source of information 1 = Salesman	Dummy
1.4 Colleague	0 = Other source of information 1 = Colleague	Dummy

Table 3.7 Studied variable, definition, explanation of all variables in the analysis of the determinant that affect on awareness and adoption of nanomaterials in construction work (continue)

<i>Variables</i>	Definition and explanation	Scale of measurement
2. Size of firm		
2.1 10-19 workers	0 = other size of firm 1= have 10 – 19 workers	Nominal scale
2.2 20-49 workers	0 = other size of firm 1= have 20 – 49 workers	Dummy
2.3 more than 49 workers	0 = other size of firm 1= have more than 49 workers	Dummy

3.4 Variables and measurement

The variables are constructed using dummy dependent and independent variables as explained below.

Dependent variables: Knowledge divides on construction nanoproducts

Knowledge is a fundamental factor of technology adoption (Behavior intention in IDT, TRA, TAM and TPB) so before conducting an examination, awareness examination is required. The dependent variable of “knowledge divides on construction nanoproducts,” was first constructed from questionnaire in section 3. The divide of knowledge on construction nanoproducts was counted as “yes/no” of 10 questions. For the answer “yes” was counted as 1 score while “no” was counted as 0 score. The total score of knowledge on construction products is 10. However, the Criterion Reference Test (CRT) was employed to classify the divide on knowledge about construction nanoproducts, considered by 60 percent (Weiss and Davison, 1981). That is to say, respondents who got 6 from total scores was considered as “have knowledge on construction nanoproducts/known about construction nanoproducts” while respondents who got less than 6 score was considered as “don’t have knowledge on construction nanoproducts/don’t know about construction nanoproducts”. Therefore, knowledge divides on construction nanoproducts variables was measured

as a dichotomous variable (0 = Don't know about construction nanoproducts; 1 = Know about construction nanoproducts). In model 2 and 3, knowledge divides on construction nanoproducts variable was also be a determinants on examining the awareness and adaptation of construction nanoproducts.

Awareness is somehow parallel to knowledge. According to awareness means evidence of knowledge, understanding and value of perception on importance. The dependent variable of "awareness divides on construction nanoproducts," was constructed from questionnaire in section 3. It was counted from "yes/no" of 8 questions. Those questions focus in term of "ever use" as respondent who ever use construction nanoproducts and answered "yes" was counted as 1 score while "no" was counted as 0 score. The 8 score is a total of awareness on construction nanoproducts. The cut point of divide on awareness about construction nanoproducts was assigned by 60 percent cut point. Therefore, respondents who got 5 score and over was considered as "have awareness on construction nanoproducts/Aware about construction nanoproducts" while respondents who got less than 5 score was considered as "Don't have awareness on construction nanoproducts/Unaware about construction nanoproducts". Awareness divides on construction nanoproducts variables was measured as a dichotomous variable (0 = Unaware about construction nanoproducts; 1 = Aware about construction nanoproducts). In model 3, this variable was also play as an independent variable to examine the variation on adaptation of construction nanoproducts.

Adaptation is mostly occurred after awareness but doubt about social influence may preponderate to technology adaptation as Macro Social level. This study considered adaptation divide on construction nanoproducts (adapted/non-adapted) based on 7 questions about nanotechnology in construction materials acceptance (section 4 from questionnaire) Score of adaptation was counted by Likert's scale varied as 1 = Strongly not accepted, 2 = Not accept, 3 = Neither accepted nor not accepted, 4 = Accepted and 5 = Strongly accepted. The 35 score is a total of adaptation on construction nanoproducts. The cut point of divide on awareness about construction nanoproducts was assigned by 60 percent cut point. Therefore, respondents who got 21 score and over was considered as "have adaptation on construction

nanoproducts/Adapted on construction nanoproducts” while respondents who got less than 21 score was considered as “Don’t have adaptation on construction nanoproducts/Non-adapted on construction nanoproducts”. Hence, adaptation on construction nanoproducts variable was measured as a dichotomous variable (0 = Non-adapted on construction nanoproducts; 1 = Adapted on construction nanoproducts).

Controlled variables

Other controlled variables include construction workforce’s age, gender, education, work experience, work position, performance/effort expectancy, influence of norm and influence of network. Previous studies used similar variables as predictors of examining technology acceptance model of internet usage in multiple regression models (Venkatesh et al, 2003; Kripanont, 2007).

Construction workforce’s age in this study was classified as 3 dummy categories: age 15-29 (young adult workforce), age 30-39 (adult workforce), and age 40 and over (senior workforce). Aging workers usually slower adapted to new technology than younger. Construction workforce’s gender includes 2 categories, male and female. Male have stronger biological factor than female so they are a majority group of construction workers. Education composed of 3 dummy categories: less than certificate or less than class 9, certificate or equivalent (completed high school), diploma, bachelor and over. For higher education means higher chance to aware of technology change in construction work. Religious was employed to examine disparity between culture and believe however the majority of construction workforce is Buddhism.

There were 5 dummy categories of work position in this analysis as construction labor, craftsman, foreman, architect/engineer and manager/owner due to disparity among hierarchical level of work position in firm may exist on knowledge and awareness on construction nanoproducts because of higher position such as architect/engineer and manager who have authority on decision making of materials usage commonly first access to information faster than other position. Work

experience in this analysis consisted of 4 dummy categories: 0-5 years, 6-10 years, 11-15 years and more than 15 years due to more experience with technology in construction work means more awareness and technology adaptation. Performance/effort expectancy (easy to use, benefits of use, cost of technology and availability) was mentioned by previous psychological studies on human behavior intention on perception such as Theory of Reason Action (TRA) (Fishbein, 1967), Theory of Acceptance Model (TAM) (Davis, 1986) Theory of Plan Behavior (TPB) (Ajzen, 1985) and Unified Theory of Acceptance and Use of Technology (UTAUT) model (Venkatesh et al, 2003) as a main determiner for human behavior intention on environment. Positive correlation of performance/effort expectancy mean the higher work position probably has positive perception on new information and technology. In Theory of Acceptance Model (TAM) also confirmed that size of group has significant positive effect to the rate of technology adaptation.

Influence of norm on construction materials usage variable assigned as a continuous variable (0 – 5 score). This variable was employed from 5 dummy categories from questionnaire as it was computed from “yes/no” of 5 questions as followed. 1) Use better efficiency products for client even it is more complicated, 2) Use better efficiency products for client even it is more expensive, 3) use better efficiency products for client even it is rarely available, 4) use more safety products for client even it is more expensive and 5) use guarantee products for client even it is more expensive. Respondent who answered “yes” was counted as 1 score while “no” was counted as 0 score. The 5 score is a total score of Influence of norm on construction materials and this variable was treated as continuous.

Influence of network on construction materials usage variable assigned as a continuous variable (0 – 7 score). This variable was also employed from 7 dummy categories from questionnaire as it was computed from “yes/no” of 7 questions as followed. 1) Use new products because there is market competition, 2) use new products because there is new social value, 3) learn to use new products because there is market competition, 4) learn to use new products because there is new social value, 5) learn to use new expensive products because there is new social value, 6) use new

products even have less knowledge on it because there is market competition and 7) use new products even have less knowledge on it because there is new social value. Respondent who answered “yes” was counted as 1 score while “no” was counted as 0 score. Therefore, this variable was also treated as continuous.

Key independent variable: Source of information and Size of firm

The key independent variables of this study are source of information such as television and radio (one-way communication), salesman and colleague (two-way communication) and size of firm. The source of information and size of firm variables were derived from the questionnaire section 2.7 and 2.8 respectively. Due to this research is a first attempt to applied of UTATU that most scholar employed it to explain human behaviour intention of technology usage especially information technology for examine the human behaviour intention of nanotechnology usage through construction nanoproducts among Thai construction workforce. Therefore, rarely previous studied can be applied to compare with this study research. However, study of Kripanont (2007) mentioned that UTATU model is the best existed model to explain the behaviour intention on technology adoption. Moreover, her studied found that social influence have less affected on behaviour intention towards technology adoption in Thai context so this study repeat her studied outcome and focus on size of firm that exist in UTATU model and additional variable as sources of information whether have significant affect to behaviour intention (knowledge, awareness and adaptation) on technology like construction nanoproducts or not.

CHAPTER IV

RESULTS

The study findings presented in this chapter were divided into 2 parts. First part presented the results from macro level a relationship between demographic and socio-economic variables and the divide of nanopolicy at international level. The second part was also divided into 2 sections as firstly, it presents descriptive results of demographic and social characteristics of Thai construction workforce and sampling on knowledge and awareness of nanoproducts. Second, the multivariate results are presented to highlight the extent to which demographic and social characteristics of Thai construction workforce is associated with the dividing of knowledge and awareness on nanoproducts. The multivariate results intend to show the risk exposure to unknown impacts of nanoproducts among users by classifying between “knowing” and “do not know” as well as “aware” and “unaware” from questionnaire scoring results as well. It is not enough to only examine the nano-divide at national level, but at the bottom group of people such as construction workers at work site should be also investigated. Therefore, this study employed the Top-down analysis method (metaphor from molecular manufacturing as nanotechnology so call “build from top”) to examine the existing of nano-divide from international to local level as follows.

4.1 Macro level analysis

Demographic indicators can indicate the national development on human capital and economic growth. However, to examine the nanopolicy activities among 250 nations, the study employed the data from many resources i.e. European Commission on Nanotechnology, National Nanotechnology Initiative, online articles on nanotechnology regulation and policy worldwide, etc. Results showed that most developed and developing countries already recognized the benefits of nanotechnology

and established their policy for working with this tiny technology as shown in table 1 about distribution of nanopolicy among countries.

Table 4.1 Nanotechnology policy divides between developed and developing countries

Country	Have nanotechnology policy		Total
	Have	Do not have	
Developed country	68.2 (15)	31.8 (7)	100.0 (22)
Less developed country	18.9 (43)	81.1 (185)	100.0 (228)
Total	76.8 (192)	23.2 (58)	100.0 (250)

After employing all demographic and socio-economic development indicators from 250 nations, some countries have no indicators provided on PRB database are excluded from this study and finally the analysis was conducted as follows.

Step 1 to explore the relationship of demographic and socio-economic development indicators on nanopolicy dividing between developed and developing nations, the t-test statistic was employed and the mean difference between each demographic and socio-economic development indicators on nanopolicy were conducted. Step 2 to examine the statistical relationship of demographic and socio-economic indicators on nanopolicy dividing, the simple dummy dependent variable on regression (Linear Probability Model) was employed. Results indicated that almost all development indicators are significantly associated with nanopolicy variable, except death rate and population density as shown in Table 4.2.

4.1.1 Relationship between demographics indicators and nanotechnology policy divides

According to the Boserupian concept and Davis's Multiphasic Response Theory about relationship between demographic and technology, table 4.2 below indicated that most demographic and social development indicators have correlated with nanopolicy at statistical significant level .001. As higher mean difference value means wider gap of demographic and development indicators on nanopolicy. For fertility indicator such as birth rate, growth rate and total fertility rate shows the mean difference in positive direction which indicates that there are existing gap of development from nanotechnology policy forming in each country. Policy support usually indicates that concerned stakeholders are interested in developing according to regulation and agreement. Without policy support, it will be difficult to implement any involved facilities like education, research and development, investment, etc.

Table 4.2 Relationship of demographic indicators on nanotechnology policy divide when focuses on mean difference

Domain	Mean of nanopolicy		Mean difference	t-test	Sig.	Total
	Have	Don't have				
<i>Demographic development factors</i>						
-Birth rate	14.21 (58)	26.73 (151)	12.52	7.85	.000	100 (209)
-Death rate	8.62 (58)	9.42 (151)	0.80	1.06	.291	100 (209)
-Growth rate (percent)	0.55 (58)	1.73 (151)	1.18	8.52	.000	100 (209)
-Infant Mortality Rate	13.32 (58)	44.92 (149)	31.60	6.06	.000	100 (207)
-Maternal Mortality Ratio	66.78 (55)	448.58 (113)	381.80	5.88	.000	100 (168)
-Total Fertility Rate	1.86 (58)	3.51 (150)	1.65	7.28	.000	100 (208)
-Child dependency Ratio	0.32 (58)	0.58 (150)	0.26	8.24	.000	100 (208)
-Elderly dependency ratio	0.17 (58)	0.09 (150)	-0.08	-8.20	.000	100 (208)
-Life Expectancy at birth (all)	74.38 (58)	64.20 (149)	-10.118	-5.724	.000	100 (207)
-Urban population (percent)	67.28 (58)	50.58 (151)	-16.69	-4.56	.000	100 (209)
-Population density (sq.m.)	351.53 (58)	469.88 (188)	118.34	0.31	.758	100 (246)

From results indicate that there are slight differences between developed and developing societies on having policy about nanotechnology across demographic factors. However, in mortality indicators like maternal mortality ratio indicate the wider effect of different public health conditions on having nanotechnology policy consideration (mean difference at 382). That is to say, wider mean difference in public health indicator (MMR) pointed out societies which have difference in public health development system will have bigger gap on nanotechnology development according to policy support like African countries.

4.1.2 Relationship between development indicators and nanopolicy divides

Considering the relationship between social and economic development indicators and having of nanotechnology policy at international level, results show that all socio-economic development factors are correlated with nanopolicy at statistical significant level .001. Especially, social development indicator like literacy rate has the widest mean difference (-31.83) among other socio-economic development indicators as meaning of difference on literacy rate among countries could result the difference of having policy support on nanotechnology. Percent of contraceptive use among married couples indicated that couples in developed society have ability to access and use family planning method (a type of innovation) to control their fertility as further enjoy economic growth of their society. Higher percent of contraceptive use means higher development in that society as Table 4.3 indicates the gap of development and these indicators relate to the gap of policy providing on nanotechnology as well.

For economic development indicator confirmed as same as other previous development indicators that society where has higher economic development will also have higher Gross national index and amount of carbon dioxide emission, while the country also has lower number of population who live under \$US 1 a day and percent of natural remained. The existing of mean difference of these economic

development indicators still show in the same appearance of previous demographic and social development indicators.

Table 4.3 Relationship between socio-economic indicators on nanotechnology policy divides when focuses on mean difference (continue)

Domain	Nanopolicy		Mean difference	t-test	Sig.	Total
	Have	Don't have				
<i>Social development factors</i>						
-Literacy rate of population age 15-24, female	90.46 (37)	58.63 (141)	-31.83	-4.52	.000	100 (178)
-Literacy rate of population age 15-24, male	91.11 (37)	63.33 (141)	-27.78	-3.97	.000	100 (178)
-Percent of Contraceptive use among married women (modern)	55.23 (48)	30.15 (112)	-25.08	-7.46	.000	100 (160)
-Under weight of under 5 yrs child (percent)	8.96 (27)	17.35 (106)	8.39	3.27	.001	100 (133)
<i>Economic development factors</i>						
-Gross National Index PPP	20,585.82 (55)	8,347.62 (127)	-12,238.2	-6.41	.000	100 (182)
-Population live under \$US 1 a day	2.51 (58)	9.39 (151)	6.875	2.91	.050	100 (209)
-Carbon dioxide emission (metric ton per capita)	7.25 (55)	3.27 (128)	-3.98	-4.64	.000	100 (183)
-Natural remain (percent)	57.17 (54)	69.29 (125)	12.12	2.77	.050	100 (179)

4.1.3 Influential of demographics indicators on nanotechnology policy divides

To provide clearer picture of relationship among each demographic and socio-economic development indicators on nanopolicy, the study also analyzed through the dummy variable on regression analysis as shown in table 4.4. The result indicates that demographic development indicators such as growth rate, total fertility

rate, child and elderly dependency ratio have casual relationship to the nanopolicy generating at international level.

Table 4.4 Influential of demographics indicators on nanotechnology policy divides

Domain	Constant	β	Wald	Sig.	Model X ²	Sig. (Model X ²)	N
<i>Demographic development factors</i>							
-Birth rate	2.09	-0.16	34.31	0.000	63.52	0.000	209
-Death rate	-0.64	-0.04	1.11	0.291	1.167	0.280	209
-Growth rate (percent)	0.65	-1.47	40.86	0.000	62.33	0.000	209
-Infant Mortality Rate	0.23	-0.05	21.46	0.000	45.61	0.000	207
-Maternal Mortality Ratio	0.39	-0.01	15.78	0.000	51.42	0.000	168
-Total Fertility Rate	2.06	-1.23	29.58	0.000	60.26	0.000	208
-Child dependency ratio	2.31	-7.61	36.55	0.000	64.49	0.000	208
-Elderly dependency ratio	-3.20	16.40	39.69	0.000	50.28	0.000	208
-Life Expectancy at birth (all)	-10.16	0.13	23.62	0.000	41.43	0.000	207
-Urban population (percent)	-2.71	0.03	17.57	0.000	19.89	0.000	209
-Population density (sq.m.)	-1.17	0.00	0.09	0.760	0.11	0.744	246

Above table indicated that countries where have lower fertility probably have chance to considering on the having of nanopolicy than higher fertility society. Aging societies probably have higher chance to provide nanopolicy than other societies as well as societies where have higher life expectancy at birth will tend to have nanopolicy as well.

4.1.4 Influence of development indicators on nanotechnology policy divides

Focusing on results of relationship between socio-economic indicators on nanopolicy found that all socio-economic indicators have significant relation with nanopolicy at statistical significant level .05. For countries where have higher literacy rate also probably provide nanopolicy than lower literacy rate society.

Table 4.5 Influential of socio-economic indicators on nanotechnology policy divides

Independent variable	Constant	β	Wald	Sig.	Model X ²	Sig. (Model X ²)	N
<i>Social development indicator</i>							
-Literacy rate of population age 15-24, female	-3.94	0.03	12.64	0.000	23.99	0.000	178
-Literacy rate of population age 15-24, male	-3.95	0.03	9.58	0.002	19.59	0.000	178
-Percent of contraceptive use (modern)	-3.52	0.06	32.05	0.000	46.03	0.000	160
-Under weight of under 5 yrs child (percent)	-0.42	-0.08	8.82	0.003	11.96	0.001	133
<i>Economic development factors</i>							
-GNI_PPP	-1.84	0.00	26.47	0.000	33.19	0.000	182
-Population live under \$US 1 per day	-0.71	-0.05	6.60	0.010	11.01	0.001	209
-Carbon dioxide emission (metric ton per capita)	-1.48	0.13	15.29	0.000	18.87	0.000	183
-Natural remain (percent)	0.18	-0.02	7.19	0.007	7.32	0.007	179

Focusing on economic development factors, countries with better economic condition (higher gross national income and energy consumption) have higher opportunity to generate nanopolicy than poorer economic conditions (higher population live under \$US 1 a day).

Findings revealed that most development indicators are significantly affected by having nanopolicy. When the demographic development indicators were considered, finding revealed that most fertility indicators have strong effect. Birth rate and growth rate indicated that countries having low fertility are more likely to have nanopolicy at statistical significant level .001. Aging societies are more likely to have nanopolicy at statistical significant level .001 as well as percent of urban indicated that countries with more urbanized are more likely to have nanopolicy at statistical significant level .001. However, the death rate and population density do not have casual relation with nanopolicy among nations. Overall, it can be said that low fertility nations are more likely to focus on nanotechnology regulation and policy while nanotechnology has been promoted in most developed countries at present.

Consideration of social aspect also revealed that countries having more social development are more likely to have nanopolicy. Literacy indicator for both sex and percent of contraceptive use among married women (modern methods) pointed out the modern society which positive literacy rate countries (better education) are more likely to have nanopolicy at statistical significant level .001 while nations where are better infant health are more likely to have nanopolicy at statistical significant level .010 also. These findings confirm the influence of social indicators on national development (Andrews, 1983).

For economic indicators also confirmed the same direction that more economic development areas are more likely to have nanopolicy. Furthermore, these findings strongly confirmed the existing gap of nanotechnology regulation and policy application between developed and developing countries. The finding is in accordance with a study of Schummer (2007) which showed that nanotechnologies can simultaneously and unavoidably generate the disparity gap between the rich and the poor.

4.2 Micro level analysis

The lack of available data for the relationship between labor force's perceptions on nanomaterials is a limitation of this area as it has never been done before so this part of the study employed a quantitative field survey in many parts of Thailand. The results of construction workforce's characteristics, social influence factors on technology perception will be firstly presented. Later, the multivariate analysis's results are presented to show the relationship between independent variables and awareness of nanomaterial usage.

4.2.1 Demographic and social characteristic of sample

Even the expected sample size is 1,155 persons however the explore of existing data found that about 10 percent (10 firms) of samples is a firm greater than 300 persons and may involve with heavy construction that should not include in this study as they may not really apply nanoproducts so the final sample size for this study was 1,055 workers aged between 15 and 70, obtained from questionnaires collection. It can be said that these samples are free of regional effects since their construction sites are always being mobile. So, only regions which have equal distribution on size of firms (small, medium and large firms) are sample regions for this study.

Table 4.6 Demographic and social characteristic distribution of samples

	Percent	Number
Total	100.0	(1,055)
Demographic characteristic		
Age group		
- Age 15-29	20.4	(215)
- Age 30-39	37.4	(395)
- Age 40+	42.2	(445)
Gender		
- Female	10.2	(108)
- Male	89.8	(947)
Education		
- Less than certificate level	30.3	(320)
- Certificate level	22.9	(242)
- Diploma level	19.6	(207)
- Higher than diploma level	27.1	(286)
Religious		
- Buddhism	99.1	(1,046)
- Christian	0.5	(5)
- Muslim	0.4	(4)
Social characteristic		
Position		
- Construction labor	11.5	(121)
- Craftsman	49.3	(520)
- Foreman	17.3	(183)
- Architect / Engineer	13.6	(144)
- Manager	8.2	(87)
Work experience in construction		
- Experience 0-5 years	26.9	(294)
- Experience 6-10 years	32.3	(341)
- Experience 11-15 years	17.0	(179)
- Experience > 15 years	23.8	(251)
Size of firm		
- 10-19 persons	31.8	(335)
- 20-49 persons	27.5	(290)
- > 49 persons	40.8	(430)

Table 4.6 Demographic and social characteristic distribution of samples (continue)

	Percent	Number
<i>Easy to use material</i>		
- Easy	47.4	(500)
- Complicate	52.6	(555)
<i>Benefit of use material</i>		
- Poorer	53.8	(568)
- Fair	38.7	(408)
- Better	7.5	(79)
<i>Cost of material</i>		
- Cheaper	1.6	(17)
- Fair	52.2	(551)
- Expensive	46.2	(487)
<i>Accessibility of material</i>		
- Common	1.9	(20)
- Fair	23.0	(243)
- Hard to access	75.1	(792)

The data indicates that the largest study sample aged more than 40 years old (42%). Male is majority of construction workforce (90%). The majority of construction workforces have education less than certificate level or grade 9 as equivalent (30%). Buddhism is a major religious of construction workforce (99%). Most of study sample is craftsman (49%) while there are few managers was sampled (8%) this present as the pyramid shape of position that there are less workforce at top when compares with bottom level. Most of construction workforce has work experience between 6-10 years (32%). Most sampling firms are big companies (more than 49 persons) (41%). At individual level, most respondents feel that recent construction materials are more complex than previous (53%) while the benefit of use recent material is poorer (54%). However, most of them feel the cost of recent materials are still acceptable (52%) even most construction workforce think it becomes harder to access those material when compares with the past (75%).

4.2.2 Source of information of study sample

Table 4.7 presented the relationship between source of information about construction materials and demographic and social characteristic as one-way

communication (TV and radio) and two-way communication (salesman and colleague).

Obviously in terms of age group, it shows that construction worker aged 15-29 gains information about construction material from television, salesman and radio as 28%, 23% and 21%, respectively at statistical significant level .001 while it showed that construction worker who aged more than 40 years access construction material information from television, radio and salesman, 28%, 20% and 19%, respectively at statistical significant level .05. However, both male and female workers access information from their colleague than other source of information as 32% and 27%, respectively at statistical significant level .001.

Considering on education reveals that construction worker who has education background less than certificate level access construction material information from their colleague, television and salesman as 33%, 31% and 12% respectively at statistical significant level .01. For those who obtain certificate gains construction material information from television and radio as 28% and 23% respectively at statistical significant level .05 For worker who obtain diploma gains construction material information from colleague, television and radio as 30%, 28% and 23% respectively at statistical significant level .05. For well educated worker who have own higher than diploma level gain gains construction material information from colleague, television, salesman and radio as 33%, 26%, 26% and 16% respectively at statistical significant level .05.

Table 4.7 Demographic and Social characteristic on source of information about construction materials

	Source of information on construction materials				Total
	TV	Radio	Salesman	Colleague	
Age group¹					
- age 15-29	28.4*** (188)	21.3*** (141)	22.5*** (149)	21.9 (185)	100.0 (663)
- age 30-39	28.1 (299)	20.1 (214)	20.6 (219)	31.1 (331)	100.0 (1,063)
- age 40+	28.4* (329)	19.9* (231)	18.5*** (214)	33.2 (384)	100.0 (1,158)
Gender¹					
- Female	31.6 (84)	19.5 (52)	21.8 (58)	27.1*** (72)	100.0 (266)
- Male	28.0 (732)	20.4 (534)	20.0 (524)	31.6*** (828)	100.0 (2,618)
Education¹					
- Less than certificate	30.8** (230)	24.7 (184)	11.8*** (88)	32.7*** (244)	100.0 (746)
- Certificate	28.0* (198)	22.6*** (160)	19.9 (141)	29.5 (209)	100.0 (708)
- Diploma	28.4*** (178)	18.5 (116)	23.4*** (147)	29.7* (186)	100.0 (627)
- > Diploma	26.2* (210)	15.7*** (126)	25.7*** (206)	32.5*** (261)	100.0 (803)
Religious¹					
- Buddhism	28.3 (811)	20.3 (582)	20.1 (576)	31.2 (892)	100.0 (2,861)
- Christian	18.2 (2)	9.1 (1)	36.4 (4)	36.4 (4)	100.0 (11)
- Islam	25.0 (3)	25.0 (3)	16.7 (2)	33.3 (4)	100.0 (12)

¹ respondent can choose more than 1 source of information

*p<.05, **p<.01, ***p<.001

Table 4.7 Demographic and Social characteristic on source of information about construction materials (continue)

	Source of information on construction materials				Total
	TV	Radio	Salesman	Colleague	
<i>Work position</i>¹					
- Labor	34.1 (98)	27.5* (79)	11.5*** (33)	26.8*** (77)	100.0 (287)
-Craftsman	29.0 (402)	22.4** (310)	16.2*** (244)	32.4 (448)	100.0 (1,384)
- Foreman	27.0 (142)	17.9 (94)	24.4*** (128)	34.7 (161)	100.0 (525)
- Architect / Engineer	26.5 (112)	16.1* (68)	25.6*** (108)	31.8** (134)	100.0 (422)
- Manager	25.2 (62)	14.2** (35)	28.0*** (69)	32.5 (80)	100.0 (246)
<i>Work experience</i>¹					
- 0-5 years	28.9* (231)	21.1 (168)	21.3* (170)	28.7** (229)	100.0 (798)
- 6-10 years	27.5** (244)	19.8* (176)	20.0 (178)	32.7 (290)	100.0 (888)
- 11-15 years	27.1 (132)	19.3 (94)	20.3 (99)	33.3* (162)	100.0 (487)
- more than 15 years	29.4** (209)	20.8 (148)	19.0 (135)	30.8 (219)	100.0 (711)
<i>Size of firm</i>¹					
- 10-19 persons	25.9*** (227)	23.2* (203)	17.8*** (156)	33.0 (289)	100.0 (875)
- 20-49 persons	29.9*** (250)	19.4 (162)	20.8* (174)	30.0 (251)	100.0 (837)
- >49 persons	28.9 (339)	18.9* (221)	21.5 (252)	30.7 (360)	100.0 (1,172)

¹ respondent can choose more than 1 source of information

*p<.05, **p<.01, ***p<.001

Relationship between work position and source of information for construction material indicate that construction labor access to information about construction material from radio, colleague and salesman as 28%, 27% and 12%, respectively at statistical significant level .05. For worker who works as craftsman access to information about construction material from radio and salesman as 22% and 16%, respectively at statistical significant level .01. For architect/engineer obtain

information about construction material from colleague, salesman and radio as 32%, 26% and 16%, respectively at statistical significant level .05. Manager obtains information about construction material from colleague, salesman and radio as 28% and 14%, respectively at statistical significant level .01.

Considering on the relationship between work experience and source of information for construction material reveals that worker who has construction work experience between 0 and 5 years access information about construction material from television, colleague and salesman as 29%, 29% and 21%, respectively at statistical significant level .05. For worker who has construction work experience between 6 and 10 years access information about construction material from television and radio as 28% and 20%, respectively at statistical significant level .05. For worker who has construction work experience between 11 and 15 years only obtain information about construction material from colleague as 33% at statistical significant level .05. For those who have construction work experience more than 15 years only obtain information about construction material from television as 29% at statistical significant level .01.

Firms of 10-19 workers gain information from television, radio and salesman as 30%, 23% and 18%, respectively at statistical significant level .05. For firm of medium firm (20-49 workers) obtain information from television and salesman as 30% and 29%, respectively at statistical significant level .05. For big firm (more than 49 workers but limit to 300 workers) only gain information from radio as 19% at statistical significant level .05.

Data on study samples' perception on source of information about construction materials in the next table 4.7 show that colleague plays a major role as source of information for worker who perceive that recent materials are more complicate to use than previous and follow with television, radio and salesman as 29%, 29%, 22% and 21%, respectively at statistical significant level .01. As same as worker who feel that recent materials are more easy to apply than previous gain information about construction material from colleague, television, salesman and radio as 34%, 28%, 20% and 19%, respectively at statistical significant level .01.

Worker who feel unsatisfied with benefit of recent materials usage gain information about construction material from television, salesman and radio as 28%, 22% and 20%, respectively at statistical significant level .05. Worker who feel fair with benefit of recent materials usage gain information about construction material from television, radio and salesman as 28%, 21% and 19%, respectively at statistical significant level .05. Worker who feel satisfied with benefit of recent materials usage gain information about construction material from television, radio and salesman as 27%, 19% and 14%, respectively at statistical significant level .05.

Worker who perceives that recent material is cheaper than previous gain information about construction material from television and salesman as 21% and 21%, respectively at statistical significant level .01. Worker who perceives that recent material is fair price gain information about construction material from television and salesman as 29% and 21%, respectively at statistical significant level .01. Worker who perceives that recent material is expensive than previous gains information about construction material from television and salesman as 28% and 19%, respectively at statistical significant level .01. Worker who perceives that recent material is common available gain information about construction material from television, radio and salesman as 33%, 20% and 13%, respectively at statistical significant level .05. Worker who perceives that recent material is fair available gain information about construction material from television, salesman and radio as 27%, 23% and 21%, respectively at statistical significant level .05. Worker who perceives that recent material is hard to access gain information about construction material from television, radio and salesman as 29%, 20% and 20%, respectively at statistical significant level .05.

Table 4.7 Demographic and Social characteristic on source of information about construction materials (continue)

	Source of information on construction materials				Total
	TV	Radio	Salesman	Colleague	
<i>Easy to use materials</i>¹					
- Complicate	28.7*** (484)	21.5*** (363)	20.8*** (350)	29.0** (488)	100.0 (1,685)
- Easy	27.7*** (332)	18.6*** (223)	19.3*** (232)	34.4** (412)	100.0 (1,199)
<i>Benefit to use materials</i>¹					
- Poorer	28.3*** (457)	19.8* (319)	21.5*** (346)	30.4 (490)	100.0 (1,612)
- Fair	28.4*** (314)	21.2* (235)	19.3*** (213)	31.1 (344)	100.0 (1,106)
- Better	27.1*** (45)	19.3* (32)	13.9*** (23)	39.8 (66)	100.0 (166)
<i>Cost of materials</i>¹					
- Cheaper	21.2*** (7)	18.2 (6)	21.2** (7)	39.4 (13)	100.0 (33)
- Fair	28.9*** (446)	19.9 (307)	21.3** (328)	29.9 (460)	100.0 (1,541)
- Expensive	27.7*** (363)	20.8 (273)	18.9** (247)	32.6 (427)	100.0 (1,310)
<i>Accessibility of materials</i>¹					
- Common	32.7* (18)	20.0* (11)	12.7*** (7)	34.5 (19)	100.0 (55)
- Fair	27.2* (202)	20.9* (155)	22.8*** (169)	29.1 (216)	100.0 (742)
- Hard to access	28.6* (596)	20.1* (420)	19.5*** (406)	31.9 (665)	100.0 (2,087)

¹ respondent can choose more than 1 source of information

*p<.05, **p<.01, ***p<.001

The results of relationship between influence of social norm and network of construction workforce on source of information about construction materials indicated that worker who feels that social norm has no influence on their behavior gain information about construction material from television, salesman, colleague and radio as 30%, 15%, 15% and 14%, respectively at statistical significant level .001.

Worker who feels that social norm has influence on their behavior gain information about construction material from colleague, television, salesman, and radio, respectively at statistical significant level .001.

Table 4.7 Demographic and Social characteristic on source of information about construction materials (continue)

	Source of information on construction materials				Total
	TV	Radio	Salesman	Colleague	
<i>Influence of norm</i>¹					
0 score	29.6*** (40)	14.1*** (19)	14.8*** (20)	14.5*** (56)	100.0 (135)
1 score	30.1*** (52)	20.8*** (36)	15.6*** (27)	33.5*** (58)	100.0 (173)
2 score	26.6*** (53)	18.6*** (37)	21.6*** (43)	33.2*** (66)	100.0 (199)
3 score	27.0*** (131)	18.6*** (90)	23.7*** (115)	30.7*** (149)	100.0 (485)
4 score	28.6*** (237)	21.0*** (174)	19.8*** (164)	30.6*** (253)	100.0 (828)
5 score	28.5*** (303)	21.6*** (230)	20.0*** (213)	29.9*** (318)	100.0 (1,064)
<i>Influence of network</i>¹					
0 score	27.4*** (80)	17.5*** (51)	17.8*** (52)	37.3*** (109)	100.0 (292)
1 score	25.6*** (55)	12.1*** (26)	25.1*** (54)	37.2*** (80)	100.0 (215)
2 score	26.2*** (48)	16.9*** (31)	21.3*** (39)	35.5*** (65)	100.0 (183)
3 score	28.6*** (99)	18.5*** (64)	20.5*** (71)	32.4*** (112)	100.0 (346)
4 score	28.0*** (181)	22.8*** (147)	19.5*** (126)	29.7*** (192)	100.0 (646)
5 score	30.5*** (160)	20.8*** (109)	19.5*** (102)	29.2*** (153)	100.0 (524)
6 score	29.5*** (76)	24.8*** (64)	19.0*** (49)	26.7*** (69)	100.0 (258)
7 score	27.9*** (117)	22.4*** (94)	21.2*** (89)	28.6*** (120)	100.0 (420)

¹ respondent can choose more than 1 source of information
 *p<.05, **p<.01, ***p<.001

The results of relationship between influences of social network of construction workforce on source of information about construction materials indicated that worker who feels that social norm has no influence on their behavior gain information about construction material from colleague, television, salesman and radio as 37%, 27%, 18% and 18%, respectively at statistical significant level .001. Worker who feels that social network has influence on their behavior gain information about construction material from colleague, television, radio, and salesman, respectively at statistical significant level .001.

4.2.3 Knowledge score of study samples

In table 4.8 presented the knowledge score relating to construction nanoproducts based on demographic and social characteristic differences of workers. This portion explored the knowledge score on age group, gender, education, religion, work position and experience, size of firm, performance/expectancy factors, communication and influence of norm and network.

For the examination on knowledge difference among Thai construction workforce, this research employed educational evaluation method as scoring by questionnaire design to detect the level of knowledge on construction nanoproducts. The scoring of knowledge conducted through questionnaires surveying and results was counted by accumulating of scoring and presented in table 4.8. Results revealed that mean score of knowledge about construction nanoproducts slightly decreased when age of samples increased. Samples aged 40 and over have least knowledge on construction nanoproducts when compared with other age groups. The results of relationship between gender and knowledge scoring of construction nanoproducts indicated that female samples have lower knowledge than male samples.

Table 4.8 Demographic and social characteristic of construction workforce and knowledge score on nanoproducts

	Mean	Mode	Knowledge score on nanoproducts in construction industry										Total	
			0	1	2	3	4	5	6	7	8	9		10
Demographic characteristic														
<i>Age group</i>														
- age 15-29	2.87	0	37.2 (93)	7.6 (19)	13.2 (33)	7.6 (19)	4.0 (10)	6.0 (15)	6.4 (16)	7.2 (18)	4.4 (11)	4.0 (10)	2.4 (6)	100.0 (250)
- age 30-39	2.39	0	38.7 (165)	10.6 (45)	12.4 (53)	9.6 (41)	6.8 (29)	6.1 (26)	4.7 (20)	6.1 (26)	1.2 (5)	1.2 (5)	2.6 (11)	100.0 (426)
- age 40+	1.64	0	49.4 (233)	12.1 (57)	14.0 (66)	6.4 (30)	4.2 (20)	5.7 (27)	2.3 (11)	3.4 (16)	1.3 (6)	1.1 (5)	0.2 (1)	100.0 (472)
<i>Gender</i>														
- Female	1.96	0	48.7 (57)	3.4 (4)	16.2 (19)	12.0 (14)	4.3 (5)	1.7 (2)	2.6 (3)	7.7 (9)	1.7 (2)	1.7 (2)	0.0 (0)	100.0 (117)
- Male	2.21	0	42.1 (434)	11.3 (117)	12.9 (133)	7.4 (76)	5.2 (54)	6.4 (66)	4.3 (44)	4.9 (51)	1.9 (20)	1.7 (18)	1.7 (18)	100.0 (1,031)

Results of the relationship between educational level and knowledge score on construction nanoproducts show that more than half (59.4%) of samples who completed less than certificate level do not have knowledge on construction nanoproducts. Interestingly, samples that completed at diploma have better score of knowledge than other groups that means they have better knowledge about construction nanoproducts. However, overall mean score of knowledge about construction nanoproducts focused on education is still lower than 60 percent (mean score less than 6). Due to most of samples are Buddhism (98.9%), it should not have any difference on knowledge score compared by religions. However, the results still confirmed that overall mean score of knowledge about nanoproducts is still lower than 60 percent when focuses on relationship with religious.

On the next portion of table 4.8, results of relationship between work position such as manage, architect/engineer, foreman, craftsman and labor and knowledge score on construction nanoproducts presented that architect/engineer has the highest mean score of knowledge (2.82) by comparing with other work positions. Labor is a group that has the lowest knowledge on construction nanoproducts (mean score = 0.91). Interestingly, manager who has authority to decide for using construction products has lower knowledge score compared with foreman. For the relationship between experience and knowledge on construction nanoproducts, it shows that samples who work in construction industry less than 5 years has the highest knowledge on construction nanoproducts while samples who has work experience more than 15 years has the least knowledge score (mean score = 1.62). Moreover, samples who have work experience between 11 and 15 years have better knowledge score than samples who have work experience between 6 and 10 years. This indicated that knowledge score on construction nanoproducts might not get along with the number of years experience of samples as knowledge score is still less than 60 percent on average.

Table 4.8 Demographic and social characteristic of construction workforce and knowledge score on nanoproducts (continue)

	Mean	Mode	Knowledge score on nanoproducts in construction industry										Total									
			0	1	2	3	4	5	6	7	8	9		10								
Position																						
- Labor	0.91	0	68.0 (85)	11.2 (14)	8.0 (10)	2.4 (3)	3.2 (4)	3.2 (4)	1.6 (2)	4.0 (5)	1.6 (2)	0.0 (0)	0.0 (0)	0.0 (0)	1.6 (2)	1.6 (2)	0.0 (0)	0.0 (0)	1.6 (2)	0.0 (0)	100.0 (125)	
- Craftsman	2.02	1	48.1 (269)	8.1 (45)	14.0 (78)	7.2 (40)	5.7 (32)	5.7 (32)	1.4 (8)	3.9 (22)	1.4 (8)	5.5 (31)	5.5 (31)	2.0 (11)	2.3 (13)	2.3 (13)	1.8 (10)	1.8 (10)	2.3 (13)	1.8 (10)	100.0 (559)	
- Foreman	2.74	2	28.6 (58)	11.3 (23)	15.8 (32)	9.4 (19)	6.9 (14)	6.9 (14)	9.9 (20)	9.9 (20)	9.9 (20)	3.9 (8)	3.9 (8)	1.0 (2)	2.5 (5)	2.5 (5)	1.0 (2)	1.0 (2)	2.5 (5)	1.0 (2)	100.0 (203)	
- Architect / Engineer	2.82	2	26.5 (44)	15.7 (26)	15.1 (25)	11.4 (19)	0.6 (1)	0.6 (1)	7.8 (13)	7.8 (13)	7.8 (13)	9.0 (15)	9.0 (15)	4.2 (7)	0.0 (0)	0.0 (0)	1.8 (3)	1.8 (3)	0.0 (0)	1.8 (3)	1.8 (3)	100.0 (166)
- Manager	2.51	0	36.8 (35)	13.7 (13)	7.4 (7)	9.5 (9)	8.4 (8)	8.4 (8)	4.2 (4)	8.4 (8)	4.2 (4)	6.3 (6)	6.3 (6)	2.1 (2)	0.0 (0)	0.0 (0)	3.2 (3)	3.2 (3)	0.0 (0)	3.2 (3)	3.2 (3)	100.0 (95)
Experience																						
- 0-5 years	2.56	1	45.1 (142)	5.7 (18)	11.1 (35)	7.9 (25)	3.8 (12)	3.8 (12)	5.7 (18)	5.1 (16)	5.7 (18)	5.1 (16)	5.1 (16)	3.8 (12)	3.8 (12)	3.8 (12)	2.9 (9)	2.9 (9)	3.8 (12)	2.9 (9)	100.0 (315)	
- 6-10 years	2.21	1	36.2 (129)	15.7 (56)	14.9 (53)	7.9 (28)	6.2 (22)	6.2 (22)	4.8 (17)	5.3 (19)	4.8 (17)	5.1 (18)	5.1 (18)	1.1 (4)	0.3 (1)	0.3 (1)	2.5 (9)	2.5 (9)	0.3 (1)	2.5 (9)	2.5 (9)	100.0 (356)
- 11-15 years	2.33	1	41.3 (83)	10.4 (21)	10.0 (20)	7.5 (15)	6.0 (12)	6.0 (12)	5.0 (10)	9.5 (19)	5.0 (10)	6.0 (12)	6.0 (12)	2.5 (5)	2.0 (4)	2.0 (4)	0.0 (0)	0.0 (0)	2.0 (4)	0.0 (0)	100.0 (201)	
- >15 years	1.62	1	49.6 (137)	9.4 (26)	15.9 (44)	8.0 (22)	4.7 (13)	4.7 (13)	0.7 (2)	5.1 (14)	0.7 (2)	5.1 (14)	5.1 (14)	0.4 (1)	1.1 (3)	1.1 (3)	0.0 (0)	0.0 (0)	1.1 (3)	0.0 (0)	100.0 (276)	

Table 4.8 Demographic and social characteristic of construction workforce and knowledge score on nanoproducts (continue)

	Mean	Mode	Knowledge score on nanoproducts in construction industry										Total	
			0	1	2	3	4	5	6	7	8	9		10
<i>Size of firm</i>														
- 10-19 persons	1.89	1	41.5 (139)	11.6 (39)	18.2 (61)	8.7 (29)	5.4 (18)	4.8 (16)	4.2 (14)	3.3 (11)	0.9 (3)	0.6 (2)	0.9 (3)	100.0 (335)
- 20-49 persons	2.29	1	38.3 (111)	12.4 (36)	13.8 (40)	8.6 (25)	6.9 (20)	5.9 (17)	4.5 (13)	3.8 (11)	1.7 (5)	2.1 (6)	2.1 (6)	100.0 (290)
- more than 49 persons	2.32	1	46.1 (241)	8.8 (46)	9.8 (51)	6.9 (36)	4.0 (21)	6.7 (35)	3.8 (20)	7.3 (38)	2.7 (14)	2.3 (12)	1.7 (9)	100.0 (523)
<i>Easy to use materials</i>														
- Complicate	2.66	0	37.7 (228)	7.0 (42)	14.2 (86)	8.8 (53)	5.6 (34)	7.6 (46)	5.5 (33)	5.1 (31)	3.1 (19)	2.8 (17)	2.5 (15)	100.0 (604)
- Easy	1.65	0	48.3 (263)	14.5 (79)	12.1 (66)	6.8 (37)	4.6 (25)	4.0 (22)	2.6 (14)	5.3 (29)	0.6 (3)	0.6 (3)	0.6 (3)	100.0 (544)
<i>Benefit to use materials</i>														
- Poorer	2.37	0	40.3 (248)	9.9 (61)	12.8 (79)	8.6 (53)	6.5 (40)	6.7 (41)	4.5 (28)	4.4 (27)	1.3 (8)	2.4 (15)	2.6 (16)	100.0 (616)
- Fair	2.13	0	42.3 (190)	11.6 (52)	14.3 (64)	7.6 (34)	3.6 (16)	5.8 (26)	3.8 (17)	6.9 (31)	2.9 (13)	0.9 (4)	0.4 (2)	100.0 (449)
- Better	1.14	0	63.9 (53)	9.6 (8)	10.8 (9)	3.6 (3)	3.6 (3)	1.2 (1)	2.4 (2)	2.4 (2)	1.2 (1)	1.2 (1)	0.0 (0)	100.0 (83)

Results of relationship between organizational size and knowledge score on construction nanoproducts revealed that samples from bigger companies seem to have little higher knowledge than samples from smaller companies when considering on mean score. However, the conflicted results existed when focuses on samples who got 0 score on knowledge about construction nanoproducts as samples who work in medium size companies (20-49 workers) seem to have least 0 score of knowledge about construction nanoproducts by comparing with other size of companies.

Focusing on the relationship among performance/expectancy factors (easy to use recent materials, feeling of better use/cost of usage and materials accessibility), results of cross tabulation show that samples who perceived that recent materials are more complicated to use than previous have higher knowledge score on construction nanoproducts than one who feels easier of use recent materials. Samples who feel unsatisfied with benefit of recent materials usage have higher knowledge score on construction nanoproducts than samples who feel more satisfy with recent material. Results on average for both feeling of satisfy to use recent materials from how easy to use and better quality revealed below 60 percent (a cut point). In the next portion of table 4.8 shows the relationship between cost and accessibility of recent materials and knowledge score on construction nanoproducts. Samples who accepted that the cost of materials is fair have highest knowledge score on construction nanoproducts than other groups while samples who feel recent materials is common to access also have highest knowledge score on nanoproducts. However, both degrees of satisfying with recent materials still present poor knowledge score (less than 60 percent on average).

Samples who gained information about construction materials from salesman seem to have highest knowledge score on construction nanoproducts while samples who received information from his colleague seem to have lowest knowledge score about construction nanoproducts.

Table 4.8 Demographic and social characteristic of construction workforce and knowledge score on nanoproducts (continue)

	Mean	Mode	Knowledge score on nanoproducts in construction industry										Total	
			0	1	2	3	4	5	6	7	8	9		10
Cost of materials														
- Cheaper	1.00	0	52.6 (10)	15.8 (3)	10.5 (2)	21.1 (4)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	100.0 (19)
- Fair	2.35	0	41.1 (246)	9.9 (59)	11.9 (71)	9.2 (55)	4.7 (28)	7.0 (42)	5.2 (31)	5.0 (30)	2.0 (12)	2.5 (15)	1.5 (9)	100.0 (598)
- Expensive	2.04	0	44.3 (235)	11.1 (59)	14.9 (79)	5.8 (31)	5.8 (31)	4.9 (26)	3.0 (16)	5.6 (30)	1.9 (10)	0.9 (5)	1.7 (9)	100.0 (531)
Accessibility of materials														
- Common	3.93	2	11.1 (3)	3.7 (1)	29.6 (8)	3.7 (1)	3.7 (1)	25.9 (7)	3.7 (1)	7.4 (2)	3.7 (1)	3.7 (1)	3.7 (1)	100.0 (27)
- Fair	3.29	0	28.7 (79)	10.5 (29)	10.5 (29)	7.6 (21)	5.8 (16)	10.5 (29)	5.8 (16)	8.7 (24)	5.5 (15)	2.5 (7)	3.6 (10)	100.0 (275)
- Hard to access	1.77	0	48.3 (409)	10.8 (91)	13.6 (115)	8.0 (68)	5.0 (42)	3.8 (32)	3.5 (30)	4.0 (34)	0.7 (6)	1.4 (12)	0.8 (7)	100.0 (846)
Communication¹														
- TV	2.53	2	36.2 (314)	11.3 (98)	14.5 (126)	8.3 (72)	5.8 (50)	5.5 (48)	5.0 (43)	6.8 (59)	2.5 (22)	2.3 (20)	1.8 (16)	100.0 (868)
- Radio	2.77	2	35.6 (222)	9.9 (62)	11.7 (73)	8.2 (51)	7.4 (46)	5.8 (36)	5.3 (33)	8.0 (50)	3.0 (19)	2.6 (16)	2.6 (16)	100.0 (624)
- Salesman	2.82	2	30.3 (197)	12.0 (78)	14.3 (93)	9.4 (61)	6.3 (41)	8.1 (53)	6.0 (39)	5.8 (38)	2.5 (16)	2.9 (19)	2.5 (16)	100.0 (651)
- Colleague	2.37	2	38.9 (382)	10.9 (107)	13.3 (131)	8.7 (85)	5.6 (55)	6.8 (67)	4.5 (44)	5.7 (56)	2.1 (21)	1.6 (16)	1.8 (18)	100.0 (982)

¹ respondent can choose more than 1 source of information

Table 4.8 Demographic and social characteristic of construction workforce and knowledge score on nanoproducts (continue)

	Mean	Mode	Knowledge score on nanoproducts in construction industry										Total		
			0	1	2	3	4	5	6	7	8	9		10	
<i>Influence of norm</i>															
0 score	1.65	1	61.7 (50)	14.8 (12)	17.3 (14)	2.5 (2)	0.0 (0)	0.0 (0)	2.5 (2)	0.0 (0)	0.0 (0)	1.2 (1)	0.0 (0)	0.0 (0)	100.0 (81)
1 score	2.41	2	64.9 (48)	12.2 (9)	5.4 (4)	5.4 (4)	4.1 (3)	1.4 (1)	1.4 (1)	2.7 (2)	0.0 (0)	0.0 (0)	1.4 (1)	1.4 (1)	100.0 (74)
2 score	2.43	2	42.2 (38)	8.9 (8)	10.0 (9)	5.6 (5)	8.9 (8)	16.7 (15)	1.1 (1)	3.3 (3)	0.0 (0)	0.0 (0)	2.2 (2)	1.1 (1)	100.0 (90)
3 score	2.50	2	36.5 (65)	16.3 (29)	15.7 (28)	9.6 (17)	6.7 (12)	6.7 (12)	4.5 (8)	2.8 (5)	0.6 (1)	0.6 (1)	0.6 (1)	0.0 (0)	100.0 (178)
4 score	2.39	2	40.9 (128)	14.4 (45)	10.2 (32)	11.5 (36)	4.8 (15)	4.8 (15)	3.5 (11)	5.4 (17)	1.9 (6)	1.9 (6)	1.9 (6)	0.6 (2)	100.0 (313)
5 score	2.39	2	39.3 (162)	4.4 (18)	15.8 (65)	6.3 (26)	5.1 (21)	6.1 (25)	5.8 (24)	8.0 (33)	3.4 (14)	3.4 (14)	2.4 (10)	3.4 (14)	100.0 (412)

The results of relationship between influence of norm and network of samples and knowledge score on construction nanoproducts indicated that sample who feel that norm (moral) have influence on their decision of using suitable materials in construction site have not much difference on increasing of knowledge score about construction nanoproducts. Moreover, results still show the overall average knowledge score underline of 60 percent.

Table 4.8 Demographic and social characteristic of construction workforce and knowledge score on nanoproducts (continue)

	Mean	Mode	Knowledge score on nanoproducts in construction industry										Total								
			0	1	2	3	4	5	6	7	8	9		10							
<i>Influence of network</i>																					
0 score	1.80	1	68.3 (110)	6.8 (11)	13.0 (21)	2.5 (4)	3.7 (6)	1.9 (3)	1.9 (3)	1.9 (3)	1.9 (3)	0.6 (1)	0.6 (1)	0.0 (0)	0.6 (1)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.6 (1)	100.0 (161)
1 score	2.51	2	55.1 (65)	11.0 (13)	9.3 (11)	13.6 (16)	3.4 (4)	3.4 (4)	3.4 (4)	3.4 (4)	3.4 (4)	0.8 (1)	0.8 (1)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	100.0 (118)
2 score	2.45	1	46.2 (43)	9.7 (9)	14.0 (13)	5.4 (5)	2.2 (2)	4.3 (4)	4.3 (4)	4.3 (4)	4.3 (4)	2.2 (2)	2.2 (2)	2.2 (2)	2.2 (2)	2.2 (2)	3.2 (3)	3.2 (3)	3.2 (3)	8.6 (8)	100.0 (93)
3 score	2.61	2	38.1 (56)	19.7 (29)	15.6 (23)	10.2 (15)	4.1 (6)	4.1 (6)	4.1 (6)	4.1 (6)	4.1 (6)	1.4 (2)	1.4 (2)	1.4 (2)	1.4 (2)	1.4 (2)	5.4 (8)	5.4 (8)	5.4 (8)	0.0 (0)	100.0 (147)
4 score	2.77	2	32.6 (72)	8.6 (19)	14.5 (32)	11.3 (25)	8.1 (18)	8.1 (18)	8.6 (19)	8.6 (19)	8.6 (19)	7.2 (16)	7.2 (16)	7.2 (16)	7.2 (16)	7.2 (16)	7.2 (16)	7.2 (16)	7.2 (16)	1.4 (3)	100.0 (221)
5 score	2.92	2	33.0 (59)	12.3 (22)	16.2 (29)	8.4 (15)	2.8 (5)	2.8 (5)	7.3 (13)	7.3 (13)	7.3 (13)	6.1 (11)	6.1 (11)	6.1 (11)	6.1 (11)	6.1 (11)	7.3 (13)	7.3 (13)	7.3 (13)	1.1 (2)	100.0 (179)
6 score	2.67	2	34.5 (30)	8.0 (7)	9.2 (8)	6.9 (6)	10.3 (9)	10.3 (9)	14.9 (13)	14.9 (13)	14.9 (13)	6.9 (6)	6.9 (6)	6.9 (6)	6.9 (6)	6.9 (6)	5.7 (5)	5.7 (5)	5.7 (5)	3.4 (3)	100.0 (87)
7 score	2.49	1	39.4 (56)	7.7 (11)	10.6 (15)	2.8 (4)	6.3 (9)	6.3 (9)	4.2 (6)	4.2 (6)	4.2 (6)	2.1 (3)	2.1 (3)	2.1 (3)	2.1 (3)	2.1 (3)	9.2 (13)	9.2 (13)	9.2 (13)	3.5 (5)	100.0 (142)

Sample who feel that their decision on recent material usage was influenced by social network have slightly increase of knowledge score on construction nanoproducts. However, the average scores of knowledge are still being less than 60 percent.

For knowledge score of demographic and social characteristic of construction workforce on nanoproducts, it indicated that overall knowledge score for demographic characteristics (age group and gender) is lower than 3 score (mean score 1.64-2.87) from total 10 score. Importantly, construction workforce age more 40 years old seems to have 0 score more than other age groups (49%) while age group 15-29 has least 0 score (37%). Construction female workforce seems to have knowledge score less than male (mean score as 1.96) due to present higher 0 score (49%).

Results for social characteristic of sampling on knowledge of nanoproducts show that there is not variation of knowledge score among education as overall score less than 3 (mean score 1.37-2.91). Interestingly, construction workforce who completes diploma seems to have least 0 score by comparing with those of other education level. This may say that workers who complete diploma (usually work as foreman) have slightly higher knowledge than worker who complete bachelor and more (usually work as manager, architect and engineer). Obvious effects from size of firm to knowledge score pointed out that larger firms (more than 49 workers) have highest 0 score (46%) while medium firms (20-49 workers) have least 0 score (38%). However, overall score is still low as an effect from size of firm to knowledge on nanoproducts (mean score 1.89-2.32). For factors of performance/expectancy (easy to use, benefit, cost and accessibility of materials), it shows that worker who feel easy to use recent construction materials has more 0 score than another (48%) as same as they have lower mean score (1.65). For relation between benefit and cost of using recent materials and knowledge score on nanoproducts, it might say that workers who feel more benefit and expensive use of recent materials have lower knowledge score than others (64% and 44%, respectively) as same as worker who feel hard to access on recent materials have lower score on knowledge of nanoproducts.

Focus on relationship between source of information and knowledge about nanoproducts, it is interestingly found that salesman seems to be a source of knowledge on nanoproducts that workers who access it will have higher knowledge score than other sources. On contrary colleague is the poorest source for knowledge on nanoproducts while it is a main source of recent materials that most construction workers expose to.

For influence of norm and network on knowledge score of nanoproducts it revealed that higher score on norm and network also present higher score of knowledge on nanoproducts. This could say that norm and network play role on knowledge of nanoproducts among Thai construction workforce.

4.2.4 Known and unknown on construction nanoproducts of samples

In table 4.9 presented the relationship between knowledge divided on nanoproducts among samples as follows.

Table 4.9 Demographic and social characteristic of construction workforce on knowledge divide towards nanoproducts

	Knowledge in nanoproducts in construction industry¹		Total
	don't have knowledge	have knowledge	
Age group			
- age 15-29	75.6 (189)	24.4 (61)	100.0 (250)
- age 30-39	84.3 (359)	15.7 (67)	100.0 (426)
- age 40+	91.7 (433)	8.3 (39)	100.0 (472)
Gender			
- Female	86.3 (101)	13.7 (16.0)	100.0 (117)
- Male	85.4 (880)	14.6 (151)	100.0 (1,031)
Education			
- Less than certificate	93.3 (333)	6.7 (24)	100.0 (357)
- Certificate	86.0 (215)	14.0 (35)	100.0 (250)
- Diploma	79.7 (177)	20.3 (45)	100.0 (222)
- > Diploma	80.3 (256)	19.7 (63)	100.0 (319)

¹ knowledge was divided by 0 = knowledge score is less than 60 percent,
1= knowledge score is 60 percent and over

The results of examined relationship between demographic and social characteristic of construction workforce on knowledge about nanoproducts show over all picture that most construction workforce has low knowledge about nanoproducts even there is nanoproducts available in Thai construction market more than 5 years. The next step of this study will explore the results of Table 4.6 in forms of knowledge divide about nanoproducts as knowledge score was converted in to dichotomous variable (0 = don't have knowledge; 1 = have knowledge) as in table below.

Table 4.9 Demographic and social characteristic of construction workforce on knowledge divide towards nanoproducts (continue)

	Knowledge in nanoproducts in construction industry¹		Total
	don't have knowledge	have knowledge	
<i>Religious</i>			
- Buddhism	85.3 (968)	14.7 (167)	100.0 (1,135)
- Christian	100.0 (5)	0.0 (0)	100.0 (5)
- Islam	100.0 (8)	0.0 (0)	100.0 (8)
	(121)	(4)	(125)
<i>Position</i>			
- Labour	96.8 (121)	3.2 (4)	100.0 (125)
- Craftsman	86.9 (486)	13.1 (73)	100.0 (559)
- Foreman	81.8 (166)	18.2 (37)	100.0 (203)
- Architect / Engineer	77.1 (128)	22.9 (38)	100.0 (166)
- Manager	84.2 (80)	15.8 (15)	100.0 (95)

¹ knowledge was divided by 0 = knowledge score is less than 60 percent,
1= knowledge score is 60 percent and over

Data from dichotomous dependent variable on knowledge divide show better clear picture that workers age more than 40 years old have highest percent of “don't know on nanoproducts” by comparing with other age groups (92%). There is

slightly different between knowledge divided of construction nanoproducts in gender. Interestingly, workers who completed diploma have more chance to know nanoproducts by comparing with other educational groups (20%).

There are not much variation results from religious comparison, however, the consideration at work position revealed that most construction labours have less chance to know nanoproducts when compare with other work positions (97%). While architect and engineer have more chance to know nanoproducts than other groups (23%). For workers who have work experience between 0-5 years seem to have more chance to know nanoproducts (21%) than others while workers who have work experience more than 15 years seem to be worst group that don't have knowledge on nanoproducts (93%).

Table 4.9 Demographic and social characteristic of construction workforce on knowledge divide towards nanoproducts (continue)

	Knowledge in nanoproducts in construction industry¹		Total
	don't have knowledge	have knowledge	
<i>Experience</i>			
- 0-5 years	78.7 (248)	21.3 (67)	100.0 (315)
- 6-10 years	86.2 (307)	13.8 (49)	100.0 (356)
- 11-15 years	84.6 (170)	15.4 (31)	100.0 (201)
- more than 15 years	92.8 (256)	7.2 (20)	100.0 (276)
<i>Size of firm</i>			
- 10-19 persons	90.1 (302)	9.9 (33)	100.0 (335)
- 20-49 persons	85.9 (249)	14.1 (41)	100.0 (290)
- More than 49 persons	82.2 (430)	17.8 (93)	100.0 (523)
<i>Easy to use materials</i>			
- Complicate	81.0 (489)	19.0 (115)	100.0 (604)

Table 4.9 Demographic and social characteristic of construction workforce on knowledge divide towards nanoproducts (continue)

	Knowledge in nanoproducts in construction industry¹		Total
	don't have knowledge	have knowledge	
- Easy	90.4 (492)	9.6 (52)	100.0 (544)
<i>Benefit to use materials</i>			
- Poorer	84.7 (522)	15.3 (94)	100.0 (616)
- Fair	85.1 (382)	14.9 (67)	100.0 (449)
- Better	92.8 (77)	7.2 (6)	100.0 (83)
<i>Cost of materials</i>			
- Cheaper	100.0 (19)	0.0 (0)	100.0 (19)
- Fair	83.8 (501)	16.2 (97)	100.0 (598)
- Expensive	86.8 (461)	13.2 (70)	100.0 (531)
<i>Accessibility of materials</i>			
- Common	77.8 (21)	22.2 (6)	100.0 (27)
- Fair	73.8 (203)	26.2 (72)	100.0 (275)
- Hard to access	89.5 (757)	10.5 (89)	100.0 (846)
<i>Communication²</i>			
TV	81.6 (708)	18.4 (160)	100.0 (868)
Radio	78.5 (490)	21.5 (134)	100.0 (624)
Salesman	80.3 (523)	19.7 (128)	100.0 (651)
colleague	84.2 (827)	15.8 (155)	100.0 (982)

¹ knowledge was divided by 0 = knowledge score is less than 60 percent,
1 = knowledge score is 60 percent and over

² respondent can choose more than 1 source of information

Consideration on size of firm, it is found that the smallest firm size (10-19 workers) is a worst group that have less knowledge on construction nanoproducts (90%) while firms with more than 49 workers have knowledge on nanoproducts better than other (17.8%). Focus on performance/effort expectancy (easy to use materials) about knowledge on nanoproducts revealed slightly difference about 9 percent of worker's knowledge on nanoproducts as when traditional products easy to use then the knowledge on nanoproducts is lower than using complicated construction products.

Results for performance/effort expectancy factors (benefit, cost and accessibility) on recent construction materials show the relationship with knowledge on nanoproducts that worker feels better using of recent materials seem to have less chance to know nanoproducts (93%). Interestingly, workers who feel that recent materials are cheaper than previous have least chance to know nanoproducts (100%). Moreover, workers who feel recent materials are harder to access than the past then they have less chance to know nanoproducts than others (90%). For relationship between communication factors and knowledge divide on nanoproducts, radio became a major source that workers who access it will have more chance to know nanoproducts than other source while colleague still be the poorest source of information for nanoproducts.

For influence of norm and network on knowledge divide on nanoproducts, it revealed that increasing of norm score also slightly increased chance to have knowledge on nanoproducts as well as increasing of network score. This could say that norm and network play role on increasing chance to have knowledge of nanoproducts among Thai construction workforce.

Table 4.9 Demographic and social characteristic of construction workforce on knowledge divide towards nanoproducts (continue)

	Knowledge in nanoproducts in construction industry¹		Total
	don't have knowledge	have knowledge	
<i>Influence of norm</i>			
0 score	96.3 (78)	3.7 (3)	100.0 (81)
1 score	93.2 (69)	6.8 (5)	100.0 (74)
2 score	92.2 (83)	7.8 (7)	100.0 (90)
3 score	91.6 (163)	8.4 (15)	100.0 (178)
4 score	86.6 (271)	13.4 (42)	100.0 (313)
5 score	76.9 (317)	23.1 (95)	100.0 (412)
<i>Influence of network</i>			
0 score	96.3 (155)	3.7 (6)	100.0 (161)
1 score	95.8 (113)	4.2 (5)	100.0 (118)
2 score	81.7 (76)	18.3 (17)	100.0 (93)
3 score	91.8 (135)	8.2 (12)	100.0 (147)
4 score	83.7 (185)	16.3 (36)	100.0 (221)
5 score	79.9 (143)	20.1 (36)	100.0 (179)
6 score	83.9 (73)	16.1 (14)	100.0 (87)
7 score	71.1 (101)	28.9 (41)	100.0 (142)

¹ knowledge was divided by 0 = knowledge score is less than 60 percent,
1= knowledge score is 60 percent and over

Table 4.10 Relationship between score of knowledge and awareness on nanoproducts of construction workforce

<i>Knowledge</i>	Awareness score on nanoproducts in construction industry										Total	
	Mean	Mode	0	1	2	3	4	5	6	7		8
0 score	0.00	0	100.0 (491)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	100.0 (491)
1 score	2.96	0	23.1 (28)	6.6 (8)	22.3 (27)	9.9 (12)	11.6 (14)	8.3 (10)	5.0 (6)	8.3 (10)	5.0 (6)	100.0 (121)
2 score	3.70	4	12.5 (19)	7.9 (12)	8.6 (13)	13.8 (21)	23.0 (35)	11.2 (17)	9.2 (14)	10.5 (16)	3.3 (5)	100.0 (152)
3 score	4.26	4	5.6 (5)	4.4 (4)	6.7 (6)	14.4 (13)	25.6 (23)	17.8 (16)	12.2 (11)	6.7 (6)	6.7 (6)	100.0 (90)
4 score	3.69	3	8.5 (5)	11.9 (7)	5.1 (3)	25.4 (15)	10.2 (6)	22.0 (13)	5.1 (3)	5.1 (3)	6.8 (4)	100.0 (59)
5 score	3.63	5	5.9 (4)	11.8 (8)	7.4 (5)	16.2 (11)	16.2 (11)	35.3 (24)	5.9 (4)	0.0 (0)	1.5 (1)	100.0 (68)
6 score	4.34	5	4.3 (2)	4.3 (2)	6.4 (3)	10.6 (5)	17.0 (8)	36.2 (17)	12.8 (6)	8.5 (4)	0.0 (0)	100.0 (47)
7 score	4.65	4	3.3 (2)	3.3 (2)	1.7 (1)	8.3 (5)	30.0 (18)	25.0 (15)	13.3 (8)	11.7 (7)	3.3 (2)	100.0 (60)
8 score	5.23	5	0.0 (0)	4.5 (1)	9.1 (2)	9.1 (2)	0.0 (0)	36.4 (8)	9.1 (2)	18.2 (4)	13.6 (3)	100.0 (22)
9 score	5.45	8	0.0 (0)	10.0 (2)	5.0 (1)	25.0 (5)	0.0 (0)	10.0 (2)	0.0 (0)	0.0 (0)	50.0 (10)	100.0 (20)
10 score	6.39	8	0.0 (0)	0.0 (0)	0.0 (0)	16.7 (3)	5.6 (1)	11.1 (2)	11.1 (2)	0.0 (0)	55.6 (10)	100.0 (18)

N = 1,148 df = 80 r = 0.454 p value = 0.001

Table 4.11 Relationship between knowledge and awareness issues

	Awareness								Total
	A	B	C	D	E	F	G	H	
1. Construction nanomaterials couldn't saw by own eyes.	14.4 (238)	6.3 (105)	7.3 (121)	15.5 (256)	5.4 (89)	12.9 (213)	19.1 (316)	19.2 (317)	100.0 (1,655)
2. There are already construction nanomaterials available in the market.	13.3 (269)	6.9 (139)	9.0 (182)	16.0 (323)	5.2 (105)	14.1 (285)	17.6 (357)	18.0 (364)	100.0 (2,024)
3. There are more than 50 construction nanomaterials available in the market.	13.1 (93)	9.4 (67)	12.3 (87)	15.7 (111)	7.5 (53)	12.7 (90)	14.4 (102)	15.0 (106)	100.0 (709)
4. There are more than 100 construction nanomaterials available in the market.	11.3 (53)	10.4 (49)	12.8 (60)	15.8 (74)	9.6 (45)	13.2 (62)	13.6 (64)	13.2 (62)	100.0 (469)
5. There are no any study and production of construction nanomaterials in Thailand.	10.9 (63)	10.9 (63)	11.9 (69)	14.2 (82)	9.3 (54)	12.8 (74)	14.7 (85)	15.2 (88)	100.0 (578)
6. Nanoparticles can be inhaled through our respiratory system.	13.6 (158)	7.7 (89)	9.4 (109)	15.3 (178)	6.3 (73)	14.5 (169)	16.9 (196)	16.4 (191)	100.0 (1,163)
7. Nanoparticles can be penetrated through dermis by exposure.	13.7 (141)	7.9 (81)	10.2 (105)	15.0 (155)	6.7 (69)	14.4 (148)	16.4 (169)	15.8 (163)	100.0 (1,031)
8. Nanoparticles can be absorbed through human tract.	13.6 (146)	8.0 (86)	9.8 (105)	15.4 (165)	5.6 (60)	14.6 (156)	16.7 (179)	16.2 (173)	100.0 (1,070)
9. Nanoparticles can be accumulated in living organism.	13.5 (159)	7.5 (88)	9.8 (115)	15.2 (179)	6.7 (79)	15.0 (177)	16.5 (194)	15.8 (186)	100.0 (1,177)
10. Accumulation of nanoparticles can harm to living organism.	13.6 (148)	8.2 (89)	10.2 (111)	14.8 (161)	6.6 (72)	15.1 (165)	16.1 (175)	15.5 (169)	100.0 (1,090)

A. You ever use construction nanomaterials in construction operation.
 B. You ever use self-cleaning tile in construction operation.
 C. You ever use Anti-bacteria sanitary ware in construction operation.
 D. You ever use Anti fungi (Hydrophobic) adhesive in construction operation.
 E. You ever use Self-cleaning window in construction operation.
 F. You ever use Cement strength catalyzed (NanoCem) in construction operation.
 G. You ever use Anti-scratch/UV protection wood coating in construction operation.
 H. You ever use self-cleaning painting in construction operation.

The relationship between knowledge and awareness issues in table 4.11 shown that sample who know about construction nanoproducts also have experience about nano-coating for woodwork, hydrophobic adhesive and self-cleaning painting in construction operation, respectively.

4.2.5 Knowledge and awareness score on construction nanoproducts

This part of results examined the relationship between knowledge and awareness on nanoproducts among construction workforce (Table 4.10). It revealed that increasing of knowledge score would dramatically increase awareness score on nanoproducts.

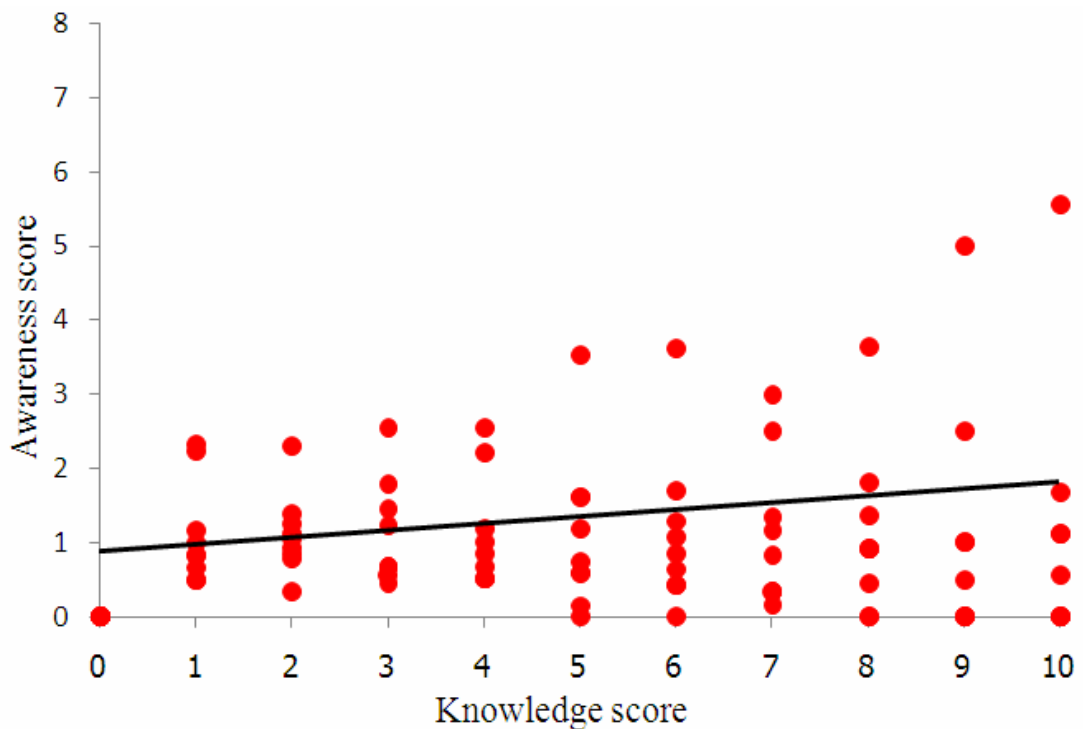


Figure 4.1 Scatter plot of relationship between knowledge and awareness score on nanoproducts

From figure 4.1, it is shown that when knowledge score is 0 then awareness score is also null. On average mean score of knowledge varied between 2.96 and 6.39 while mode of answer score varied between 0 and 8 from total 10 score. To have

clearer understanding of such relationship between knowledge and awareness score on nanoproducts, the Regression Analysis was also employed to examine this relationship as the result shown in Table 4.10.

Table 4.12 Result of relationship between knowledge and awareness score on nanoproducts

	Awareness score	
	Coefficient	S.E.
knowledge score	0.65***	0.012
Constant	0.84***	0.074

N = 1,148

df = 1

Model Chi-Square = 929.11

R² = 0.454

* = p<0.05, ** = p<0.01, *** = p<0.001

Without controlled other factors but only focusing on relationship between knowledge and awareness on nanoproducts among Thai construction workforce, the result from regression analysis revealed that when knowledge increases at 1 score it will also increase awareness on nanoproducts by 0.65 score at statistical significant level .001. That is to say, the increasing of knowledge on construction nanoproducts also increases the awareness on construction nanoproducts among construction workforce. This finding is similar to a study of Scheufele and Lewenstein (2005) that when people was informed about nanotechnology, they will recognized it in terms of benefit more than risk and public reaction can be interpreted as the evidence of knowledge so called “awareness”.

4.2.6 Known on nanoproducts and source of information

After examine the relationship between knowledge and awareness on nanoproducts then next step was designed by considering only number of workers who respond as they know what are nanoproducts from knowledge scoring 1-10 (607 persons). After that researcher explores data by showing knowledge and awareness divided in table 4.13 as follows.

Table 4.13 Demographic and Social characteristic on source of information about nanoproducts in Thai construction workforce

	Source of information on nanoproducts				Total
	TV	Radio	Salesman	Colleague	
Age group¹					
- age 15-29	28.2*** (127)	20.6* (93)	23.7** (107)	27.5 (124)	100.0 (451)
- age 30-39	27.5 (203)	19.9 (147)	22.7 (168)	29.9 (221)	100.0 (739)
- age 40+	33.0 (189)	23.8 (136)	24.5** (140)	18.7 (207)	100.0 (572)
Gender¹					
- Female	29.4 (47)	18.8 (30)	22.5 (36)	29.4 (47)	100.0 (160)
- Male	27.7 (472)	20.3 (346)	22.3 (379)	29.7 (505)	100.0 (1,702)
Education¹					
- < certificate	28.7* (100)	24.1 (84)	16.0*** (56)	31.2 (109)	100.0 (349)
- Certificate	28.0** (120)	23.8*** (102)	20.6 (88)	27.6 (118)	100.0 (428)
- Diploma	29.0** (137)	19.1 (90)	23.3* (110)	28.6 (135)	100.0 (472)
- > diploma	26.4** (162)	16.3*** (100)	26.3*** (161)	31.0 (190)	100.0 (613)
Religious¹					
- Buddhism	27.9 (517)	20.2 (374)	22.2 (411)	29.6 (548)	100.0 (1,850)
- Christian	12.5 (1)	12.5 (1)	37.5 (3)	37.5 (3)	100.0 (8)
- Islam	25.0 (1)	25.0 (1)	25.0 (1)	25.0 (1)	100.0 (4)

¹ respondent can choose more than 1 source of information

*p<.05, **p<.01, ***p<.001

From table 4.13, results on relationship between sample's age groups and source of information on construction nanoproducts revealed that construction worker aged 15-29 gains information about construction nanoproducts from television, salesman and radio as 28%, 24% and 21%, respectively at statistical significant level .05 while it showed that construction worker who aged more than 40 years only access

construction nanoproducts information from salesman as 25%, at statistical significant level .01.

Table 4.13 Demographic and Social characteristic on source of information about nanoproducts in Thai construction workforce (continue)

	Source of information on nanoproducts				Total
	TV	Radio	Salesman	Colleague	
Position¹					
- Labor	27.9* (29)	23.1 (24)	18.3** (19)	30.8 (32)	100.0 (104)
- Craftsman	28.9** (237)	23.1*** (190)	19.4*** (159)	28.6 (235)	100.0 (821)
- Foreman	26.8 (109)	18.7 (76)	23.6 (96)	30.8* (125)	100.0 (406)
- Architect / Engineer	27.1 (95)	16.0** (56)	26.3** (92)	30.6 (107)	100.0 (350)
- Manager	27.1 (49)	16.6 (30)	27.1** (49)	29.3 (53)	100.0 (181)
Experience¹					
- 0-5 years	28.2 (136)	19.7 (95)	23.4 (113)	28.8 (139)	100.0 (483)
- 6-10 years	26.8*** (168)	20.4 (128)	21.8* (137)	31.1 (195)	100.0 (628)
- 11-15 years	28.0 (91)	21.2 (69)	21.5 (70)	29.2 (95)	100.0 (325)
- more than 15 years	29.1*** (124)	19.7 (84)	22.3 (95)	28.9 (123)	100.0 (426)
Size of firm¹					
- 10-19 persons	26.2** (155)	23.4** (138)	20.5** (121)	29.9 (177)	100.0 (591)
- 20-49 persons	28.9*** (166)	19.3 (111)	23.3* (134)	28.5 (164)	100.0 (575)
- more than 49 persons	28.4 (198)	18.2** (127)	23.0 (160)	30.3 (211)	100.0 (969)

¹ respondent can choose more than 1 source of information

*p<.05, **p<.01, ***p<.001

Considering on education reveals that construction worker who has education background less than certificate level access information about construction

nanoproducts from television and salesman as 29% and 16% respectively at statistical significant level .05. For those who obtain certificate gains construction nanoproducts information from television and radio as 28% and 24% respectively at statistical significant level .01. For worker who obtain diploma gains construction nanoproducts information from colleague, television and salesman as 29% and 23% respectively at statistical significant level .05. For well educated worker who have own higher than diploma level gain gains construction material information from television, salesman and radio as 26%, 26% and 16% respectively at statistical significant level .01.

Relationship between work position and source of information for construction nanoproducts indicate that construction labor access to information about construction material from television and salesman as 28% and 18%, respectively at statistical significant level .05. For worker who works as craftsman access to information about construction nanoproducts from television, radio and salesman as 29%, 23% and 19%, respectively at statistical significant level .01. For foreman only obtain information about construction nanoproducts from colleague as 31%, at statistical significant level .05. For architect/engineer obtain information about construction nanoproducts from salesman and radio as 26% and 16%, respectively at statistical significant level .01. Manager only obtains information about construction nanoproducts from salesman as 27% at statistical significant level .01.

Considering on the relationship between work experience and source of information for construction nanoproducts reveals that worker who has construction work experience between 6 and 10 years access information about construction nanoproducts from television and salesman as 27% and 22%, respectively at statistical significant level .05. For those who have construction work experience more than 15 years only obtain information about construction nanoproducts from television as 29% at statistical significant level .001.

Firms of 10-19 workers gain information from television, radio and salesman as 26%, 23% and 21%, respectively at statistical significant level .01. For firm of medium firm (20-49 workers) obtain information from television and salesman as 29% and 23%, respectively at statistical significant level .05. For big firm (more

than 49 workers but limit to 300 workers) only gain information from radio as 18% at statistical significant level .01.

Table 4.13 Demographic and Social characteristic on source of information about nanoproducts in Thai construction workforce (continue)

	Source of information on nanoproducts				Total
	TV	Radio	Salesman	Colleague	
<i>Easy to use materials</i> ¹					
- Complicate	27.7*** (317)	20.9*** (240)	23.1*** (265)	28.3* (324)	100.0 (1,146)
- Easy	28.2*** (202)	19.0*** (136)	20.9*** (150)	31.8* (228)	100.0 (716)
<i>Benefit to use materials</i> ¹					
- Poorer	24.8*** (318)	29.3 (376)	20.8*** (267)	25.0* (321)	100.0 (1,282)
- Fair	27.4*** (181)	20.5 (135)	20.8*** (137)	31.4* (207)	100.0 (660)
- Better	28.6*** (20)	21.4 (15)	15.7*** (11)	34.3* (24)	100.0 (70)
<i>Cost of materials</i> ¹					
- Cheaper	15.8*** (3)	15.8 (3)	26.3* (5)	42.1 (8)	100.0 (19)
- Fair	27.7*** (288)	19.8 (206)	23.2* (241)	29.2 (303)	100.0 (1,038)
- Expensive	28.3*** (228)	20.7 (167)	21.0* (169)	29.9 (241)	100.0 (805)
<i>Accessibility of materials</i> ¹					
- Common	33.3 (16)	18.8 (9)	12.5*** (6)	35.4 (17)	100.0 (48)
- Fair	26.6 (151)	20.6 (117)	23.9*** (136)	28.9 (164)	100.0 (568)
- Hard to access	28.3 (352)	20.1 (250)	21.9*** (273)	29.8 (371)	100.0 (1,246)

¹ respondent can choose more than 1 source of information

*p<.05, **p<.01, ***p<.001

Data on study samples' perception on source of information about construction nanoproducts in the above table 4.13 show worker who perceive that recent materials are more complicate to use than previous access construction nanoproducts

information from colleague, television, salesman and radio as 28%, 28%, 23% and 21%, respectively at statistical significant .05. As similar as worker who feel that recent materials are more easy to apply than previous gain information about construction nanoproducts from colleague, television, salesman and radio as 32%, 28%, 21% and 19%, respectively at statistical significant level.05. Worker who feel unsatisfied with benefit of recent materials usage gain information about construction nanoproducts from colleague, television and salesman as 25%, 25% and 21%, respectively at statistical significant level.05. Worker who feel fair with benefit of recent materials usage gain information about construction nanoproducts from colleague, television and salesman as 31%, 27% and 21%, respectively at statistical significant .05. Worker who feel satisfied with benefit of recent materials usage gain information about construction material from colleague, television and salesman as 34%, 29% and 16%, respectively at statistical significant level .05.

Worker who perceives that recent material is cheaper than previous gain information about construction nanoproducts from salesman and television as 26% and 16%, respectively at statistical significant level .05. Worker who perceives that recent material is fair price gain information about construction nanoproducts from television and salesman as 28% and 23%, respectively at statistical significant level .05. Worker who perceives that recent material is expensive than previous one normally obtains information about construction nanoproducts from television and salesman as 28% and 21%, respectively at statistical significant level .05. Worker who perceives that recent material is common available only gains information about construction nanoproducts from salesman as 13% at statistical significant level .001. Worker who perceives that recent material is fair available only gain information about construction nanoproducts from salesman as 23% at statistical significant level .001. Worker who perceives that recent material is hard to access only gain information about construction nanoproducts from salesman as 22% at statistical significant level .001.

The results of relationship between influence of social norm and network of construction workforce on source of information about construction nanoproducts indicated that worker who feels that social norm has no influence on their behavior gain information about construction nanoproducts from colleague, television,

salesman, and radio as 46%, 25%, 17% and 12%, respectively at statistical significant level .01.

Table 4.13 Demographic and Social characteristic on source of information about nanoproducts in Thai construction workforce (continue)

	Source of information on nanoproducts				Total
	TV	Radio	Salesman	Colleague	
<i>Influence of norm</i> ¹					
0 score	24.6*** (16)	12.3*** (8)	16.9*** (11)	46.2** (30)	100.0 (65)
1 score	30.0*** (21)	21.4*** (15)	15.7*** (11)	32.9** (23)	100.0 (70)
2 score	27.2*** (34)	16.8*** (21)	26.4*** (33)	29.6** (37)	100.0 (125)
3 score	27.0*** (85)	19.4*** (61)	24.4*** (77)	29.2** (92)	100.0 (315)
4 score	27.4*** (156)	19.9*** (113)	22.7*** (129)	30.1** (171)	100.0 (569)
5 score	28.8*** (207)	22.0*** (158)	21.4*** (154)	27.7** (199)	100.0 (718)
<i>Influence of network</i> ¹					
0 score	26.1*** (31)	21.8*** (26)	19.3** (23)	32.8** (39)	100.0 (119)
1 score	23.4*** (26)	10.8*** (12)	29.7** (33)	36.0** (40)	100.0 (111)
2 score	26.4*** (24)	16.5*** (15)	23.1** (21)	34.1** (31)	100.0 (91)
3 score	28.4*** (64)	16.4*** (37)	24.0** (54)	31.1** (70)	100.0 (225)
4 score	28.1*** (135)	21.7*** (104)	21.3** (102)	29.0** (139)	100.0 (480)
5 score	29.9*** (112)	20.5*** (77)	20.8** (78)	28.8** (108)	100.0 (375)
6 score	27.1*** (49)	23.8*** (43)	23.2** (42)	26.0** (47)	100.0 (181)
7 score	27.9*** (78)	22.1*** (62)	22.1** (62)	27.9** (78)	100.0 (280)

¹ respondent can choose more than 1 source of information

*p<.05, **p<.01, ***p<.001

The results of relationship between influences of social network of construction workforce on source of information about construction materials indicated that worker who feels that social norm has no influence on their behavior gain information about construction nanoproducts from colleague, television, radio and salesman as 33%, 26%, 22% and 19%, respectively at statistical significant level .01. Worker who feels that social network has influence on their behavior gain information about construction nanoproducts from colleague, television, salesman, and radio, respectively at statistical significant level .01.

The results of examined relationship between demographic and social characteristic of construction workforce on awareness score about construction nanoproducts are shown as follows.

4.2.7 Awareness score on nanoproducts, demographic and social characteristic of samples

Table 4.13 indicated the relationship between awareness score on nanoproducts and socio-demographic characteristic factors of samples. The samples in this portion will be selected by consideration of samples that have knowledge on nanoproducts as 607 cases.

Table 4.14 Demographic and social characteristic of construction workforce and awareness score on nanoproducts

	Mean	Mode	Awareness score on nanoproducts in construction industry								Total	
			0	1	2	3	4	5	6	7		8
Age group												
- age 15-29	4.30	5	0.6 (1)	7.0 (11)	9.6 (15)	16.6 (26)	19.1 (30)	22.9 (36)	12.1 (19)	6.4 (10)	5.7 (9)	100.0 (157)
- age 30-39	3.92	5	6.5 (17)	8.8 (23)	11.9 (31)	14.9 (39)	15.3 (40)	21.8 (57)	8.0 (21)	5.4 (14)	7.3 (19)	100.0 (261)
- age 40+	3.73	0	19.7 (47)	5.0 (12)	6.3 (15)	11.3 (27)	19.2 (46)	13.0 (31)	6.7 (16)	10.9 (26)	7.9 (19)	100.0 (239)
Gender												
- Female	4.43	4	3.3 (2)	3.3 (2)	10.0 (6)	8.3 (5)	31.7 (19)	11.7 (7)	18.3 (11)	6.7 (4)	6.7 (4)	100.0 (60)
- Male	3.89	5	10.6 (63)	7.4 (44)	9.2 (55)	14.6 (87)	16.2 (97)	19.6 (117)	7.5 (45)	7.7 (46)	7.2 (43)	100.0 (597)

Table 4.14 Demographic and social characteristic of construction workforce and awareness score on nanoproducts (continue)

	Mean	Mode	Awareness score on nanoproducts in construction industry								Total			
			0	1	2	3	4	5	6	7		8		
Education														
- less than certificate	3.36	0	20.0 (29)	10.3 (15)	13.8 (20)	11.0 (16)	10.3 (15)	11.0 (16)	10.3 (15)	11.0 (16)	4.8 (7)	9.7 (14)	9.0 (13)	100.0 (145)
- Certificate	3.92	5	11.1 (15)	7.4 (10)	3.0 (4)	13.3 (18)	21.5 (29)	13.7 (22)	25.9 (35)	7.4 (10)	7.4 (10)	4.4 (6)	5.9 (8)	100.0 (135)
- Diploma	4.20	5	2.5 (4)	5.0 (8)	13.7 (22)	13.7 (22)	20.5 (33)	23.6 (38)	8.7 (14)	8.7 (14)	5.0 (8)	5.0 (8)	7.5 (12)	100.0 (161)
- Bachelor	4.16	4	7.9 (17)	6.0 (13)	6.9 (15)	16.7 (36)	18.1 (39)	16.2 (35)	11.6 (25)	11.6 (25)	10.2 (22)	6.5 (14)	6.5 (14)	100.0 (216)
Religious														
- Buddhism	3.94	5	9.9 (64)	7.1 (46)	9.4 (61)	13.9 (90)	17.6 (114)	18.8 (122)	8.6 (56)	8.6 (56)	7.7 (50)	7.1 (46)	7.1 (46)	100.0 (649)
- Christian	2.00	3	33.3 (1)	0.0 (0)	0.0 (0)	66.7 (2)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	100.0 (3)
- Islam	5.20	4	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	40.0 (2)	40.0 (2)	0.0 (0)	0.0 (0)	0.0 (0)	20.0 (1)	20.0 (1)	100.0 (5)

From table 4.13, results from age groups of worker who know about nanoproducts pointed out that samples that aged between 15 and 29 obtained higher awareness score on construction nanoproducts than other age cohort (mean score =4.3). Moreover, awareness score seem to be slightly decreased when age of samples increased. Most female samples obtained higher awareness score on construction nanoproducts than male samples (mean score = 4.43) while male gains better mode score on awareness about construction nanoproducts (mode = 5).

The relationship between educational level and awareness score on construction nanoproducts shows that samples who completed higher than diploma (bachelor and over) have higher awareness score on construction nanoproducts than others. Interestingly, samples that completed less than certificate level seem to unaware of construction nanoproducts by comparing with others. However, overall mean score of awareness about construction nanoproducts when focusing on education is still lower than 60 percent. Due to most of samples are Buddhism (98.9%) that it may not be benefit to present compared results among religions, however, the results still confirmed that overall mean score of awareness about nanoproducts is still lower than 60 percent as previous.

On the next part of table 4.13, results of relationship between work position and awareness score on construction nanoproducts presented that manager have highest mean score of awareness (5.28) when compare with other work positions. Labor is a group that has lowest awareness score on construction nanoproducts (mean score = 2.75). Interestingly, foreman has awareness score more than architect/engineer who supervised them. For the relationship between experience and awareness on construction nanoproducts, it is shown that samples who work in construction industry more than 15 years have highest awareness score on construction nanoproducts while samples who have work experience between 6 and 10 years have least awareness score (mean score = 3.61). This indicated that awareness score on construction nanoproducts might not go along with the increasing number of experience year of samples and awareness score is still less than 60 percent on average.

Table 4.14 Demographic and social characteristic of construction workforce and awareness score on nanoproducts (continue)

<i>Position</i>	Mean	Mode	Awareness score on nanoproducts in construction industry								Total	
			0	1	2	3	4	5	6	7		8
- Labor	2.75	0	32.5 (13)	7.5 (3)	5.0 (2)	22.5 (9)	10.0 (4)	2.5 (1)	10.0 (4)	2.5 (1)	7.5 (3)	100.0 (40)
- Craftsman	3.75	4	10.7 (31)	7.6 (22)	11.4 (33)	13.8 (40)	20.0 (58)	16.9 (49)	6.6 (19)	5.5 (16)	7.6 (22)	100.0 (290)
- Foreman	4.08	5	10.3 (15)	6.2 (9)	4.8 (7)	11.7 (17)	15.9 (23)	28.3 (41)	10.3 (15)	9.0 (13)	3.4 (5)	100.0 (145)
- Architect / Engineer	3.97	4	4.1 (5)	5.7 (7)	14.8 (18)	16.4 (20)	22.1 (27)	16.4 (20)	7.4 (9)	7.4 (9)	5.7 (7)	100.0 (122)
- Manager	5.28	5	1.7 (1)	8.3 (5)	1.7 (1)	10.0 (6)	6.7 (4)	21.7 (13)	15.0 (9)	18.3 (11)	16.7 (10)	100.0 (60)
Experience												
- 0-5 years	4.05	5	6.4 (11)	8.7 (15)	6.4 (11)	17.9 (31)	15.6 (27)	21.4 (37)	12.1 (21)	4.6 (8)	6.9 (12)	100.0 (173)
- 6-10 years	3.61	5	15.4 (35)	4.4 (10)	14.1 (32)	15.4 (35)	11.0 (25)	19.4 (44)	7.0 (16)	7.0 (16)	6.2 (14)	100.0 (227)
- 11-15 years	4.08	4	5.9 (7)	9.3 (11)	5.9 (7)	12.7 (15)	23.7 (28)	21.2 (25)	7.6 (9)	6.8 (8)	6.8 (8)	100.0 (118)
- more than 15 years	4.24	4	8.6 (12)	7.2 (10)	7.9 (11)	7.9 (11)	25.9 (36)	12.9 (18)	7.2 (10)	12.9 (18)	9.4 (13)	100.0 (139)

Table 4.14 Demographic and social characteristic of construction workforce and awareness score on nanoproducts (continue)

	Mean	Mode	Awareness score on nanoproducts in construction industry								Total		
			0	1	2	3	4	5	6	7		8	
Size of firm													
- 10-19 persons	3.99	5	15.3 (30)	3.1 (6)	8.7 (17)	16.8 (33)	8.7 (17)	8.7 (17)	17.9 (35)	11.7 (23)	8.7 (17)	9.2 (18)	100.0 (196)
- 20-49 persons	3.94	5	12.8 (23)	10.1 (18)	6.7 (12)	11.2 (20)	14.5 (26)	14.5 (26)	18.4 (33)	5.6 (10)	12.3 (22)	8.4 (15)	100.0 (179)
- More than 49 persons	3.91	4	4.3 (12)	7.8 (22)	11.3 (32)	13.8 (39)	25.9 (73)	25.9 (73)	19.9 (56)	8.2 (23)	3.9 (11)	5.0 (14)	100.0 (282)
Easy to use materials													
- Complicate	4.55	5	4.8 (18)	5.1 (19)	5.6 (21)	11.4 (43)	19.4 (73)	19.4 (73)	24.7 (93)	10.1 (38)	9.0 (34)	9.8 (37)	100.0 (376)
- Easy to use	3.14	3	16.7 (47)	9.6 (27)	14.2 (40)	17.4 (49)	15.3 (43)	15.3 (43)	11.0 (31)	6.4 (18)	5.7 (16)	3.6 (10)	100.0 (281)
Benefit to use materials													
- Poorer	4.58	5	4.3 (16)	4.1 (15)	7.3 (27)	12.0 (44)	17.9 (66)	17.9 (66)	23.6 (87)	11.1 (41)	9.8 (36)	9.8 (36)	100.0 (368)
- Fair	3.08	0	18.1 (47)	11.6 (30)	10.8 (28)	15.8 (41)	16.2 (42)	16.2 (42)	13.5 (35)	5.4 (14)	5.0 (13)	3.5 (9)	100.0 (259)
- Better	3.50	4	6.7 (2)	3.3 (1)	20.0 (6)	23.3 (7)	26.7 (8)	26.7 (8)	6.7 (2)	3.3 (1)	3.3 (1)	6.7 (2)	100.0 (30)

Results of awareness score on construction nanoproducts related with size of firms revealed that samples from smaller companies (10-19 workers) seem to have little higher awareness score on construction nanoproducts than samples from larger companies when considering on mean score and answer mode. However, the conflicted results existed when focus on samples who got 0 score on awareness about construction nanoproducts as samples who work in smaller size companies (10-19 workers) seem to have 0 score of knowledge about construction nanoproducts more than other size of companies.

Considering on the relationship between performance/expectancy factors (easy to use recent materials, feeling of better use/cost of usage and materials accessibility), results of cross tabulation show that samples who perceived that recent materials are more complicated to use than previous have higher mean awareness score on construction nanoproducts than one who feels easier of use recent materials. Samples who feel unsatisfied with benefit of recent materials usage have higher awareness score on construction nanoproducts than samples who feel more satisfied with recent material. Results on average for both feeling of satisfy to use recent materials from how easy to use and better quality still present under 60 percent (a cut point) of knowledge about construction nanoproducts. In the next part of table 4.8 also shows the relationship between cost and accessibility of recent materials and knowledge score on construction nanoproducts that samples who accepted the cost of materials is fair have higher awareness score on construction nanoproducts than other groups while samples who feel recent materials is fair to access also have higher awareness score on nanoproducts than others. However, both degree of satisfying with recent materials still present poor knowledge score result that less than 60 percent on average. Interestingly, when focus on source of information revealed that gaining information about construction materials from salesman also have higher awareness score than obtained information from other sources.

Table 4.14 Demographic and social characteristic of construction workforce and awareness score on nanoproducts
(continue)

	Mean	Mode	Awareness score on nanoproducts in construction industry								Total	
			0	1	2	3	4	5	6	7		8
<i>Cost of materials</i>												
- Cheaper	3.56	4	11.1 (1)	0.0 (0)	11.1 (1)	22.2 (2)	44.4 (4)	0.0 (0)	0.0 (0)	0.0 (0)	11.1 (1)	100.0 (9)
- Fair	3.89	5	9.1 (32)	8.2 (29)	11.1 (39)	12.5 (44)	16.5 (58)	20.5 (72)	8.5 (30)	7.1 (25)	6.5 (23)	100.0 (352)
- Expensive	4.01	4	10.8 (32)	5.7 (17)	7.1 (21)	15.5 (46)	18.2 (54)	17.6 (52)	8.8 (26)	8.4 (25)	7.8 (23)	100.0 (296)
<i>Accessibility of materials</i>												
- Easy to access	2.88	2	4.2 (1)	29.2 (7)	33.3 (8)	0.0 (0)	8.3 (2)	8.3 (2)	4.2 (1)	8.3 (2)	4.2 (1)	100.0 (24)
- Fair	4.17	5	8.7 (17)	7.1 (14)	5.6 (11)	13.8 (27)	17.3 (34)	24.5 (48)	4.1 (8)	9.7 (19)	9.2 (18)	100.0 (196)
- Hard to access	3.9	4	10.8 (47)	5.7 (25)	9.6 (42)	14.9 (65)	18.3 (80)	16.9 (74)	10.8 (47)	6.6 (29)	6.4 (28)	100.0 (437)
<i>Communication</i>¹												
- TV	4.16	5	7.0 (39)	6.9 (38)	9.9 (55)	11.9 (66)	18.1 (100)	20.8 (115)	8.8 (49)	8.3 (46)	8.3 (46)	100.0 (554)
- Radio	4.21	5	8.0 (32)	7.2 (29)	8.0 (32)	13.4 (54)	15.7 (63)	20.1 (81)	9.5 (38)	8.2 (33)	10.0 (40)	100.0 (402)
- Salesman	4.31	5	6.4 (29)	5.5 (25)	6.4 (29)	14.3 (65)	19.2 (87)	21.8 (99)	9.0 (41)	8.8 (40)	8.6 (39)	100.0 (454)
- Colleague	3.95	5	9.8 (59)	7.2 (43)	9.5 (57)	13.2 (79)	17.8 (107)	19.2 (115)	8.8 (53)	7.2 (43)	7.3 (44)	100.0 (600)

¹ respondent can choose more than 1 source of information

Table 4.14 Demographic and social characteristic of construction workforce and awareness score on nanoproducts (continue)

	Mean	Mode	Awareness score on nanoproducts in construction industry								Total			
			0	1	2	3	4	5	6	7		8		
<i>Influence of norm</i>														
0 score	0.71	0	71.0 (22)	6.5 (2)	6.5 (2)	12.9 (4)	3.2 (1)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	100.0 (31)
1 score	3.62	4	11.5 (3)	3.8 (1)	15.4 (4)	15.4 (4)	23.1 (6)	15.4 (4)	3.8 (1)	3.8 (1)	3.8 (1)	7.7 (2)	7.7 (2)	100.0 (26)
2 score	3.65	3	15.4 (8)	3.8 (2)	3.8 (2)	28.8 (15)	13.5 (7)	9.6 (5)	13.5 (7)	7.7 (4)	7.7 (4)	3.8 (2)	3.8 (2)	100.0 (52)
3 score	3.44	5	10.6 (12)	9.7 (11)	18.6 (21)	5.3 (6)	20.4 (23)	23.9 (27)	4.4 (5)	4.4 (5)	2.7 (3)	4.4 (5)	4.4 (5)	100.0 (113)
4 score	4.10	4	5.9 (11)	5.4 (10)	9.2 (17)	16.8 (31)	22.2 (41)	15.7 (29)	11.4 (21)	11.4 (21)	7.0 (13)	6.5 (12)	6.5 (12)	100.0 (185)
5 score	4.54	5	3.6 (9)	8.0 (20)	6.0 (15)	12.8 (32)	15.2 (38)	23.6 (59)	8.8 (22)	8.8 (22)	11.6 (29)	10.4 (26)	10.4 (26)	100.0 (250)

In terms of influence of norm and awareness score on nanoproducts, it is shown that the increasing of norm score about decision factor to use appropriate construction materials also increased awareness score on construction nanoproducts.

Table 4.14 Demographic and social characteristic of construction workforce and awareness score on nanoproducts (continue)

	Mean	Mode	Awareness score on nanoproducts in construction industry								Total		
			0	1	2	3	4	5	6	7		8	
<i>Influence of network</i>													
0 score	3.22	3	17.6 (9)	3.9 (2)	13.7 (7)	25.5 (13)	11.8 (6)	9.8 (5)	7.8 (4)	2.0 (1)	100.0 (51)		
1 score	3.17	4	11.3 (6)	3.8 (2)	15.1 (8)	22.6 (12)	34.0 (18)	3.8 (2)	7.5 (4)	1.9 (1)	100.0 (53)		
2 score	3.78	5	14.0 (7)	6.0 (3)	6.0 (3)	12.0 (6)	20.0 (10)	24.0 (12)	6.0 (3)	4.0 (20)	100.0 (50)		
3 score	3.37	2	13.2 (12)	8.8 (8)	20.9 (19)	9.9 (9)	9.9 (9)	18.7 (17)	11.0 (10)	4.4 (4)	100.0 (91)		
4 score	4.01	5	7.4 (11)	7.4 (11)	2.7 (4)	12.8 (19)	22.1 (33)	31.5 (47)	11.4 (17)	2.7 (4)	100.0 (149)		
5 score	4.10	4	9.2 (11)	6.7 (8)	10.0 (12)	12.5 (15)	19.2 (23)	15.0 (18)	5.8 (7)	7.5 (9)	100.0 (120)		
6 score	4.26	3	3.5 (2)	10.5 (6)	10.5 (6)	15.8 (9)	14.0 (8)	14.0 (8)	8.8 (5)	8.8 (5)	100.0 (57)		
7 score	4.99	8	8.1 (7)	7.0 (6)	2.3 (2)	10.5 (9)	10.5 (9)	17.4 (15)	7.0 (6)	24.4 (21)	100.0 (86)		

Relationship between influence of network and awareness score on nanoproducts indicated that the increasing of network score about decision factor to use appropriate construction materials also increased awareness score on construction nanoproducts.

4.2.8 Awareness divided and socio-demographic of samples who have knowledge on construction nanoproducts

Table 4.15 presented the relationship between awareness divided (aware/unaware of nanoproducts) and demographic and social characteristic of samples who have knowledge on construction nanoproducts. The awareness score was converted in to dichotomous variable (0 = don't have knowledge; 1 = have knowledge) as shown in table.

Results from table about awareness divide show better clear picture that workers of all age groups are likely to ignore about construction nanoproducts especially workers who age between 30-39 years. Focusing on worker having awareness of nanoproducts, it is found that workers aged 40 and over have higher awareness on nanoproducts than others age groups. The results also repeated ignorance at overall in gender while male samples was more ignore on knowing nanoproducts than female. Interestingly, workers who completed bachelor are aware of nanoproducts more than others while workers who complete certificate level have least awareness on construction nanoproducts when compare with others groups. Overall picture revealed that focusing on age group, gender, education and religious can say that more than half of samples "don't have awareness on construction nanoproducts".

Table 4.15 Demographic and social characteristic of construction workforce on awareness divide towards nanoproducts

	Awareness in nanoproducts in construction industry¹		Total
	don't have awareness	have awareness	
<i>Age group</i>			
- age 15-29	75.8 (119)	24.2 (38)	100.0 (157)
- age 30-39	79.3 (207)	20.7 (54)	100.0 (261)
- age 40+	74.5 (178)	25.5 (61)	100.0 (239)
<i>Gender</i>			
- Female	68.3 (41)	31.7 (19)	100.0 (60)
- Male	77.6 (463)	22.4 (134)	100.0 (597)
<i>Education</i>			
- less than certificate	76.6 (111)	23.4 (34)	100.0 (145)
- Certificate	82.2 (111)	17.8 (24)	100.0 (135)
- Diploma	78.9 (127)	21.1 (34)	100.0 (161)
- Bachelor	71.8 (155)	28.2 (61)	100.0 (216)
<i>Religious</i>			
- Buddhism	76.6 (497)	23.4 (152)	100.0 (649)
- Christian	100.0 (3)	0.0 (0)	100.0 (3)
- Islam	80.0 (4)	20.0 (1)	100.0 (5)

¹ awareness was divided by 0 = awareness score is less than 60 percent,
1= knowledge score is 60 percent and over

Table 4.15 Demographic and social characteristic of construction workforce on awareness divide towards nanoproducts (continue)

	Awareness in nanoproducts in construction industry¹		Total
	don't have awareness	have awareness	
<i>Position</i>			
- Labor	80.0 (32)	20.0 (8)	100.0 (40)
- Craftsman	80.3 (233)	19.7 (57)	100.0 (290)
- Foreman	77.2 (112)	22.8 (33)	100.0 (145)
- Architect / Engineer	79.5 (97)	20.5 (25)	100.0 (122)
- Manager	50.0 (30)	50.0 (30)	100.0 (60)
<i>Experience</i>			
- 0-5 years	76.3 (132)	23.7 (41)	100.0 (173)
- 6-10 years	79.7 (181)	20.3 (46)	100.0 (227)
- 11-15 years	78.8 (93)	21.2 (25)	100.0 (118)
- more than 15 years	70.5 (98)	29.5 (41)	100.0 (139)
<i>Size of firm</i>			
- 10-19 persons	70.4 (138)	29.6 (58)	100.0 (196)
- 20-49 persons	73.7 (132)	26.3 (47)	100.0 (1790)
- More than 49 persons	83.0 (234)	17.0 (48)	100.0 (282)

¹ awareness was divided by 0 = awareness score is less than 60 percent,
1 = knowledge score is 60 percent and over

The consideration on relation of work position and awareness score on nanoproducts revealed that manager have higher awareness score on construction nanoproducts than others position (50%) while craftsman and labor were groups that have lesser awareness on nanoproducts than others position. For relation between experience and awareness score on nanoproducts, it can found that samples who have work experience more than 15 years have higher awareness score on nanoproducts than others while samples who have work experience 6-10 years have lesser awareness score on nanoproducts than others. On the views of size of firm that indicate samples who work in smaller companies (10-19 workers) have higher awareness of construction nanoproducts than others while samples who work in larger companies (more than 49 workers) have least awareness on construction nanoproducts when compare with others.

Results for performance/effort expectancy factors on recent construction materials shown the relationship with awareness on nanoproducts that worker feel easy to use recent materials seem to have lesser awareness score on nanoproducts than others. Interestingly, workers who feel that recent materials are more expensive than previous have higher awareness score on nanoproducts than others while workers who feel recent materials are cheaper than previous have lower awareness score on nanoproducts than others. Moreover, workers who feel recent materials are harder to access than the past then they have higher awareness score on nanoproducts than others. For relationship between communication factors and awareness divide on nanoproducts, radio became a main source that workers who access it tend to have higher awareness score on nanoproducts than other source while colleague still be a poorest source of information for awareness score on nanoproducts.

Table 4.15 Demographic and social characteristic of construction workforce on awareness divide towards nanoproducts (continue)

	Awareness in nanoproducts in construction industry¹		Total
	don't have awareness	have awareness	
<i>Easy to use materials</i>			
- Complicate	71.0 (267)	29.0 (109)	100.0 (376)
- Easy to use	84.3 (237)	15.7 (44)	100.0 (281)
<i>Benefit to use materials</i>			
- Poorer	69.3 (255)	30.7 (113)	100.0 (368)
- Fair	86.1 (223)	13.9 (36)	100.0 (259)
- Better	86.7 (26)	13.3 (4)	100.0 (30)
<i>Cost of materials</i>			
- Cheaper	88.9 (8)	11.1 (1)	100.0 (9)
- Fair	77.8 (274)	22.2 (78)	100.0 (352)
- Expensive	75.0 (222)	25.0 (74)	100.0 (296)
<i>Accessibility of materials</i>			
- Easy to access	83.3 (20)	16.7 (4)	100.0 (24)
- Fair	77.0 (151)	23.0 (45)	100.0 (196)
- Hard to access	76.2 (333)	23.8 (104)	100.0 (437)
<i>Communication²</i>			
- TV	74.5 (413)	25.5 (141)	100.0 (554)
- Radio	72.4 (291)	27.6 (111)	100.0 (402)
- Salesman	73.6 (334)	26.4 (120)	100.0 (454)
- Colleague	76.7 (460)	23.3 (140)	100.0 (600)

¹ awareness was divided by 0 = awareness score is less than 60 percent,
1= knowledge score is 60 percent and over

² respondent can choose more than 1 source of information

Table 4.15 Demographic and social characteristic of construction workforce on awareness divide towards nanoproducts (continue)

	Awareness in nanoproducts in construction industry¹		Total
	don't have awareness	have awareness	
<i>Influence of norm</i>			
0 score	100.0 (31)	0.0 (0)	100.0 (31)
1 score	84.6 (22)	15.4 (4)	100.0 (26)
2 score	75.0 (39)	25.0 (13)	100.0 (52)
3 score	88.5 (100)	11.5 (13)	100.0 (113)
4 score	75.1 (139)	24.9 (46)	100.0 (185)
5 score	69.2 (173)	30.8 (77)	100.0 (250)
<i>Influence of network</i>			
0 score	82.4 (42)	17.6 (9)	100.0 (51)
1 score	90.6 (48)	9.4 (5)	100.0 (53)
2 score	82.0 (41)	18.0 (9)	100.0 (50)
3 score	81.3 (74)	18.7 (17)	100.0 (91)
4 score	83.9 (125)	16.1 (24)	100.0 (149)
5 score	72.5 (87)	27.5 (33)	100.0 (120)
6 score	68.4 (39)	31.6 (18)	100.0 (57)
7 score	55.8 (48)	44.2 (38)	100.0 (86)

¹ awareness was divided by 0 = awareness score is less than 60 percent,
1 = knowledge score is 60 percent and over

Table 4.15 Demographic and social characteristic of construction workforce on awareness divide towards nanoproducts (continue)

	Awareness in nanoproducts in construction industry¹		Total
	don't have awareness	have awareness	
<i>Knowledge</i>			
1 score	81.8 (99)	18.2 (22)	100.0 (121)
2 score	77.0 (117)	23.0 (35)	100.0 (152)
3 score	74.4 (67)	25.6 (23)	100.0 (90)
4 score	83.1 (49)	16.9 (10)	100.0 (59)
5 score	92.6 (63)	7.4 (5)	100.0 (68)
6 score	78.7 (37)	21.3 (10)	100.0 (47)
7 score	71.7 (43)	28.3 (17)	100.0 (60)
8 score	59.1 (13)	40.9 (9)	100.0 (22)
9 score	50.0 (10)	50.0 (10)	100.0 (20)
10 score	33.3 (6)	66.7 (12)	100.0 (18)

¹ awareness was divided by 0 = awareness score is less than 60 percent,
1= knowledge score is 60 percent and over

For influence of norm and network on awareness divide on nanoproducts revealed that increasing of norm score also slightly increased chance to have awareness on nanoproducts as well as increasing of network score. This could say that norm and network play role on increasing chance to have awareness on nanoproducts among samples. Results on relationship between knowledge and awareness score on construction nanoproducts also presented in the same direction that increasing of knowledge score on nanoproducts also increases the awareness score on construction nanoproducts too.

Table 4.16 Relationship between Awareness and Adaptation issues

	Adaptation							Total
	A	B	C	D	E	F	G	
1. You have ever used construction nanomaterials in construction operation.	12.5 (70)	15.7 (88)	19.8 (111)	10.2 (57)	13.4 (75)	15.2 (85)	13.2 (74)	100.0 (560)
2. You have ever used self-cleaning tile in construction operation.	13.5 (46)	17.5 (60)	20.5 (70)	9.9 (34)	12.3 (42)	14.0 (48)	12.3 (42)	100.0 (342)
3. You have ever used Anti-bacteria sanitary ware in construction operation.	11.0 (47)	15.2 (65)	24.1 (103)	10.5 (45)	12.6 (54)	13.3 (57)	13.1 (56)	100.0 (427)
4. You have ever used Anti fungi (Hydrophobic) adhesive in construction operation.	9.9 (70.0)	15.5 (109)	21.9 (154)	8.2 (58)	13.8 (97)	16.3 (115)	14.3 (101)	100.0 (704)
5. You have ever used Self-cleaning window in construction operation.	11.5 (29)	16.3 (41)	18.3 (46)	10.7 (27)	12.7 (32)	15.9 (40)	14.7 (37)	100.0 (252)
6. You have ever used Cement strength catalyzed (NanoCem) in construction operation.	10.6 (65)	14.2 (87)	21.3 (130)	9.5 (58)	13.6 (83)	15.9 (97)	14.9 (91)	100.0 (611)
7. You have ever used Anti-scratch/UV protection wood coating in construction operation.	9.9 (82)	14.8 (123)	21.7 (180)	9.9 (82)	14.6 (121)	15.8 (131)	13.5 (112)	100.0 (831)
8. You have ever used self-cleaning painting in construction operation.	10.0 (86)	15.4 (133)	21.6 (186)	10.2 (88)	14.6 (126)	14.6 (126)	13.6 (117)	100.0 (862)

- A. Nanotechnology will generate job in construction industry.
- B. Nanomaterials will make construction industry being more environmental friendly.
- C. Government should encourage nanomaterials usage in construction industry.
- D. **No** risk from nanomaterials usage in construction.
- E. Price is **not** influential factor for you to make decision on nanomaterials usage.
- F. Efficiency is **not** influential factor for you to make decision on nanomaterials usage.
- G. Skill is **not** influential factor for you to make decision on nanomaterials usage.
- H. You have ever used self-cleaning painting in construction operation.

Results derived from table 4.16 indicated that most samples who have awareness on construction nanoproducts were also accepted an issue that government should encourage nanomaterials usage in construction industry while they were more concerned on risk from nanomaterials usage in construction than other issues.

4.2.9 Adaptation score on construction nanoproducts, demographic and social characteristic of samples

After examining the relationship between knowledge and awareness, this part of results is aimed to examine the relationship between awareness and adaptation on nanoproducts among construction workforce. This study employed the Unified Theory of Acceptance and Use of Technology (UTAUT) model (Venkatesh et al., 2003) which was used to investigate the user behaviour on information technology adoption. Researcher believes that UTAUT can be applied to investigate the relationship of awareness and adaptation of user behaviour on nanotechnology as well. Therefore, it is necessary to explore the distribution characteristic of samples on adaptation to use construction nanoproducts as previously conduct on the relationship between knowledge and awareness as well.

Table 4.17 Demographic and social characteristic of construction workforce on range of adaptation score on construction nanoproducts

	Adaptation score on construction nanoproducts					Total
	7-18	19-21	22-25	26-28	29-35	
Age group						
- age 15-29	30.6 (48)	31.2 (49)	29.9 (47)	5.1 (8)	3.2 (5)	100.0 (157)
- age 30-39	25.3 (66)	41.0 (107)	26.1 (68)	5.0 (13)	2.7 (7)	100.0 (261)
- age 40+	23.4 (56)	33.1 (79)	34.3 (82)	6.3 (15)	2.9 (7)	100.0 (239)
Gender						
- Female	33.3 (20)	23.3 (14)	36.7 (22)	3.3 (2)	3.3 (2)	100.0 (60)
- Male	25.1 (150)	37.0 (221)	29.3 (175)	5.7 (34)	2.8 (17)	100.0 (597)

Above table (table 4.16) shows results of construction workforce who know about construction nanoproducts that young workforce cohort (aged 15-29 and aged 30-39) has attitude of low adapted to use construction nanoproducts (adaptation score between 7-21). However, senior workforce (aged more than 39 years) seem to have positive attitude of little higher adaptation score (22-25 score of adaptation on construction nanoproducts) than other cohorts. Female seems to have medium adaptation score while rarely low adaptation exist among male workforce.

Table 4.17 Demographic and social characteristic of construction workforce on range of adaptation score on construction nanoproducts (continue)

	Adaptation score on construction nanoproducts					Total
	7-18	19-21	22-25	26-28	29-35	
<i>Education</i>						
- less than certificate	32.4 (47)	28.3 (41)	24.8 (36)	9.7 (14)	4.8 (7)	100.0 (145)
- Certificate	26.7 (36)	45.9 (62)	22.2 (30)	0.0 (0)	5.2 (7)	100.0 (135)
- Diploma	31.1 (50)	31.1 (50)	30.4 (49)	4.3 (7)	3.1 (5)	100.0 (161)
- Bachelor	17.1 (37)	38.0 (82)	38.0 (82)	6.9 (15)	0.0 (0)	100.0 (216)
<i>Religious</i>						
- Buddhism	26.2 (170)	36.2 (235)	29.7 (193)	4.9 (32)	2.9 (19)	100.0 (649)
- Christian	0.0 (0)	0.0 (0)	33.3 (1)	66.7 (2)	0.0 (0)	100.0 (3)
- Islam	0.0 (0)	0.0 (0)	60.0 (3)	40.0 (2)	0.0 (0)	100.0 (5)

The relationship between educational level and adaptation on construction nanoproducts shown that samples who completed less than certificate level and diploma have rarely low adaptation score (average 7-18). While higher range score of adaptation existed among workforce who completed certificate and bachelor degree. However, overall range score of adaptation on construction nanoproducts when focus on education still lower than 60 percent (less than 22). Due to most of samples are Buddhism (98.9%) that it may not be benefit to present results however, the results still confirmed that overall range score of adaptation about nanoproducts still very low.

Table 4.17 Demographic and social characteristic of construction workforce on range of adaptation score on construction nanoproducts (continue)

	Adaptation score on construction nanoproducts					Total
	7-18	19-21	22-25	26-28	29-35	
<i>Position</i>						
- Labour	22.5 (9)	35.0 (14)	22.5 (9)	17.5 (7)	2.5 (1)	100.0 (40)
- Craftsman	29.0 (84)	37.9 (110)	24.8 (72)	4.5 (13)	3.8 (11)	100.0 (290)
- Foreman	26.9 (39)	31.0 (45)	35.2 (51)	2.1 (3)	4.8 (7)	100.0 (145)
- Architect / Engineer	21.3 (26)	37.7 (46)	35.2 (43)	5.7 (7)	0.0 (0)	100.0 (122)
- Manager	20.0 (12)	33.3 (20)	36.7 (22)	10.0 (6)	0.0 (0)	100.0 (60)
<i>Experience</i>						
- 0-5 years	30.1 (52)	34.1 (59)	26.6 (46)	5.8 (10)	3.5 (6)	100.0 (173)
- 6-10 years	22.5 (51)	37.9 (86)	32.2 (73)	3.5 (8)	4.0 (9)	100.0 (227)
- 11-15 years	26.3 (31)	37.3 (44)	27.1 (32)	7.6 (9)	1.7 (2)	100.0 (118)
- more than 16 years	25.9 (36)	33.1 (46)	33.1 (46)	6.5 (9)	1.4 (2)	100.0 (139)

On the part of relationship between work position and adaptation score on construction nanoproducts presented that most manager and foreman have middle range score of adaptation about construction nanoproducts (22-25) while architect/engineer, craftsman and construction labor seem to have lower adaptation score about construction nanoproducts at rarely low range (19-21). For the relationship between experience and adaptation on construction nanoproducts, it shown that most samples who have experience in construction industry has adaptation score on construction nanoproducts at rarely low range (19-21). This indicated that even there are construction nanoproducts available in Thai construction market for more than 5 years however construction workforce seem to not sure about its potential risk while most of them prefer that government should encourage to use more nanotechnology in Thai construction sector (Table 4.16).

Results of adaptation score on construction nanoproducts related with size of firms pointed out that samples from smaller and medium size companies (10-19 workers and 20-49 workers, respectively) seem to have middle range score (22-25) of adaptation on construction nanoproducts while larger companies (more than 49 workers) has rarely low score of adaptation about construction nanoproducts (19-21).

Table 4.17 Demographic and social characteristic of construction workforce on range of adaptation score on construction nanoproducts (continue)

	Adaptation score on construction nanoproducts					Total
	7-18	19-21	22-25	26-28	29-35	
<i>Size of firm</i>						
- 10-19 persons	23.5 (46)	39.3 (77)	27.6 (54)	4.1 (8)	5.6 (11)	100.0 (196)
- 20-49 persons	19.6 (35)	36.3 (65)	36.9 (66)	7.3 (13)	0.0 (0)	100.0 (179)
- More than 49 persons	31.6 (89)	33.0 (93)	27.3 (77)	5.3 (15)	2.8 (8)	100.0 (282)
<i>Easy to use materials</i>						
- Complicate	25.0 (94)	38.3 (144)	29.5 (111)	4.8 (18)	2.4 (9)	100.0 (376)
- Easy to use	27.0 (76)	32.4 (91)	30.6 (86)	6.4 (18)	3.6 (10)	100.0 (281)
<i>Benefit to use materials</i>						
- Poorer	23.9 (88)	35.6 (131)	30.7 (113)	6.5 (24)	3.3 (12)	100.0 (368)
- Fair	28.6 (74)	36.7 (95)	27.8 (72)	4.2 (11)	2.7 (7)	100.0 (259)
- Better	26.7 (8)	30.0 (9)	40.0 (12)	3.3 (1)	0.0 (0)	100.0 (30)

Considering on the relationship between performance/expectancy factors (easy to use recent materials, feeling of better use/cost of usage and materials accessibility), results of cross tabulation shown that most samples who perceived that recent materials are more complicated to use than previous have rarely low score of adaptation about nanoproducts (19-21). Samples who feel unsatisfied with benefit of recent materials usage have rarely low adaptation score on construction nanoproducts while samples who feel more satisfy with recent material has middle range score of adaptation on nanoproducts (22-25).

In the next part of table 4.8 also shows the relationship between cost and accessibility of recent materials and adaptation score on construction nanoproducts that samples who accepted the cost of materials is fair has very low adaptation score (19-21) on construction nanoproducts while samples who feel recent materials is expensive has low adaptation score on construction nanoproducts (7-18). However, both degree of satisfying with recent materials still present poor knowledge score result that it is less than 60 percent on average (lower than 22).

Table 4.17 Demographic and social characteristic of construction workforce on range of adaptation score on construction nanoproducts (continue)

	Adaptation score on construction nanoproducts					Total
	7-18	19-21	22-25	26-28	29-35	
<i>Cost of materials</i>						
- Cheaper	11.1 (1)	33.3 (3)	55.6 (5)	0.0 (0)	0.0 (0)	100.0 (9)
- Fair	16.2 (57)	39.2 (138)	35.5 (125)	7.1 (25)	2.0 (7)	100.0 (352)
- Expensive	37.8 (112)	31.8 (94)	22.6 (67)	3.7 (11)	4.1 (12)	100.0 (296)
<i>Accessibility of materials</i>						
- Easy to access	37.5 (9)	50.0 (12)	12.5 (3)	0.0 (0)	0.0 (0)	100.0 (24)
- Fair	20.9 (41)	37.2 (73)	36.2 (71)	5.1 (10)	0.5 (1)	100.0 (196)
- Hard to access	27.5 (120)	34.3 (150)	28.1 (123)	5.9 (26)	4.1 (18)	100.0 (437)
<i>Communication</i>						
- TV	25.5 (141)	38.3 (212)	27.6 (153)	5.6 (31)	3.1 (17)	100.0 (554)
- Radio	26.6 (107)	38.6 (155)	25.9 (104)	5.7 (23)	3.2 (13)	100.0 (402)
- Salesman	24.9 (113)	35.2 (160)	32.2 (146)	5.5 (25)	2.2 (10)	100.0 (454)
- Colleague	26.0 (156)	36.0 (216)	30.3 (182)	5.5 (33)	2.2 (13)	100.0 (600)

Samples who feel recent materials is fair and rarely hard to access have rarely low adaptation score on nanoproducts (19-21). Interestingly, when focus on source of information, it is revealed that most samples obtain information about

construction materials from television, radio, salesman and colleague have very low adaptation score (19-21) about construction nanoproducts.

Relationship between influence of norm and adaptation score on nanoproducts indicated that the increasing of norm score does not really increase adaptation score on construction nanoproducts.

Table 4.17 Demographic and social characteristic of construction workforce on range of adaptation score on construction nanoproducts (continue)

	Adaptation score on construction nanoproducts					Total
	7-18	19-21	22-25	26-28	29-35	
<i>Influence of norm</i>						
0 score	22.6 (7)	32.3 (10)	38.7 (12)	6.5 (2)	0.0 (0)	100.0 (31)
1 score	34.6 (9)	50.0 (13)	15.4 (4)	0.0 (0)	0.0 (0)	100.0 (26)
2 score	23.1 (12)	32.7 (17)	34.6 (18)	1.9 (1)	7.7 (4)	100.0 (52)
3 score	23.0 (26)	39.8 (45)	27.4 (31)	6.2 (7)	3.5 (4)	100.0 (113)
4 score	24.3 (45)	31.4 (58)	38.4 (71)	4.3 (8)	1.6 (3)	100.0 (185)
5 score	28.4 (71)	36.8 (92)	24.4 (61)	7.2 (18)	3.2 (8)	100.0 (250)
<i>Influence of network</i>						
0 score	17.6 (9)	23.5 (12)	33.3 (17)	7.8 (4)	17.6 (9)	100.0 (51)
1 score	52.8 (28)	13.2 (7)	26.4 (14)	3.8 (2)	3.8 (2)	100.0 (53)
2 score	42.0 (21)	20.0 (10)	36.0 (18)	2.0 (1)	0.0 (0)	100.0 (50)
3 score	26.4 (24)	38.5 (35)	24.2 (22)	9.9 (9)	1.1 (1)	100.0 (91)
4 score	14.8 (22)	48.3 (72)	34.9 (52)	2.0 (3)	0.0 (0)	100.0 (149)
5 score	20.0 (24)	39.2 (47)	35.8 (43)	0.8 (1)	4.2 (5)	100.0 (120)
6 score	43.9 (25)	31.6 (18)	19.3 (11)	5.3 (3)	0.0 (0)	100.0 (57)
7 score	19.8 (17)	39.5 (34)	23.3 (20)	15.1 (13)	2.3 (2)	100.0 (86)

For influence of network on adaptation score about nanoproducts also indicated as the same direction that increasing of network score does not really increases adaptation score on construction nanoproducts.

Table 4.17 Demographic and social characteristic of construction workforce on range of adaptation score on construction nanoproducts (continue)

	Adaptation score on construction nanoproducts					Total
	7-18	19-21	22-25	26-28	29-35	
<i>Knowledge</i>						
1 score	27.3 (33)	28.1 (34)	33.9 (41)	8.3 (10)	2.5 (3)	100.0 (121)
2 score	23.0 (35)	32.9 (50)	35.5 (54)	3.9 (6)	4.6 (7)	100.0 (152)
3 score	25.6 (23)	24.4 (22)	40.0 (36)	7.8 (7)	2.2 (2)	100.0 (90)
4 score	25.4 (15)	42.4 (25)	22.0 (13)	5.1 (3)	5.1 (3)	100.0 (59)
5 score	29.4 (20)	47.1 (32)	20.6 (14)	2.9 (2)	0.0 (0)	100.0 (68)
6 score	19.1 (9)	48.9 (23)	27.7 (13)	0.0 (0)	4.3 (2)	100.0 (47)
7 score	31.7 (19)	43.3 (26)	23.3 (14)	1.7 (1)	0.0 (0)	100.0 (60)
8 score	31.8 (7)	27.3 (6)	22.7 (5)	18.2 (4)	0.0 (0)	100.0 (22)
9 score	25.0 (5)	35.0 (7)	20.0 (4)	10.0 (2)	10.0 (2)	100.0 (20)
10 score	22.2 (4)	55.6 (10)	16.7 (3)	5.6 (1)	0.0 (0)	100.0 (18)

Focusing on relationship between knowledge score of construction nanoproducts and adaptation score found that knowledge score fluctuate on the increase of adaptation score about construction nanoproducts.

Table 4.17 Demographic and social characteristic of construction workforce on range of adaptation score on construction nanoproducts (continue)

	Adaptation score on construction nanoproducts					Total
	7-18	19-21	22-25	26-28	29-35	
<i>Awareness</i>						
0 score	12.3 (8)	33.8 (22)	46.2 (30)	4.6 (3)	3.1 (2)	100.0 (65)
1 score	34.8 (16)	32.6 (15)	28.3 (13)	4.3 (2)	0.0 (0)	100.0 (46)
2 score	29.5 (18)	52.5 (32)	13.1 (8)	1.6 (1)	3.3 (2)	100.0 (61)
3 score	21.7 (20)	41.3 (38)	28.3 (26)	6.5 (6)	2.2 (2)	100.0 (92)
4 score	31.0 (36)	30.2 (35)	32.8 (38)	3.4 (4)	2.6 (3)	100.0 (116)
5 score	26.6 (33)	37.9 (47)	21.8 (27)	9.7 (12)	4.0 (5)	100.0 (124)
6 score	26.8 (15)	28.6 (16)	37.5 (21)	5.4 (3)	1.8 (1)	100.0 (56)
7 score	30.0 (15)	24.0 (12)	42.0 (21)	0.0 (0)	4.0 (2)	100.0 (50)
8 score	19.1 (9)	38.3 (18)	27.7 (13)	10.6 (5)	4.3 (2)	100.0 (47)

For relationship between awareness score of construction nanoproducts and adaptation score also found in the same result of relationship between knowledge score and adaptation score about construction nanoproducts. However, it needed to examine these relationships on adaptation score in form of scatter plot that show in figure 4.2 as follows.

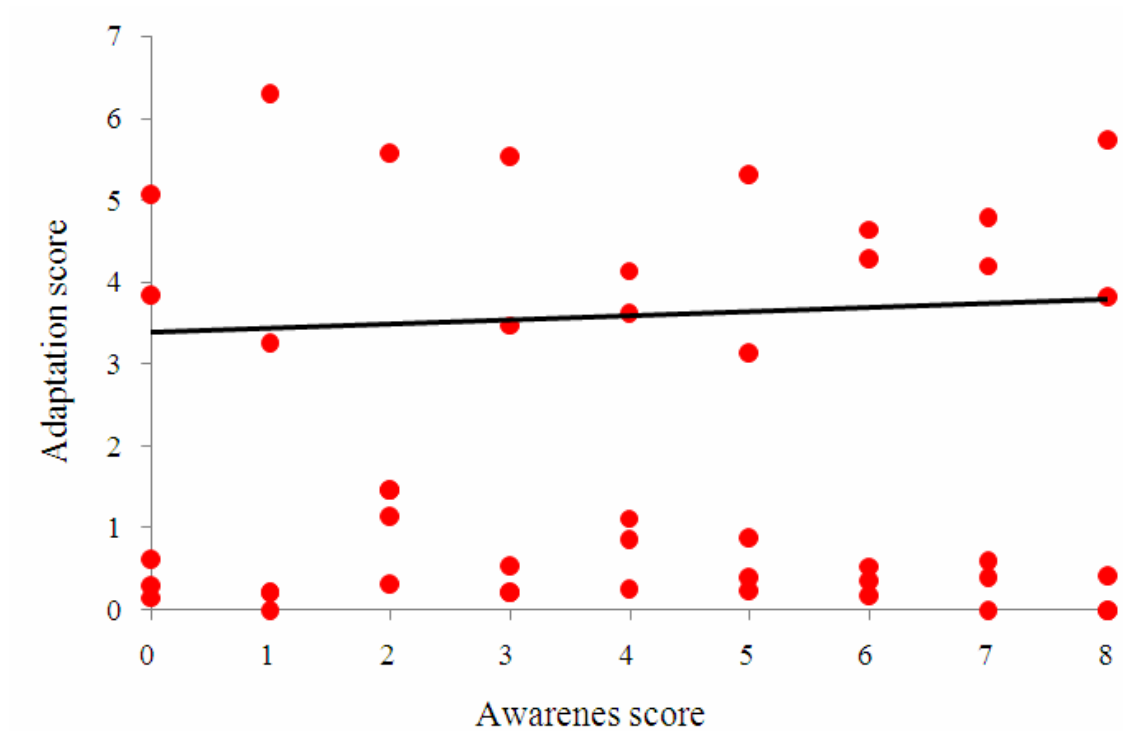


Figure 4.2 Scatter plot of relationship between awareness and adaptation score on nanoproducts

From table 4.17, it shows the relationship between awareness and adaptation through score marking that the increasing of awareness score also slightly increases the adaptation score at statistical significant level .05.

4.2.10 Adaptation divided and socio-demographic of samples who have knowledge on construction nanoproducts

Table 4.18 below presented the relationship between adaptation divided (adapted/not adapted of construction nanoproducts) and demographic and social characteristic of samples whose have shown that they have knowledge on construction nanoproducts as adaptation score was converted in to dichotomous variable (0 = don't adapted to use nanoproducts; 1 = adapted to use nanoproducts) as shown in table.

Table 4.18 Demographic and social characteristic of construction workforce on adaptation divide towards nanoproducts

	Adaptation in nanoproducts in construction industry		Total
	Don't adapt (don't want to use nanoproducts)	Adapted (want to use nanoproducts)	
Age group			
- age 15-29	61.8 (97)	38.2 (60)	100.0 (157)
- age 30-39	66.3 (173)	33.7 (88)	100.0 (261)
- age 40+	56.5 (135)	43.5 (104)	100.0 (239)
Gender			
- Female	56.7 (34)	43.3 (26)	100.0 (60)
- Male	62.1 (371)	37.9 (226)	100.0 (597)
Education			
- less than certificate	60.7 (88)	39.3 (57)	100.0 (145)
- Certificate	72.6 (98)	27.4 (37)	100.0 (135)
- Diploma	62.1 (100)	37.9 (61)	100.0 (161)
- Bachelor	55.1 (119)	44.9 (97)	100.0 (216)
Religious			
- Buddhism	62.4 (405)	37.6 (244)	100.0 (649)
- Christian	0.0 (0)	100.0 (3)	100.0 (3)
- Islam	0.0 (0)	100.0 (5)	100.0 (5)

Results from table about adaptation divide shows better clear picture that most age groups tend to refuse adapting to use construction nanoproducts especially workers who age between 30-39 years. The results also repeated non-adapted to use construction nanoproducts at overall in gender. Even most samples do not adapted to use nanoproducts but interestingly, workers who completed certificate has highest probability to not adapted of nanoproducts usage (72.6%) while workers who complete bachelor level rarely accepted to use construction nanoproducts when

compare with others groups (44.9%). Overall picture revealed that focusing on age group, gender, education and religious can say that more than 60 percent of samples “have negative attitude on construction nanoproducts”.

Table 4.18 Demographic and social characteristic of construction workforce on adaptation divide towards nanoproducts (continue)

	Adaptation in nanoproducts in construction industry		Total
	Don't adapt (don't want to use nanoproducts)	Adapted (want to use nanoproducts)	
<i>Position</i>			
- Labor	57.5 (23)	42.5 (17)	100.0 (40)
- Craftsman	66.9 (194)	33.1 (96)	100.0 (290)
- Foreman	57.9 (84)	42.1 (61)	100.0 (145)
- Architect / Engineer	59.0 (72)	41.0 (50)	100.0 (122)
- Manager	53.3 (32)	46.7 (28)	100.0 (60)
<i>Experience</i>			
- 0-5 years	64.2 (111)	35.8 (62)	100.0 (173)
- 6-10 years	60.4 (137)	39.6 (90)	100.0 (227)
- 11-15 years	63.6 (75)	36.4 (43)	100.0 (118)
- more than 16 years	59.0 (82)	41.0 (57)	100.0 (139)
<i>Size of firm</i>			
- 10-19 persons	62.8 (123)	37.2 (73)	100.0 (196)
- 20-49 persons	55.9 (100)	44.1 (79)	100.0 (179)
- More than 49 persons	64.5 (182)	35.5 (100)	100.0 (282)

Table 4.18 Demographic and social characteristic of construction workforce on adaptation divide towards nanoproducts (continue)

	Adaptation in nanoproducts in construction industry		Total
	Don't adapt (don't want to use nanoproducts)	Adapted (want to use nanoproducts)	
<i>Easy to use materials</i>			
- Complicate	63.3 (238)	36.7 (138)	100.0 (376)
- Easy to use	59.4 (167)	40.6 (114)	100.0 (281)
<i>Benefit to use materials</i>			
- Poorer	59.5 (219)	40.5 (149)	100.0 (368)
- Fair	65.3 (169)	34.7 (90)	100.0 (259)
- Better	56.7 (17)	43.3 (13)	100.0 (30)
<i>Cost of materials</i>			
- Cheaper	44.4 (4)	55.6 (5)	100.0 (9)
- Fair	55.4 (195)	44.6 (157)	100.0 (352)
- Expensive	69.6 (206)	30.4 (90)	100.0 (296)
<i>Accessibility of materials</i>			
- Easy to access	87.5 (21)	12.5 (3)	100.0 (24)
- Fair	58.2 (114)	41.8 (82)	100.0 (196)
- Hard to access	61.8 (270)	38.2 (167)	100.0 (437)
<i>Communication</i>			
- TV	63.7 (353)	36.3 (201)	100.0 (554)
- Radio	65.2 (262)	34.8 (140)	100.0 (402)
- Salesman	60.1 (273)	39.9 (181)	100.0 (454)
- Colleague	62.0 (372)	38.0 (228)	100.0 (600)

The consideration on relation of work position and adaptation divide on nanoproducts revealed that manager has highest probability to adapt on construction nanoproducts usage than others position (47%) while craftsman has highest probability to refuse for adapting on construction nanoproducts (66.9%). Relation between experience and adaptation score on nanoproducts shows that samples that have work experience more than 15 years have highest probability of adapted to construction nanoproducts usage (41%) while samples who have work experience 0-5 years have highest probability to not adapted on construction nanoproducts usage (64%). On the views of firm size that indicate samples who work in medium companies (20-49 workers) have highest probability to adapted on construction nanoproducts usage (44.1%) while samples who work in larger companies (more than 49 workers) have highest probability of not adapted to construction nanoproducts usage (64.5%).

Results for performance/effort expectancy factors on recent construction materials shown the relationship with awareness on nanoproducts that worker feel complicate to use recent materials seem to have highest probability of not adapted on construction nanoproducts usage (63.3%). Interestingly, workers who feel that recent materials are fair in cost than previous have higher probability of not adapted to nanoproducts usage while workers who feel recent materials are cheaper than previous have higher probability of adapted to nanoproducts usage (55.6%). Samples whose feel recent materials are easier to access than the past have higher probability of not adapted to nanoproducts usage (87.5%) while samples who feel recent materials are common available than the past have higher probability of adapted to nanoproducts usage (41.8%).

Relationship between communication factors and adaptation divide on nanoproducts, workers who access to radio have highest probability to not adapt on construction nanoproducts usage (65.2%) while samples who obtain information about recent construction material from salesman have higher probability of adapted to nanoproducts usage (39.9%).

Table 4.18 Demographic and social characteristic of construction workforce on adaptation divide towards nanoproducts (continue)

	Adaptation in nanoproducts in construction industry		Total
	Don't adapt (don't want to use nanoproducts)	Adapted (want to use nanoproducts)	
<i>Influence of norm</i>			
0 score	54.8 (17)	45.2 (14)	100.0 (31)
1 score	84.6 (22)	15.4 (4)	100.0 (26)
2 score	55.8 (29)	44.2 (23)	100.0 (52)
3 score	62.8 (71)	37.2 (42)	100.0 (113)
4 score	55.7 (103)	44.3 (82)	100.0 (185)
5 score	65.2 (163)	34.8 (87)	100.0 (250)
<i>Influence of network</i>			
0 score	41.2 (21)	58.8 (30)	100.0 (51)
1 score	66.0 (35)	34.0 (18)	100.0 (53)
2 score	62.0 (31)	38.0 (19)	100.0 (50)
3 score	64.8 (59)	35.2 (32)	100.0 (91)
4 score	63.1 (94)	36.9 (55)	100.0 (149)
5 score	59.2 (71)	40.8 (49)	100.0 (120)
6 score	75.4 (43)	24.6 (14)	100.0 (57)
7 score	59.3 (51)	40.7 (35)	100.0 (86)

For influence of norm and network on awareness divide on nanoproducts revealed that increasing of norm score not really increased chance to not adapted or adapt on construction nanoproducts usage while increasing of network score also present in same direction. This could say that norm and network may not play obviously role on increasing chance to adapt on nanoproducts usage among samples.

Table 4.18 Demographic and social characteristic of construction workforce on adaptation divide towards nanoproducts (continue)

	Adaptation in nanoproducts in construction industry		Total
	Don't adapt (don't want to use nanoproducts)	Adapted (want to use nanoproducts)	
<i>Knowledge</i>			
1 score	55.4 (67)	44.6 (54)	100.0 (121)
2 score	55.9 (85)	44.1 (67)	100.0 (152)
3 score	50.0 (45)	50.0 (45)	100.0 (90)
4 score	67.8 (40)	32.2 (19)	100.0 (59)
5 score	76.5 (52)	23.5 (16)	100.0 (68)
6 score	68.1 (32)	31.9 (15)	100.0 (47)
7 score	75.0 (45)	25.0 (15)	100.0 (60)
8 score	59.1 (13)	40.9 (9)	100.0 (22)
9 score	60.0 (12)	40.0 (8)	100.0 (20)
10 score	77.8 (14)	22.2 (4)	100.0 (18)
<i>Awareness</i>			
0 score	46.2 (30)	53.8 (35)	100.0 (65)
1 score	67.4 (31)	32.6 (15)	100.0 (46)
2 score	82.0 (50)	18.0 (11)	100.0 (61.0)
3 score	63.0 (58)	37.0 (34)	100.0 (92)
4 score	61.2 (71)	38.8 (45)	100.0 (116)
5 score	64.5 (80)	35.5 (44)	100.0 (124)
6 score	55.4 (31)	44.6 (25)	100.0 (56)
7 score	54.0 (27)	46.0 (23)	100.0 (50)
8 score	57.4 (27)	42.6 (20)	100.0 (47)

Relationship of knowledge and awareness score on adaptation divide of nanoproducts usage revealed that increasing of knowledge score on construction nanoproducts not really increased chance to not adapted or adapt on construction nanoproducts usage while increasing of awareness score also present in same direction.

4.2.11 Risk and knowledge divided of samples

Due to many studies about Nanotoxicology confirm the possible risk impact of human health from engineered nanoparticle. In Europe, nanoproducts considered to be a type of chemical due to it is engineered and can not break out as other natural particles that raise some concerned among public and private agencies. For example Nano Risk framework has been applied in US as well as other European countries to provide trusted to public about how safety nanoproducts will be. However, the special training and information must be also addressed among workers who have chance to expose to those engineered particles (ETUC, 2008; Takemura, 2008). Moreover, some engineered nanoparticles (such as ZnO, TiO₂, SiO₂, etc.) were already suspected as they can react as carcinogen to ROS (Lee et al, 2009; Lim et al, 2009). Therefore, It is interesting in exploring the risk of construction workforce who may expose to construction nanoproducts as data in table 4.19 presented the relationship between knowledge divided (don't know/known about nanoproducts) and risk divided (risk/non-risk from ever use nanoproducts) of samples as follows.

Table 4.19 Risk from ever use nanoproducts and knowledge divide in construction workers

	Risk from ever use nanoproducts		Total
	Non-risk	Risk	
Don't have knowledge on nanoproducts	50.7 (249)	49.3 (242)	100.0 (491)
Have knowledge on nanoproducts	9.9 (65)	90.1 (592)	100.0 (657)

Samples who don't have knowledge on construction nanoproducts facing with risk from ever use nanoproducts about 49.3 percent while risk percent from ever use construction nanoproducts increase to 90.1 percent for samples who have knowledge on nanoproducts. On the other hand, there are only 9.9 percent of samples who have knowledge on nanoproducts but don't expose to construction nanoproducts at their work place.

Table 4.20 Risk from ever use nanoproducts and knowledge divide in construction workers who don't have knowledge on nanoproducts

	<u>Risk from ever use nanoproducts</u>		<u>Total</u>
	<u>Non-risk</u>	<u>Risk</u>	
<i>Age group</i>			
- age 15-29	69.9 (65)	30.1 (28)	100.0 (93)
- age 30-39	46.7 (77)	53.3 (88)	100.0 (165)
- age 40+	45.9 (107)	54.1 (126)	100.0 (233)
<i>Gender</i>			
- Female	68.4 (39)	31.6 (18)	100.0 (57)
- Male	48.4 (210)	51.6 (224)	100.0 (434)
<i>Education</i>			
- less than certificate	50.9 (108)	49.1 (104)	100.0 (212)
- Certificate	53.0 (61)	47.0 (54)	100.0 (115)
- Diploma	63.9 (39)	36.1 (22)	100.0 (61)
- Bachelor	39.8 (41)	60.2 (62)	100.0 (103)

Consideration on age groups and risk from ever use nanoproducts, it is found that samples who don't have knowledge about construction nanoproducts increase their chance to expose to construction nanoproducts when their age increases. Male samples expose to construction nanoproducts more than female (51.6%). Sample

who complete bachelor and over have higher chance to expose construction nanoproducts than others (60.2%).

Table 4.20 Risk from ever use nanoproducts and knowledge divide in construction
Workers who don't have knowledge on nanoproducts (continue)

	Risk from ever use nanoproducts		Total
	Non-risk	Risk	
<i>Position</i>			
- Labor	50.6 (43)	49.4 (42)	100.0 (85)
- Craftsman	53.2 (143)	46.8 (126)	100.0 (269)
- Foreman	58.6 (34)	41.4 (24)	100.0 (58)
- Architect / Engineer	38.6 (17)	61.4 (27)	100.0 (44)
- Manager	34.3 (12)	65.7 (23)	100.0 (35)
<i>Experience</i>			
- 0-5 years	66.9 (95)	33.1 (47)	100.0 (142)
- 6-10 years	38.8 (50)	61.2 (79)	100.0 (129)
- 11-15 years	55.4 (46)	44.6 (37)	100.0 (83)
- More than 15 years	42.3 (58)	57.7 (79)	100.0 (137)
<i>Size of firm</i>			
- 10-19 persons	33.1 (46)	66.9 (93)	100.0 (139)
- 20-49 persons	59.5 (66)	40.5 (45)	100.0 (111)
- More than 49 persons	56.8 (137)	43.2 (104)	100.0 (241)

Table 4.20 Risk from ever use nanoproducts and knowledge divide in construction workers who don't have knowledge on nanoproducts (continue)

	Risk from ever use nanoproducts		Total
	Non-risk	Risk	
<i>Communication</i>			
- TV	53.2 (167)	46.8 (147)	100.0 (314)
- Radio	44.6 (99)	55.4 (123)	100.0 (222)
- Salesman	51.8 (102)	48.2 (95)	100.0 (197)
- Colleague	45.5 (174)	54.5 (208)	100.0 (382)

Manager is a person who has higher chance to expose construction nanoproducts than other (65.7%) while samples who have work experience 6-10 years have higher chance to expose construction nanoproducts than others (61.2%). Samples who work in smaller firm (10-19 workers) have higher chance to expose construction nanoproducts than others (66.9%) while samples who gained information from radio have higher chance to expose construction nanoproducts than others (55.4%).

For samples who have knowledge on construction nanoproducts, data on relationship between age groups and risk from ever use nanoproducts can revealed that younger age groups (15-29 years) have higher chance to expose construction nanoproducts than others (99.4%). Female samples whose have knowledge on nanoproducts have higher chance to expose construction nanoproducts more than male (96.7%). Sample who complete diploma and have knowledge on nanoproducts have higher chance to expose construction nanoproducts more than (97.5%). Manager who have knowledge on nanoproducts have higher chance to expose construction nanoproducts more than others (98.3%).

Table 4.21 Risk from ever use nanoproducts and knowledge divide in construction workforce who have knowledge on nanoproducts

	Risk from ever use nanoproducts		Total
	Non-risk	Risk	
<i>Age group</i>			
- age 15-29	0.6 (1)	99.4 (156)	100.0 (157)
- age 30-39	6.5 (17)	93.5 (244)	100.0 (261)
- age 40+	19.7 (47)	80.3 (192)	100.0 (239)
<i>Gender</i>			
- Female	3.3 (2)	96.7 (58)	100.0 (60)
- Male	10.6 (63)	89.4 (534)	100.0 (597)
<i>Education</i>			
- less than Certificate	20.0 (29)	80.0 (116)	100.0 (145)
- Certificate	11.1 (15)	88.9 (120)	100.0 (135)
- Diploma	2.5 (4)	97.5 (157)	100.0 (161)
- Bachelor	7.9 (17)	92.1 (199)	100.0 (216)
<i>Position</i>			
- Labor	32.5 (13)	67.5 (27)	100.0 (40)
- Craftsman	10.7 (31)	89.3 (259)	100.0 (290)
- Foreman	10.3 (15)	89.7 (130)	100.0 (145)
- Architect / Engineer	4.1 (5)	95.9 (117)	100.0 (122)
- Manager	1.7 (1)	98.3 (59)	100.0 (60)

Table 4.21 Risk from ever use nanoproducts and knowledge divide in construction workforce who have knowledge on nanoproducts (continue)

	Risk from ever use nanoproducts		Total
	Non-risk	Risk	
<i>Experience</i>			
- 0-5 years	6.4 (11)	93.6 (162)	100.0 (173)
- 6-10 years	15.4 (35)	84.6 (192)	100.0 (227)
- 11-15 years	5.9 (7)	94.1 (111)	100.0 (118)
- More than 15 years	8.6 (12)	91.4 (127)	100.0 (139)
<i>Size of firm</i>			
- 10-19 persons	15.3 (30)	84.7 (166)	100.0 (196)
- 20-49 persons	12.8 (23)	87.2 (156)	100.0 (179)
- More than 49 persons	4.3 (12)	95.7 (270)	100.0 (282)
<i>Communication</i>			
- TV	7.0 (39)	93.0 (515)	100.0 (554)
- Radio	8.0 (32)	92.0 (370)	100.0 (402)
- Salesman	6.4 (29)	93.6 (425)	100.0 (454)
- Colleague	9.8 (59)	90.2 (541)	100.0 (600)

Samples that have work experience 11-15 years and have knowledge on nanoproducts have higher chance to expose construction nanoproducts more than others (94.1%). Sample who work in larger firm (more than 49 workers) and have knowledge on nanoproducts have higher chance to expose construction nanoproducts more than others (95.7%). Samples that obtain information about construction materials from salesman and have knowledge on nanoproducts have higher chance to expose construction nanoproducts more than others (93.6%).

Table 4.22 Logistic regression result focusing on determinants of knowledge divides about construction nanoproducts and socio-demographic of Thai construction workforce

	Model 1		Model 2		Model 3		Model 4	
	Odd	S.E.	Odd	S.E.	Odd	S.E.	Odd	S.E.
<i>Age 30-39 (ref.)</i>								
Age 15-29	1.53	0.34	1.53	0.35	1.58*	0.37	1.31	0.32
Age 40+	0.89	0.16	0.93	0.16	0.80	0.15	0.80	0.15
<i>Female (ref.)</i>								
Male	1.33	0.33	1.23	0.32	1.17	0.31	1.01	0.27
<i>Complicate (ref.)</i>								
Easy to use	0.69*	0.10	0.70*	0.10	0.67**	0.10	0.83	0.13
<i>Not efficiency (ref.)</i>								
Fair efficiency	0.95	0.14	0.97	0.14	0.95	0.14	0.90	0.14
<i>Fair price (ref.)</i>								
Expensive	0.96	0.13	0.97	0.14	0.81	0.12	0.81	0.13
<i>Easy to access (ref.)</i>								
Fair to access	1.88***	0.33	1.86***	0.33	2.03***	0.36	1.87***	0.34
<i>Bachelor (ref.)</i>								
Less than certificate	0.30***	0.05	0.56*	0.15	0.51*	0.14	0.64	0.18
Certificate	0.41***	0.08	0.68	0.18	0.68	0.18	0.68	0.19
Diploma	0.93	0.20	1.21	0.32	1.25	0.33	1.27	0.35
<i>More than 15 years (ref.)</i>								
experience 0-5 years	0.75	0.19	0.75	0.19	0.69	0.17	0.73	0.19
experience 6-10 years	1.61**	0.33	1.63*	0.34	1.45	0.31	1.63*	0.36
experience 11-15 years	0.97	0.21	0.94	0.21	0.93	0.21	1.01	0.23
Influence of norm	1.02	0.05	1.01	0.05	1.01	0.05	0.98	0.05
influence of network	1.14	0.04	1.14***	0.04	1.14***	0.04	1.09*	0.04

Table 4.22 Logistic regression result focusing on determinants of knowledge divides about construction nanoproducts and socio-demographic of Thai construction workforce (continue)

	Model 1		Model 2		Model 3		Model 4	
	Odd	S.E.	Odd	S.E.	Odd	S.E.	Odd	S.E.
<i>Architect/Engineer (ref.)</i>								
Construction labor			0.29**	0.11	0.27***	0.11	0.26***	0.11
Craftsman			0.40**	0.12	0.37***	0.12	0.40**	0.13
Foreman			0.72	0.23	0.71	0.23	0.71	0.24
Manager			0.57	0.19	0.50*	0.17	0.50**	0.17
<i>More than 49 workers (ref.)</i>								
10-19 workers					2.25***	0.42	2.17***	0.42
20-49 workers					1.58	0.28	1.49*	0.27
<i>Television (ref.)</i>								
Radio							1.80***	0.29
Salesman							2.29***	0.36
Colleague							1.61	0.34
Log-likelihood	-638.59		-630.49		-620.36		-593.29	
df	15		19		21		24	
p value	0.000		0.000		0.000		0.000	
N	1,055		1,055		1,055		1,055	

* p < 0.05, ** p < 0.01, * p < 0.001

Table 4.22 above showed that in model 1, the determinants of knowledge about construction nanoproducts when work position, size of firm and communication factors are not considered, indicated that worker who feels easy to use recent construction materials is 31 percent less likely to know about construction nanoproducts than one who feels it is complicate to use recent construction materials at statistical significant level .05. Worker who feels recent construction materials is fair to access, is 0.88 time more likely to know about construction nanoproducts than one who feels recent construction materials is easy to access at statistical significant level .001. For education, worker who completed less than certificate is 70 percent less likely to know about construction nanoproducts than one who completed bachelor degree at statistical significant level .001 while worker who completed at certificate is 59 percent less likely to know about construction nanoproducts than one who completed bachelor degree at statistical significant level .001. Work experience pointed out that workers who have 6-10 years of experience are 0.61 time more likely to know about construction nanoproducts than one who have more than 15 years of work experience at statistical significant level .01.

When work position was added in model 2, the results showed that influence of performance/effort expectancy factor does not show any change to knowledge divide on construction nanoproducts while little positive effect on knowledge about construction nanoproducts was increased for worker who completed less than certificate by comparing with one who completed bachelor degree. There are also minor change for work experience and influence of network on knowledge about construction nanoproducts. Construction labor is 71 percent less likely to know about construction nanoproducts than architect/engineer at statistical significant level .01 while craftsman is 60 percent less likely to know about construction nanoproducts than architect/engineer at statistical significant level .01.

Considering on size of firm in model 3 indicated that construction workforce age 15-29 years is 0.58 time more likely to know about construction nanoproducts than construction workforce age 30-39 years at statistical significant level .05. Worker who feels recent construction materials is easy to use is 33% less

likely to know about construction nanoproducts than worker who feel recent construction materials complicate to use at statistical significant level .01. Worker who feels recent construction materials is fair to access, is 1.03 times more likely to know about construction nanoproducts than one who feel recent construction materials is easy to access at statistical significant level .001. Worker in small firm (10-19 persons) is 1.25 times more likely to know about construction nanoproducts than worker in large firm (more than 49 persons) at statistical significant level .001.

In model 4 with additional considering of communication channel, result indicated that construction workforce who feels recent construction materials is fair to access, is 0.87 times more likely to know about construction nanoproducts than one who feel recent construction materials is easy to access at statistical significant level .001. Workers who have 6-10 years of experience are 0.63 time more likely to know about construction nanoproducts than one who have more than 15 years of work experience at statistical significant level .05. Worker who feels that social network influence on their behavior is 0.09 times more likely to know about construction nanoproducts than one who feel that social network have no influence to their behavior at statistical significant level .05. Construction labor is 74% less likely to know about construction nanoproducts than architect/engineer at statistical significant level .001. Craftsman is 60% less likely to know about construction nanoproducts than architect/engineer at statistical significant level .01. Manager is 50% less likely to know about construction nanoproducts than architect/engineer at statistical significant level .01. For the size of firm indicate that worker in small firm (10-19 persons) is 1.17 times more likely to know about construction nanoproducts than worker in large firm (more than 49 persons) at statistical significant level .001. Worker in medium firm (20-49 persons) is 0.49 times more likely to know about construction nanoproducts than worker in large firm (more than 49 persons) at statistical significant level .05. For source of information point out that worker who access information about construction material from radio is 0.80 times more likely to know about construction nanoproducts than worker access information about construction material from television at statistical significant level .001. Worker who access information about construction material from salesman is 1.29 times more likely to know about construction

nanoproducts than worker access information about construction material from television at statistical significant level .001.

That is to say, factors of the feeling of access to recent construction materials, work experience, influence of network, size of firm and communication have positive effects on knowledge about construction nanoproducts while work position showed negative effect. As finding from model 2-4 in table 4.22 indicated that construction labor that has least education among construction workforce also is less likely to know construction nanoproducts when compare with architect/engineer who is well educated.

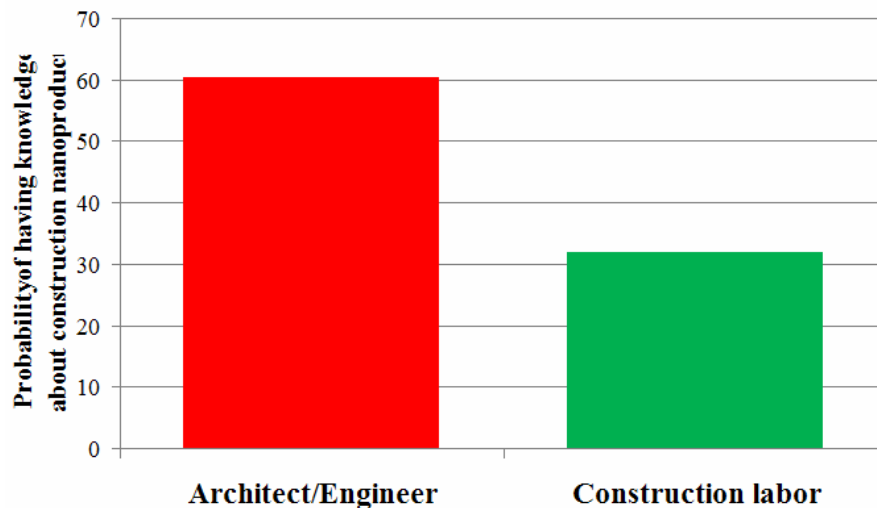


Figure 4.3 Predicted adjusted proportional probability of knowledge divides on construction nanoproducts focusing on construction labor compared with architect/engineer

After controlled other variables, in model 4 (table 4.22) and figure 4.3 showed the adjusted proportional probability of knowledge of construction labor compared with architect/engineer that there is knowledge divide gap about 28 percent. This findings respond to the second research objective about influential factor on knowledge divide of construction nanoproducts as work position is a determinant factor of knowledge divide especially between unskilled (construction labor) and skilled workforce (architect/engineer).

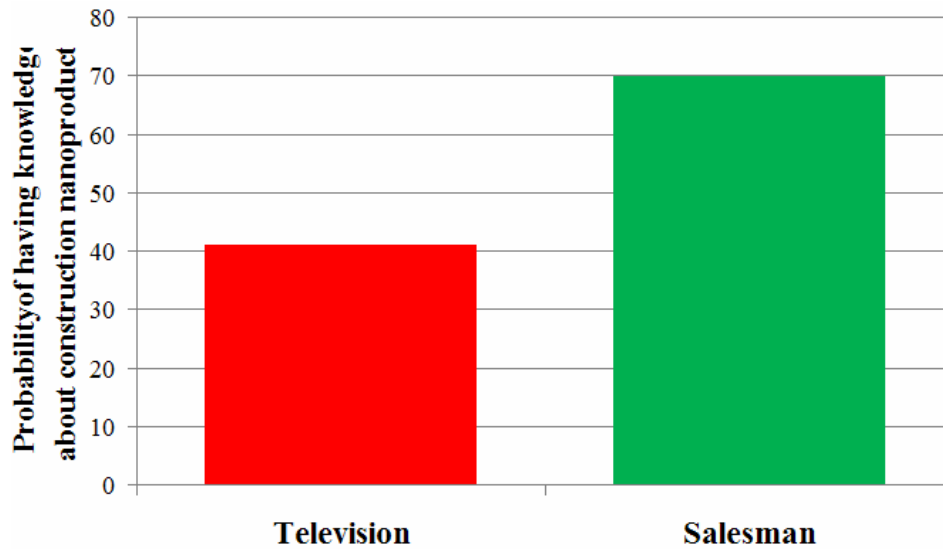


Figure 4.4 Predicted adjusted proportional probability of knowledge divides on construction nanoproducts focusing on information from salesman compared with television

As study of Project on Emerging Nanotechnologies at the Woodrow Wilson International Center for Scholars about public perception of nanotechnology and information distribution in US indicated that only 22% of respondents heard about nanotechnology from public television and radio, 17% from other people (Cobb and Macoubrie, 2004; Macoubrie, 2005). In above figure showed the interesting results that after predicted proportional probability of knowledge divides on construction nanoproducts. It is found that knowledge gap on construction nanoproducts among construction workforce who obtain information from salesman is 29 percent different compare with obtain information from television that compare with previous study as same as low information available in average and gap of information occurring especially in matter of construction nanoproducts information.

Figure 4.5 below showed the 27 percent difference gap of knowledge about construction nanoproducts from results of predicted proportional probability among construction workforce who obtain information from colleague compare with obtain information from television.

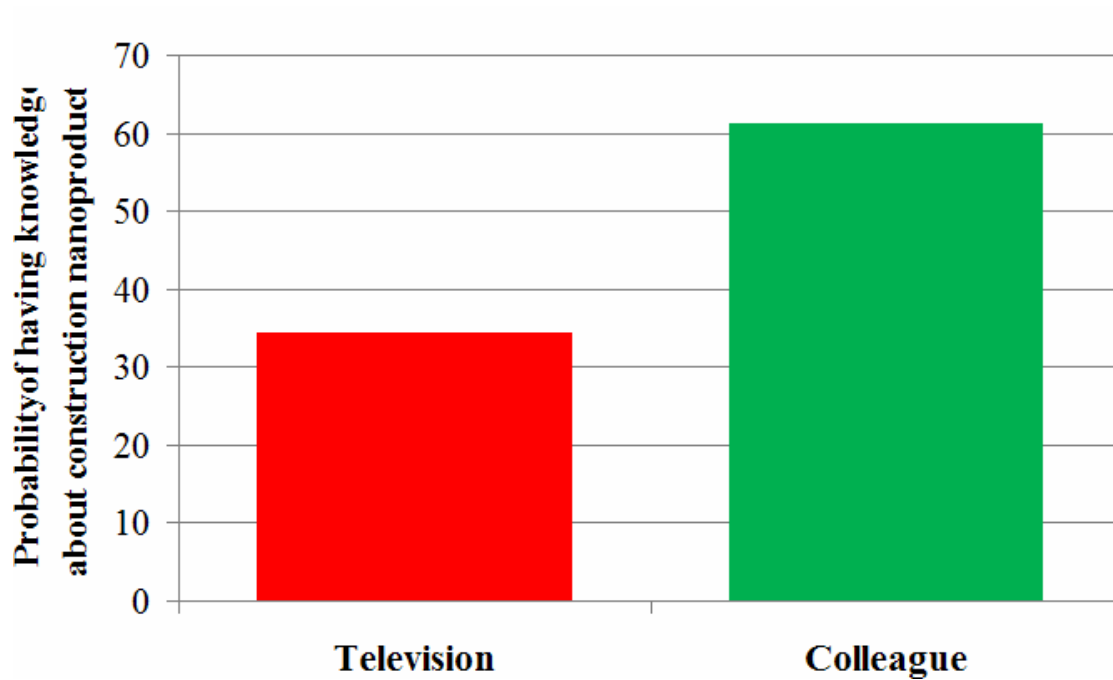


Figure 4.5 Predicted adjusted proportional probability of knowledge divides on construction nanoproducts focusing on information from colleague compared with television

After showing the result of knowledge divide on construction nanoproducts that results of next part will confirm whether what determinants will increase or decrease probability of awareness about construction nanoproducts among samples. From table 4.21 in model 1, the determinants of awareness about construction nanoproducts when not considered on work position, size of firm and communication factors and knowledge divide on construction nanoproducts, it indicated that male is 53 percent less likely to aware of construction nanoproducts than female. Worker who feels recent construction materials is fair efficiency, is 0.57 percent less likely to aware of construction nanoproducts than one who feel recent construction materials is not efficiency. For education, worker who completed certificate is 57 percent less likely to aware of construction nanoproducts than one who completed bachelor degree while worker who completed at diploma is 40 percent less likely to aware of construction nanoproducts than one who completed bachelor degree as well. Report of the Woodrow Wilson International Center for Scholars in 2005 about US public perception on nanotechnology mention that among concern of risk from nanotechnology application the top three issues are 1) unknown impact of

nanomaterials on health risk, 2) chronic impacts to human and environmental quality, 3) human health risk related to retrospective experience of DDT, Asbestos, nuclear weapon, lead in gasoline, GMO, etc. while urgent requirement on information for public was ranked at nine of ten concerned issue among US people from this study.

Table 4.23 Logistic regression result focusing on determinants of awareness divides about construction nanoproducts and socio-demographic of Thai construction workforce

	Model 1		Model 2		Model 3		Model 4		Model 5	
	Odd	S.E.	Odd	S.E.	Odd	S.E.	Odd	S.E.	Odd	S.E.
<i>Age 30-39 (ref.)</i>										
Age 15-29	1.09	0.35	1.19	0.38	1.17	0.38	1.13	0.37	1.10	0.36
Age 40+	1.60	0.45	1.40	0.41	1.31	0.38	1.35	0.40	1.34	0.40
<i>Female (ref.)</i>										
Male	0.45*	0.16	0.45*	0.17	0.43*	0.16	0.40*	0.15	0.36**	0.13
<i>Complicate (ref.)</i>										
Easy to use	0.71	0.17	0.73	0.18	0.76	0.19	0.82	0.21	0.93	0.25
<i>Not efficiency (ref.)</i>										
Fair efficiency	0.46**	0.12	0.44**	0.11	0.44**	0.11	0.44**	0.12	0.42**	0.11
<i>Fair price (ref.)</i>										
Expensive	1.28	0.27	1.25	0.27	1.08	0.25	1.12	0.26	1.17	0.28
<i>Easy to access (ref.)</i>										
Fair to access	0.84	0.20	0.83	0.20	0.88	0.22	0.85	0.21	0.80	0.20
<i>Bachelor (ref.)</i>										
Less than certificate	0.74	0.22	0.86	0.36	0.78	0.32	0.83	0.35	0.93	0.40
Certificate	0.43**	0.13	0.51	0.21	0.46	0.19	0.44*	0.18	0.45	0.19
Diploma	0.58*	0.16	0.58	0.21	0.55	0.20	0.54	0.20	0.52	0.19
More than 15 years (ref.)										
experience 0-5 years	0.89	0.34	0.93	0.36	0.91	0.35	0.89	0.35	0.74	0.30
experience 6-10 years	0.84	0.27	0.86	0.28	0.82	0.27	0.82	0.28	0.74	0.25
experience 11-15 years	0.62	0.21	0.60	0.21	0.62	0.22	0.63	0.23	0.60	0.22
Influence of norm	1.33**	0.13	1.34**	0.13	1.35**	0.14	1.33**	0.14	1.30**	0.13
influence of network	1.24	0.07	1.21***	0.07	1.21**	0.07	1.18**	0.07	1.15*	0.07

Table 4.23 Logistic regression result focusing on determinants of awareness divides about construction nanoproducts and socio-demographic of Thai construction workforce (continue)

	Model 1		Model 2		Model 3		Model 4		Model 5	
	Odd	S.E.	Odd	S.E.	Odd	S.E.	Odd	S.E.	Odd	S.E.
<i>Architect/Engineer (ref.)</i>										
Construction labor	1.27	0.81	1.24	0.80	1.10	0.72	1.14	0.75		
Craftsman	1.29	0.54	1.32	0.56	1.27	0.54	1.33	0.57		
Foreman	1.70	0.72	1.80	0.77	1.78	0.77	1.95	0.85		
Manager	3.67	1.46	3.34**	1.34	3.39**	1.38	3.49**	1.44		
<i>More than 49 workers (ref.)</i>										
10-19 workers			1.85*	0.52	1.67	0.48	1.86*	0.55		
20-49 workers			1.40	0.37	1.36	0.36	1.47	0.40		
<i>Television (ref.)</i>										
Radio					1.71*	0.43	1.51	0.38		
Salesman					1.46	0.39	1.49	0.40		
Colleague					0.59	0.22	0.61	0.23		
<i>Don't know about nanoproducts (ref.)</i>										
Know about nanoproducts									2.12**	0.56
Log-likelihood	-296.31		-290.12		-287.68		-283.70		-279.61	
df	15		19		21		24		25	
p value	0.000		0.000		0.000		0.000		0.000	
N	607		607		607		607		607	

* p < 0.05, ** p < 0.01, * p < 0.001

Workers who feel norm influence on decision of materials usage is 0.26 times more likely to aware of construction nanoproducts than one who feel free from influence of network while workers who feel network influence on decision of materials usage is 0.24 time more likely to know about construction nanoproducts than one who feel free from influence of network.

Additional work position factor in model 2 showed interested results that, manager is 2.28 times more likely to aware of construction nanoproducts than architect/engineer as the confirm of awareness divide existed among white collar. In model 3 when size of firm was considered. Worker in small firm (10-19 persons) is 1.08 times more likely to aware of construction nanoproducts than worker in large firm (more than 49 persons) as size of firm play some effects according to previous study of UTAUT model (Venkatesh et al, 2003; Kripanont, 2007). In model 4 with additional considering of communication channel, worker who listened to radio is 0.71 time more likely to aware of construction nanoproducts than one who watched television. In last model confirmed the relationship between knowledge and awareness on construction nanoproducts that workers who know about construction nanoproducts is 1.32 times more likely to aware of construction nanoproducts than worker who does not know about construction nanoproducts.

Conclusion results of determinants on awareness divide about construction nanoproducts showed that, influence of norm, influence of network, work position, size of firm and knowledge divide on construction nanoproducts have positive effect on knowledge about construction nanoproducts while gender and feeling about efficiency of recent construction materials showed negative effect. In Nanoethics Asia 2009: An International Workshop (NEA2009), organized by Center for Ethic of Science and Technology, Faculty of Art, Chulalongkorn University and Center for Innovative Nanotechnology, Chulalongkorn University, a representative of National Nanotechnology Center (NANOTEC), Ministry of Science and Technology stated that NANOTEC already arranged NanoRisk Network research cooperate with local and international agencies such as Organization for Economic Co-operation and Development (OECD), International Organization for Standardization (ISO),

International Federation of Classification Societies (IFCS), Kanzawa University, King Mongkut’s University of Technology Thonburi, Food and Drug Administration (FDA) Ministry of Public Health (MOPH), Department of Medical Sciences (MOPH) on research and laboratory studies on health and environmental impacts from nanomaterials application in consumer products with the objective to “maximize benefit and minimize risk”. However, research plan just are going to conduct from 2008 to 2012 which focus on impact of silver nanoparticle (most available in Thai consumer products) while ZnO, SiO₂ and TiO₂ that widely use in construction products still be less considered.

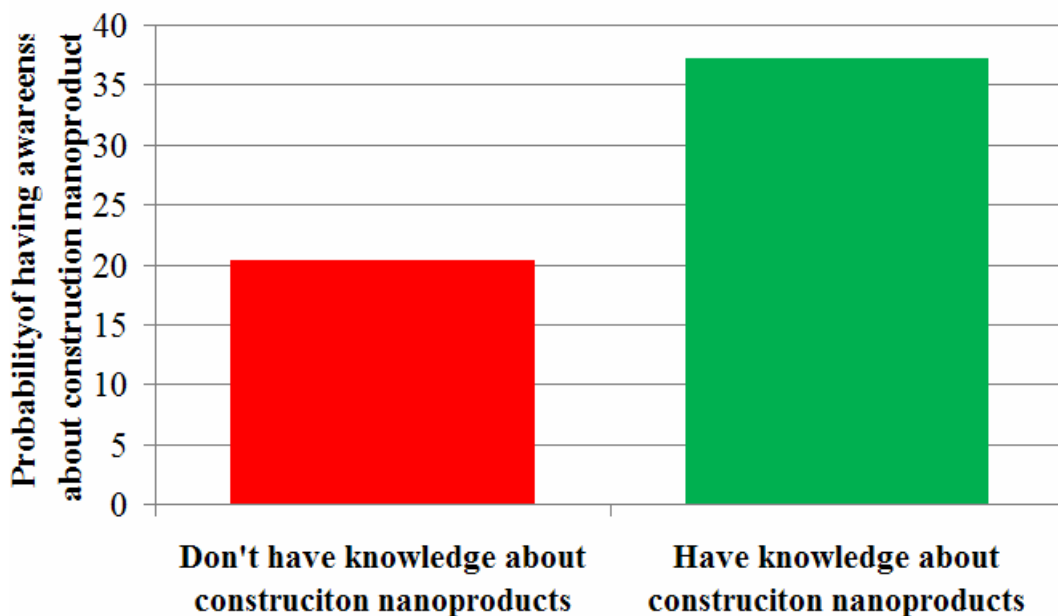


Figure 4.6 Predicted adjusted proportional probability of awareness divides on construction nanoproducts focusing on construction workforce who known about construction nanoproducts compared with those of don’t know.

After controlled other variables in model 5 (table 4.22) in figure 4.6 showed the adjusted proportional probability of awareness on workforce who know about construction nanoproducts compare with one who don’t know that there is awareness divide gap about 15 percent.

After showing the result of awareness divide on construction nanoproducts that results of next part will examine what determinants affect on probability of adaptation on construction nanoproducts among samples. From table 4.24 below in

model 1, the determinants of adaptation on construction nanoproducts when not considered on work position, size of firm and communication factors, knowledge and awareness divide on construction nanoproducts, it indicated that workers who aged more than 39 years is 0.72 time more likely adapted to use construction nanoproducts than one who aged 30-39 years. Worker who feels recent construction materials is fair efficiency is 33 percent less likely adapted to use construction nanoproducts than one who feels recent construction materials is not efficiency. Worker who feels recent construction materials is expensive is 51 percent less likely adapted to use construction nanoproducts than one who feels recent construction materials is fair price. For education, workers who completed certificate is 53 percent less likely to adapted to use construction nanoproducts than one who completed bachelor degree and over.

In model 2, it is found that even though additional factors of knowledge divide on construction nanoproducts can not predict the probability of adaptation divide about construction nanoproducts but it showed negative effect. For last model when consider the factor of awareness on construction nanoproducts, results indicated that worker who know about construction nanoproducts is 36 percent less likely to adapted to use construction nanoproducts. Overall results of determinants on adaptation divide about construction nanoproducts showed that, workforce aged 40 and over have positive effect on adapt to use construction nanoproducts while feeling about efficiency of recent construction materials, cost of recent construction materials and knowledge divide on construction nanoproducts showed negative effect to adaptation on construction nanoproducts usage.

Table 4.24 Logistic regression result focusing on determinants of adaptation divides about construction nanoproducts and socio-demographic of Thai construction workforce

	Model 1		Model 2		Model 3	
	Odd	S.E.	Odd	S.E.	Odd	S.E.
<i>Age 30-39 (ref.)</i>						
Age 15-29	1.99*	0.56	2.02*	0.57	2.02*	0.57
Age 40+	1.94**	0.46	1.97**	0.47	1.94**	0.47
<i>Female (ref.)</i>						
Male	0.71	0.24	0.74	0.25	0.78	0.26
<i>Complicate (ref.)</i>						
Easy to use	1.25	0.26	1.20	0.25	1.21	0.25
<i>Not efficiency (ref.)</i>						
Fair efficiency	0.67*	0.14	0.67	0.14	0.69	0.14
<i>Fair price (ref.)</i>						
Expensive	0.59**	0.12	0.58**	0.11	0.57**	0.11
<i>Easy to access (ref.)</i>						
Fair to access	1.50*	0.31	1.52*	0.31	1.54*	0.32
<i>Bachelor (ref.)</i>						
Less than certificate	1.11	0.39	1.05	0.37	1.05	0.38
Certificate	0.52	0.18	0.50*	0.18	0.52	0.18
Diploma	0.68	0.20	0.67	0.20	0.70	0.21
<i>More than 15 years (ref.)</i>						
experience 0-5 years	0.86	0.29	0.93	0.31	0.94	0.32
experience 6-10 years	1.19	0.33	1.23	0.35	1.25	0.35
experience 11-15 years	0.96	0.29	0.99	0.30	1.01	0.31
Influence of norm	1.07	0.08	1.08	0.08	1.06	0.08
influence of network	0.92	0.04	0.92	0.05	0.92	0.05
<i>Architect/Engineer (ref.)</i>						
Construction labor	0.93	0.47	0.94	0.47	0.91	0.47
Craftsman	1.11	0.38	1.10	0.38	1.07	0.37
Foreman	1.36	0.46	1.35	0.46	1.30	0.44
Manager	1.09	0.39	1.09	0.40	1.02	0.37
<i>More than 49 workers (ref.)</i>						
10-19 workers	1.35	0.33	1.31	0.32	1.27	0.31
20-49 workers	1.24	0.27	1.21	0.27	1.19	0.26
<i>Television (ref.)</i>						
Radio	0.69	0.13	0.72	0.14	0.71	0.14
Salesman	1.21	0.26	1.18	0.25	1.16	0.25
Colleague	0.83	0.26	0.82	0.26	0.84	0.27

Table 4.24 Logistic regression result focusing on determinants of adaptation divides about construction nanoproducts and socio-demographic of Thai construction workforce (continue)

	Model 1		Model 2		Model 3	
	Odd	S.E.	Odd	S.E.	Odd	S.E.
<i>Don't know nanoproducts (ref.)</i>						
Know about nanoproducts			0.73	0.17	0.70	0.17
<i>Unaware on nanoproducts (ref.)</i>						
Aware about nanoproducts					1.35	0.30
Log-likelihood	-380.33		-379.44		-378.55	
Df	24		25		26	
p value	0.001		0.001		0.001	
N	607		607		607	

* p < 0.05, ** p < 0.01, * p < 0.001

After controlled other variables in model 3 (table 4.23) results in figure 4.7 below showed the adjusted proportional probability of adaptation on construction nanoproducts usage that workforce who know about construction nanoproducts compare with one who don't know that there is adaptation divide gap about 10 percent.

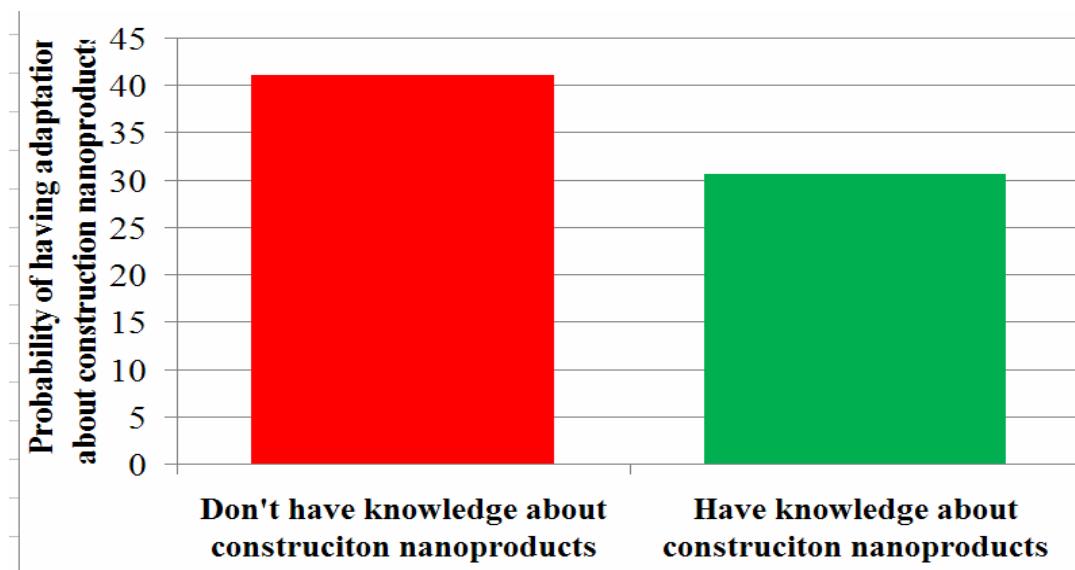


Figure 4.7 Predicted adjusted proportional probability of adaptation divides on construction nanoproducts focusing on construction workforce who know about construction nanoproducts compared with those of don't know.

As result in figure 4.7 showed that concept applied for the one who already have high knowledge (well educated) like white collar (manager, architect/engineer) are usually consider to be early adopter on innovation as they required less adaptation on new material and technology due to more skilled accumulation while blue collar (foreman, craftsman and labor) is the one who need more time to learn new technology application due to less background on literacy capability and less skilled accumulation through academic training system.

To describe the findings of adaptation (adoption) of this research, Technology Adoption Life Cycle (Roger, 1962) was employed to compare with proportional adaptation diffusion on nanotechnology (construction nanoproducts) in Thai construction workforce. To representative of Demographic and social development is age group and education of construction workers as they have relative affect on adaptation divide of construction nanoproducts at statistical significant level .005 as follows.

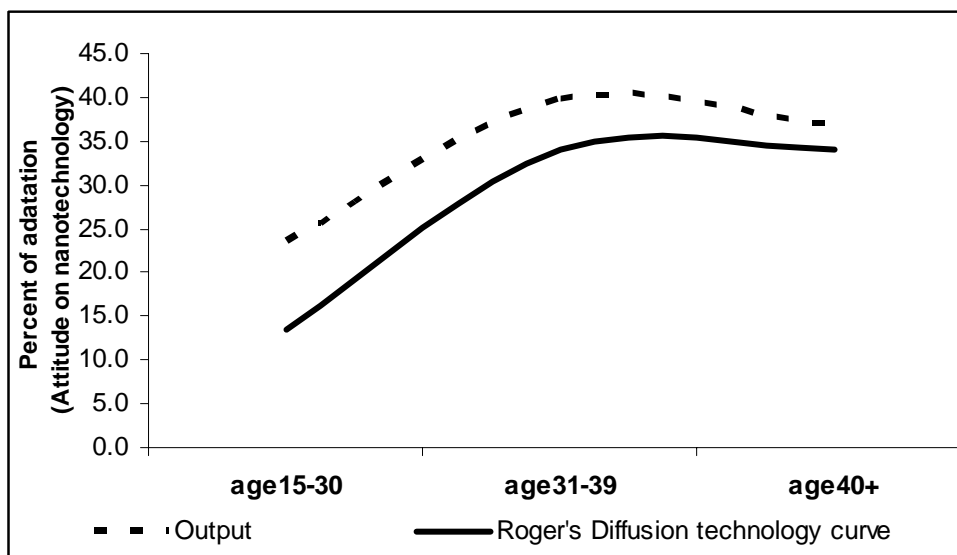


Figure 4.8 Comparison between Roger’s Diffusion technology curve and output of age cohort on proportional adaptation pattern (adoption)

For demographic characteristic, age represent the pattern of life behavior change as young generation are more active and high performance that associate with ability to obtain education, however, according to Roger’s bell curve (Technology

Adoption Life Cycle) view demographic and psychographic of proportional adoption with in a society as younger worker is always is classified as early adopter group due to well educated and eager to learn innovation than other age cohort. As figure 4.8 the adoption proportion on construction nanoproducts for age cohort of construction workforce similar to the concept of Diffusion Technology curve (Bohlen and Beal, 1957; Roger, 1995). As construction workforce age 15-30 years is early adopter, worker age 31-39 is early majority and worker age more than 39 years is late majority for construction nanoproducts adoption (figure 2.5) (Bohlen and Beal, 1957).

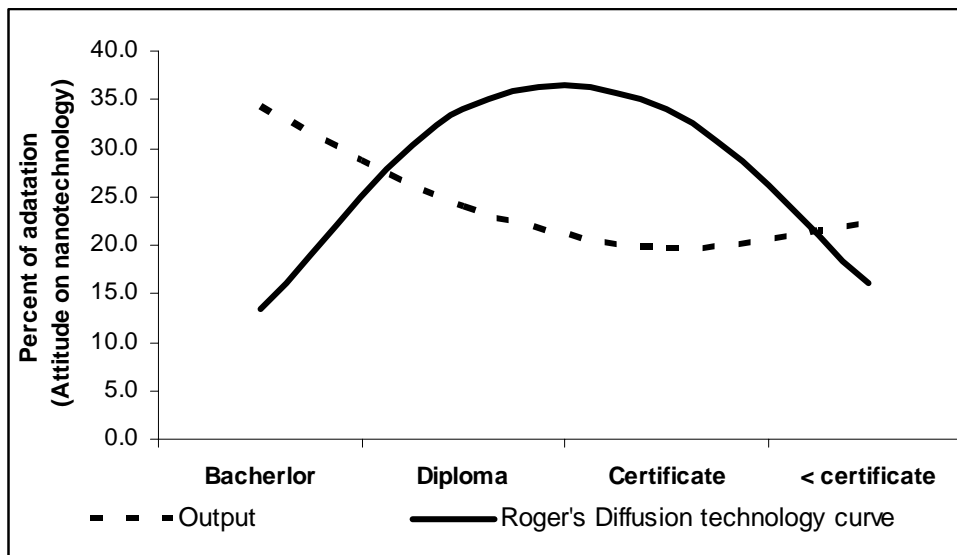


Figure 4.9 Comparison between Roger's Diffusion technology curve and output of education on proportional adaptation pattern (adoption)

Education is normally represented quality of people in society as social development indicator (Literacy rate) as high educated person is easier to accept innovation faster than low educated person. From Roger's Technology Adoption Life Cycle, when considering on education level, it pointed out that in a society, higher educated people is always being classified as early adopter group due to rich of knowledge background that can accept innovation easier than low educated one. The adoption proportion on construction nanoproducts for education of construction workforce is inverted to the concept of Diffusion Technology curve especially for worker who completed diploma and certificate that suppose to be early and late

majority. This means worker who completed diploma and certificate have less adaptation (proportional adoption) than normal distribution. Therefore, specific attention to promote adoption on construction nanoproducts may need to focus on this finding.

CHAPTER V

DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

Findings from this research brings about result grouped and discussed into 3 following parts according to research objectives 1) relationship between socio-demographic factors on nanopolicy divided 2) influential factors on awareness and adaptation divided on construction nanoproducts usage and 3) relationship between social influence factors and awareness of risk and adaptation of construction nanoproducts usage. Lastly, conclusions are summarized and policy recommendations proposed according to awareness issue in policy of National Nanotechnology Center (NANOTEC), Ministry of Science and Technology (MOST).

5.1 Discussion

5.1.1 Relationship between socio-demographic factors on nanopolicy divided

Comparative analyses based on quantitative evidence reveal that socio-demographic factors through indicators from Population Reference Bureau (PRB) 2007 have a mean difference on nanopolicy providing. For demographic factors, fertility indicators as Birth rate and Total Fertility Rate (TFR) significantly related with having or not have nanopolicy so called “nanopolicy divided” as same as most mortality indicators like Maternal Mortality Ratio (MMR), Infant Mortality Rate (IMR) and life expectancy at birth also produced in the same results. Especially for MMR, mean difference between developed and developing countries is wider than other demographic indicators as this demographic indicators usually represent the overall picture of human resource development condition at national level like public health providing so the findings seems to tell us that for lower conditions of human

resource development, the future gaps of nanopolicy could be wider than developed countries. Considered on social indicators such as literacy rate and percent of contraceptive use presented the relationship in the same direction as mean difference of literacy rate representing human development indicated the difference between developed and developing nations on encouraging of nanotechnology development in their nation. For economic indicators like gross national index (PPP), Carbon dioxide emission, percent of natural remain which represents the national development also gives the mean difference at statistical significant level to the nanopolicy divided. Analysis of the influence of demographic indicators on nanopolicy indicated that country where is becoming aging society (negative direction of child dependency ratio and positive direction of elderly dependency ratio) having more chance to integrated nanotechnology into their national policy development than others countries. Interesting comparison between demographic and socio-economic indicators showed that demographic indicators like MMR, child and elderly dependency ratio seems to present more clearer pictures on nanopolicy divided than economic indicators such as gross national index (PPP) and Carbon dioxide emission which represent economic interest. These can be explaining that most nanopolicy available focus on human development rather than economic development due to nanotechnology now becomes hot potato among scientists who work with health and environment at national level while most nanoproducts seem to be dominated by private sectors. The government policy supports mostly on human development conditions rather than commercial and industrial sectors at the moment.

The overall result supports the comment of the Action Group on Erosion, Technology and Concentration (ETC Group) in Winnipeg that emerging nanotechnology will increase the gap of development between rich and poor countries though difference of socioeconomic condition (ETC-Group, 2003; Schummer, 2007). According to Social Intelligence concept on how individual responds to social change and be able to adapt themselves, unawareness of technology change among developing countries could increase the gap of the countries' development and brought about weakness on international competition in future. Without alerting of such change, it may lead to ignorance on human capital arrangement though educational system, as

well as budget support for research and development on coming technology like nanotechnology. These limitations can come along with ignorance on policy concern about nanotechnology (Maclurcan, 2005). The qualitative research of comparative study between Australia and Thailand of Maclurcan mentioned that Australian workers seem to concern about nanotechnology only if the regulation was enforced otherwise low to medium concerns about risk is lower than benefit on using nanotechnology in their work (Maclurcan, 2009).

5.1.2 Influential factors on awareness and adaptation divided on construction nanoproducts usage

After nanopolicy divided was confirmed at the macro analysis, the micro analysis was examined through samples of Thai construction workforces who are confronting with construction nanoproducts. Results revealed the determinants on knowledge, awareness and adaptation divided about construction nanoproducts usage that workers who feel satisfied with recent construction materials available will ignore to learn new materials such as construction nanoproducts. However, overall knowledge score on construction nanoproducts showed that the mean score was still low on average. This finding was similar to the study in US about public concerns on nanotechnology as US citizens still have low awareness about nanoproducts (Scheufele and Lewenstein, 2005; Sheetz et al., 2005). However, the determinant of knowledge, awareness about nanoproducts among people have never been study yet therefore this is the first research done to examine such a research gap aimed to understand how to encourage knowledge and awareness that may help to reduce social gaps about public understanding on opportunity as well as risk of nanotechnology usage in future.

The research results indicated the existed divided in knowledge, awareness and adaptation among Thai construction workforce about construction nanoproducts that workers who have better knowledge about construction nanoproducts are also having higher awareness about construction nanoproducts than others. This confirms the idea that awareness will come after knowledge was raised. However, when focus

on adaptation about construction nanoproducts of workers, it was found that workers who have better knowledge about construction nanoproducts are less likely to adapt on usage than workers who have less knowledge about construction nanoproducts. This finding can be explained by Acceptance among construction workforce that government should support nanotechnology usage in construction industry. However the most concerned issue of construction nanoproducts usage and their risk was also concerned (table 4.16).

According to Social Intelligence concept, this finding confirmed the existing of Social Intelligence among construction workforce as their respond to unknown risk impact of new technology even overall score of knowledge and awareness of construction nanoproducts usage are still lower than 60 percent. There are some relationship between size of firm and knowledge and awareness on construction nanoproducts usage that small firms (10-19 workers) seem to have lower risk to expose to construction nanoproducts than large firm (more than 49 workers) due to traditionally, workers in small firm contact with salesman more often than workers in large firm through purchasing activities.

5.1.3 Relationship between social influence factors and awareness of risk and adaptation of construction nanoproducts usage

According to social influence (norm, network and communication) in UTATU model (Venkatesh, 2003; Kripanont, 2007), results pointed out that workers who obtained information from salesman and radio are more likely to have better knowledge about construction nanoproducts than other groups. Even though colleague is a main source of information about construction materials knowledge but it is not found any association with knowledge score on construction nanoproducts. Therefore, if the information of nanoproducts was transferred to peer by salesman who often comes to introduce new technology about construction then it probably also was distributed to others in the same firm. From empirical discussion with some salesman who also sell construction nanoproducts, researcher found that risk of health impacts from using of nanoproducts including particles like Silica Dioxide (SiO_2) and Titanium

Dioxide (TiO_2) was ignored to be discussed with their clients as a result of sample's overall knowledge score was low on average. For influence of network on decision of construction materials usage, the finding showed the positive effects of network on knowledge score about construction nanoproducts. According to study of TUAUT model by Kripanont (2007) found that social influence had no relationship with technology adoption in case of Information Technology as well as this study applied TUAUT model to examine technology adoption in case of nanotechnology among Thai construction workforce and found that network played some role on nanotechnology learning while communication (salesman and radio) played stronger effect on knowledge and awareness on construction nanoproducts than other sources of information.

The findings from multivariate logistic regression analyses showed that knowledge divide also existed among work positions as the manager tends have better awareness about construction nanoproducts than architect or engineer while construction labor has poorer knowledge about construction nanoproducts than architect and engineer. This finding indicated the inequity of knowledge distribution that brings about awareness disparity about construction nanoproducts which contains unknown health and environmental impact particles. According to The European Trade Union Confederation (ETUC) demonstrated on public declaration, training, and regulation to promote awareness about nanoproducts that they may expose during daily work during operating, packaging or even logistic process owing to concerned health and environmental impacts of unintended left-behind particles (ETUC, 2008). Obvious developed societies are quicker respond to technology dynamic that may affect to their daily life faster than developing societies. As result from macro and micro analysis already showed the nanotechnology divided in terms of knowledge, awareness and adaptation, it could bring about policy recommendation to promote appropriate practice for nanotechnology which some scholar may called "disruptive technology" or "the second industrial revolution".

According to Framework Strategies for Thailand Nanotechnology development 2004 – 2013 (figure 2.2), awareness is one of clustering approach at

national and international level as NANOTEC, Ministry of Science and Technology (MOST) already launched a unit of awareness promotion program especially focusing on young generation and also through academic system like publishing and website (NANOTEC, 2003). According to the fifth strategy of NANOTEC policy, Awareness raising was promoted by outreach programme in many parts of Thailand. However, the public knowledge and awareness are still under mystery period especially for the workforce who works and contacts directly with nanoproducts. Naturally, these workers can not participate the formal conference, training and workshop arranged in public space like hotel or academic institute.

5.2 Conclusion

Richard P. Feynman (Nobel Laureate physicist 1965) stated that “There's Plenty of Room at the Bottom” in 1959 that raises awareness among scientists throughout the world about future potentiality of nanotechnology. However, this research intends to again raise awareness that “There's Plenty of Unknown Risk at the Bottom” that is needed to further investigate as well. To achieve such goal, social paradigm may need to be shifted to nano approach as an alternative understanding under this globalization and dynamic. Awareness measurement should be the first approach that helps us to understand how society responds to this technology especially for vulnerable people like workers who is the first group to expose uncertain health risk from nanomaterials.

This research investigated the relationship of socio-demographic indicators on nanopolicy divided and influence factors on knowledge, awareness and adaptation on construction nanoproducts usage among Thai construction workforce. The findings confirm that nations where have difference backgrounds on socio-demographic factors such as mortality, literacy rate, urbanization, etc. are more likely to have the wide gap of development through nanopolicy divided. At micro analysis, higher knowledge on construction nanoproducts also brings about better awareness of construction nanoproducts usage. Knowledge divided existed among size of firm as same as work position. Network factors play a role on knowledge divided on construction

nanoproducts. To promote knowledge and awareness about construction nanoproducts, we may consider to information distribution through salesman and radio and focusing on worker's colleague as the main target, especially in large firm.

The empirical evidence from discussion with salesman found that knowledge and awareness of salesman especially on health impacts of construction nanoproducts usage is not enough distributed to their client. In fact, salesman even have not enough knowledge about possible impacts of construction nanoproducts usage as they were trained with limited information focusing only how to maximize their products selling instead of caring on health and environmental issues. Therefore, specific attention should be given to overcome such disadvantageous situations. To avoid future conflict of mistrust from public on nanoproducts due to unclear health and environmental impacts, many governments such as US, Japan, Korea, etc. launched national survey on public awareness and concern of nanotechnology implication and most results indicated the low knowledge and awareness outcomes. This study found the determinants of knowledge, awareness and adaptation on nanoproducts that could bring about future policy which will implement for encourage public knowledge and understanding on nanoproducts and nanotechnology.

5.3 Recommendations

- Findings suggest that overall gaps of divided in policy at international level have happened due to different backgrounds on demographic and socio-economic condition. Moreover results from macro analysis of demographic and development indicators confirmed the gap between developed and developing countries on policy support for nanotechnology. This gap could generate the left-behind nations where have less awareness about nanotechnology development for international future competition which could enhance human capital resource such as better effective public health and medical treatment system, better energy conservation system and better facilities to promote quality of life. Presently most policies have not only focused on economic development from nanotechnology but also sustainable development on human and environment especially in aging society such as

Environmental Protection Agency (EPA), Environmental Defense Fund, Health and Environmental Alliance, etc as some policies focus on risk of exposure to nanomaterials in workplace. In Asian, Ministry of Environmental Public of Korea also participated “Manufacturing Nano Substance Labor Party” under the OECD policies since 2006. For Thai agency, like NANOTEC already has program to promote medical technology development towards nanotechnology. However, public awareness still needs more emphasized not only young generation but also among working groups.

- Awareness raising strategy was already integrated as a part of NANOTEC policy however vulnerable groups who exposed to nanoproducts like construction workforce still lack of knowledge and awareness on potential health risk and environmental impacts from improper management of nanoproducts application and waste management which are needed specific knowledge, training and workshop. Therefore concerned agencies should also launch program emphasized on concerned workforce who may have chance to expose nanoproducts.

- Many studies about health and environmental impacts of nanoparticles are still under progress in abroad and their results seem to show the possible impacts of unintended negative outcomes from using particle at nano-scale. The finding from this study found that existing fear from risk of using nanoproducts among Thai construct workers draw back adaptation of construction nanoproducts usage so the urgent research on risk assessment which is applied in international level (like Nano risk assessment framework of DuPont and Nanotechnology safety) should be also regulated to ensure the human health and environmental impacts from unintended left-behind nanoparticles which could indirectly raise knowledge and awareness of public and concerned workforce.

- Not only outreach program for construction workforce is recommended but mass communication and public training should also be emphasized. Finding from this research confirmed result as same as shown in a study in Australia that one-way communication like radio can increase knowledge among construction workforces at statistical significant level as well as information from salesman. However, majority of

Thai construction workforce who is labor still depends on material information from their colleague. The target group of knowledge distribution should also focus on peer especially in large firm where low knowledge and awareness existed.

- Dose and exposure behavior on nanoparticles was not examine in this research due to limitation on collective tools and time duration, however it was considered the importance to understand how workers expose to each nanoproducs, how workers practice on applying products and waste management of nanoproducs to see correlation of incident on health symptom of workers from harmful particles such as TiO₂, SiO₂ and ZnO which common appear in painting color (self-cleaning or anti-bacteria function) and coating materials. Further study tried to look on the dose and exposure route factors of workers is strongly suggested.

- For further study, that thesis committee suggested that the research tool (questionnaire) should be conducted by classified the questions suitable for variation background of respondent's knowledge such as manger, foreman, labor since the variation may affect to the respondent' answering in the questionnaire. Moreover, the researcher should consider the outliner on size and type of firm such as huge companies may access to nanoproducs different from sub-contractor who works more closely to common nanoproducs like nano painting or anti-bacterial adhesive which is not mention on this study.

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APPENDIX

Part 1 Information about Occupation

1.1 Recent work position

- 1. Owner
- 2. Engineer
- 3. Architect
- 4. Foreman
- 5. Craftsman (Be optional)
 - 1. Cement / Concrete
 - 2. Steel work
 - 3. Wood
 - 4. Painting
 - 5. Tile / Finishing
 - 6. Electricity
 - 7. Mechanic
 - 8. Plumbing
 - 9. Other (specify)
- 6. Construction labor

1.2 Year of experience in construction workyears

1.3 Experience on construction materials usage (be optional)

- 1. Have not
- 2. Cement / Concrete
- 3. Steel
- 4. Wood
- 5. Glass
- 6. Adhesive
- 7. Road finishing (Bituminous)
- 8. Other (specify)

1.4 Experience on technology / construction system (be optional)

- 1. Computer Aided Drafting (AutoCAD)
- 2. Structure work
- 3. Building environmental system (Sanitary / Ventilation)
- 4. Lighting / Electricity
- 5. Hydraulic in civil work
- 6. Coating / Finishing
- 7. Construction management
- 8. Other (specify)

Part 2 Information about recent construction materials usage

A. Recent construction usage behavior

2.1 Your easiness of construction materials usage

(Your major construction materials such as cement, wood, steel, etc.)

- 1. I'm using complex materials that need learning period
- 2. I'm using common materials that not required learning period

2.2 Efficiency of present construction materials

(Your major construction materials such as cement, wood, steel, etc.)

- 1. I feel recent materials is more efficiency than previous
- 2. I feel no difference of recent materials to previous
- 3. I feel recent materials is poorer efficiency than previous

2.3 Cost of present construction materials

(Your major construction materials such as cement, wood, steel, etc.)

- 1. I feel recent materials is expensive when compare with its efficiency
- 2. I feel recent materials is fair when compare with its efficiency
- 3. I feel recent materials is cheap efficiency than previous

2.4 Availability of present construction materials

(Your major construction materials such as cement, wood, steel, etc.)

- 1. I feel recent materials is easy to access
- 2. I feel recent materials is common available
- 3. I feel recent materials is hard to access

B. Social influence on your construction materials usage

2.5 Influence of socio-economic factors on your norm for decision of construction materials usage

Item	Yes	No
1. You want to use efficient materials even it is complicate to use and need learning period		
2. You want to use efficient materials even it is more expensive than others		
3. You want to use efficient materials even it is hard to access		
4. You want to use safety materials even it is more expensive than others		
5. You want to use standard materials even it is more expensive than poorer qualified materials		

2.5 Influence of construction network on your norm for decision of construction materials usage

Item	Yes	No
1. You use new materials because market competition		
2. You use new materials because new social value		
3. You're interested in learning of new complicated materials because market competition		
4. You're interested in learning of new complicated materials because new social value		
5. You're interested in using of new expensive materials because new social value		
6. You use new materials because market competition even you have less knowledge about those new materials		
7. You use new materials because new social value even you have less knowledge about those new materials		

2.7 Construction materials learning

Item	Yes	No
1.You obtain information about new construction materials from TV		
2.You obtain information about new construction materials from radio		
3.You obtain information about new construction materials from newspaper or magazine		
4.You obtain information about new construction materials from Internet		
5.You obtain information about new construction materials from brochure		
6.You obtain information about new construction materials from exhibition		
7.You obtain information about new construction materials from conference		
8.You obtain information about new construction materials from salesman		
9.You obtain information about new construction materials from colleague		
10.You obtain information about new construction materials from your competitors		

2.8 If you obtain information about new construction materials from other source of information, please specify.....

2.9 Size of your firm/organization persons

(Only count for number of manager, architect, engineer, draftsman, foreman, craftsman and construction labor)

Part 3 Information about knowledge and awareness on construction nanoproducts

3.1 Information about knowledge on construction nanoproducts

Item	Yes	No	Don't know
1. Construction nanomaterials couldn't saw by own eyes			
2. There are already construction nanomaterials available in the market			
3. There are more than 50 construction nanomaterials available in the market			
4. There are more than 100 construction nanomaterials available in the market			
5. There are no any study and production of construction nanomaterials in Thailand			
6. Nanoparticles can be inhaled through our respiratory system			
7. Nanoparticles can be penetrated through dermis by exposure			
8. Nanoparticles can be absorbed through human tract			
9. Nanoparticles can be accumulated in living organism			
10. Accumulation of nanoparticles can harm to living organism			

3.2 Information about awareness on construction nanoproducts

Item	Yes	No	Don't know
1. You ever use construction nanomaterials in construction operation			
2. You ever use self-cleaning tile in construction operation			
3. You ever use Anti-bacteria sanitary ware in construction operation			
4. You ever use Anti fungi (Hydrophobic) adhesive in construction operation			
5. You ever use Self-cleaning window in construction operation			
6. You ever use Cement strength catalyzed (NanoCem) in construction operation			
7. You ever use Anti-scratch/UV protection wood coating in construction operation			
8. You ever use self-cleaning painting in construction operation			

Part 4 Information about adaptation on construction nanoproducts

Item	Least agree	Less agree	Agree	More agree	Most agree
1. Nanotechnology will generate job in construction industry					
2. Nanomaterials will make construction industry being more environmental friendly					
3. Government should encourage nanomaterials usage in construction industry					
4. No risk from nanomaterials usage in construction					
5. Price is not influence to you decision on nanomaterials usage					
6. Efficiency is not influence to you decision on nanomaterials usage					
7. Skill is not influence to you decision on nanomaterials usage					

Thank you very much for your corporation

BIOGRAPHY

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