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Abdalaziz Aldaihani
aaldaiha@utk.edu

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To the Graduate Council:

I am submitting herewith a dissertation written by Abdalaziz Aldaihani entitled "The Role of Computer Mediated Technologies (CMTs) in Scientific Collaboration in Kuwait." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Communication and Information.

Suzie Allard, Major Professor

We have read this dissertation and recommend its acceptance:

Aly Fathy, Carol Tenopir, Kenneth Levine

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

The Role of Computer Mediated Technologies (CMTs)

In Scientific Collaboration in Kuwait

A Dissertation Presented for
The Doctor of Philosophy Degree
The University of Tennessee, Knoxville

Abdalaziz H. Aldaihani
December 2011

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ABSTRACT

This study focuses on a component of computer-mediated communicated which is labeled computer mediated technologies (CMTs) and is composed of the latest group of internet technology and digital media including social networking, Web2.0, Smartphone and Videoconferencing. The computer mediated technologies (CMTs) have the potential to facilitate scientific collaboration between scientists from north and south.

This dissertation is a quantitative study that investigates the relationship between CMT use and collaboration, CMT use and research productivity, scientific collaboration and research productivity in Kuwait and the digital divide between developing and developed countries. This study answers the following questions: (1) To what degree has the scientific community in Kuwait adopted CMTs? (2) Are there any differences in the use of CMTs between faculty members (at KU) and researchers (in KISR) for scientific collaboration? (3) To what extent is CMT use associated with scientific collaboration in Kuwait? (4) To what extent is CMT use associated with research productivity in Kuwait? (5) What is the relationship between scientific collaboration and research productivity in Kuwait?

The results show that the scientific community in Kuwait is very connected to the internet and has adopted using CMT channels in their daily work. However, there is a difference between academia and research scientists in their educational and collaboration activities. The difference is more notable when Kuwaiti scientists collaborated with scientists in the U.S. and Canada and there is a relationship with the use of CMTs for collaboration. The findings further suggest that scientists who graduated from developed countries collaborate more than scientists who graduated from developing areas. Also there is a correlation between gaining a PhD from

developed countries and increased publication in foreign journals. The results support the assumption that collaboration leads to research productivity. But there is a real problem facing the Kuwaiti scientists because they spend little time on their research activities.

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Chapter I: Introduction

Changes in the international scientific collaboration environment as a result of the introduction of social networking, internet, and web technology have undeniably arrived on the agenda of research in science over the two last decades. As a consequence, a number of studies concerned with the impact of information technology and computer-mediated technologies (CMTs) on the scientific collaboration process have been carried out, but the uses and practices of scientists and researchers appear to represent something of a gap which needs to be bridged. CMTs are a new generation of social software, consisting of systems that facilitate human communication, interaction, and collaboration among members of large communities, including advanced computer-mediated communication (email, instant messaging), Smartphones (Droid, iPhone, Blackberry), social networking (Facebook, Twitter) and Web 2.0 (Wiki, Blogs). The term covers a variety of techniques and channels that facilitate communication and support collaboration among users. Scientists usually engage in scientific collaboration in order to answer important scientific questions, particularly in response to efforts by funding agencies to encourage collaboration. Funding agencies encourage collaboration via large initiatives that require collaborative proposals, and through programs that foster collaboration between information technologists and domain scientists (Birnholtz, 2005). Therefore, this study is an attempt to contribute to this debate and to help to bridge this gap by investigating how faculty members and scientists use CMTs within an academic environment. The main purpose of this study is to investigate the role of CMTs in scientific collaboration in the Arab world and Kuwait and its relation to research productivity.

Scientific collaboration is increasingly important in knowledge production and scientific processes (Hicks & Katz, 1996; Price, 1963). Researchers in the sciences have found that

collaboration is generally increasing in science, and in universities it has become so common that they are said to "collaborate rather than compete" (Melin & Persson, 1998, p. 47).

There has been increasing interest in the role CMTs are playing in the scientific collaboration process; to some degree this is a result of changes that have occurred in information technology itself, but it is mainly because of changing communication patterns. What is the future scenario for the scientific collaboration process, in light of the expansion and use of computer-mediated technologies?

The role of CMTs and their impact on science in the developing countries has been important to the scientific community. According to Davidson et al., (2002), given the importance of CMTs to the scientific community in developed countries, CMTs and the internet, "will free Third World science from its relative isolation, and integrate it successfully into the global scientific community" (as cited in Duque, 2005, p. 757).

These technologies provide exciting new opportunities for scientists in the developed countries to obtain large amounts of current information on almost any topic, to communicate their thoughts in dynamic new ways, and to work more efficiently than ever before. Without access to these benefits of new communication technologies, scientists in developing countries may fall even further behind their peers in other countries (Tiene, 2002).

It may no longer make sense to view CMTs, social networking, and web technology as simply an "optional technology" for science; they are on the verge of becoming a "required technology." As communication technologies increasingly become a prerequisite for scientific research and international scientific collaboration, it is important to understand their impact on scientific communities in developing countries (Davidson, 2002; Duque et al., 2005; Ynalvez, 2006). This research studies the new generation of web technology and social networking that

may have a central role in facilitating scientific collaboration between scientists and reducing the digital inequality between scientific communities in Kuwait and those in developed areas.

Science has been a major force in the development of the modern world. It has had a great impact on industry, commerce, and the social life of nations. Today, the majority of developing countries support some form of scientific and technological activities. Scientific and technological advancement as a result of research and development activities has been a fundamental principle in Kuwaiti governmental plans and programs over the last decade. It has been implemented via institutional mechanisms that have included government planning and policies, particularly in relation to researchers and doctoral training.

Currently, Facebook, Twitter and other social networking applications are an essential part of everyday life. People use these technologies to present themselves online, to form friendships, to give each other support, and to organize their work. In the academic and scientific landscape, scientists collaborate to gain skills or knowledge they need for their research, to access equipment or data, to acquire funding, or to gain prestige (Pikas, 2006). The use of CMT channels to support collaboration is one of the major shifts in scientific practices in the digital era. For example, today we can access thousands of blogs that provide responsible opinions about science policy and climate change. Moreover, lately this technology facilitates frank discussions about scientific discoveries. As a result of their seemingly limitless nature, these blogs take scientific communication to a different level (Bonetta, 2007).

Objectives of This Study

This research explores the role and impact of Computer Mediated Technologies on the practice of science in Kuwait using methods, concepts, and perspectives situated at the intersection of scientific collaboration, the diffusion of CMTs, and research productivity. Furthermore, this

study seeks to examine and characterize the diffusion of the internet and CMTs and their impact on the nature of knowledge production in Kuwaiti scientific communities.

This study also discusses the value and meaning of using communication technologies in scientific collaboration between scientists from developing and developed countries. In addition, it considers how scientists from developing countries perceive the diffusion of these new technologies in the collaborative process. To what extent does the diffusion of CMTs and other digital media impact collaboration among scientists in the academic and research sectors of Kuwait? Are the research and academic institutions of Kuwait equipped to meet the challenges posed by the new path of development? The study also seeks to include all aspects of science that pertain to Kuwaiti scientists' patterns of communication technology use, methods of scientific collaboration, and scientific and research productivity.

This dissertation entails four research objectives: first, to describe the scientific community of Kuwait by investigating the uses of CMTs among members of scientific communities in Kuwait, and the expansion of CMT use between researchers and faculty members in Kuwait. The second objective is to discover whether there is empirical evidence to support the assertion that the internet and CMTs—Web 2.0, CMC, social networking and the Smartphone—enhance the collaboration between scientists of developing countries and those of developed countries. Third, this study investigates whether there is any direct correlation between the uses of the internet and CMT systems by scientists in developing countries and an increase in their publication and research productivity, both locally and globally. The fourth objective addresses whether the location of the collaboration (Europe, the United States and Canada, or the Arab world) shapes Kuwaiti scientists' application of communication technologies—in terms of current use, ready access, intensity and extent of experience, and

diversity of use. It is also important to discover how scientific collaboration develops Kuwaiti scientists' collaborative behavior, both nationally and internationally, and their publication and scientific productivity in local or foreign scholarly journals.

An extensive review of the literature provided no evidence of studies conducted in Kuwait that targeted the scientific collaboration and productivity of its scientists in relation to the diffusion and use of the internet and CMTs. This study has the potential to contribute to the understanding of concepts and relationships in the areas of science and communication technology studies, the internet, CMTs, scientific collaboration, and the diffusion of these technologies among developing countries. In addition to the benefits mentioned, this study is important for expanding the field of information science regarding technology-mediated collaboration in general, and regarding Web 2.0, CMC, and social networking in particular, by providing baseline data that can be used as building blocks for future studies, research and development, scientific productivity, and technology adoption initiatives in Kuwait.

The relationship between information communication technology (ICT) use and science in developed countries have been consistently positive (Castells, 2000; Koku & Wellman, 2002; Walsh & Maloney, 2003), but the impact of these technologies within developing countries has yet be fully examined. Thus far, only a few comparative studies have examined the role of these technologies in the work of scientists located in developing countries (Duque, 2007; Ynalvez et al., 2005; Ynalvez & Shrum, 2006). In general, there are few scholars who have investigated the networking consequences of CMT use in the science and knowledge sectors of these countries.

Broader Impacts of the Study

This study has the potential to contribute to the advancement of concepts and relationships in the areas of technology innovation, science, development, and communication. It

focuses on the interaction between the role of CMT use, scientific collaboration, and productivity among scientists of the developing world.

The broader impacts of this study relate to the digital inequality—or digital divide—issues that are of critical importance to the globalization of science. The question then becomes the role of this new technology in reducing digital inequality among the scientists of the world.

This research is different from previous studies in many ways, primarily because it will investigate the role and impact of CMTs on the work of Kuwaiti scientists, the conduct of which reflects regional differences. For example, in some collaborations, scientists combined face-to-face interaction with email, videoconferencing, or online chatting; conversations may begin using one medium and end using a different one (Wellman et al., 1996; Haythornthwaite, 2005). By examining the use of these technologies in the collaborative process, it is also possible to analyze other aspects of the internet and CMTs not studied before, for instance, the number of communication technologies used in the collaborative process, and in which stages of collaboration, as well as the degree to which scientists depend on these technologies to communicate with their colleagues, the types of information or data they exchange during the collaborative process, the number of collaboration technologies they use for each type of information, and which of these technologies are appropriate for international use.

Additionally, this study may also spawn areas of future research, including the ways in which this generation of CMTs will produce and reproduce new types of collaboration behavior and the use of innovative methods such as virtual team environments and e-research. Many previous studies in scientific collaboration have demonstrated some constraints in accessing information (Bordons & Gomez, 2000; Coleman, 1988; Katz & Martin, 1997; Melin & Persson, 1996) and the challenges that scientists face when they use this technology in collaboration.

It has been argued that using CMT channels can allow scientists from developing countries to reach the experts, instruments, and databases in remote locations that their local institutions cannot afford (Luo, 2008). It is crucial to determine how and to what degree Kuwaiti scientists are utilizing the new technologies provided by the internet, Web2.0, and social media to support and increase their scientific and research productivity.

Given the rapid changes in the nature and structure of communication technology, as well as the claims and counter-claims about the impact of CMTs on development in general and on scientific collaboration in particular, a review of this nature is important to help scholars, researchers, and policymakers support the scientific development of the Arab world as the countries of the region seek to separate fact from wishful thinking in order to focus on the most effective strategies and technologies. While there is evidence of the usefulness of ICTs in many developed countries, questions regarding their suitability in a range of situations remain.

To date, no descriptive study has examined the use of CMTs and electronic communication technologies by individual scientists in Kuwait, a region that has not yet been explored regarding these issues. This study's results will enhance understanding of knowledge production and serve as a basis for formulating policies to integrate developing countries into the global scientific community. The findings of this research can also be used to update the policies involving global science and the diffusion of innovations within science agencies, such as the Kuwait Institute of Science and Research (KISR), the Kuwait Foundation for the Advancement of Science (KFAS), and Kuwait University.

Research Questions

The study sought to answer the following six questions:

RQ 1: To what degree has the scientific community in Kuwait adopted CMTs?

RQ 2: Are there any differences in the use of CMTs between faculty members (at KU) and researchers (in KISR) for scientific collaboration?

RQ 3: To what extent is CMT use associated with scientific collaboration in Kuwait?

RQ 4: To what extent is CMT use associated with research productivity in Kuwait?

RQ 5: What is the relationship between scientific collaboration and research productivity in Kuwait?

Research Hypotheses

Four research hypotheses, which address the study's research questions, were used to frame this investigation into the relationships between CMT use and scientific collaboration in Kuwait:

H1: Scientists who have used CMTs will be more connected than those who do not use CMTs in their communication and collaboration, both locally and internationally.

H2: Faculty members and engineers at KU will have more networks internationally than researchers (in KISR).

H3: Researchers in KISR will have more networks locally than faculty members of KU.

H4: Kuwaiti scientists who studied in developed countries will be more advanced in using the internet and CMTs than scientists who studied in developing countries.

Chapter II: Literature Review

The second chapter discusses the importance of internet technology and computer mediated technologies in scientific collaboration and their impact on knowledge production and productivity. What is meant by "CMT"? What is scientific collaboration? What is the potential that scientific collaboration promises for the scientists and researchers, particularly for engineers and researchers from developing areas?

Computer Mediated Technologies (CMTs)

We are living in the midst of rapid changes brought about by information communication technologies (ICTs) and internet technology. We have experienced spectacular changes in the way we learn, work, and communicate with others. The new communication technologies and social networking applications are providing the foundation for a transformation of existing social relations into an information society (Pohjola, 2003).

The United Nation emphasizes the critical role of these ICTs by supporting the collaborative process. For example, ICTs are considered by many different conferences in the United Nation as bridges between developed and developing countries (DOT Force, 2002) and as an opportunity for countries to free themselves from the tyranny of geography (USESCWA, 2008). Similarly, the Arab Knowledge Report (2009) maintained that ICTs represent the key means to disseminate and circulate knowledge, in addition to their role in developing, supporting, facilitating, and accelerating scientific research to the widest possible scope. A Geneva declaration states, "Under favorable conditions, these technologies can be powerful instruments, increasing productivity, generating economic growth, job creation and employability, and improving the quality of life of all" (World Summit at Geneva, 2003).

The impact of CMTs is broader than that of ICTs because CMTs operate through a new generation of social software that incorporates a range of communication and information

retrieval technologies. These technologies facilitate human communication, interaction, and collaboration between individuals and within large communities, and include advanced social networks, CMC, Smartphones, videoconferencing, and Web 2.0. CMT services and channels such as Twitter, Skype, Blogs, LinkedIn, Facebook and the free software movement are some examples of features that can help scientists, engineers, and other researchers seamlessly access, create, organize, and disseminate information for their institutions, themselves, and their colleagues. These innovations help to define the information society: a stage of the social development characterized by the capacity of its members in accessing and share knowledge from any moment and from any place.

CMTs allow researchers to add, share, and rate bookmarks. Users create personal profiles, which allow everyone to assess the authenticity of fellow users. This capability creates an accessible environment where researchers and scientists can work together to evaluate new research, discuss current controversies and opportunities and, an outcome especially useful for first-time authors, promote their research. There is some evidence that CMTs are opening up even more opportunities for engineers and scientists (from developed and developing countries) to better engage in scientific collaboration (Walsh & Maloney, 2003), making communication and online work easier and more productive (Lee & Bozeman, 2004).

This study views CMTs as indispensable technologies for producing and disseminating scientific knowledge (Duque et al. 2005; Rogers 1995; Ynalvez, 2006). As an essential tool for producing knowledge, CMTs are supporting scientists and researchers by providing: (a) access to experts, (b) access to material and resources, (c) information and databases essential for research, (d) a means of exchange of ideas across disciplines, (e) instruction in new skills, and (e) a means of developing personal and organizational networks (Ehikhamenor 2003; Ynalvez, 2006).

The impact of CMTs on development can be mediated through several channels, including the ways and the speed of acquiring information and knowledge (i.e., the impact on knowledge production) across societies and sectors, knowledge creation through the transformation of traditional research productivity as well as the creation of new production regimes, and networking with its influence on the way research is carried out (Duque, 2007; Hargittai, 2004; Kalb et al., 2009). Therefore, a good starting point for an analysis of the effect of scientific collaboration is obtained by assessing the significance of CMTs' use in scientific collaboration as a factor of development in the modern era.

The practice of scientific collaboration via computation and communication technologies is not new. Many scholars have tried in the past—and others are still trying and will continue to try—to find the proper mechanism to utilize technology in scientific collaboration. As early as 1945, Vannevar Bush explored how computers, which he dubbed the "Memex," might be used to help scientists keep pace with the explosion of scientific knowledge. Doug Engelbart (1963) wrote about the use of computing to support intellectual work and building prototype systems for computer-supported meetings. The first real proposal for an open library was made by visionary scientists and computer scholars in the late 1980s, when they described digital libraries as "center[s] without walls, in which researchers can perform their research without regard to physical location --interacting with colleagues, accessing instrumentation, sharing data and computational resources, and accessing information in digital libraries" (Wulf, 1989, p. 19).

One salient feature of knowledge production in modern science is the increasing role of collaborative work, or scientific collaboration (Bordons & Gomez, 2000; Thorsteindottir, 2000). Thus, the rapid growth of scientific collaboration naturally leads to inquiries about the reasons for collaboration.

Scientific Collaboration

Collaboration is defined as "to work jointly with others or together, especially in an intellectual endeavor" (Webster, 2008). Also, according to the *Oxford English Dictionary*, collaboration is defined as "to cooperate, especially in literary, artistic, or scientific work," and is a term derived from the Latin words *collaborate*, meaning to work alongside one another. According to Kvan (2000), collaboration can be thought of as joint problem-solving; it means working with others with shared goals for which the team attempts to find explanations or solutions that are satisfying for all problems and to all those concerned.

Scientific collaboration has emerged as the new organizational mode of doing research on a large scale, as well as in smaller endeavors. Many scientists have argued that collaboration at the international level expedites the process of learning, minimizes the risks in early-stage research, and helps to increase the exchange of knowledge (Justus et al., 2005). Since Price (1963) began his study of big science and its relationship to co-authorship, there have been a number of studies from both sociological and scientific perspectives that examine the phenomenon of scientific collaboration using bibliometrics. Price's study showed that collaboration has often taken the shape of counting co-authorships (Glanzel, 2001; Lukkonen et al., 1993; Price, 1963).

Major scholars in scholarly communication studies, such as Bordons and Gomez (2000) Katz (1994), and Melin (2000), have provided definitions of scientific collaboration. These scholars have defined scientific collaboration as the specialized interaction between two or more scientists, where a goal is projected and attained by means of shared knowledge and effort. Melin and Persson (1996) defined collaboration as an intense form of interaction, which allows for effective communication as well as the sharing of competencies and resources. Katz and Martin (1997) identified it as the joint work of researchers to achieve the common goal of generating

new knowledge. Axelsson, Sonnenwald, and Spante (2006) provided a different definition for the collaborative process as a "human behavior among two or more individuals that facilitates the sharing of meaning and completion of tasks, with respect to a mutually-shared super ordinate goal" (2006, p. 4). Later, Ramsey (2008) divided this idea of collaboration into three areas: individual efforts, collaborative tasks, and shared goals.

In this study, scientific collaboration is defined as a system to bring together the work of two or a group of scientists by using the internet and computer mediated technologies to conduct research, write a research paper, or coordinate the course of an experiment that brings mutually beneficial outcomes to all. However, the benefits of scientific collaboration may differ from one scientist to another. In this study's survey, this definition will be introduced again in the beginning of the survey to help the participants in the Kuwait Scientists Survey to understand and remember what we mean by the term "scientific collaboration."

To support scientific collaboration among scientists and engineers from different disciplines and different countries, we need a new communication technique that facilitates collaboration among scientists around the world or, in other words, a rich communication environment that enables scientists to concentrate on scientific production tasks. In addition, there is a need to share access to primary scientific resources such as instruments, analysis tools, information sources, and data.

The concept of scientific collaboration as distributed intelligence relies heavily on information and communication technologies to overcome barriers of time and space (Castells 2000; Hacket, 2005; Thorsteindottir 2000). It represents one of the main pillars for the establishment of a knowledge society (Bordons & Gomez 2000; Castells 2000; Hinds & Kiesler, 2002; Walsh et al., 2000; Walsh & Maloney, 2002). Studies of scientists and engineers at work

suggest that the degree and quality of interaction with colleagues, particularly spontaneous and informal conversations, is an important predictor of productivity (Kraut et al., 1988, 1990).

Scientific research is a particularly active arena for collaboration that is driven by both the rise of "Big Science" (Price, 1986) and the emergence of collaboration and communication technologies (such as CMTs) that facilitate work in geographically distributed groups (Finholt & Olson, 1997; Hesse et al., 1993). Furthermore, recent research on this topic has suggested that we are currently at a crucial juncture in the development and adoption of computer-mediated communication (CMC), computer-supported cooperative work (CSCW), and networked-based collaboration technologies (Atkins et al., 2003; Barjak, 2006; Walsh et al., 2000).

Interdisciplinary Research (Big Science)

Scientists and engineers usually enter multi-collaborations in order to answer important scientific questions, as the result of efforts by funding agencies to encourage collaboration. This encouragement is enacted through large initiatives that require collaborative proposals, and through programs that foster collaboration between information technologists and domain scientists. The U.S. National Science Foundation (USNSF), for example, has put into place programs such as the Knowledge and Distributed Intelligence Initiative (Cummings & Kielser, 2004). Many scholars have asserted that we need a better understanding of how scientific collaboration works and what makes it desirable in order to develop and implement effective e-science or big science (Cummings & Kiesler, 2005; Glanzel 2001; Nentwich, 2003).

"E-science" is the term often applied to the use of advanced computing technologies to support scientists. It focuses on "global collaboration in key areas of science, and the next generation of infrastructure that will enable it" (Hey et al., 2002, p.4). The last three decades have seen some earnest endeavors to make this dream become true. One of the most ambitious

projects appeared in the United Kingdom in 2001 under the name of "e-Science." E-Science has been defined as:

> Large scale science that will increasingly be carried out through distributed global collaboration enabled by the Internet. Typically, a feature of such collaborative scientific enterprise is that they will require access to very large data collection, very large scale computing resources and high performance visualization back to the individual user scientist. (Berman et al., 2003)

E-Science offers a promising vision of how the internet and communication technology can support and enhance scientific collaboration by enabling scientists to generate, share, and discuss their ideas, experiments, and results in a more effective manner.

Collaboration is a significant indicator of the nature of scientific activity. In the transition from "little science" to "big science" (Price, 1963), the nature of collaborative activity has changed to some extent from one strictly between individual scientists, to one mediated by organizations or national and international bodies. Scientific collaboration has been directly linked to "big science," a term first used by the physicist Alvin Weinberg to describe research in big research organizations set up in costly facilities, mainly in the field of physics (Clery, 2009). Examples include the recently inaugurated Large Hadron Collider (LHC) in Geneva, the largest European particle accelerator, and the European Organization for Nuclear Research (CERN), which is a good example of transatlantic international collaboration (Clery, 2009).

The term "big science" refers to the post-World War II phenomenon of large, expensive, interdisciplinary research projects (Price, 1986). The scale of these projects has grown, in order to bring methodologies and knowledge from multiple domains to bear on large-scale problems, such as AIDS research and particle physics. The majority of physics and natural studies require experimental or observational "big science" equipment that is sufficiently complex, massive, or

expensive as to be beyond the reach of individual laboratories or investigators. In order to do any research at all in these fields, scientists usually must join in a collaboration to access that equipment (Birnholtz, 2005).

In most cases, the reason for collaboration is to bring multiple perspectives to bear on difficult problems. Such an approach has been particularly valuable in recent responses to public health threats such as AIDS and SARS (Birnholtz, 2005). In the former instance, global teams of AIDS researchers with a somewhat longer time horizon are able to bring together researchers from the fields of immunology, epidemiology, and others to solve critical problems (Olson et al., 2008).

According to Birnholtz (2005), the collaborative nature and large scale of high energy physics or big science also demonstrate that the evaluation of individual scientists' performance is different from that of small science performance. In many fields, scientists' productivity is measured by the number of their publications and citations. Thus, communication plays a critical role in the operation of the high energy physics community; it enables scientists to fulfill various tasks. These tasks include how scientists evaluate one another's work during informal conversation, how they establish and maintain relationships with colleagues, how they access experts' knowledge, how they gain from others' corroboration of their own research results, and how they display their research abilities (Luo, 2008). In addition, through these collaborations, junior scientists become familiar with the successes of senior scientists, whom they can use as role models for their own careers. Thus, acquiring the capacity to access communication about physicists, data, and ideas is necessary for the training of high energy physicists (Birnholtz, 2005).

Scientific grand challenges require interdisciplinary solutions and this drives a need for sophisticated collaborative frameworks, such as the Data Observation Network for Earth (DataONE). DataONE is poised to be the foundation of new, innovative environmental science conducted through a distributed framework and sustainable cyber-infrastructure that meets the needs of science and society for open, persistent, robust, and secures access to well-described and easily-discovered Earth observational data. The DataONE project aims to create an international network where earth and environmental scientists can exchange research. This network will serve scientists and social scientists of diverse disciplines, from biologists to librarians. Another good example is the National Institutes of Health (NIH), where multi-team projects have been funded to tackle large-scale undertakings, such as the Human Brain Project in the neuroscience community (Birnholtz, 2005).

Development and Computer Mediated Technologies (CMTs)

Computer and internet technologies have fundamentally changed the way science develops and the way scientists collaborate and communicate. Communication and development have a positive relationship (Rogers, 1986). At present, there is a debate about the impact of the internet and CMTs on the development process in developing countries. Some of the questions that arise in the course of this discussion are: What is the role of new communication technology in supporting the development process? What is the impact of new information technology in advancing science and knowledge production? How can scientific collaboration improve scientific publication and productivity in less developed countries? What is the future of social networking and web technology in facilitating the exchange of knowledge between developed and developing countries? What is the impact of these technologies on knowledge management in the future?

Determining the impact digital media and communication technologies have on scientific development is a long-term endeavor. One factor is the ability of human resources to manage new technologies within the framework of scientific development strategies. Starting with the falling costs of all things digital, there has been a steady flow of investment into communications infrastructure around the world. Smartphone and broadband (wired and wireless) internet networks carrying both information and data are being deployed in all developing countries; in time most rural areas will be covered. These technologies are sophisticated but convenient by allowing scientific research to take digital media for granted and make advances at an increasing rate in the years ahead. Therefore, the question becomes how to determine where investments in CMTs should be made, how, and on what scale. The options should be narrowed down to the choices between short- and long-term interests; executive decisions by national planners and policy-makers also must be made regarding the importance of digital media and communication technologies in their human and scientific development priorities.

The relationship between communication and development is not new. Long before the emergence of the new communication technologies, social networking and Web 2.0, communication and development scholars had argued that there was a strong link between communication technologies—especially mass media—and the level of development in any country (Obijiofor et al., 2000). Therefore, the two concepts knowledge production (science), and communication, play an indispensable role in any effort undertaken to develop knowledge-based science. Measuring the successes and failures in the practices or performance of knowledge production and communication can identify how far, and in which direction, developing Arab countries are likely to move in order to transform their development.

Mass media— newspapers, radio, and television—were regarded as the drivers of development for most of the past century. The founders of the discipline of communication, such as Wilbur Schramm, Everett Rogers and Lucian Pye, led this campaign. According to their views, a certain number of mass media channels are required in every developing country that wishes to be developed. This argument was based on the assumption that mass media carried the characteristics of modernity. Lerner (1958) observed, "No modern society functions efficiently without a developed system of mass media" (p. 55). In a similar vein, Pye (1963) argued:

> It was the pressure of communications which brought about the downfall of traditional societies. And in the future, it will be the creation of new channels of communication and the ready acceptance of new content of communications which will be decisive in determining the prospects of nation-building (p. 3).

In the United States and Western Europe, scientists have identified scientific collaboration as an important facet of the changing nature of science over the last century. Knowledge production is "increasingly collaborative rather than competitive" (Sooryamoorthy & Shrum, 2007, p.746) because of the ability to enhance collaboration and facilitate scientists' decisions regarding task accomplishment by sharing information, ideas, and access to expertise (Bordons & Gomez, 2000; Duque et al., 2005; Katz & Martin, 1997). Therefore, collaboration, such as that which may occur between developing and developed countries, can advance science in two ways: by increasing the number of participants, and by increasing the diversity of approaches. One way to broaden participation is to reach out to scientists in developing countries. Scholars have assumed that using new communication technology, particularly CMTs and the internet, in support of collaborations, provides the potential for allowing researchers

from developing areas to pool resources with scientists from more developed countries who are working in the same field (Duque et al., 2005; Finholt, 2002; Rogers, 1995; Ynalvez et al., 2005).

Scientists and faculty members who work in developing countries do not have many opportunities to engage in informal collegial communication. In addition, they do not have as many resources at their disposal as scientists in research universities in the United States and Western Europe do. Therefore, scientists from developing countries have been isolated in both informational and interpersonal dimensions (Davidson et al., 2002; Shrum, 2005). It has also been observed that the opportunities for scientists from developing countries to access timely scientific information are seriously limited. According to Luo (2008), journals, books, preprints, and manuscripts of unpublished work are essential sources for active scientists seeking timely information: "Acquisition costs, as well as inadequate libraries and documentation centers, prevent most scientists in developing countries from accessing these resources" (p. 43).

Developing countries tend to realize a larger return on investment in science when portions of their research funding are spent to support collaboration with scientists in more advanced countries (Nentwich, 2005). Nentwich (2005) noted that these collaborations can provide advice, key lab materials, equipment, student and staff training, and research project funding, to help increase the return on investment. Moreover, universities and research institutions can also benefit from funded collaborative research (Maglaughlin & Sonnenwald, 2005).

In an examination of the Arab knowledge landscape, this study reveals that an acute digital gap remains. Investigation of Arabic digital content, which is a guide to the utilization and production of knowledge in Arabic, demonstrates that developing Arab countries and their

societies fall short according to most criteria (UNESCWA, 2008). The Knowledge Arab Report (2009) recommended that Arab countries take serious steps on various levels in the domain of technology policy and legislation; as long as many issues related to Arabic language usage on the internet are not settled, the state of Arabic knowledge content will never evolve beyond an extremely low threshold level, but rather will continue to draw upon other, random sources for content and draw solace from past traditions, both good and bad.

Scientific Collaboration as a Factor of Development

The production of scientific knowledge is a growing process that depends on three factors: (a) human input, (b) physical input, and (c) information input. Information input is founded on researchers' continuing ability to access and share data. CMTs can play an essential role in this component since they reduce many traditional difficulties—especially those of time and distance—for scientists and researchers in developing countries by providing powerful new tools and new modes of production based on collaboration.

Kuwait and other developing countries look to scientific collaboration to support national scientific and economic development. Scientific collaboration has been called a springboard for economic prosperity and sustainable development (US Office of Science & Technology Policy, 2000). However, in current scientific endeavors, development in any country cannot achieve its goals except through direct contributions of and collaboration among peer scientists on a national basis. Therefore, collaboration should be encouraged and supported, especially when it directly contributes to actualizing aims of scientific research and science development among national scientific institutions.

Many countries have research programs that require collaboration between universities and industries, including small and medium sized enterprises. Nentwich (2003) pointed out that in Western Europe, for example, the Swedish agency VINNOVA was established to support

national and regional innovation and economic growth through collaboration between academia and industry. The same study argued that all collaborations in advanced countries should require all research proposals to include both academic and business participants (Nentwich, 2003).

Kuwait has fused the task of knowledge production to the attainment of national growth and development, meaning that the results of scientific research are invested in extending development to broader and newer horizons, in order to meet the challenges that face modern societies. These values have led to the creation of new opportunities for and the enhancement of the potential and capabilities of Kuwaiti scientists.

The State of Kuwait

With an area of 17, 818 square kilometers and a population of 3.3 million, the state of Kuwait is bordered by Saudi Arabia to the south and Iraq to the north and west. The Arabian Gulf, with nine small islands, forms the eastern coast boundary.

The recent history of Kuwait goes back to the 18th century, when tribes from Central Arabia settled here under the sovereignty of Banu Khaled. These tribes came to be known as the Utub of Quran, the initial name given to Kuwait. It became a major center for spice trading between India and Europe (Abu-Hakima, 1983; Casey, 2007).

On June 19, 1961 Kuwait became a fully independent country, following an agreement between the British and the Emir of Kuwait at that time, Abdullah Al-Saleem Al-Sabah. Kuwait's oil fields were discovered and exploited in the 1930s, and Kuwait's oil industry spurred tremendous growth during the next several decades. The massive development of the petroleum industry transformed Kuwait into one of the richest countries in the Arabian Peninsula.

Today, Kuwait owns the world's fifth-largest proven oil reserve and is among the world's most prosperous nations. Petroleum and petroleum products account for nearly 95% of export revenues and 80% of government income. Kuwaiti officials have committed to increasing oil

production to 4 million barrels per day by 2020. Kuwait has a gross domestic product (GDP) purchasing power parity (PPP) of USD $138.6 billion and a per capita income of USD $40,300, the eleventh highest in the world. According to the Kuwaiti Constitution, all natural resources and their associated revenues are considered government property (Casey, 2007). Its human development index (HDI) stands at 0.871, the third highest in the Arab world. With a GDP growth rate of 5.7%, Kuwait has one of the fastest growing economies in the region.

The majority of Kuwait's population identifies itself as Muslim. Estimates of the percentage of people in Kuwait who practice Islam vary between 89% and 99%. Despite Islam's being the state religion, Kuwait has communities of Christians (est. 300,000 to 400,000), Hindus (est. 300,000), Buddhists (est. 100,000), and Sikhs (est. 10,000). It is a tax-free country and provides many social services to its citizens, either free of charge or at highly subsidized rates. Such services include housing, education, food, water, and electricity.

Kuwait is a constitutional monarchy and has the oldest directly-elected parliament in the Gulf region. The head of the state is the Emir, who appoints a Prime Minister; until recently, this position was occupied by the crown prince. The National Assembly has the power to dismiss the Prime Minister or any member of the cabinet (Abu-Hakima, 1983). The National Assembly consists of 50 elected members and, until May 16, 2005, parliamentary elections and National Assembly membership were limited to males who had been citizens of Kuwait for at least 30 years. In May 2005, Kuwaiti women were given the right to vote and stand for seats in the National Assembly. Women candidates contested the 2006 and 2008 elections, but did not win any seats. On May 18, 2009, however, four Kuwaiti women won seats in the National Assembly, making history in the Arabian Gulf. Kuwait's 93.3% literacy rate, one of the Arab world's highest, is the result of extensive government support for the education system.

The Scientific Community in Kuwait

Kuwait is at the periphery of the global scientific system; its scientific manpower and infrastructure are far behind other Arab countries such as Egypt, Tunisia, and Jordan. Much of the contribution of Kuwait's knowledge to global science is derived from its petroleum sciences. This is the only field in which it has an internationally-recognized research outlet, the Petroleum Research and Studies Center, which includes divisions for petroleum production, petrochemical processes, and petroleum refining.

It is important to understand the unique nature of the scientific community in Kuwait. The questions to consider are whether or not there exists a collaboration culture, and whether there are organizations or institutions that support science and scientific production in Kuwait.

In developing countries, governments are the main resources for and supporters of scientific research. This is true in Kuwait as well, but there are some companies and private organizations that support the sciences and knowledge production in the State of Kuwait. The rest of this chapter seeks to shed light on some institutions and colleges that constitute the scientific community. One of these scientific communities is the Kuwait Foundation for the Advancement of Sciences (KFAS).

Kuwait Foundation for the Advancement of Sciences (KFAS)

The Kuwait Foundation for the Advancement of Sciences (KFAS) is a private, non-profit organization. The main objectives of KFAS are to provide research grants, to encourage researchers, and to support the infrastructure of national scientific institutions for research by providing funding for individual or group research in Kuwaiti institutions. Grants may also be awarded to non-Kuwaiti institutions, provided the research project is administered by a Kuwaiti institution. Funded research covers all of the scientific areas that address national concerns.

These areas include biology, engineering and technology, medicine, and natural and social sciences (for more information, go to http://www.kfas.com/).

The goal of KFAS is to promote scientific, technological, and intellectual progress within the State of Kuwait and the region. The specific objectives are as follows:

1. Provide financial sustenance for research in basic and applied sciences.
2. Support projects of national priority.
3. Award prizes and recognition at national, regional and international levels.
4. Organize scientific symposia and conferences.
5. Enrich the Arabic language library by publishing journals, books, and encyclopedias.
6. Promote scientific and cultural awareness.

In fulfillment of these objectives supporting scientific research, and encouraging scientists and scholars in Kuwait and other Arabic countries, KFAS awards prizes in the fields of science, arts and letters, economic and social studies, and Arabic and Islamic scientific heritage. Two prizes in each field are awarded annually, one for Kuwaiti scientists and the other for scientists of other Arab countries. Each prize is comprised of a cash sum of KD 30,000 (Kuwaiti dinars, equivalent to USD $100,000). KFAS prizes are designed to recognize intellectual achievements that serve the interests of scientific advancement and support efforts to raise the standards of culture in various fields (http://www.kfas.com/).

Today universities and scientific centers have a role in any process that advances knowledge in developed countries. Next to teaching and research, making a contribution to economic growth has become a central task (Hessels & Lente, 2008). For that reason, the scientific environments in Kuwait Institute for Scientific Research-KISR and Kuwait University KU are relevant to the present study.

Kuwait Institute for Scientific Research (KISR)

The second institution that constitutes the scientific community in the State of Kuwait is the Kuwait Institute for Scientific Research (KISR), established in 1967 by the Arabian Oil Company Limited (Japan) in fulfillment of its obligations under the oil concession agreement with the State of Kuwait. KISR was established to carry out applied scientific research in three fields: petroleum, desert agriculture, and marine biology. The main objectives of this institute were to carry out applied scientific research, especially related to industry, energy, agriculture, and the national economy, to contribute to the economic and social development of the state, and to advise the government on the country's scientific research policies.

An Amiri Decree in 1981 (Law No. 28) formally established KISR as an independent public institution. The law specified that the institute would be governed by a Board of Trustees chaired by a minister chosen by the Council of Ministers. The revised objectives of KISR are to carry out applied scientific research that contributes to the advancement of national industry and to undertake studies relating to the preservation of the environment, resources of natural wealth and their discovery, sources of water and energy, methods of agricultural exploitation, and the promotion of water wealth. The law entrusted the institute with undertaking research and scientific and technological consultations for both governmental and private institutions in Kuwait, the Gulf region, and the Arab world. According to its website (http://www.kisr.edu.kw/), KISR is authorized to:

1. Conduct scientific research and studies concerned with the progress of national industry and which facilitate the preservation of the environment;
2. Encourage Kuwait to practice scientific research and nourish the spirit of research in the younger generation;

3. Explore and study natural resources and means for exploiting them, energy and water resources, and methods to improve agriculture and develop aquatic resources;
4. Render scientific, technological and research consultation services to the government and to national scientific establishment;
5. Follow up on the development of scientific and technological progress, and adapt it in ways that associated with the local environment;
6. Establish and foster relations, and carry out mutual research with higher education institutes, and the technological and scientific sectors in Kuwait and various parts of the world; and
7. Participate in the study of ways to verify the resources of the national economy by investing the results of scientific and technological research in industry, and directing it in the service of the State's economic and social development goals.

Scientific Research at Kuwait University

Scientific research at Kuwait University is integral to its mission of higher education that provides for the parallel growth of research. Hence, academic process and research creativity go hand in hand in chartering institutional development towards high quality, merit-based programs compatible with international standards of accreditation and recognition.

Kuwait University has a well-integrated and advanced system of scientific research, the fundamentals of which are envisioned, developed, and implemented through the Office of the Vice President for Research. This office defines institutional research policy, identifies programs, and develops the system of grant support for institutional creative enterprise. The grants are available to faculty members through the Research Administration (RA) for pursuing research that is original and scientifically sound.

The Office of the Vice President for Research (OVPR) supports and sustains basic and applied research throughout institutional faculties, laying the foundation of grant support through critical policy, programs, and procedures. The office encourages priority research of national, regional, and global concern, and it nurtures creativity, encourages excellence, and builds inter-institutional and cross-country alliances, cooperation, and partnerships to raise the spectrum of scientific research at Kuwait University. Funding endeavors began in 1979/80, and the first grants were awarded to 87 projects. Today, the RA's annual funding activity is responsible for over 648 project (519 ongoing projects and an additional 129 under development) and over 561 published papers in peer-reviewed journals of international repute (Annual Report of Kuwait University, 2010). These activities provide evidence of the extent of faculty research performance and productivity and the quality of institutional research programs.

The faculty members are encouraged to pursue studies that would yield potentially significant research of immense scientific, social, and national value. The projects are submitted on standard grant applications and subjected to well-established review and assessment procedures. The researchers have access to equipment and manpower for their projects, in addition to the contributions of visiting experts; on completion of projects, final reports are expected in addition to scholarly publication. The research policy advocates equality of opportunity for grant support for all faculty members. No exceptions are made on grounds of specialization or discipline, and grants are awarded based on the project's merit and relevancy. Kuwait University research grants are currently available in eight distinct categories:

1. University Research Grants—for faculty members pursuing well-defined proposals with clear objectives that could yield original results and contribute to scientific advancement.
2. External Grants—for joint studies in collaboration with external institutions.

3. General Facility Grants—for strengthening research resources by way of labs, equipment and facilities for research implementation.
4. National Grants -- for undertaking specialized studies strategic to national, social, or community interests.
5. Priority Research—for specialized focus on issues of priority concern.
6. Research Initiation Grant (RIG) —an institutional initiative to encourage new academic staff to participate in sponsored programs.
7. University Services Grants—for developing the institutional services sector.
8. Graduate Studies Grants—for advancing Master's and Doctoral degree candidates' creative potentialities. (Annual Report of Kuwait University, 2010).

The research support system offers three levels of funding support, and all grants undergo a standard review process. The maximum duration for a project is three years. The projects are submitted on standard Research Support Applications and regulations governing the research support procedure are outlined in the Manual of Research Support. In addition to research support, the institutional research activity has an intense agenda of Special Programs that includes:

1. Scientific Forums—an open platform for scientific presentations, discussions and dialogue.
2. Performance Awards – Recognizing/rewarding outstanding accomplishments in research.
3. Special Projects -- Commissioning special studies of direct relevance to social, community, and national concern.

4. Research Gathering – Organizing special scientific meetings for promoting research interaction and to display latest developments in technology and trends in scientific research. (Annual Report of Kuwait University, 2010).

Apart from these commitments, some of the latest programs initiated by the Research Administration concern the establishment of the International Advisory Board for developing institutional areas of research strength, research marketing for investing significant research findings and discoveries having commercial potential, patents for ensuring researchers' rights, Graduate Research Awards for rewarding meritorious research accomplishments of graduate students, Undergraduate Research Awards for early recognition of the creative potential of undergraduate students, the Research Support Services Survey for studying the quality of grant services and procedures, a think tank for critical thinking and brainstorming about strategic advancement, and globalizing research for building local, regional and global alliances and partnerships for scientific discovery, expertise, interactivity, and exchange (Annual Report of Kuwait University, 2010).

The purpose of this research is to focus on CMTs and scientific collaboration and its impact on the publication and research productivity of the scientific communities in Kuwait. Three Colleges from Kuwait University were chosen to participate in this online survey; the study will investigate the role of CMT use in scientific collaboration at the Colleges of Engineering and Petroleum, Science, and Medicine.

The College of Engineering and Petroleum

This institution provides quality engineering education for the needs of society and the institutional vision to develop an elite college as the leading engineering institution in the Middle East and Arab world. It is recognized for its outstanding educational, research, and outreach programs and for the quality, character, and integrity of its graduates. The College endeavors to create a dynamic academic and research environment, keeping pace with scientific and technological developments in engineering for addressing immediate and long-term needs. The College has eight departments in which it awards Bachelors of Engineering degrees: Chemical, Civil, Computer, Electrical, Industrial and Management Systems, Mechanical and Petroleum Engineering, and Architecture. Graduate programs are offered in the Chemical, Civil, Electrical, Mechanical, Computer, and Petroleum Engineering Departments.

The College of Medicine

The College of Medicine was established in 1973, and has since developed into an internationally recognized medical school, serving Kuwait and the Gulf region. The faculty offers a seven-year medical program, and currently has 600 students enrolled, in addition to 300 academic, technical and administrative staff. The college is organized into several departments, including Anatomy, Biochemistry, Community Medicine and Behavioral Science, Medicine, Microbiology, Nuclear Medicine, Obstetrics and Gynecology, Pediatrics, Pathology, Pharmacology and Toxicology, Physiology, Primary Care, Psychiatry, Radiology, and Surgery. The college offers undergraduate and graduate programs in microbiology, pathology, physiology and pharmacology. In addition, a doctoral program offers advanced degrees in microbiology and physiology. The college's mission involves rigorous pursuit of knowledge, education, and training in the field of medicine, providing professional training to residents and high-quality

medical services to the community, in addition to supporting, encouraging, and maintaining excellence in biomedical, psychosocial, and allied fields of research.

The College of Science

This college originated as the combined Science, Arts and Education Faculty in 1966/67. In 1971, the College of Science became an independent college with six departments -- Mathematics, Chemistry, Physics, Zoology, Botany, and Geology. In 1977, the Department of Biochemistry was added, followed by the Department of Statistics and Operations Research in 1989. In 1997, the Departments of Zoology, Botany, and Microbiology and Biochemistry were merged under the umbrella of the new Department of Biological Sciences. Likewise, a new Department of Earth and Environmental Sciences was established by grouping together Geology, Desert Studies, Marine, and Environmental Sciences. The college has nearly 3,000 students. A comprehensive evaluation of programs ensures academic standards are maintained, for turning out competent graduates for community and national needs. The faculty contributes to community services, provides technical and scientific support to public and private sectors, organizes workshops and training courses for public benefit, and effectively contributes to the country's development.

Public Authority for Applied Education and Training (PAAET)

The third scientific community is the College of Technological Studies at PAAET. PAAET was established on December 28, 1982 by law number 63 with the objective of developing and upgrading personnel to meet the challenge of the shortfall in technical manpower created by the industrialization of the State of Kuwait. The foundations of applied education and training were laid, along with developing oil exploration, production, and export in Kuwait. The applied education sector includes four Colleges: Basic Education, Business Studies,

Technological Studies, and Health Sciences. In addition to these four colleges, PAAET contains a number of training institutes such as the Higher Institute of Energy, the Higher Institute of Telecommunication and Navigation, and the Industrial Training, Constructional, Nursing, and Vocational Training Institutes. The College of Technological Studies was chosen to participate in this study as another academic institution.

The College of Technological Studies at PAAET

The College of Technological Studies (CTS) supports and maintains faculty-wide research interests that address a multitude of critical concerns affecting humanity, society, environment, and quality of life, and aims to resolve scientific complexities for the benefit of mankind. The current impetus is evoking international interest in the quality of Kuwait's scientific research, and it encourages scientific collaboration and multidisciplinary research. The College prepares tomorrow's engineering professionals for the challenges of the fast-changing, information-driven world. The goal is greater than teaching technical skills; the CTS seek to inspire engineering knowledge originators who are visionaries and creative designers, because they will become the next generation of leaders who will transform knowledge and problem solving. Its programs focus on nine areas of concentration:

1. Manufacturing Engineering Technology
2. Automotive and Marine Engineering
3. Mechanical Power & Refrigeration Engineering
4. Electrical Engineering Technology
5. Electronics and Computer Engineering Technology
6. Civil Engineering Technology
7. Chemical Engineering Technology

8. Petroleum Engineering Technology
9. Applied Science Technology

The Arab World and CMTs

The Arab countries are part of an emerging and fast developing region, which is characterized by a wealth of natural resources and ongoing institutional reforms of both the public and private sectors (e.g. market liberalization). Internet and computer mediated technologies are unquestionably key platforms for growth and development in the Arab world, and several developments have been taking place in this area over the past years. For analytical purposes, it is useful to distinguish between two groups of countries within the Arab world: the countries that belong to the Gulf Cooperation Council (GCC) on the one hand, and the countries that are part of the broader Middle East region and North Africa on the other hand.

In 2008, GCC countries, with the addition of Libya, had GDP per capita levels above USD $20,000, with Qatar, the United Arab Emirates (UAE), Kuwait, Saudia Arabia, and Bahrain leading the way (Table 2.1). All of the remaining countries are characterized as middle and/or lower-income economies, with GDP per capita levels of well below USD $10,000. This difference in income levels has a direct impact on the spread of internet and computer services.

The population density of Arab countries is considerably lower than that of developed countries. In Sudan, Somalia, Saudi Arabia, and Oman, less than 20 people, on average, reside per square kilometer, because large parts of these countries are uninhabited desert landscape. There is still a significant percentage of the population in the Arab states that reside in rural areas (e.g. 17.4 per cent in the case of Saudi Arabia and 44 per cent in the case of Morocco).

The Arab world countries have made remarkable progress in most of the pivotal aspects of internet and CMT use, particularly in infrastructures where investment is ongoing. The first connections to the internet in the Arab region date back to the early 1990s. For example, Tunisia

was the first Arab country to link to the internet (1991). Kuwait established internet services in 1992 as a part of its reconstruction after the Iraqi invasion. In 1993, Egypt and the UAE established links to the internet (Wheeler, 2000).

Table 2.1: Countries of Arab World by Income Grouping

Low-income	Lower-middle-income	Upper-middle-income	High-income
Comoros	Djibouti	Algeria	Bahrain*
Mauritania	Egypt	Lebanon	Kuwait*
Somalia	Iraq	Libya	Oman*
Yemen	Jordan		Qatar*
	Morocco		Saudi Arabia*
	Sudan		United Arab Emirates*
	Syria		
	Tunisia		

Source: ITU World Telecommunication/ICT Indicators Database 2010.
*Refers to Gulf Cooperation Council (GCC) member countries.

Five Arab countries have been listed among the top fifty most ready to utilize information communication technologies, all of them Gulf Cooperation Council (GCC) countries: Oman, the UAE, Qatar, Bahrain, and Kuwait, occupying the 28th, 37th, 39th, and 50th ranks, respectively (World Economic Forum, 2008b). Compared to other regions, internet usage, particularly broadband access, is still rather limited and out of the reach of most people in the region, especially for those living in rural areas. The Arab States are characterized by important disparities in terms of income level, corresponding to differences in CMT development. GCC countries, which are among the wealthier economies worldwide, have witnessed high ICT access. Other countries, such as Comoros, Djibouti, Mauritania, Sudan, and Yemen, on the other hand, are among the poorest countries in the world, with very low CMT penetration levels (Table 2.2). The region also features several high-population countries, such as Egypt, Sudan, Algeria, Morocco, Iraq, and Saudi Arabia, which provide important growth markets for CMT services, featuring high levels of new additions of mobile subscriptions, internet users, and broadband subscribers, as of 2008 (ITU, 2010).

In general, there seems to be a linear relationship between the population of the Arab countires, which currently represents around five per cent of the global population, and its share in global internet and CMT services (ITU, 2010).

CMTs and the Diffusion of Innovation

By the end of 2008, Arab countries had one of the lowest average internet user penetration levels in the world, with only 16 out of 100 inhabitants using the internet. These countries lie far behind Europe and the Americas on this measure and ahead of only the African region. Despite the fact that over the past four years, the number of internet users has been growing at 37 per cent annually, Arab countries still fall well below the world average in terms

of penetration (Figure 2.1). The significant difference in internet user usage between GCC countries and other Arab States is further explained by examining internet user penetration rates and income levels.

Table 2.2:Internet Users in Arab World by Countries

		Internet users			Internet users per 100 inhabitants		
		(000s)		CAGR (%)			CAGR (%)
		2003	2008	2003-2008	2003	2008	2003-2008
1	Algeria	700.0	4'100.0	42.40	2.20	11.93	40.3
2	Bahrain	150.0	402.9	21.80	21.55	51.95	19.2
3	Comoros	5.0	23.0	35.70	0.85	3.48	32.6
4	Djibouti	4.9	19.2	31.60	0.63	2.26	29.3
5	Egypt	3'000.0	13'573.0	35.20	4.04	16.65	32.8
6	Iraq	30.0	300.0	58.50	0.11	1.00	54.9
7	Jordan	444.0	1'595.2	29.10	8.47	26.00	25.2
8	Kuwait	567.0	1'000.0	12.00	22.40	34.26	8.9
9	Lebanon	500.0	945.0	13.60	12.61	22.53	12.3
10	Libya	160.0	323.0	15.10	2.81	5.13	12.8
11	Mauritania	12.0	60.0	38.00	0.42	1.87	34.5
12	Morocco	1'000.0	10'442.5	59.90	3.35	33.04	58.0
13	Oman	183.3	557.0	24.90	7.26	20.00	22.5
14	Qatar	140.8	436.0	25.40	19.24	34.04	12.1
15	Saudi Arabia	1'800.0	7'761.8	33.90	8.00	30.80	30.9
16	Somalia	30.0	102.0	27.70	0.38	1.14	24.9
17	Sudan	200.0	4'200.0	83.80	0.54	10.16	79.9
18	Syria	610.0	3'565.0	42.30	3.40	16.79	37.7
19	Tunisia	630.0	2'800.0	34.80	6.49	27.53	33.5
20	United Arab Emirates	1'110.0	2'922.0	21.40	29.48	65.15	17.2
21	Yemen	120.0	370.0	25.30	0.60	1.61	21.7
	Arab States	**11'396.9**	**55'497.6**	**37.20**	**3.71**	**16.28**	**34.4**

Source: ITU World Telecommunication/ICT Indicators Database 2010.

Figure 2.1: Internet uses by region, 2004-2008.

In the last several years, Arab countries have witnessed a significant increase in the average international internet bandwidth available per inhabitant. The total number of fixed broadband subscribers reached 4.3 million by the end of 2008 and the number of mobile broadband subscriptions stood at 11.4 million, representing one and three per cent penetration respectively (ITU, 2010).

Between 2003 and 2009, Egypt, Morocco, Saudi Arabia, and Sudan were the countries with the highest number of net additions of internet users, mainly due to their large populations. One of the key factors that impact or limit internet development in the Arab States is the lack of computers in households and businesses.

Another problem that faces the Arab world is the lack of digital literacy among citizens. There is also a dearth of computers in schools and universities, and a considerable scarcity of

online Arabic language content (less than 1 per cent of total online internet content). Moreover, because of institutional barriers (e.g., government ownership) in many Arab countries, market liberalization came late to the region; in some of these countries, this began at the end of the 1990s (ITU, 2010).

With regard to information technology development, Arab countries are still at the very early developmental stages. When studying information technology and internet usage in individual countries, it can be concluded that GCC countries have, in general, higher penetration rates due to their wealthier economies, ability to attract visitors and foreign professionals, and an early adoption of policies addressed to the telecommunication market (ITU, 2010). As another factor, the region shows significant differences between mobile cellular and internet users. In countries where mobile cellular penetration exceeds 100 per cent (mostly GCC countries), the differences are even higher. While in terms of mobile penetration the region is doing well in international comparisons, it is lagging behind the world average in all other information technology services. In the next chapter, the digital divide and knowledge production in the developed and developing countries will be identified and discussed.

Chapter III: The Digital Divide

This chapter discusses the digital divide concept and considers the following questions: What is the digital divide? What is the appropriate definition today for this term after the global expansion of the internet and communication technology? What are the differences between developed and developing countries in science and knowledge production? What is the relevance of the concept of the "Peripherality Hypothesis"? What is the future of the diffusion of CMTs in the developing countries? What is the importance of the Collaboration Process for Developing Courtiers?

Kofi Annan, the former Secretary General of the United Nations (1997-2006), called attention to the clear inequalities in science and the scientific process between developing and developed countries, and to the challenges of building bridges across this gap to bring the U.N. and the world scientific community closer together (Annan, 2003). Annan asserted the importance of reducing the inequalities in science between developed and developing countries: "This unbalanced distribution of scientific activity generates serious problems, not only for the scientific community in the developing countries, but for development itself" (Annan, 2003, p. 1485).

The problem of the digital divide between the developed and developing countries is one key example of the uneven dissemination of science described above. The digital divide is far from closed, and in most parts of the world it is still widening (van Dijk, 2005). Furthermore, in instances where the digital divide has stopped widening it is becoming deeper. The gap is manifested in ICT products and outputs such as internet access and cell-phones, and in ICT inputs such as engineers and scientists.

The term “digital divide” is increasingly being used to “describe the social implications of unequal access of some sectors of the community to information and communication technology and the acquisition of necessary skills” (National Office for the Information Economy, 2002a, p. 1). The digital divide represents an opportunity to identify the inequalities between the technological haves and have-nots (DiMaggio & Hargittai, 2001).

In the past, a divide between nations has been explained in terms of disparate access to resources like capital, raw materials, and human capital, or in terms of information gaps such as in the knowledge that is needed to combine physical resources to produce economically valuable commodities. In recent years, the gaps in science, as represented by knowledge production, technology, and internet usage, have gained in importance, as these factors are recognized as determinants of levels of development (Pohjola, 2003).

With the expansion of web technologies and social networking, people have experienced spectacular changes in the ways they can learn, work, communicate with others, and entertain themselves in this information society. At the same time, observers have witnessed a growing gap, a new form of divide or exclusion, which is gradually separating those who can derive many benefits from the new information society and those who cannot (Wang, 2010).

In this research, the digital divide can be explained in two ways: (1) the existing gap between those countries that have sufficient electronic scientific research and information technologies, and those that do not, and (2) the difference in internet and ICT literacy and aptitude between the scientists of developed and developing countries.

Earlier research on the digital divide focused on inequities in access to the internet and digital technologies (Bucy, 2000; Hargittai & Hinnant, 2008; Norris, 2001). With the subsequent global expansion of internet and information communication technologies, some researchers

suggested a conceptual shift in emphasis of the digital divide research focus from material access to actual use of these technologies (Livingstone & Helsper, 2007; Selwyn, 2004).

Digital Divide

Some scholars have offered a refined understanding of the digital divide by viewing it as a complex and dynamic phenomenon that is essentially multifaceted (e.g., van Dijk, 2002; van Dijk & Hacker, 2003). Kling (1999) grouped access into technical access (meaning the physical availability of technology), and social access (referring to the mix of professional knowledge, economic resources, and technical skills required for effectual use of technology). Attewell (2001) and Hargittai (2002) suggested a similar differentiation between the issues of access to and ability to use these technologies, referring to these conditions respectively as the "first-level" and "second-level" digital divide.

To clarify the differences between developed and developing countries in terms of information, it is helpful to depict the levels of accessibility and use in the developing countries of the Arab world. There are several important factors that affect the levels of accessibility and use of ICTs, such as possessing the computer skills and literacy necessary for technology-enabled services, or having enough money to acquire the essential devices and to pay for services. Such factors not only affect the degree of access and usage, but also have unique implications for the capacity of and opportunities for members to take part in an information society.

Accessibility

Accessibility refers to the ease of access to personal computers and internet connections, at home and in other locations, so that individuals can connect to the internet to use its services. Increasingly, the quality of technology, such as broadband connections and higher processing power and storage capacity, affects the intention to use and satisfaction of using, technology-

enabled services, thus, this study included the various markers of technological quality as indicators of accessibility. These indicators include the extent to which individuals:

- have a home computer (desktop and/or notebook computer);
- have home computers connected to the internet;
- have a good-quality computer;
- have a broadband connection;
- have a computer at home that can be used without permission.

Usage of CMTs

"Usage" refers to the actual use of computers and services enabled by CMTs. Services include those that are commonly available and are essential to the functioning of individuals in a society. Such essential functions include searching for information on the internet, communicating with others by sending and receiving email, short messages, bulletin board messages, and instant messages, and producing template-based websites to share information with others. It also entails the amount of time spent using those technology-enabled services. The indicators of usage level were implemented in this study through responses to the following questions:

1. In what year did you initially acquire a computer?
2. What is the frequency of your internet use?
3. What is the average duration, in number of hours, of each time you use the computer and internet?

Computer Skills/Literacy

Computer skills/literacy refers to individuals' self-assessments of their abilities to use the technology-enabled services mentioned above. It also captures their self-perceptions of their

knowledge of using computers and the internet, as well as the number of hours of training in computer and internet use that they have received. In fact, computer skills/literacy is highly correlated with general literacy and educational attainment (ICT Literacy Panel, 2007). This study included indicators for measuring computer skills/literacy, according to the following concepts:

1. Knowledge (self-assessment) regarding various kinds of online activities;
2. Overall knowledge (self-perception) of computers and the internet;
3. Level of computer training received.

Peripherality Hypothesis and Developing Countries

Perhaps the most discussed and controversial issue in respect to the differences in science and knowledge production between developed and developing countries is the Hypothesis of Peripherality. This hypothesis holds that the use of the internet and CMTs gives an advantage to and increases the participation of peripheral researchers and scientists, who are "those less senior, less eminent, or not located in major institutions" (Walsh & Roselle, 1999, p. 61). The advantage for these scientists consists of their participation in using informal communication channels, their participation in collaborative activities, their access to resources and information, and their participation in decision-making processes (Vasileiadou, 2009b). The hypothesis suggests that, since computer-mediated communication (CMC) provides fewer cues about one's social status, communication through CMC would have an equalizing effect on hierarchy structures (Hinds & Kiesler, 1995; Sproul & Kiesler, 1986, 1991). (Note that CMC implies the use of CMTs.) The concept of Reduced Social Cues and its analytical contribution is based on two fundamental principles that generally characterize CMC: (a) a lack of information about the social context in which communication takes place (Hinds & Kiesler, 1995; Tanis & Postmes,

2003; Walther, 1992), and (b) a lack of commonly accepted standards to guide the development of communication itself (Spears & Lee, 1994).

In general, scientists in developing countries do not have many opportunities to engage in informal collegial communication. Nor do they have as many information resources as scientists have in research universities in the United States and western Europe. Thus, scientists from developing countries have been isolated in both informational and interpersonal dimensions (Davidson et al., 2002). Journals, books, newsletters, preprints, and manuscripts of unpublished work are essential sources for active researchers to gain timely information (Luo, 2008). It has been observed that the opportunities for scientists in developing countries to access these kinds of timely scientific information sources are seriously limited. They usually work in smaller research communities, and these tend to be dispersed over wide areas. Thus, because they are geographically separated, infrastructure problems of transportation and communication hinder scientists in developing regions from engaging in regular collegial communication (Luo, 2008).

Empirical evidence supporting the Peripherality Hypothesis is contradictory. One good example supporting the study of this relationship is found in the work of Walsh and Bayma (1996), in which 67 scientists in four different fields were interviewed in order to explore the equalization effect of this Hypothesis within the "virtual college." The findings confirmed that CMC provides more opportunities for interaction with colleagues and access to resources to younger scientists and to those not located at prominent institutions, but then went on to suggest that, instead of a transformation of the organizational structure of science, the situation necessitated expanding the set of active scientists working in a field: "While there is some reorganization of the social structure due to CMC use, this reorganization seems to be largely

limited to changing (expanding) who can participate, with only minor changes in the content of participation in the research group" (Walsh & Bayma, 1996, p. 350).

Even though the Peripherality Hypothesis has been empirically contested, especially in recent studies (Barjak, 2004; Koku et al., 2001), there is still much discussion about whether the use of CMTs and the internet can lead to an expansion in the number of active scientists.

The Importance of Collaboration for Developing Countries

Developing countries tend to realize a larger return on investment in science when portions of their research funding support collaboration with scientists in more advanced countries (Nentwich, 2005). Nentwich (2005) speculated that these collaborations can provide advice, key lab materials, equipment, student and staff training, and research project funding to help increase the return on investment. Moreover, universities and research institutions can also benefit from funded collaborative research (Maglaughlin & Sonnenwald, 2005).

In the United States and western Europe, scientists have identified scientific collaboration as an important facet of the changing nature of science over the last century (Duque, 2007; Walsh et al., 2000). These studies indicated that scientific output and knowledge production is "increasingly collaborative rather than competitive" (Sooryamoorthy & Shrum, 2007, p. 746) because of the ability to enhance collaboration and facilitate scientists' decisions regarding task accomplishment through sharing information, ideas, and access to expertise (Bordons & Gomez, 2000; Duque et al., 2005; Katz & Martin, 1997). Therefore, collaboration, such as that which may occur between developing and developed countries, has the capacity for advancing science in two ways: by increasing the number of participants and by increasing the diversity of approaches. One way to broaden participation is to facilitate the involvement of scientists working in developing countries. Scholars have assumed that the use of new communication technology, particularly CMTs and the internet, for collaboration possesses the potential to allow

researchers from developing areas to pool resources with scientists in the same field in more developed countries (Duque et al. 2005; Finholt, 2002; Rogers, 1995; Ynalvez et al., 2005). But the reality faced by scientists in developing countries is that they do not have as many resources as scientists in research universities in the United States and Western Europe (Luo, 2008). Therefore, scientists from developing countries have been seen as isolated on both informational and interpersonal dimensions (Davidson et al., 2002; Shrum, 2005). It has also been observed that the opportunities for scientists from developing countries to access timely scientific information are seriously limited. According to Luo (2008), journals, books, preprints, and manuscripts of unpublished work are essential sources for active scientists seeking timely information, but "[a]cquisition costs, as well as inadequate libraries and documentation centers, prevent most scientists in developing countries from accessing these resources" (p. 43).

The United Nation also emphasizes the critical role of ICTs in supporting the collaborative process. For example, ICTs are considered by many different conferences in the UN as bridges between developed and developing countries (DOT Force, 2002), and as an opportunity for countries to free themselves from the tyranny of geography (USESCWA, 2008). Similarly, the *Arab Knowledge Report* (2009) maintained that ICTs represent the key means to disseminate and circulate knowledge, in addition to their role in developing, supporting, facilitating, and accelerating scientific research of the widest possible scope.

Arab countries have made remarkable progress in most of the pivotal aspects of increasing access to the internet and CMTs, particularly in infrastructure, in which investment is ongoing. In 2008, these countries recorded levels of development in technological performance which exceeded those observed in all other regions of the world. Five Arab countries have been listed among the top fifty nations that are most ready to utilize information communication

technologies, all of which are Gulf Cooperation Council countries: Oman, the UAE, Qatar, Bahrain, and Kuwait, occupying the twenty-eighth, thirty-seventh, thirty-ninth, and fiftieth ranks, respectively (World Economic Forum, 2008b).

Also in 2008, the United Nations Economic and Social Commission for Western Asia (UNESCWA) studied the Arab knowledge landscape and discovered that the digital gap remains large. Investigation of Arabic digital content, which is indicative of the utilization and production of knowledge in Arabic, demonstrates that the Arab countries and their societies fall short according to most criteria (UNESCWA, 2008). The *Knowledge Arab Report* (2009) recommended that Arab countries take serious steps on various levels in the domain of technology policy and legislation. The Report noted that, as long as many issues related to Arabic language usage on the internet are not settled, the state of Arabic knowledge content will remain at an extremely low threshold level, and instead will continue to draw upon random sources for content, while seeking comfort from past tradition, both good and bad (*Arab Knowledge Report*, 2009).

The inequality evident today in the utilization of new technologies in Arab countries and in the use and production of Arabic digital content also affects sections of society within each country. According to the *Knowledge Report*, no Arab countries will be able to emerge from their current technological developmental stage, nor will they be able to contribute to the development of Arabic digital content, unless they open themselves up to those parties that, to whatever extent possible, are active and relevant. Similarly, Arab countries must orient themselves to the adaptation and reformulation of the production of technological knowledge, thus enabling more enlightened and creative utilization of the available tools of technology.

There is a major role for the government and private sectors and for the organizations of civil society in reaching this goal (*Arab Knowledge Report*, 2009).

Diffusion of Innovation

Diffusion of Innovation Theory has been widely applied in studies of the adoption of new technologies, focusing on the communication patterns supporting diffusion of an innovation through a social network. Rogers (2003) defined innovation as "an idea, a practice, or object that is perceived as new by an individual or another unit of adoption" (p. 36). This formulation of the diffusion of innovation model is examined in this research framework. Orlikowski and Iacono (2001) posited that in the case of technology innovation, researchers study diffusion of innovation in order to know how many people, organizations, or nations have adopted the technology, as well as the depth of the penetration or diffusion of the technology. This is an important assessment for the current study, which includes an attempt to understand how CMTs circulate among scientists in academia and research centers in Kuwait.

The Diffusion of Innovation Theory is often used to explain the adoption of new technologies such as the iPhone, Facebook, and wikis (Ellison et al., 2007; Hester & Scott, 2008). Rogers (1995) defined diffusion as "the process by which an innovation is communicated through certain channels over time among the members of a social system" (p. 10). He outlined five stages in the innovation decision process of an individual or an organization: knowledge, persuasion, decision, implementation, and confirmation. Individuals or other decision-making units first become aware of the existence of an innovation during the knowledge stage; persuasion occurs when they form a "general perception" of the innovation (Rogers, 1995, p. 168). This general perception is the basis for the decision to adopt or reject the technology.

Rogers (1995) broke down "general perception" into five perceived characteristics of innovations to explain why they are adopted at different rates: relative advantage, compatibility, complexity, trialability, and observability. In other words, the rate of adoption is affected by the degree to which an innovation is: (a) perceived as being better than the status quo or alternative innovation (relative advantage), (b) compatible with the values, needs and past experiences of potential adopters (compatibility), (c) perceived as difficult to understand and use (complexity), (d) available to be tried out before a decision must be made (trialability), and (e) able to be observed while being successfully used by other people (observability).

The perceptions of individual potential adopters play a pivotal role in the adoption process; however, it is impossible and unrealistic to expect that all potential adopters will adopt the innovation within the same time frame. Individual differences in innovation explain individual variations in the rate of adoption of an innovation. Based upon the point in the process when an individual adopts an innovation, he or she is placed into one of five adopter categories: (a) innovator, a risk-taker who is among the first to adopt an innovation, (b) early adopter, an opinion leader who disseminates advice and information about an innovation and who is respected by other potential adopters, (c) early majority, one of the group of people who adopts an innovation relatively early, but only after some deliberation, (d) late majority, a person who is somewhat skeptical of an innovation and waits to adopt a new technology until most of the uncertainty surrounding the innovation is removed, and (e) laggard, a traditionalist who tends to be suspicious of new innovations, often adopting it only after it has been superseded by a later innovation.

According to Diffusion Theory, in addition to adoption by individuals, a successful innovation has a relatively slow initial period of growth, followed by rapid increase in the rate of

its adoption before its diffusion. Thus, a critical mass must be reached before the rate of adoption of a particular innovation is self-sustaining (Rogers, 1995). This theory was used in this study to determine the role of scientists' perceptions of an innovation through their use of the internet and CMTs, that is, how scientists adopt computer-mediated technologies for their collaboration and communication activities with other scientists, both locally and globally.

Chapter IV: Methodology

This research used an online survey created for this study, referred to as The Kuwait Scientists' Survey (KSS), to collect quantitative data from scientists in Kuwait. Conducting the KSS in English is appropriate because English-language proficiency is necessary for publication in international journals and presentation at international conferences. It is also because Kuwaiti scientists are encouraged to publish in high impact journals, many of which are published in English. In addition, the internet and digital media are primarily an English text phenomenon.

The KSS includes measures of demographics, scientific and academic activities, collaborative behavior, access to various types of communication technologies, and use of CMTs. Participants in this study represented a variety of research fields in two organizational settings: government research institutes (research sector) and state universities (academic sector).

In contrast with studies of research productivity that use bibliometric techniques, this investigation replicated the studies conducted in Africa, South America, and India, by Professors Shrum and Ynalvez of Louisiana State University. Therefore, the research relied on self-reported publication productivity by Kuwaiti scientists obtained through an online survey. Using self-reported productivity for collaboration has many advantages, particularly in that it relies on scientists' own definitions of significant collaboration, rather than on an externally-imposed concept. The quantitative survey questionnaire used in the Kuwait sites is based on a template that has been used in India, Kenya, and Ghana in 2000-2002 (Ynalvez et al., 2005) and in the Philippines in 2005 (Ynalvez, 2006). The questionnaire was designed to elicit information about the background of the scientists and faculty members, their use of CMT channels, their experience with information exchange, their evaluation of CMT facilities, and their contacts and journal article publication via CMT channels.

While many studies conducted in the developed world use bibliometrics to study this phenomenon, a bibliometric approach is not suited for studying this issue in the developing world. Bibliometrics tend to measure both productivity and collaboration by co-authorship. In addition, bibliometric analysis is based on databases that often do not include the journals of developing countries. Many scholars, such as Gaillard (1992) and Shrum and Shenhav (1997), found that these measures are inadequate as indicators of scientific and research productivity outside the developed world.

Data Gathering

Population and Sample

Scientists in Kuwait conduct scientific research in universities and governmental institutes. Since this study concentrated on a select number of university colleges and one institute for scientific research, it was appropriate to contact all scientists in each unit. Also, because the study included the natural sciences departments in Kuwait, it was important that the data-gathering process involved as many faculty members and scientists as possible. Thus, each scientist and faculty member registered in the five institutions (the College of Science, and the College of Engineering, the College of Medicine from Kuwait University, and the Public Authority for Applied Education & Training, and the Kuwait Institute of Science and Research) was contacted by the investigator and invited to participate.

Access

Access to the Kuwait University and the government research institute KISR was not an obstacle; the researcher has educational and personal ties with individuals in the study locations, ,having earned bachelor's degrees from Kuwait University, as well as having worked there as an assistant teacher. Access to the scientists of KISR was made possible through direct contact. Prior to contacting the scientists and faculty members, the investigator acquired authorization

from department chairs and institute directors. Once permission was granted, department chairs and directors were asked to email to the researcher the list of scientists and researchers in each unit, including their phone numbers and email addresses.

Invitations were sent to all scientists and researchers in both units. A link was sent to the participants because the survey was posted online, where it was available for three weeks. At the end of the second week, the researcher sent a follow up email to thank those who participated and to encourage the other scientists to participate.

The College of Science, the College of Medicine, and the College of Engineering and Petroleum were chosen from Kuwait University (Table 4.1). Only the College of Technological Studies was chosen to represent the academic sector of PAAET, and all KISR departments were chosen to represent a research institution. In the end, 429 scientists and researchers participated in the study. All of the 429 participants were classified into one of seven scientific fields (Table 4.2).

Table 4.1: Location and Number of Scientists

Institution	**Location**	**Scientists & Researchers**
College of Science (KU)	Al-Khaldiyah City	81
College of Engineering	Al-Khaldiyah City	114
College of Medicine	Al-Jabriyah City	76
KISR	Al-Shuwaikh City	120
College of Technological Studies (PAAET)	Al-Shuwaikh City	38
Total		**429 Scientists& Researchers**

Table 4.2: Scientific Fields Represented

Engineering and Computers	Chemistry Engineering and Petroleum
Biomedical, Medical and Health Studies	Math, Statistical and Physics
Agriculture, Geology and Marine Studies	Natural Sciences
Biology and Ecology and Environment	

Variables

This study has three variables: CMT use, scientific collaboration, and research productivity. Initially, this research studied CMT use as an independent variable and scientific collaboration as a dependent variable. In the second part, this research studied scientific collaboration as an independent variable and research productivity as a dependent variable. Further explanation about how these variables were measured is discussed below.

In the beginning, the survey of Kuwait scientists defined two important terms. The first one is CMT systems. In the professional activities section, the participants were asked about how they used communication technologies, and the role those technologies played in the research systems in their institutions. In this part of the questionnaire, it was important to understand how these technologies helped Kuwaiti scientists in their research, and how researchers and faculty members adopted and used these new technologies in their scientific collaboration. The survey also asked the participants to disclose their opinions about the role and impact of CMT use in the scientific community in Kuwait. The scientists were also asked about the types of communication technologies they use in their research, and its relation to the work environment.

In the second part of the survey covering professional activities, the participants were asked about their computer and internet utilization. For example, participants were asked, when

they started to use computers and the internet, how often they use computers, and for how many hours they use CMTs.

These questions were intended to create an understanding of the big picture of the scientific community in Kuwait, and how CMTs are utilized in research systems there. This information about CMT use in the scientific process in Kuwait was useful for making comparisons between Kuwaiti scientists and other scientists in the developing and developed countries identified in Chapter 2.

Operationalization

Measuring Computer Mediated Technologies' Uses and Channels

This section explains how computer-mediated technologies were measured in two different ways. For the first measurement, CMTs were seen as one medium or one technology. This perspective was measured using four aspects of CMT use: current use, ready access, intensity of use, and extent of use. This method is an extension of Ynalvez's (2006) operationalization of internet use (i.e., current use, ready access, and intensity of use), which was employed in a study of the internet in developing countries (Ynalvez et al., 2005). On the other hand, *extent of use* is the indicator which is prerequisite to developing and stabilizing proficiency skills and strengthening feelings about confidence in the use of the internet and CMTs. Confidence and proficiency with hardware and software occurs over the long term, and may be a concept best captured by measuring experience in number of years. Reviewing Ynalvez's (2006) measurement approach and incorporating another indicator, the first aspect in the series, *current use*, refers to the degree to which scientists define themselves as users of information and communication technology (Ynalvez et al., 2005). In this study, current use was measured by asking the participants if they had computers at home and work. The second aspect, *ready access*, is largely contextual and pertains to the degree to which particular CMTs are present,

available, and accessible for use within the immediate environment (Ynalvez et al., 2005). In this survey, ready access was measured by asking the scientists in which year they first used CMTs. The third aspect, *intensity of use*, pertains to the temporal intensity and frequency of hardware-software-user interaction within a typical day. In this survey, intensity of use was measured by how many hours the participants spent send/receiving CMT messages. The fourth aspect, *extent of use*, pertains to the temporal extent of hardware-software-user interaction over extended periods of time, which constitutes prolonged routine exposure. According to Ynalvez (2006), there is a difference between a first-time user and one who has interacted with a communication technology for years, who through repeated and continuous exposure has incorporated a technological practice into a pattern of his daily life (Ynalvez, 2006). In this survey, extent of use was measured by asking the participants whether they characterized themselves as advanced or basic users.

The second measurement approach looked at CMTs as group of technologies. It was measured by divided the channels of CMTs into five systems or tools: (CMC, Web 2.0, social networking, Smartphone and videoconferencing). Each of these technologies presents a new way of communication that has its own characteristics (Table 4.3).

Table 4.3: CMT Use and CMTs Channels

Computer Mediated Technologies Uses	Measured by 5 indicators	1- Current use: 2- Ready access: 3- Extend of use: 4- Intensity of use:
CMTs Channels	Five technologies	1-CMC 2-Web2.0 3-Social networking 4-Smartphone 5-Video-conferencing

Measuring Scientific Collaboration

In this survey, collaboration was measured by two methods (Table 4.4). For the first, the collaboration process was measured by using seven indicators: does the respondent collaborate (1 = yes, 0 = no), respondent has collaborators in his/her institution (1 = yes, 0 = no), respondent has collaborators in Kuwait but in different locations (1 = yes, 0 = no), respondent has collaborators in the Arab world (1 = yes, 0 = no), respondent has collaborators in Western Europe (1 = yes, 0 = no), respondent has collaborators in the U.S. and Canada (1 = yes, 0 = no), and respondent has collaborators in other countries (1 = yes, 0 = no).

Table 4.4: Scientific Collaboration

Scientific Collaboration - to measure collaboration, uses two ways: 1-Seven indicators 2-Last three projects	Measured by 7 indicators	1- Does Respondent collaborate? 2- Respondent has collaborators in his/her institution. 3- Respondent has collaborators in Kuwait. 4- Respondent has collaborators in Arab world. 5- Respondent has collaborators in Europe. 6- Respondent has collaborators in the U.S. 7- Respondent has collaborators in other countries
	Last Three Projects (Degree of collaboration)	1- Is this collaboration? If yes, where is located? 2- Is this collaboration? If yes, where is located? 3- Is this collaboration? If yes, where is located?

In the second method, the collaboration process was measured according to the extent to which the interviewee's research projects were collaborative. In an open-ended question, each scientist was asked to briefly describe up to three specific projects. Each item was dichotomously coded in order to indicate whether the project involved collaboration.

Measuring Research Productivity

Previous studies that measured productivity followed the methodologies of Walsh et al. (2000) and Duque et al. (2005), both of which used a self-reported number of publications in scholarly journals, with the former using a two-year period and the latter a five-year period, which addressed the exposure dimension of productivity.

The research productivity measures employed by Duque et al. (2005) and Ynalvez (2006) are similar to the normal-count short-term measures (i.e., number of articles published in national scholarly journals), from outputs in foreign or international scholarly journals (i.e., number of articles published in international scholarly journals). On the other hand, Barjak (2004) referred to another form of conceptual splits in research productivity, representing different stages of the research process. Interestingly, Barjak (2004) employed the terms "formal" and "informal" to describe forms of output, where formal output implies articles in peer-reviewed scholarly journals, while informal output refers to briefing notes, working papers, and papers presented at scientific meetings. The conceptual divide between domestic versus foreign output and formal versus informal output captures the conflict that scientists in developing areas experience as a result of the tension between the abstract and alien thematic interests in international science, versus the local demands for a more meaningful knowledge base that is oriented toward solving immediate problems. In this study, productivity included other measures that have to do mainly with scientists in government research institutes, such as the number of reports written, and other similar forms of written output (Ynalvez, 2006).

The KSS gathered information relating to seven productivity indicators through a series of questions pertaining to the number of papers written from 2008-2011, and papers presented at national workshops and international conferences, published and unpublished reports, grants, patents, articles in foreign and in national journals, and a number of published book chapters.

The object of these derivations is to accumulate aggregated measures of total productivity in scholarly journals (Xie & Shauman, 1998; Walsh et al., 2000) and at professional meetings (Barjak, 2004), which are comparable with previous studies. However, these indicators simply assume equal weights between domestic and foreign output, because it is impossible to ascertain

which outlet or sphere would carry heavier weight and priority for respondent scientists (Ynalvez, 2006). The research productivity section included two questions to ascertain participants' attitudes about CMT uses and the impact on their research productivity (Table 4.5).

Control variables in this analysis include: Field, coded as seven dummy (0, 1) variables – medical, biomedical, engineering, science, math and statistics, marine and desert studies, and chemical and petroleum; Gender (1 = male; 0 = female); Age, measured as an ordinal or continuous variable depending on the analysis used; Educational Credentials (1 = Hold a PhD, 2 = Master's degree, 3 = BS/BA, 4 = Diploma, 5 = Other); Location of education (0 = received in developing countries, in the Arab World and others, 1 = in developed countries, such as the US and Western Europe). Nationality (1 = Kuwaiti; 0 = Non-Kuwaiti). Since Kuwaiti scientists and researchers are encouraged to publish in international journals, many of which are published in English, and since the internet is primarily an English text phenomenon, the study controls for the language variable.

Table 4.5: Research Productivity

Research Productivity	Measured by using 7 indicators	1- Number of publications in domestic journals. 2- Number of publication in foreign journals. 3- Papers presented at national workshops. 4- Papers presented at international conferences. 5- Published and unpublished reports. 6- Published book chapters. 7- Scientific and academic awards.

The study asked participants to report to what extent they feel comfortable communicating in English (using a Likert scale, with 1 = very comfortable, and 5 = not comfortable).

Finally, at the end of this survey, the participants encountered questions that asked them about their opinions about the impact of communication technologies on science and scientific collaboration in Kuwait, and how this relationship improves the research system in general.

Instrument Development

The data collection instrument addressed the objectives of the study. Before this instrument was applied, it was examined for content and face validity by three faculty members from the University of Tennessee's College of Communication and Information, and also by four Ph.D. students. The instrument was examined in Kuwait by three faculty members from Kuwait University, and by four scientists from KISR. The following chapter of this study reveals how scientific activities and productivity and collaboration are associated in order to establish how Kuwaiti scientists understand and use CMTs in their collaboration and communication with other scientists locally and internationally.

Chapter V: Findings and Results

The goals behind this exploratory study are to describe the scientific community (researchers, engineers, faculty members and scientists) in Kuwait, and to study the role of computer-mediated technologies (CMTs) in scientific collaboration and research productivity in Kuwait. This chapter presents the results of the analysis of the survey data, which were collected to address the research questions and to test the hypotheses described above.

Demographic Characteristics of the Scientific Community

This study employed a series of survey questions designed to describe Kuwaiti scientists who have adopted computer-mediated technologies (CMTs) and the internet. Their access and utilization of the internet and CMTs are examined.

Acquiring computer skills is an essential step in order to comprehend internet technology, digital media, and social networking; this skill is prerequisite for using these technologies. This survey measured computer and CMT usage by the scientific community of Kuwait, including when and how they began to use computer-mediated technologies in their research work and for scientific collaboration.

Table 5.1 shows the demographic profile of the Kuwaiti scientists who participated in the study (n = 106), each of whom worked at one of the two state universities (Kuwaiti University, referred to here as KU, or the Public Authority for Applied Education and Training, indicated by the acronym PAAET), or at a government research institute (Kuwait Institute for Science Research, referred to here as KISR). These three locations collectively constitute the country's premier research training centers and scientific production sites for all sciences.

Among all Kuwaiti scientists participating in the survey, 78.6% obtained their Ph.D. from an institution of higher learning in a developed country, while 21.4% obtained their Ph.D. from a

developing country. The majority (64.3%) of Kuwaiti scientists who received advance graduate education in a scientific core discipline had obtained the degree from the U.S. or Canada. In this study, some participants did not answer the demographic questions. For example, the combined frequency level for many of these categories is in the 80-90 range; however there were sufficient answers in each demographic group to make analysis by demographics meaningful.

Table 5.1 Demographics of Sample

		Frequency	%
Gender	Male	71	85.5
	Female	12	14.5
		Frequency	%
Sector	Academic	63	77.8
	Research	18	22.2
		Frequency	%
PhD	PhD	55	64.7
	Non PhD	30	35.3
		Avg.	
Age	Male	41.4	
	Female	47.4	
		Frequency	%
PhD Origin	Developed Country	66	78.6
	Developing Country	18	21.4
		Frequency	%
Nationality	Kuwaiti	60	70.6
	Non-Kuwaiti	25	29.4
		Frequency	%
Field	Engineering and Computers	39	48.1
	Oil Engineering and Petroleum	6	7.4
	Medical, Health Studies and Biomedical	16	19.8
	Math, Statistical and Physics	1	1.2
	Agriculture, Geology & Marine Studies	7	8.6
	Natural Science and Geography	5	6.2
	Biology, Ecology and Environment	7	8.6

Table 5.1 also indicates that the scientists' mean age is 44 years; a vast majority of them (85.5%) are male. Furthermore, most of these scientists (64.7%) have doctoral degrees, and the majority of these faculty members and researchers were originally from Kuwait (70.6%).

In terms of their field of study, most scientists (48.1%) were from the engineering and computer science field, while 19.8% come from medical, health, or biomedical fields. In this sample, the combined fields of biology, ecology and environmental science, and the additional combined field of agriculture, geology and marine studies, are each represented by 8.6% of participants. Oil engineering and petroleum is the disciplinary home of 7.4% of the respondents, while the natural science and geography category comprised only 6.2%. Very few participating scientists identified themselves as working in the field of mathematics, statistics, or physics (1.2%).

In terms of location, 70.2% of the sample answered that they work at Kuwait University. This finding is consistent with expectations, given that Kuwait University is the country's premier and largest scientific community.

Computer Access and Use

From the descriptive statistics presented in Table 5.2, all participants reported having personal computers (PCs) at work, and having ready access to them. Virtually all participants (96%) reported that these computers are connected to the internet. Most had acquired access to a PC for the first time in the beginning of 1998. On average, scientists with Ph.D. degrees acquired computers at home earlier (1992) than scientists who do not have a Ph.D. (1998). Faculty members at KU spend more hours (μ=3.24 hours per week) using a computer than researchers from KISR (μ=2.94 hours per week).

Table 5.2: Computer Use - Scientists and by Sector

Computer Use				Sector						By Degree			
				Academic			Research			PhD		Non PhD	
	N	Mean	SD	N	Mean	SD	N	Mean	SD	Mean	SD	Mean	SD
Computer at Home	106	1.01	0.10	63	1.00	0.00	18	1.06	0.24	1.00	0.00	1.03	0.18
Year First Acquired	105	1994	6.21	63	1992	5.18	18	1996	6.17	1992	5.76	1998	5.49
Number of People Using Computer at Home	103	2.33	1.60	63	2.40	1.66	17	2.06	1.56	2.55	1.79	1.83	1.07
Connected to Internet	101	1.07	0.26	62	1.05	0.22	16	1.06	0.25	1.04	0.19	1.07	0.27
Computer at Work	105	1.00	0.00	63	1.00	0.00	18	1.00	0.00	1.00	0.00	1.00	0.00
Year Computer was first Available at Work	99	1998	6.18	62	1997	6.43	18	2000	3.90	1997	6.06	2000	4.75
Location of Computer	101	1.31	0.61	62	1.21	0.55	18	1.50	0.51	1.17	0.50	1.50	0.63
Number of People Using Computer at Work	101	1.55	1.37	62	1.44	1.30	18	1.39	0.61	1.39	1.23	1.60	1.30
Work Computer Connected to Internet	101	1.04	0.20	62	1.06	0.25	18	1.00	0.00	1.06	0.23	1.03	0.18
Number of Hours on Computer per week	101	3.24	1.30	63	3.27	1.45	18	2.94	0.80	3.13	1.36	3.33	1.32
Computer Use for Fun	105	2.07	0.97	63	2.05	0.94	18	2.28	1.07	2.18	1.00	1.97	0.93
Comfort Using Computers	101	2.53	1.16	63	2.27	1.05	18	3.44	1.25	2.36	1.13	2.90	1.27

In general, these scientists enjoy exclusive access to a conveniently-located PC. For academic and research sector settings, the average number of people who must share a computer in a work area is less than 1.5 people per computer. Among the full sample, a majority (77.2%) of PCs are located in personal offices this is consistent with what is reported about the research offices of the developed world. Almost all of the study's participants have enjoyed longstanding access to a computer at home as well. Over ninety-nine percent of these scientists report having a computer at their homes, with most of these having acquired their first home computer in 1994, on average. However, it is also important to have an understanding about the differences in the quality of the computer located in the home versus that in the workplace, but this information is not available from this online survey. In mild contrast to the response indicating that 100% of these scientists have access to a computer at work, somewhat fewer (96%) respondents reported having a connection to the internet at work, while 93.1% of participants have home PCs with an internet connection.

Data Analysis

Data gathered from the survey responses were analyzed using the statistical software application IBM SPSS Version 19. Group comparisons were analyzed using Chi-square tests of independence for categorical data, and t-tests for continuous data, in order to determine if any differences in responses by subgroups of respondents were statistically significant.

Use of the Internet and Computer-Mediated Technologies

Chi-square tests were utilized to analyze the relationships between the various CMTs channels (CMC, Web 2.0, social networking, smartphones and video-conferencing) and the sector.

Table 5.3: Chi Square Comparison of Mean CMCs Channels by Sector

	χ^2	df	Asymp. Sig. (2-sided)
CMC for Research	24.046	4	.000**
CMC for Non Research	16.254	3	.001**
Web2.0 for Research	5.066	4	.281
Web2.0 for Non Research	10.481	4	.033
Social Network for Research	6.477	4	.166
Social Network for Non Research	8.517	4	.074*
Smart Phone for Research	6.669	4	.154
Smart Phone for Non Research	19.01	4	.001**
Video Conferencing for Research	3.161	4	.531
Video Conferencing for Non Research	1.432	4	.839

*p < .05 **p < .01

There are some differences between the faculty members at KU and researchers in KISR in their use of CMT channels. The results indicate that there is a significant difference between the two sectors in terms of using CMC for research and for non-research activities. In addition, differences between the faculty and researchers in their use of Web2.0 for non-research activities and using Smartphones for non-research activities, were both statistically significant (see table 5.3). But because this comparison is to prove if there is association between the variable, this type of comparison cannot tell us which one of the two sectors was more advance in suing CMTs.

Hypotheses Findings

The results of the survey were applied in order to test the hypotheses proposed above, regarding the use of computer-mediated technologies by Kuwaiti scientists, and its impact on their research and collaborative processes. This section presents the results of this hypothesis testing.

Hypothesis 1: *Scientists who have use CMTs will be more connected than those who do not use CMTs in their communication and collaboration, both locally and internationally.*

This hypothesis was not testable, because all of the scientists who participated in the survey reported that they use CMTs for communication and collaboration, so there were no participants who qualified to be in the non-CMT-using group.

Hypothesis 2: *Faculty members and engineers at KU will have more networks internationally than researchers in KISR.*

There is partial support for this hypothesis. The three categories: collaborate with Europe and Australia, collaborate with the United States and Canada, and collaborate with other countries were grouped in the international networks. Collaborate in your department/institution, collaborate inside Kuwait and collaborate with Arab world were grouped in the local network. The faculty members at KU had more collaborative contact with their international networks than the KISR researchers did. The difference was found when the two sectors collaborate with U.S. and Canada.

X^2 (1, 77) = 8.344, p < .0

Table 5.4: Chi Square Comparison of International Network and Local Network by Sector

	χ^2	df	Asymp. Sig. (2-sided)
Collaboration in Department/Institution	1.851	1	.174
Collaboration inside Kuwait	0.02	1	.889
Collaboration in the Arab World	2.793	1	.095
Collaboration in Europe & Australia	0.669	1	0.413
Collaboration in US & Canada	8.344	1	.004**
Collaboration with Other Countries	0.006	1	0.937

**p < .01

Hypothesis 3: *Researchers in KISR will have more networks locally than faculty members of KU.*

This hypothesis was not supported. There was no significant difference found between researchers in KISR and faculty members at KU, in terms of their level of use of local networks for collaboration. The local networks as mentioned above included: within their Department/Institution, inside Kuwait, and with Arab world.

Hypothesis 4: *Kuwaiti scientists who studied in developed countries will be more advanced in using the internet and CMTs than scientists who studied in developing countries.*

Partial support was found for this hypothesis by comparing the location where the scientists completed their Ph.D. and the use CMT channels (CMC for research- CMC for non-research, Web 2.0 for research- Web 2.0 for non-research, Social networking for research- social networking for non-research, Smartphone for research- Smartphone for non-research, and Video-conferencing for research- Video-conferencing for non-research). There was a statistically significant difference reported in using CMC for research, specifically email, and where the scientists completed their Ph.D. Scientists who earned degrees from developed countries used CMC for research more than those with degrees from developing countries.

No other CMT channels, regardless of the purpose for which they were used, were involved in a statistically significant difference based on the category of the country in which the scientist earned the degree.

CMC $X^2(4, 84) = 14.110$, $p < .01$

Table 5.5: Chi-Square Comparison of Mean CMC Channels by Country Category where Degree was earned

	χ^2	df	Asymp.Sig. (2-sided)
CMC for Research	14.11	4	.007**
CMC for Non Research	5.81	3	.121
Web2.0 for Research	3.36	4	. 499
Web2.0 for Non Research	3.93	4	. 415
Social Network for Research	4.67	4	. 323
Social Network for Non Research	9.41	4	.052
Smart Phone for Research	3.56	4	.469
Smart Phone for Non Research	5.99	4	.200
Video Conferencing for Research	3.71	4	.446
Video Conferencing for Non Research	7.70	4	.103

**$p < .01$

Research Questions Findings

This section applies the findings of the study to address each of the research questions.

Research Q1: *To what degree has the scientific community in Kuwait adopted the CMTs?*

To give a meaningful answer to this question, it is necessary to summarize many of the results from the survey that mentioned this issue. For instance, when did the scientists start to use CMTs? How do they use CMT channels as a primary source for communication? How many hours do they spend sending/receiving CMTs messages, in a typical week? Did they use CMT channels such as CMC, Web 2.0, social networks, smartphones, or video-conferencing for research or non-research oriented activities?

The answers to these questions that have emerged from the survey indicate that the majority of the scientific community in Kuwait is well-connected to the internet, and has adopted CMT channels for their daily work, especially Web 2.0 technologies, and they have also adopted

the smartphone for non-research work. In terms of communication, 92.9 % of the scientists indicated that they use CMT channels as a primary tool for communication. They began to use CMTs prior to 1998. (1998 was the earliest option provided, because this question was asking about Facebook, blogs, Web2.0, Twitter and other social media; it was not about email or the internet or computers). Moreover, 81.1% of the scientists stated that CMT channels have helped them to become reachable and available.

In terms of how scientists use CMTs, 83.0% reported that they have conducted a search for information, 81.9% used an electronic journal 77.7% accessed research reports or scientific papers,(66% found and examined reference materials, 64.9 % collaborated on a scientific project, and 62.8% ordered a product or services for their research.

In terms of respondents' hours of use of CMTs, for sending/receiving messages in a typical week, 40.0 % reported using CMTs for between one to ten hours per week, while 35.8% indicated they use CMTs for between ten to twenty hours per week. Using the averages of each of the categories as point estimate, the range of the number of hours of CMT use in a typical week is approximately five to ten, or about one and half hours per a day, for the respondents in the study.

Figure 5.1: Hours scientists used in typical week.

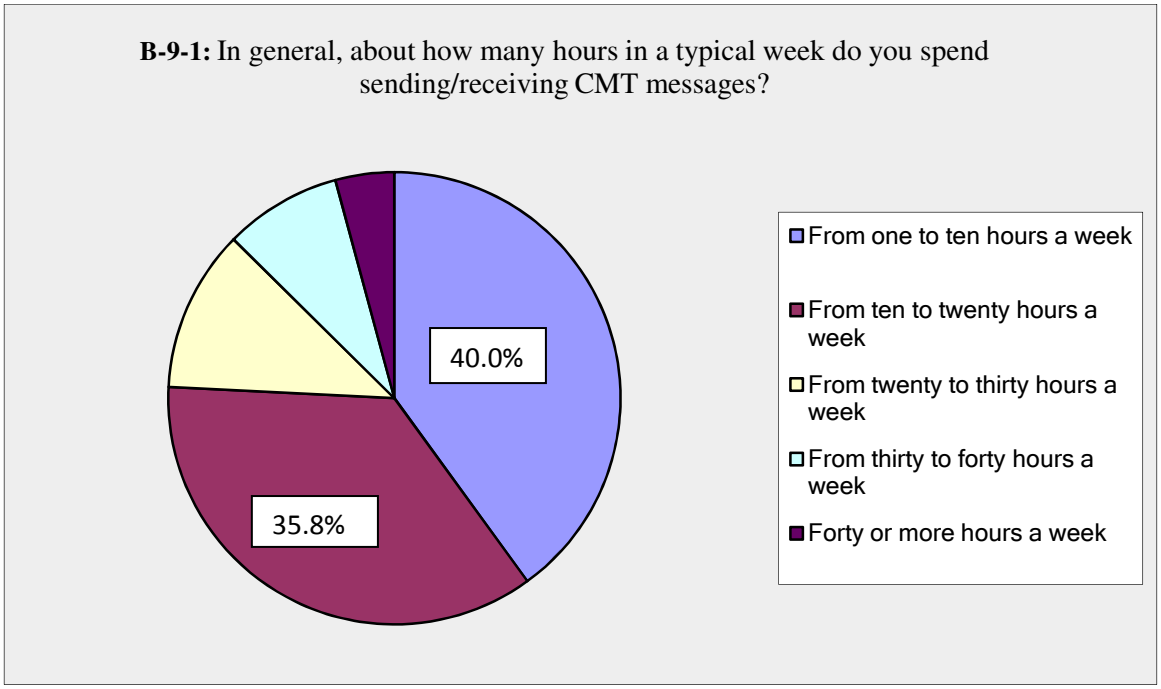


Table 5.6: CMT Channels Use by Frequency

	CMC Research	CMC Non Research	Web 2.0 Research	Web2.0 Non Research	Social Network Research	Social Network Non Research	Smart phone Research	Smart phone Non Research	Video Conf Research	Video Conf Non Research
Amount	%	%	%	%	%	%	%	%	%	%
More than Once a Day	62.6	63.3	19.0	24.6	20.3	50.7	29.2	84.7	7.7	15.1
Once a Day	14.1	21.4	6.9	14.0	8.7	23.2	15.3	2.8	7.7	17.0
Weekly	19.2	10.2	25.9	26.3	14.0	11.6	12.5	4.2	7.7	28.3
Monthly	3.0	5.1	29.3	29.3	20.3	10.1	16.7	6.9	34.6	24.5
Never	1.0	0	19.0	12.3	36.2	4.3	26.4	1.4	42.3	15.1

Research Q2: *Are there any differences in using CMTs between faculty members (at KU) and researchers (in KISR) for scientific collaboration?*

To answer RQ 2, a Chi-square analysis was run to compare the two sectors and scientific collaboration (Table 5.8). Participants were asked about their collaboration activities in the last four years, both for local collaboration (defined as collaboration within their department/institution, in Kuwait, and in the Arab world) and for international collaboration (categorized into three regions: in Europe and Australia, in the U.S. and Canada, and in other countries). The responses from faculty members at KU were significantly different from those of researchers with KISR, in their use of CMTs for scientific collaboration. There is a statistically significant difference between these two sectors, in how they reported collaborating with others located in the United States and Canada. Scientists and faculty members of KU were more likely to collaborate with this region of the world (U.S. and Canada). This was especially evident regarding collaboration in international conferences and publication in foreign journals which will be discussed in greater detail in the discussion chapter.

X^2 (1, 77) = 8.344, p < .01

Table 5.7: Chi Square Comparison of Collaboration by Sector

	χ^2	df	Asymp. Sig. (2-sided)
Collaboration in Department/Institution	1.851	1	.174
Collaboration inside Kuwait	0.02	1	.889
Collaboration in the Arab World	2.793	1	.095
Collaboration in Europe & Australia	0.669	1	0.413
Collaboration in US & Canada	8.344	1	.004**
Collaboration with Other Countries	0.006	1	0.937

**p < .01

However, in general, there are some differences between the faculty members at KU and researchers in KISR in their use of CMT channels. The results indicate that there is a significant difference between the two sectors in terms of using CMC for research and for non-research activities. In addition, there was a difference between the faculty members at KU and researchers at KISR in their use of Web2.0 for non-research activities and using Smartphones for non-research activities, were both statistically significant (see table 5.9).

Collaboration is generally related to publication productivity. There is evidence in the Kuwait data that academics benefit from increased international collaboration in terms of the number of their publications. University scientists are engaged in more international collaboration than their counterparts in research institutes.

Table 5.8: Chi Square Comparison of Mean CMCs Channels by Sector

	χ^2	df	Asymp. Sig. (2-sided)
CMC for Research	24.046	4	.000**
CMC for Non Research	16.254	3	.001**
Web2.0 for Research	5.066	4	.281
Web2.0 for Non Research	10.481	4	.033
Social Network for Research	6.477	4	.166
Social Network for Non Research	8.517	4	.074*
Smart Phone for Research	6.669	4	.154
Smart Phone for Non Research	19.01	4	.001**
Video Conferencing for Research	3.161	4	.531
Video Conferencing for Non Research	1.432	4	.839

*p < .05 **p < .01

This finding leads to the next research question, which is about the relationship between CMT use and scientific collaboration.

Research Q3: *To what extent is CMTs use associated with scientific collaboration in Kuwait?*

The study found that collaborating via CMTs was significant when scientists work with others located in Europe and Australia, and in the U.S. and Canada. The explanation may be indicated by the results in table 5.11 which contains reveal information, as self-reported by the participants, about research productivity in foreign journals and international conferences.

Table 5.9: T-Test Comparisons of Mean Collaboration by Sector

Collaboration	t	df	Sig. (2-tailed)	Mean Difference	Mean Yes	Mean No
Collaboration in Department	1.198	86	.234	4.09	15.29	11.20
Collaboration in Kuwait	.722	86	.472	1.37	15.37	14.00
Collaboration in Arab World	1.817	85	.073	3.21	17.42	14.21
Collaboration in Europe and Australia	4.228	85	.000**	6.75	19.73	12.98
Collaboration in US and Canada	2.087	82	.040*	3.43	16.30	12.87
Collaboration in Other Countries	1.008	86	.316	2.07	16.75	14.68

*p < .05 **p < .001

The results show that collaboration is positively related with developed countries (US & Canada and Europe &Australia). When scientists of Kuwait collaborate with these scientists who are from developed countries, using CMTs, the productivity is statistically significant than scientists from developing countries. However, the results indicate that the research products of Kuwaiti scientists are presented in international conferences and foreign journals when they collaborate with scientists from developed countries (see table 5.12).

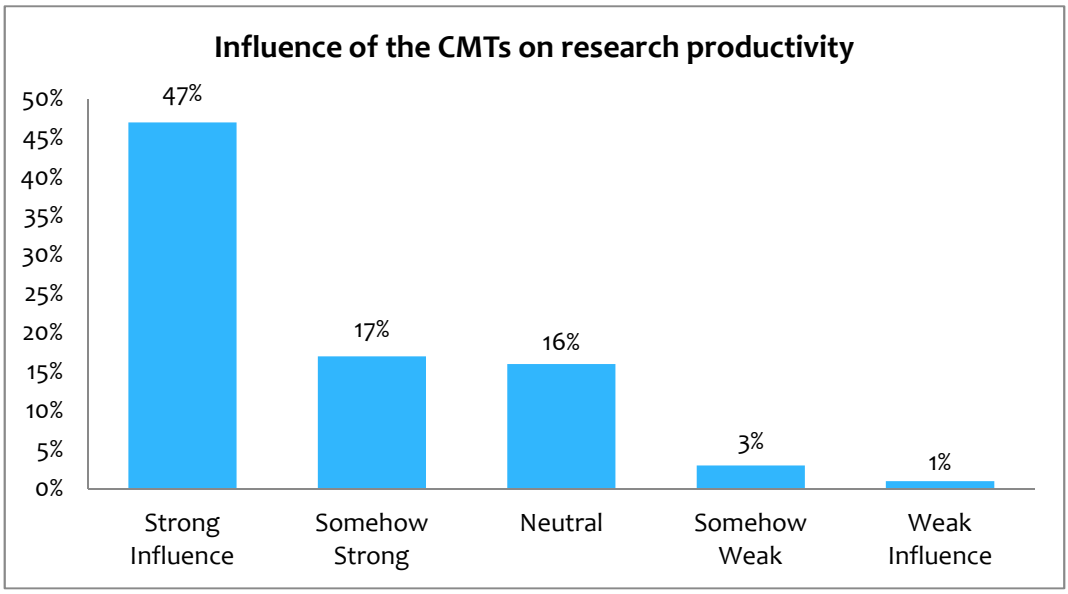
Table 5.10: Research Productivity Profile of Kuwaiti Scientists

Productivity	N	Mean	Median	Mode	SD	Skewness	Min	Max	Percentiles		
									25	50	75
Published Papers in Domestic Journal	75	1.9600	1.0000	1.00	1.36995	1.629	1.00	6.00	1.0000	1.0000	3.0000
Published Papers in Foreign Journal	80	3.4250	3.0000	1.00	1.91447	.046	1.00	6.00	1.0000	3.0000	5.0000
Paper presented at national workshops	76	2.3421	2.0000	1.00	1.48371	1.147	1.00	6.00	1.0000	2.0000	3.0000
Paper presented at International conferences	82	2.9512	3.0000	1.00	1.74202	.594	1.00	6.00	1.0000	3.0000	4.0000
Published and Unpublished reports	80	2.8500	3.0000	1.00	1.70702	.553	1.00	6.00	1.0000	3.0000	4.0000
Published book chapters	70	1.6143	1.0000	1.00	1.18313	2.367	1.00	6.00	1.0000	1.0000	2.0000
Scientific and Academic Awards	74	1.9324	1.5000	1.00	1.20877	1.472	1.00	6.00	1.0000	1.5000	3.0000

<u>Research Q4</u>: *To what extent is CMTs use associated with research productivity in Kuwait?*

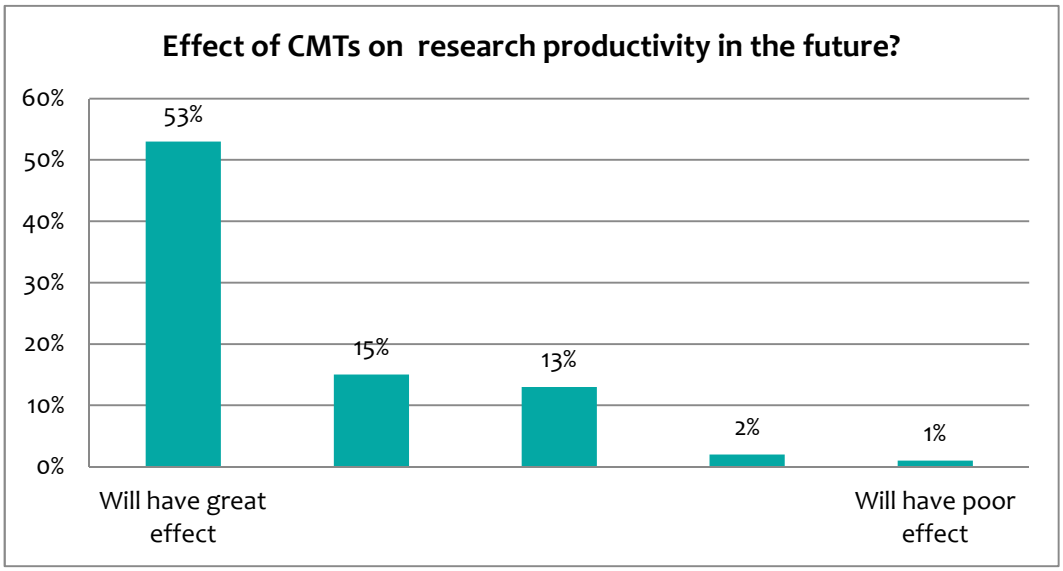
To answer RQ4, Kuwaiti scientists affirmed that CMT use has a strong influence on their research productivity. These results reflect the scientists' self-reported beliefs about the influence of CMTs.

Figure 5.2: Influence of CMTs on Research Productivity



Also, to confirm the respondents' answer about the importance of CMT use in their research productivity, I also asked Kuwaiti scientists about the future of CMT systems, and its relationship to research productivity. The answer revealed that the majority of Kuwaiti scientists believe that these technologies (CMTs) will have a profound effect on their publication and research productivity. Further, 53% of the scientists reported that CMTs will have a great effect on their productivity, and an additional 15% said that CMTs will have an effect on their productivity. Only 3% of the scientists in Kuwait believe that CMTs will have either poor or no effects on their future research productivity.

Figure 5.3: Effect of CMTs on Research Productivity



<u>Research Q5</u>: *What is the relationship between scientific collaboration and research productivity in Kuwait?*

To answer RQ 5 directly and also to support the answer of RQ 4, a correlation analysis was run to explore the relationship between productivity and scientific collaboration. The analysis revealed that there is a positively-correlated relationship between CMT use and research productivity ($r = 0.389$, $p < .001$). This suggests that as CMT use increases, research productivity also increases. Moreover, the positive correlation between scientific collaboration and research productivity was somewhat stronger ($r = 0.494$, $p < .001$). This finding suggests that as scientific collaboration increases, research productivity also increases (Table 5.11).

In addition, to comprehend the relationship between scientific collaboration, CMT use, and research productivity, and to distinguish which one of these variables has the most effect on the others, T-tests were performed to see if there is any significant effect between these three

variables. The T-test indicates that there is a strong correlation between the three variables. In general, collaboration was related to publication and research productivity.

It means that when collaboration increases, research productivity also increases. On the other hand, the relationship between CMTs use and research productivity is associated with each other. It means if CMTs use increases, research productivity also increases.

Table 5.11: Correlation between productivity, CMTs use and Collaboration

Correlations

		Productivity	Collaboration	CMT Use
Productivity	Pearson Correlation	1	.494**	.389**
	Sig. (2-tailed)		.000	.000
	N	88	86	88
Collaboration	Pearson Correlation	.494**	1	.311**
	Sig. (2-tailed)	.000		.003
	N	86	89	89
CMT Use	Pearson Correlation	.389**	.311**	1
	Sig. (2-tailed)	.000	.003	
	N	88	89	99

**. Correlation is significant at the 0.01 level (2-tailed).

Chapter VI: Discussion

This study explored the role of computer-mediated technologies (CMTs) in scientific collaboration in Kuwait. It established how Kuwaiti scientists use the internet and CMTs in their scientific collaboration, to interact with both local and international colleagues, and then sought the connection between this mediated collaboration and its impact on the level of research productivity. This study was focused on the scientific community in Kuwait, because of the significant nature of scientific development in the country. A key finding suggests that an influential factor in their productive CMT-enabled scientific collaboration is the source of the scientists' academic training, specifically holding a doctoral degree from an institution located in one of two scientifically and technologically strong composite regions: Europe and Australia, or the United States and Canada.

This research addressed the following five questions. First, to what degree has the scientific community in Kuwait adopted the CMTs? The second research question was: are there any differences in CMT usage between scientific faculty members at Kuwait University (KU) and scientific researchers in the Kuwait Institute for Scientific Research (KISR) for scientific collaboration? Third, the study addressed to what extent CMT use is associated with scientific collaboration in Kuwait. A fourth question asked to what extent CMT use is associated with research productivity in Kuwait. The fifth and final research question asked what the relationship is between scientific collaboration and research productivity in Kuwait. This chapter will discuss the implications of the findings related to each of these questions, in the context of scientific collaborations.

Degree of CMT Adoption by the Kuwait Scientific Community

The adoption of CMTs does not seem to be an obstacle to efficient and productive scientific collaborations by Kuwaiti scientists. The scientific community in Kuwait is very conversant with CMTs, and is currently using them in a variety of beneficial ways. Specific current uses of CMTs include searching for information (83.0%), using electronic journals (81.9%), accessing research reports or scientific papers (77.7%), finding and examining reference materials (66.0%), collaborating on scientific projects (64.9%), and ordering products related to his/her research (62.8%). The levels of usage for these activities suggest that scientists are engaging with CMTs to conduct their research, and that collaboration is already a CMT-enabled activity for the preponderance of Kuwaiti scientists. Later in this chapter a discussion is presented, about the nature of these collaborations and the apparent association with the scientists' level of productivity.

The results of this study can also tell us that the great majority of scientists (92%) are well connected to the internet, and have adopted the use of CMT channels into their daily work. Many have been doing so for a long time – typically for more than ten years. Therefore, it should be expected that CMTs are integrated sufficiently into these scientists' workflows that they are regarded as common communication tools, more like a telephone, rather than being perceived as a novel technology that requires additional time to be mastered.

This research shows that CMTs are an essential tool, as 92.9 % of these scientists used CMTs as their primary channel for communication. This suggests that the majority of Kuwaiti scientists have become reachable and available to potential colleagues in other locations, which would enhance their opportunities for collaboration. All of the scientists participating in this study reported that they have a computer at their place of work, whether they are situated in

academia or in a research setting. Also, the majority (72.2%) have a personal computer located in their own office.

Comparison of KU Faculty and KISR Researchers

In terms of the use of CMTs for scientific collaboration, there were some meaningful differences between faculty members at KU and the researchers at KISR. The level of use of CMTs for scientific collaboration by the faculty members at KU was significantly higher more than that of the KISR researchers, when the scientists and faculty members at KU were collaborating with their collaborators who were located in the United States/Canadian region.

The differences in collaboration levels, between participants in the academic and research settings, stem from both educational and circumstantial reasons. The educational-oriented reason is that the majority of KU faculty members graduated from institutions of higher learning in either the U.S. or Canada, so this fosters connections with faculty or colleague scientists from that region. The circumstantial reason arises from the fact that Kuwait University has existing agreements with prestigious universities and scientific centers located in the United States and Europe, to facilitate collaboration with their personnel. For example, Kuwait University agreements with Harvard University for research collaboration in economics and Kuwait University agreement with Massachusetts Institute of Technology- MIT for collaboration in sciences. Recently, October 2011, also Kuwait University revealed that it has signed a scientific collaboration agreement with drug major AstraZeneca's to conduct research on coronary arteries diseases in several Gulf Arab states.

Furthermore, there are some differences between the faculty members at KU and the researchers at KISR, in their respective levels of use of specific CMT channels. From the technological perspective, KU faculty members were more advanced in their use of CMC for both research and non-research related purposes, and also in their use of Web2.0 applications and

smartphones for non-research purposes, than the KISR researchers were. Today, CMTs and other new communications technologies have a huge influence in facilitating international collaboration. So, the knowledge and greater experience of KU faculty members in their more varied use of CMTs may help them to engage in more i networking or collaborative relationships with the international scientific community. Moreover, knowledge about using a wider variety of CMTs may guide the KU faculty members to collaborate with an international network (whether that of the U.S. and Canada, or Europe and Australia, or with other countries) more confidently and fluently than the KISR' researchers, on the whole.

CMT Use and Scientific Collaboration in Kuwait

This study established a positive correlative relationship between CMT use and scientific collaboration by Kuwait scientists (see Table 5.11). This finding suggests that if CMT use increases, scientific collaboration may also increase. While we know from the first question that the majority of these Kuwaiti scientists already use CMTs to some extent, the key is to encourage them to use the best CMTs for collaborative activities, and to get them to do so specifically for the purpose of collaboration.

CMT Use and Research Productivity in Kuwait

In their responses related to productivity, participating scientists revealed that their use of CMTs has a strong influence on their publication and research productivity. The CMTs are emerging within Kuwait and other Arab states as a transformative technology that helps to shape publication and research productivity.

These technologies represent facilitating channels for fostering collaboration between scientists in developing countries and developed countries. They also smooth the progress of development in developing countries.

When the scientists were asked about the future effects of CMTs on their productivity, they also affirmed their expectation that these technologies will have a great effect on the scientific production process in the near future. This question was designed to explore how Kuwaiti scientists perceive the future impact of CMTs on their scientific research. In this study, the author wishes to understand the influences of CMT systems on research productivity and scientific process at the present time, and the future potential of using these new technologies in the scientific development process. A thorough understanding of these phenomena is essential to help policy makers to develop the right plans for improving the production of scientific knowledge in Kuwait.

Scientific Collaboration and Research Productivity in Kuwait

This study showed a statistically significant, positively-correlated relationship between scientific collaboration and research productivity for these Kuwaiti scientists. That implies that when their level of collaboration increases, their research productivity also increases. This finding suggests that scientific collaboration is at the least an important indicator of the potential for increased research productivity. It would be interesting to do further research with scientists in Kuwait to determine if there is a causal relationship between scientific collaboration and their research productivity.

Broader Discussion

The results of this research strongly suggest that having access to a computer at work, as identified from the Kuwaiti scientist's perspective, typically means having a private computer located in an individual's private office, which is described as a "personal computer." This situation gives the Kuwaiti scientist an advantage, compared to other developing countries, where many scientists suffer from less access to computers, or the inconvenience of having computers that must be heavily shared with others, and are normally located in communal work

areas. Although this study is not able to establish the relationship of "personal computers" to productivity, the findings do suggest that having access to "personal computers" may have a positive role in helping the scientists of Kuwait to be more productive in their work. Further research could more directly establish this relationship.

However, the assumption that collaboration leads to improved research productivity is supported by findings derived from recent literature. In the developed world, recent results from Lee and Bozeman (2005) have shown that collaboration is positively related to productivity. In Kuwait study, the number of collaborations over three current projects is a significant predictor of workshops across Kuwait, while the number of collaborations with developed countries is associated with more foreign productivity (in international conferences and foreign journals) for academic scientists.

One of the important of findings of this study was discovering that the majority of scientists in Kuwait spend only one to ten hours per a week on activities related to their research work. The average is five hours per week which is approximately one hour per day, a level that is low compared to the expectations set in other productive research environments. For example, in the United States, faculty members at research universities are expected to spend approximately half their work time on research activities. This result leads to a big question about the nature of the research culture in Kuwait, and perhaps even in the Arab world. How many hours do they spend conducting research during the week? This problem goes beyond using computers or CMTs for scientific collaboration to improve their publication and productivity. Instead, the problem now is how to educate scientists in Kuwait to spend more time doing their research work. In academia in developing countries, Kuwait is not an exception; the educational mission

is often seen as the first priority compared to research. However, in many developing countries, research-intensive universities place the emphasis on research over teaching.

Using internet and communication technologies in more sophisticated ways in support of scientific research work are in the beginning stages in Kuwait, and likely in much of the Arab world. While it is useful to train scientists in Kuwait in how to use these communication technologies more effectively for scientific collaboration and to increase their scientific productivity, it is also important to educate scientists in the region about the essential role of scientific research in the production of knowledge.

The relationship between the level of research productivity and the scientist's place of graduation gives us a clue about the importance of having a graduate education from an institution located in a developed country. This survey divided the place of graduation into four regions: the Arab world, developing countries, Europe and Australia, and the U.S. and Canada. There are significant differences among the four places of graduation with respect to number of published book chapters produced by the participating scientists. In addition, scientists who graduated with their Ph.D. from an institution in the Arab world are leading in their involvement in national workshops, while scientists with degrees from developed countries, whether Europe/Australia or U.S./Canada, are significantly more visible in international conferences. Arab scientists, who graduated from Arab countries, are simply not as well represented as their colleagues who graduated from developed countries, in presenting papers at international conferences. In contrast, a U.S./Canadian graduate degree translates into a productivity advantage when it comes to scientific and academic awards.

In terms of published papers in domestic (Kuwait-based) journals, scientists with European/Australian degrees led, while scientists with Arab based degrees rank second, before

US/Canadian-graduate scientists, who were third above scientists with degrees from other developing countries. Scientists with European/Australian degrees seem to enjoy a productivity edge measured by publishing in foreign scientific journals. Once again, scientists with Arab country-based degrees seem to be at a disadvantage when it comes to published book chapters in general. Scientists with U.S./Canadian and European/Australian degrees seem to have the upper hand in foreign and international productivity.

The European/Australian graduate degree productivity advantage in producing papers in foreign journals is indeed interesting. The researcher had initially expected that this would be more of a U.S./Canadian-graduate advantage, but this analysis proved otherwise. However, developing country-graduates were also very visible in foreign journals. Also, in terms of published and unpublished reports, European/Australian graduate scientists led U.S./Canadian-graduate scientists.

Some comparisons can be made about other measures by looking at data from previous studies situated in the Philippines -East Asia (Ynalvez, 2006) and Chile-South America (Duque, 2007). These studies about scientists in developing countries examined comparable factors such as collaboration, age, gender, having a Ph.D., graduating from a developed country, and computer and internet access.

In a typical work week, Kuwaiti' scientists use computers between twenty to thirty hours on average (whether at work or home), which is on average about five hours per day. That is a somewhat lower number of hours than developed-world standards (from seven to eight hours per day). But the Kuwaiti computer-use hours are longer than for the Philippine scientists, who spend only two hours per day on average using computers, a statistic which includes their use in both home and work locations. In fact, (76.2%) of Kuwaiti scientists reported being very

comfortable using computers, which was a lower comfort level than that reported by Chilean scientists (82.7%) on the same measure.

Regarding the collaboration measurement, the level of collaboration between Kuwaiti scientists and other scientists in developed countries was greater than any part of the world. These are a correlation between the increase of collaboration and the regions of the United States/Canada and Europe/Australia (see table 5.11). Moreover, Kuwaiti scientists are collaborating more with these partners than with their colleagues in Kuwait or the Arab world. This result further suggests that a majority of Kuwaiti scientists, who graduated from universities in developed countries, collaborate more with scientists in developed areas. This observation was further supported because the study found that Kuwait University' scientists and faculty members collaborate more with scientists from the U.S./Canada and Europe/Australia, than researchers from KISR collaborate with scientists from these two areas.

In the Chile study, Duque (2007) confirmed this phenomenon as well, when he said "the increase of collaborators located in developed countries is highly significant in predicting academics publishing in foreign journals" (p.134). He stated that having an advanced education and a high degree from a developed country, significantly increases the number of international contacts available to the scientist from a developing country, and is also associated with greater size and reach of the developing-country scientist's professional networks.

Additionally, gaining a Ph.D. from a developed country seems to encourage scientists to maintain collaborative relationships with scientists in developed countries. This result is also supported by what Ynalvez (2006) found in the Philippine study. He noted that scientists in the Philippines who trained in or graduated from Australia communicate more with their collaborators in Australia (73.0%) and scientists who trained in or graduated from Japan

communicate more with their collaborators in Japan (60.0%), and also that scientists who trained in or graduated from the U.S. communicate more with their collaborators in U.S. (60.0%), than they collaborate with their locally-trained colleagues (41%). In this Kuwait study's results, there is also a correlation between gaining a Ph.D. from a developed country, and exhibiting an increased amount of publication in foreign journals. Furthermore, in the Latin American-Chile study (2007), Duque stated that having a Ph.D. from a developed area is a highly significant predictor across both the academic and research sectors.

There is no significant difference in the distribution of gender between the two sectors (academic vs. research) in this Kuwait study. However, gender was a significant factor for Chile study. Duque (2007) found that more female Chilean scientists published in foreign journals. In the Philippine study (Ynalvez, 2006), there was a significant gender effect, in that male scientists published more in foreign journals, a result which was explained by the authors as being related to male scientists' having more influence, power, and access to material resources in the Philippine research systems.

The coefficient of English proficiency used in the Chile study (Duque, 2007), was not a significant factor associated with foreign research productivity. But it was associated with higher levels of domestic publications and web publishing. In this Kuwait study, the great majority of scientists were very comfortable or comfortable in using the English language (90.1%) in their communication and collaboration with other scientists via the internet and CMT channels.

In terms of the personal characteristics of scientists in the Philippine, age had significant effect on their web browser usage levels, in those younger scientists use the web more and in more diverse ways than older scientists did. This Kuwait study revealed no significant differences based on age, between the scientists in the two sectors. This was similar to the Chile

study, in which age played no role in determining traditional publication patterns. However, the Chile study did report that youth was associated with higher levels of publishing on the web.

When is collaboration significant? In the Latin American study (Duque, 2007); collaboration was a significant factor in relation to publication productivity in foreign and domestic journals. In the Philippine study (Ynalvez, 2006); collaboration was not significantly associated with scientific productivity. Ynalvez (2006) also declared that there is no strong influence of scientific collaboration on research productivity. However, as with the Latin American study, the Kuwait study found that collaboration was significantly associated with research productivity especially that related to international conferences and foreign journals.

Scientists also were asked to indicate the field or discipline in which they worked. Engineering and computers was the most-represented discipline (57.0% of respondents), and Medical, Health studies and Biomedical was second (30.4%). The ranking by discipline of the study's participants included Biology, Ecology and Environment (27.8%), Oil Engineering and Petroleum (20.3%), Agriculture, Geology and Marine Studies (17.7%), Natural Science and Geography (16.5%), and Math, Statistics and Physics (11.4%).

Implications of This Study

Today, the internet and CMT channels, such as Facebook and Twitter, present powerful tools for collaboration and communication. The utilization of both of these facilities appears to have shifted from the simple notion of access and use, to more advanced notions of intensity, extent, and diversity of use.

The results of this study pertaining to the analysis of computer and CMT use suggest that Kuwaiti scientists today prefer CMC (email) interaction as their primary mode of communication and collaboration. There is evidence to support the claim that new CMTs (or the internet) will soon replace traditional, face-to-face interaction for professional collaboration. New CMTs have relegated the use of the landline telephone and the postal mailing system to the margins. Email, smartphones, and Facebook have taken on an increasingly central role.

These Kuwaiti scientists enjoy strong international networks, possibly as a result of more than 78 % of their Ph.D. degrees having been acquired from developed countries. Kuwaiti scientists communicate primarily through the internet and CMTs with the world today. Results from this research suggest that involvement in collaborative work is a relatively common behavior among Kuwait scientists. The predominant form of collaboration is foreign collaboration, especially when it involves colleagues from the United States or Canada. In other words, collaborative relationships by Kuwaiti scientists can be described as being primarily with foreign collaborators, and are more likely to be with scientists in the either the U.S./ Canadian region, or in the European/Australian grouping.

It appears that the computer-mediated technologies and internet technologies hold great promise as being indispensable tools in the system of scientific knowledge production for the state of Kuwait.

Limitations of the Study

In describing the limitations of this study, it is first necessary to mention some troubles that the researcher faced while gathering the data. The first problem related to the timing of this survey. The original plan was to send the online survey to scientists and faculty members in Kuwait in May of 2011, which would have been during their spring semester (in Kuwait, the academic spring semester ends in mid-June). However, the author could not put the survey online (i.e., make it available for scientists to participate) until July 10th. This was summer time, which meant that a large number of faculty members at KU and researchers at KISR were out of the country for summer vacation. Despite this, the participation in this online survey reached about 25 %. One hundred and six scientists, across both sectors, participated by completing the survey, out of the total population of the scientific community in Kuwait, which is 429 scientists. This overall response rate was quite acceptable, particularly for an online survey.

The second issue was a very low participation rate from KISR's researchers. Researchers from KISR represented about a third of all of the participants, while faculty members at Kuwait University comprised about two-thirds of the participants. This was partly a result of the KISR management's policy which forbade them from allowing the contacting of the individual researchers directly via their email, to be sure that everyone was invited to participate in the online survey. The KISR director of information and technology therefore sent the survey to each center and subdivision, rather than to the individuals, which likely led to reduced participation by KISR researchers.

The Kuwaiti quantitative survey questionnaire was drafted in English and consisted of about 81 questions pertaining to demographic information, research activities, collaborative behavior, access to various types of communication technologies, and CMT access and use behavior. By the last week of June 2011, the final version was available. The participation in

this online survey started on July 10th and was closed by the end of July 30th, making it available for only three weeks. The author did receive some emails from faculty members and scientists at Kuwait University who wanted to participate in the survey, but because of other time constraints, the deadline could not be extended. To get a better understanding of the broader scientific community, it would have been useful to include the social scientists in Kuwait, to distinguish any effects coming from the differences between members of the two paradigms in using the internet and CMTs for their collaboration and research productivity.

This study was conducted using an online survey instrument, which may have restricted the participation of any scientists who don't use computers and the internet regularly. If this work is continued in the future, it would be useful to provide the questionnaire in two options (online and on paper), in order to ensure adequate representation of any Kuwaiti scientists who may not want to or be able to participate through the online instrument.

As with any study employing survey research, this study's methodology has some inherent limitations. The data reflect participants' self-reports of their perceptions, beliefs, and actions, rather than actual observations of the phenomena being studied. In addition, the design of the study was aimed at including all members of an identified, clearly-defined population, so no sampling strategy was needed. However, participation in the study by members of that population was self-selected, which is likely to have introduced some degree of bias into the results.

Chapter VII: Conclusion

This dissertation was a quantitative study of the role of computer-mediated technologies (CMTs) in scientific collaboration in Kuwait. The study explored the relationship between scientific collaboration, CMT use, and research productivity in Kuwait's scientific community. This study discusses the value of using computer-mediated communication technologies for scientific collaboration between scientists from developing and developed countries. In addition, it considers how scientists from a developing country perceive the diffusion of these new technologies in the research process. This research also examined and characterized the expansion of the computer-mediated technologies (CMTs) and its impact on knowledge production in the Kuwaiti scientific community.

Today, CMTs present a wide array of opportunities for facilitating the development process. For Kuwait and other developing countries, being true participants in and beneficiaries of the information and communication technologies revolution does not simply mean that they accelerated their CMT usage to jump into the Information Society. Thoughtful integration of CMTs into their processes for creating new knowledge provides potential for sustainable human and scientific development.

Improvements in the knowledge production process in Kuwait and other Arab countries requires intensive efforts at both the national and international levels, placing the issue within the context of the broader scientific and human development objectives, and educational policies in Kuwait and Arab world states. At the national level, it is important to have an integrated information and communication strategy, to guide the application and use of the new technologies for scientific development goals. While this research study shows that CMTs are

being used in a variety of ways, further integration of CMTs into national scientific policies could accelerate the scientific process within the framework of Kuwait's potential.

Part of the problem is that a research agenda that addresses local needs in Kuwait may not be discussing issues that are part of the international research agenda. However, there are grand challenges in science, such as global climate change and sustainable energy, which raise questions that transcend national boundaries and immediately provide opportunities for researchers from developing nations to collaborate with the broader scientific community. For this purpose, in 2005, Kuwait launched the Kuwait-MIT Center (KMC) for Natural Resources and the Environment, to advance an expanded research agenda that encompasses the science, the engineering, and the policy of optimal development and utilization of their energy resources, while preserving and enhancing the quality of the environment. According to their publications, the overall goal of this center is to advance Kuwait and the region, and to link research and the Center to the broader arena of progress on key environmental, hydrologic, and energy resource goals, and energy-related research. While the general interest is in the renewable energy sector and oil, the initial thrust of research is on solar energy, in addition to the environment, to include the study of the movement, distribution, and quality of water throughout the region. Investigations of these environmental factors will affect the discovery of new energy sources to complement the energy research. This center was established by the Kuwait Foundation for the Advancement of Science (KFAS) to foster collaborations in research and education between Kuwait Institutions and the Massachusetts Institute of Technology in the areas of energy, water and the environment.

The history of scientific development shows that science relies on institutions committing to promoting the work of their scientists and scientific applications. In general, scientific culture

can only pass from one country to another if there are the infrastructure and the institutions for facilitation and adoption of science. To promote and improve the scientific research and development in Kuwait, the Kuwait government supports the scientific activities with generosity, and establishes the institutions and scientific centers to develop, for example, the Kuwait Institute for Scientific Research (KISR), the Scientific Center of Kuwait (TSCK), and the Health Sciences Center (HSC), at KU. Moreover, Kuwait has also established some foundations to support and encourage the exchange of scientific research between scientists and researchers inside or outside the country, such as the Kuwait Foundation for the Advancement of Science (KFAS).

Universities and scientific research centers fuel the scientific society, and produce those who will work in it. National scientific research and development activities need highly qualified graduates and researchers with enquiring and trained minds and superlative thinking skills. To the contrary, in Kuwait, 44% of university graduates receive their degrees in the humanities, 18% in public administration, and 12% in Islamic law. Graduates in natural sciences, engineering, medicine, pharmacology, health, and nursing represent just 26% of the total number of graduates. However, in 2006, Kuwait started a large-scale plan to send at least 2,000 students every year to pursue scientific degrees overseas, especially in the United States, Canada, and Europe, to be the cell that establishes the next scientific community in Kuwait.

Kuwait University is considered to be the major governmental university in the country, and is completely supported and funded by the government, as mentioned above. However, Kuwait University also complies with the world academic standards and criteria in evaluating the faculty members who work at this university. But the Kuwait constitution guarantees the Kuwaiti citizen's right to keep his governmental job, if he does not commit any major violation, or has an

extended absence, that would result in termination from the position. (Kuwait adopted this idea from socialist theory). This initiative protected Kuwaiti faculty members and scientists from the stress of having to earn tenure by working hard to accumulate enough publications to qualify for a promotion from assistant professor to associate professor, within six years. The situation is made worse by the fact that procedures for evaluating the success of the faculty members and scientists at Kuwait University is usually not measured in terms of their success in publishing research results in distinguished scientific publications. Instead, success is defined by their degree of support given to the government's plans and policies. Also, Kuwait University focuses more on locally-oriented research, which may be a result of its being funded by the government.

In developing countries, governments always play a key role in the public universities. For example, the science and technology community in Brazil has seen a shift from a research agenda entirely defined by scientists and researchers, to one driven more by the outputs that the government, as the client, wants to buy.

This study suggested some means by which scientific research institutions and university governments can address these problems. Strong international collaboration that provides sustained intellectual and technological support for strengthening the scientific capacity of developing countries is also urgently needed. Thus, Kuwait University needs more policies or perhaps incentives to encourage their researchers and faculty members to participate more in international knowledge production. Such incentives can encourage scientists to establish scientific collaborations and to conduct research that is more broadly recognized and can be published in international scientific journals.

CMT can be enormously helpful, but it does not independently motivate or enable collaboration. Building CMT-based connections with scientists in specific countries where

collaboration looks like it will have a beneficial effect may be a way to encourage future capacity-building. The utilization of CMTs can make a significant contribution in facilitating the development and building of a strong research culture. However, the critical development issue, when it comes to bringing Arab countries into more scientific collaborations, goes beyond providing hardware and encouraging the use of CMTs. It is a matter of encouraging a new scientific culture of collaboration and sharing through publication. This research found that most respondents had a computer in an individualized work space. Therefore, installing a computer in every room at KISR, or connecting every building in KU to the internet will not necessarily lend itself to the long-term development of the Kuwaiti scientific community. What must be kept in perspective is that scientific collaboration and solutions for the use of CMTs could become a valuable means of promoting development, but this depends on creating policies and incentives that can encourage change in how Kuwaiti scientists currently work. Ultimately, in order to close the scientific gap, countries in the Arab world need to develop their capacity to generate and exploit knowledge, including their capacity to do research.

Insufficient resources (especially human) for science research, and the absence of key values and traditions that promote effective scientific inquiry and training, are among the main causes of the weakening position of Kuwait in the sciences. Kuwait and Arab world countries are in need of true efforts to strengthen scientific collaboration between scientists and researchers in their countries and the centers of scientific excellence worldwide. Today, CMTs and digital media diffusion are moving with extraordinary speed. Countries such as India now play a strong role in the development of software and hardware. Overall, playing a role in the knowledge production future requires every developing country to think strategically about how their

inevitably limited resources for science and scientific research might best be deployed to the advantage of future generations.

In this research, the goal was not to prove if there is scientific collaboration in Kuwait and the Arab world or not. The goal was to comprehend the roles and mechanisms of scientific collaboration in the production of knowledge, and how this interaction could help developing countries to improve their scientific culture. Studying the potential of CMTs and other social networks is very important because this understanding will enrich our knowledge about the collaboration process and its impact on scientific development. From this study, it emerges that CMTs are not a solution for scientific development or a replacement for scientific research. Rather they are one tool that is already in place that can help facilitate strong scientific collaborations and research productivity, if supported by policy which encourages the culture of science research.

Scientific collaboration is having a positive impact on the ability of developing countries to participate in world knowledge production. From the literature, researchers from scientifically developed countries collaborating with their counterparts in developing countries report that these activities are building an international scientific capacity in those countries. Indicators show that the amount of collaborative research between developed and developing country scientists is rising. For example, scientific papers published jointly between scientists from these two categories of countries have increased. One example from the United States is the National Science Foundation (NSF), which strongly supports collaborative national projects involving academic institutions, private industry, and state and local governments, but also encourages U.S. participation in international scientific efforts. Promoting partnerships is one of NSF's core strategies. Collaboration and partnerships between disciplines and institutions and among

academe and industry enable the movement of people, ideas, and tools throughout the public and private sectors. One of NFS' strategies is to support and encourage co-authorship and publications of scientists from different countries. This aim is motivating scientists from the United States and developed countries to collaborate with scientists from developing areas.

Some incentives to improve research productivity in Kuwait

Incentives can take several forms, including grants for collaborative ventures by faculty and other researchers to develop scientific research models. Other incentives might include awards for achievement, and increases in base rewards.

An incentive program for scientific productivity should be established in Kuwait. However, incentive programs should be developed to stimulate collaboration with respect to research equipment, and between scientists across disciplines and institutions.

Some non-financial incentives include special awards to recognize an individual's achievement of a particular scientific research objective. These incentives formally reinforce the institution's position that collaboration skills enhance scientific productivity and may result in greater success for the scientists.

Another idea to improve scientific productivity, supplemented by the help of scientific organizations such as the UNESCO Institute of Statistics, is the establishment of a unit at the KISR or KU which would develop into a scientific research observatory. The role of this unit should be rationally defined, and depends on the identification of an initially limited but structured set of indicators to monitor Kuwait's performance in science and knowledge production.

The collaboration plan for an advanced information and computer-mediated technology infrastructure for Kuwait University and KISR should be defined. Collaboration in the region

and in the Arab world are important too, but should be pursued on a scientific basis. The role of collaboration is to strengthen Kuwait's participation in regional and wider international networks in science and publication, and to use those networks for the most effective and efficient implementation.

The collaboration plan would aim at strengthening partnerships between KU and KISR, as well as between these organizations on the one hand and other public agencies on the other. The collaboration plan also would encourage Kuwaiti scientists and academicians to link to international scientific networks, so that they can easily update their knowledge on innovations in science and technology. This ability would qualify them to participate in high-value joint research with their peers abroad; in this way, Kuwait can become an effective and interactive partner in regional and international networks of science.

More generally, the various activities under a "collaboration plan" should assist in incorporating Kuwaiti scientists and institutions in international networks. Using the Association Agreement with developed countries, bilateral funding agreements, institutional partnership links with foreign universities, and involving foreign experts in an advisory capacity, are all actions that can serve a useful purpose.

Recommendations for KU and KISR

Kuwait University: The functioning of KU needs to be improved by requesting a commitment to research and enforcing this by introducing new standards based on performance and auditing, by introducing more graduate programs, particularly PhD programs, and by supporting the funding of post-doctorate positions.

Kuwait Institute for Scientific Research: KISR should have a role in supporting the deployment of information technology development and applications in scientific industry in

general, as well as in the public administration sector. It should also undertake needed research projects on web and Arabized applications technologies. Arabized applications technologies mean to support the content and software that support Arabic language.

KU and KISR should provide sufficient financial support to faculty members in KU and to researchers in KISR, to participate in opportunities to enhance their own information literacy skills, such as attending professional conferences.

KISR and KU should develop and promote clear incentives for scientists, researchers, and faculty members who take part in scientific research activities. The incentives should be connected to all existing and new staff members, and should not only be financial in nature, but also should promote career progression.

KU and KISR should also offer workshops to the scientists in both sectors about the importance of using communication technologies and information in scientific research, and in facilitating scientific collaboration.

An efficient incentives policy will encourage staff to engage, where applicable, in actions to protect research productivity, and to promote its exploitation. In principle, all those directly involved in generating increased research productivity should benefit, including non-academic staff.

Measures of outputs and outcomes are needed in order to track and monitor the effectiveness of collaboration, and must be built in from the start. Quantitative and qualitative measures should be explored in more detail so that they can be built into collaborations which, along with appropriate feedback mechanisms, can enable funders and participants to see what works well in producing both good science and improved scientific research.

Training new generations: Since scientific research could take years to produce useful results, the presence of such individuals is critical to initiating new research, and to sustaining ongoing ones. They can also play an important role in training a new generation of scientists and serving as the human link across projects and institutions.

The Scientific Training Process: This type of training is important:

- To assist a new generation of scientists to achieve greater success by accessing, using, and applying information effectively, by providing them with the knowledge of resources, methods, and services which will support their research; and
- To enable a new generation of scientists to be information-literate, for ensuring their research productivity and also to develop lifelong skills for their future careers.

This study examined the association between CMTs use, scientific collaboration, and research productivity of scientists working in two institutional settings (KU and KISR) in a developing research system in Kuwait. Studying the role of CMTs in scientific collaboration provides in-depth views of how a new generation of communication technologies such as social networking and Web2.0 applications is enabling novel kinds of science collaboration.

Generally, the findings from this research have shown that: (1) the scientific community in Kuwait is connected to the internet and has adopted CMTs for their work, (2) the association between CMT use and research productivity was confirmed, and (3) the assumption that collaboration leads to research productivity was supported.

Kuwait needs a new policy environment that liberates scientific and human capabilities in the sciences by supporting freedom and funding creativity and scientific research. Without those preconditions, the full realization of Kuwait's scientific knowledge production will remain an elusive dream.

Future research agenda

Further study of scientific research, productivity, and collaboration-building in Kuwait is necessary in order to provide a more complete picture, including using other types of research methods and analyses:

1. Additional data collection for further refinement of an understanding of scientific collaboration and research productivity.
2. A Different type analysis of the data used to measure knowledge production. (It is a difficult task to measure the capability on a developing country to conduct world-class scientific research, in terms of its educational system, public institutions, and the private sector).
3. Micro-level analysis of differences between the United States and Kuwait, and a number of developing countries.

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Appendix 1

INFORMED CONSENT

You are invited to participate in a research study investigating the role of computer mediated technologies (CMTs) on scientific collaboration and how it relates to research productivity and publication of scientists, researchers and faculty members in Kuwait. The ultimate goal of my study is to improve our understanding of the role and impact of computer mediated technologies, such as Social networking, Smartphone and Web 2.0, on the research and scientific collaboration in the state of Kuwait, locally and internationally and the relationship between these technologies and science production and knowledge. This online survey will take from 20 to 30 minutes to complete.

Your participation in this study is completely voluntary. You may refuse to participate in this study or skip any questions that make you feel uncomfortable and you are free to withdraw at any time. Furthermore, your identity in this study would be anonymous. There are no questions or documents that will require your name, signature or any other personal identification.

Your responses will help us better understand how Kuwait scientists use CMTs, particularly for scientific collaboration and it may contribute to facilitating knowledge and science production in the future. If you have any questions about the study or procedures, please feel free to contact me, Abdulaziz Aldaihani at: (812) 361-9398 or aaldaiha@utk.edu. You may also contact my advisor, Dr. Suzie Allard, email: sallard@utk.edu.

If you have questions about your rights as a participant, contact the Office of Research at The University of Tennessee, Knoxville at (865) 974-3466.

By proceeding to complete the survey, you are indicating that you have read and understood the information above, and are agreeing to participate.

VITA

Dr. Abdalaziz H. Aldaihani's interested in how computer mediated technologies, internet and information technology support scientific collaboration. His research is focused on the future of new technologies and computer media in knowledge production and knowledge management in developing countries and Arab world and the role of these technologies in scientific development. How scientists from different disciplines apply and use the information and internet technology in their research work.

After, he finished his PhD program in the College of Communication & Information at The University of Tennessee. Dr. Aldaihani is going back to his country, Kuwait, to work as an assistant professor in the Department of Mass Communication at Kuwait University. Before he started the PhD program, Aldaihani was working as a media researcher in the Public relation department with the Council of Ministers in the Government of Kuwait.