

The problem of connectivity:
A sociological study of the problem of connectedness of nationally produced science and national needs in Saudi Arabia

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Abstract

This study is to investigate the problem of connectivity between nationally produced science and national needs. It is a collective case study of two academic departments within Saudi academia, the departments of petroleum engineering at Alpha and Beta Universities. The rationale for using these departments is that Saudi Arabia has an advanced petroleum industry, making petroleum engineering a good case for investigating the connectivity of nationally produced science with national needs. The main tool of the study was in-depth tape-recorded interviews. Twenty-two interviews were conducted, sixteen with current and retired faculty members at the petroleum engineering departments of Alpha and Beta and six with administrators at both universities. In addition, documents and observation were used as tools.

The two departments differ in their levels of connectivity with national industry. One is increasingly connected with national industry, while the other is completely isolated from national industry. Historical and regulatory factors play a role in this difference. Four themes were generated from the data: institutional arrangements, positive attitude and self confidence, social construction of the university, and rentier mentality. The data gathered show that the issue of connectivity is beyond the will and abilities of individual scientists;

it is a result of organizational efforts of the scientific institutions reinforced by the willingness of the productive sectors to change their behavior toward national scientists.

Acknowledgments

I would like to thank the people with whom I discussed the research problem for this dissertation as I was developing it. They are my advisor, Dr. Ellsworth (Skip) Fuhrman, Dr. Antoine Zahlan, an international consultant in Science Policy in London, United Kingdom, and Dr. Abu Baker Bagader, professor of sociology at King Abdul Aziz University, Jeddah, Saudi Arabia. Their comments and advice were a great help in developing my research problem. My continuing work with Dr. Fuhrman made it possible for a research idea to be turned into a dissertation. Special thanks to my committee members, Carol Bailey, Dan Breslau, Michael Hughes, and John Ryan. Their comments and notes provided me with great help throughout my work on this project. Special thanks to Carolyn Kroehler for her help and effort in editing this dissertation.

Special thanks to my wife Hind and my brother Suliman, both great providers of help and support. The discussions I had with my friends Yousef Al-Ajaji, department of economy at King Saud University, Saudi Arabia, and Dr. Naser Al-mohaize, sociology department at Imam Mohammed ben Saud University, Saudi Arabia, were intellectually fruitful.

I also would like to thank all the faculty in the sociology and the science and technology studies departments at Virginia Tech with whom I have had the privilege of holding discussions during my graduate work at Virginia Tech, Dale Wimberley, Alan Bayer, Gary Downey, and Saul Halfon.

I also would like to thank the current members of the sociology department staff, Brenda Husser and Joyce Moser, and the former members, Lou Ann Henderson and Michelle Wooddell, who provided continuous help for the department's students throughout my graduate education time at Virginia Tech.

The interviewees at Alpha and Beta Universities deserve sincere appreciation for their generosity in giving me time to do the interviews and in collaborating with me as I collected data for this study.

Dedication

To the three women who showed a great deal of support and enthusiasm for seeing this project finished:

To my mother, who passed away during the work on this study.

To my wife, Hend.

To my sister, Meznah.

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Chapter I: Introduction and Statement of the Problem

In today's world, science diffuses across nation states. It is seen as a major factor in gaining power and accumulating wealth for both individuals and societies. Science is introduced not only as a form of knowledge but also, and more importantly, as a tool for solving the problems humans face. According to this view, science is necessary to reach the highest efficiency in producing food, curing the sick, defending nations, and attaining economic success. Generally speaking, it is taken for granted that science is useful. Thus, science is strongly legitimized in both developed and less developed nations.

In less developed countries (LDCs), science has been seen as the pathway to advancement and progress. Policy makers in many LDCs regard science as a mechanism required for economic development. Developmental plans in these countries emphasize the role of science in achieving economic growth. The political elites of the newly independent nations in the post-World War II era saw science as the tool necessary for solving development problems as well as for accomplishing economic growth for their developing nations. Jawaharlal Nehru, the first Prime Minister of India after independence, said:

It is science alone that can solve the problems of hunger and poverty, of insanitation and illiteracy, of superstition and deadening custom and tradition, of vast resources running to waste, of a rich country inhabited by starving people. . . . At every turn we have to seek its aid. . . . The future belongs to science and those who make friends with science. (Perutz 1989: 12)

Nehru's words reflect hopes and aims that the third world elite harbor in regard to the developmental role science could play in their societies. They also illustrate the

legitimacy science has acquired in the minds of modern people.

The new nation states started establishing governmental agencies for the sake of advancing the local production of science (such as ministries of science and technology and higher education institutions) and developed national policies for science and technology. International organizations, such as UNESCO and World Bank, acted as “teachers of norms” in telling nation states how to organize and arrange powerful institutions of science effectively, through conferences, advice, workshops, and so on. Indeed, the United Nations announced 1980 as the Year of Science for Development. Drori (1997) calls the decades of the 1960s and 1970s as the time of solidly establishing the discourse of science for national development (SND). That discourse sees science from a utilitarian perspective, with science introduced mainly as a means for national progress.

1.1. LDCs and the impact of locally produced science on local development

Despite the hopes and ambitions, local science in third world countries has accomplished few utilitarian results, except in a few countries that are no longer called developing countries but are instead called newly industrializing countries (NICs), such as Brazil, China, India, and South Korea. Science for the rest of the LDCs continues to suffer problems of weakness, both qualitatively and quantitatively. More importantly, the locally produced science in LDCs suffers isolation from the local environment. The case in the Arab countries, which all are LDCs, is no exception. Science there did not become an active player in national development, despite the continuous emphasis of national developmental discourses on the expected roles of locally produced science on improving the quality of life in these societies.

Science studies in the Arab world, thus, focus on the minimal impact that science has had on local development. The most common explanations given are weak funding, the education system, and the absence of effective national strategies (UNESCO, 1995, 1998; UNDP, 2000, 2003; World Bank, 2002; Zahlan, 1975, 1980, 1984, 1999; Fergani, 1998, 1999). Such explanations usually build upon the quantitative and qualitative weaknesses of scientific production, comparing it primarily to the science produced in advanced nations. These views and explanations dominate science studies in the Arab world, including that produced by individual scientists, national institutions, and international organizations.

These studies give an informative and accurate picture of the status of science in the Arab world. However, and with respect to the significance of these studies, they do not address a central question: What about the usefulness of the locally produced science? To what extent does the locally produced science have implications for local needs? The current literature on science studies in the Arab world, although approaching science from an instrumentalist point of view, does not raise this very central question about the instrumentality of local science, nor does it analyze the actual use of the science that is locally produced.

1.2. Research Question

In this study I intended to draw attention to the problem of connectedness of the science produced in the LDCs in general and in the Arab world in particular, focusing on a country that is both a third world and an Arab country--Saudi Arabia. By connectedness,

I mean the link between science produced locally and local needs. I use connectedness as a term with the same meaning with which Hill (1987) used it when he wrote about science in the third world, saying: “[N]o matter how ‘good’ the science is, it simply is unlikely to *connect* with the surrounding user environment as it can in these advanced nations.” While Hill (and others, as I will show in the following chapter) argued that science may not be useful for developing countries, I investigate the condition that may make them useful or not. My central research question, then, is under what condition science would be useful and connected with national needs and under what condition they would not be? More precisely, how locally produced science in developing countries fails to connect with local developmental needs? What is it in the social organization of science in LDCs that prevent scientists from producing locally useful science, on the one hand, and that prevents local institutions from seeking local scientists’ help in solving their technical problems, on the other hand? In addition, when local scientists produce scientific knowledge, why and for whom do they produce it? On what do they base the choice of their research topics? Why does the scientific knowledge there suffer alienation and isolation?

One dimension of the problem of science and technology systems in the third world is that local industry and developmental sectors ignore local scientific institutions when they need scientists’ help to solve their problems or for building projects. When a local industry faces technical problems that could be solved with scientists’ help, typically that industry looks for help from foreign expert institutions located in advanced nations. Zahlan (1999) regards this behavior as a major cause for the lack of progress of an

effective science and technology system in the Arab world.

This gap between the local production sectors and local science in the third world motivates my investigation. Such a phenomenon is a major cause of the alienation of locally produced scientific knowledge from the local environment. Why is the relationship between local productivity sectors (services, governmental agencies, local industry, etc.) and local science weak? Why do local productivity sectors not rely on local research institutions for solving their problems? I intend to approach these questions concentrating on two Saudi academic departments, department of petroleum engineering (DPE) in two Saudi universities. This, then, is a qualitative case study of two academic departments in a third world country. The story of the connectivity of science produced in these two universities will reveal the conditions under which scientific knowledge is connected or isolated. Why is it isolated? And how does it become connected?

1.3.Study significance

When describing or introducing the status of science in the Arab world, literature emphasizes traditional measurements of scientific productivity such as the number of publications, number of citations, patents, and rewards; these traditional measurements make the accomplishments of the institution of science in the region look scant compared to the accomplishments of advanced nations. Emphasis on these measures produces and reinforces a consciousness that sees science mainly from a global perspective and disregards the connectedness of local science among both scientists and science policy makers. In this study, I want to draw attention to two main points. First, I hope to illuminate the issue of connectedness in locally produced science in developing countries.

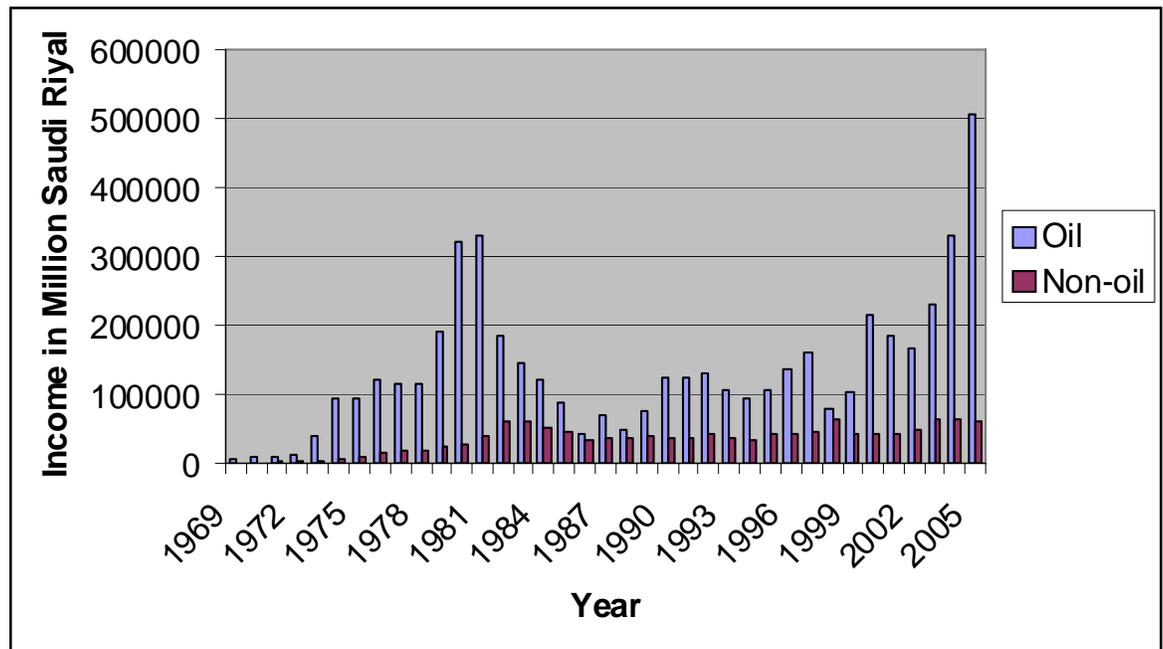
Second, I want to investigate the factors that limit the usefulness of local science in LDCs. I hope this study contributes to the current discussion of the complicated relations between science and technology, development, and national economic growth in societies where the relation between locally produced science and local needs is considered weak.

Saudi Arabia is part of the Arab world and is regarded as one of the LDCs. The pathology patterns of the institution of science there are, in general, similar to that of science in most of the LDCs, which all the Arab nations are. Like other LDCs, scientific institutions in Saudi Arabia are only weakly connected to local productive sectors; relevant literature agrees on that point (Alsultan, 1994; Alghatni, 2004). The academic field of petroleum engineering in a country like Saudi Arabia is ideal for an investigation of connectedness between local science and local industry.

Saudi Arabia is known as the largest producer of oil in the world. Oil is the main source of income for budget revenues and the major component of GDP in the Saudi economy; see Table 1.1. According to numbers generated by the Saudi Ministry of Finance, oil comprised 80 percent of Saudi budget revenues during the time from 1969 to 2005. The lowest percentage of oil's share in budget revenues was 55 percent, while it was as high as 90 percent of budget revenues in some years during the last 35 years, according to the Saudi Ministry of Finance; see Table 1.1. The government in Saudi Arabia is the major player in the national economy, which is described as an oil-based economy. The whole country's economy is significantly affected by oil prices; the economy is strong when oil prices rise and weak when oil prices dramatically drop.

Oil, then, is considered to be the major factor in determining the standard of living for Saudi people. It is fair, hence, to state that the standard of living of Saudi people is based almost entirely on oil. The country has the largest oil company in the world, ARAMCO. According to the *Petroleum Intelligence Weekly*, in 2005 ARAMCO was the number one oil company in the world for the 17th straight year; despite Saudi Arabia's status as an LDC, the country's petroleum industry is quite advanced. The story of the science and industry of the petroleum sector of Saudi Arabia should provide insight into connectedness in cases where the local demand for scientists' contributions is high.

Table 1.1: Share of oil and non-oil income for the budget revenue of Saudi Arabia, 1969-2005



Numbers are taken from Ministry of Finance, Saudi Arabia.

As the largest producer of oil in the global economy, Saudi Arabia has an advanced oil industry. According to its 2005 annual report, the Saudi national oil company,

ARAMCO, had been the biggest oil company in the world for 17 consecutive years. There is a considerable local industrial market for scientific research done in that field. Hence, one would assume that scientific knowledge related to oil, such as petroleum engineering, produced by Saudi academics, would be well linked to the country's oil industry. Whether it is or not, and how connection could be reached, is the subject of my research. I have chosen the scientific field of petroleum engineering to investigate the connectivity between science produced in Saudi Arabia and the needs of the country's industry.

Relevant literature is in agreement about the isolation of local research institutions from local demands in the Arab world as well as in Saudi Arabia (Minfikhey, 1988; Fhmme, 1993; Saeg and others, 1995; Alsharouk, 1997; Almutrif, 1996; Aldbasi, 1998; Turkistani, 1998; Ukasha, 1999; the Saudi Council of Treasure, 1990; Nuaimy, 1999; Fayed, 2000; Al-Zahrani, 1997).

Because of the significance of the petroleum sector for the local economy in Saudi Arabia, the petroleum engineering field should represent a highly connected case. However, this study reveals that the petroleum engineering field in Saudi academia presents a double-sided story of connectedness. It is a tale of two academic departments, one could say. Currently there are only two academic departments of petroleum engineering in Saudi universities. While one could serve as a typical model for the complete isolation of the produced scientific knowledge from local needs, the other has been experiencing some changes in the last ten years in regard to its relations with

national industry. Interviews and documents gathered for this study from the two Saudi DPEs reveal how social organization, attitudes, social construction of academic institutions, and professional identity are major factors in making local scientists isolated from or connected with local needs.

1.4. Study organization

Chapter two of this study presents the relevant literature. I divide the chapter into three parts. In the first, I go over the social theories of the developmental role of science, especially in third world countries. Three different theoretical approaches are reviewed in this part: the modernization, the dependency, and the sociological institutional approach. In the second part, I review the different trends of science studies in the Arab world, which Saudi Arabia is part of. These trends make up what I call the science studies discourse in the Arab world (SSDA). I then end this part with a critique of the philosophical choice that constructs the SSDA, which is the modernization theory approach. In the last part of the chapter, I introduce the sociological studies of science and the model(s) I use in this study.

Chapter three is about the methodological issues of this study, a qualitative cases study that uses in-depth semi-structured and unstructured interviews as a major tool. In Chapter four, I provide some demographical and economical data about Saudi Arabia and describe the organization of science and technology in Saudi Arabia. Chapter five provides a detailed description of the two cases, putting them in the context of the country's academia and oil industry. Chapter six presents my data analysis, where themes are introduced and described. Chapter seven is a discussion of the entire project.

Chapter II: Literature Review

2.1. Introduction

The main question of this study is why science produced in the Arab world and other LDCs contribute little to local needs. In this chapter, I review the related literature, linking theories of the social roles of science with science studies in the Arab world. My goal is to show how a sociological study could enrich the current discussions of the above problem. I divide the current chapter into three sections: sociological theories of the developmental roles of science, the discourse on science studies in the Arab world, and a critique of that discourse in light of the discussed theories.

2.2. Science and development: multiple theoretical approaches

Science lies at the heart of any development discourse; according to Agnew (1982), science is emphasized by all development theories. However, there is no consensus among these theories about the nature of science's role in development. Shrum and Shenhav (1993) distinguish between three theoretical approaches with regard to science in the developmental process of Less Developed Countries (LDCs): modernization, dependency, and institutional. While modernization theory argues that science is a means for national development by assuming a straightforward relationship between science and economic growth, dependency theory rejects this claim. For LDCs, dependency theory states, science is a means of western domination. Institutional theory, on the other hand, refuses the modernization claim of a hierarchal relationship between science and

economic growth; however, in its latest version, institutional theory assigns a more developmental role for science. The following section will review these perspectives in greater detail.

2.2.1. Modernization theory

From the perspective of sociological modernization theory, the cause of underdevelopment in LDCs is primarily their traditionalist social structure (Badham 1984). Thus, to successfully develop, LDCs must adopt social structures that are similar to those of developed societies. For LDCs, the most relevant institutions are those that advance education, science, and technology. A closely related theory, neoclassical economic, states that economic growth in an individual nation yields benefits for all nations, both developed and less developed. Both theories see science as strongly linked to technology. According to this perspective, science, technology, and education offer means for countries to exploit their resources (Shrum and Shenhav 1993)

After World War II, these theories led to the promotion of science and education as prescriptions for economic growth, especially for LDCs (Schofer et al 2000).

Modernization theory sees the main factors that influence the process of national development as internal, discounting external factors. This perspective states that science, when nationally institutionalized, is a crucial tool for national development. The modernist position came to dominate the discourse of science, producing what Drori (1997) calls the “Science for National Development” (SND) policy model. The model suggests that science can bring economic growth to a country through two separate

branches: a scientifically sophisticated work force and scientists' research. The skillful scientific force would transform the produced scientific knowledge into technological devices.

Both of these elements could be achieved through education. Thus, scientific training came to be seen as a positive investment in human capital that would lead to increased labor force productivity and efficiency (Schofer et al 2000). Also, science education would promote positive feelings with regard to modernity. According to Drori (1997), the SND model suggests a causal relationship between the growth of scientific knowledge and the economic status of a nation. Technology, in turn, would mediate this relationship. This model rests upon four assumptions. First, it assumes that science is a national project that intends to benefit the whole nation and relies on its support financially and socially. Second, SND assumes a national science policy that explicitly aims to lead to economic development. Third, for SND, science is not a socially constructed phenomenon, but rather a real social institution. Fourth, the SND perspective eliminates or marginalizes discussion of the social role of science, focusing discussion solely upon science's relationship to economic growth (Drori 1997).

Because of these mechanisms, SND led to an environment in which the legitimacy of science was taken for granted. That creates large acceptance account for the expansion of science to a limit where the question of why science diffuses in the world would not be raised for decades (Schofer 2003). Thus, socially, there was no real questioning of the

value of science in society. This perspective will emerge when I show how science studies in the Arab world have viewed the problem of science in the region.

2.2.2. Dependency theory

Dependency theory offered a different approach to the role of science in developing LDCs. In the 1950s, Prebisch and his colleagues noticed that economic growth in advanced countries did not lead, as new economic theorists suggested, to economic growth in poor countries. In fact, the opposite occurred; economic growth in rich countries largely correlated with economic decline in poor countries. That led to the development of dependency theory. The theory, then, states that stunted development in LDCs is caused by their dependence on developed countries (Ferraro 1996). Thus, dependency theory offers a different narration of the development process than that proposed by modernization theory.

According to dependency theory, the national development of LDCs is significantly affected by external factors, since these nations depend on exchange relationships that serve the interests of advanced capitalist economies (Shrum and Shenhav 1993). The theory sees science (western science) as a mechanism of western domination over LDCs. Because of the continuing declining in classical colonial economic and political ties, domination through knowledge structures becomes vital (Goonatilake 1984).

With regard to the developmental promises of science for LDCs, dependency theory states that the SND model is unlikely to work effectively in these countries. Even when a

less developed country succeeds in producing “good” science, that science would not benefit the local economy, as it does in advanced nations (Hill 1987). Moreover, science produced in LDCs may help reinforce these nations’ dependencies because that science would be translated into technology devices by more advanced nations; the LDCs may produce the scientific advances but do not have the technological infrastructure necessary to exploit their own discoveries. Furthermore, since scientific activities are costly, the financial and human resources that LDCs direct toward scientific institutions could more practically serve local needs.

Finally, dependency theory argues that science is globally organized to produce knowledge that solves practical problems of the dominant core countries. Scientific institutions and elites in these countries determine the research agenda for international science (Shenhav and Kamens 1991). Science produced in LDCs is linked to that agenda more than it is to local needs (Shenhav 1987, Shrum and Shenhav 1993).

This perspective informs a core element of this study. To address the question of why locally produced science in LDCs has little local usefulness, one of the things that we must consider is how scientists in LDCs choose their research problems. Specifically, it is important to question the mechanisms and agenda(s) that determine scientific inquiry in LDCs.

Goonatilake (1984), citing Ramaseshan, found that the boards of referees in elite Indian science institutes—responsible for judging local works--were all foreigners. Thus, the

Indian scientists had to follow the rules and styles of scientists from abroad. The board of referee also determines the research problems for graduate work in these institutes, usually based on what appears in western journals. Thus, elite and productive Indian scientists end up researching problems that have no relevance to their society. They are part of a social network that is led and directed by foreign scientists and foreign journals. This arrangement isolates local science from national activities on one hand and creates dependency on western science on the other hand. LDCs scientists illustrate the mechanisms of such processes through their own experience. A leading Indian scientist, interviewed by Shiva and Bandyopadhyay, says:

“Whatever we do, we always look to the west and see what they are doing. Suppose I want a new subject, I go on looking through new journals to find out what are the new lines coming up. I suddenly see surface physics coming up and start working on it... We draw up projects by looking through papers in *Physical Review* etc. to find out what types of things are being done... You have to publish in these journals, so you must do something which they are doing. If you want to publish something in *Physical Review*, you will try and read *Physical Review* and try to do something like the work published; otherwise they won't publish your work” Goonatilake (1984: 102).

Scientists in LDCs produce scientific knowledge based on their involvement in foreign social networks. This point constitutes a core element of this study. One of the things that I plan to investigate is the social networks scientists in LDCs become involved in when choosing their research problems and the authoritative actors in such networks. Such networks could involve human and non-human actors, such as journals, associations, conferences, and so on. They are Latourian actor-networks. I intend to use actor-network as a method but not as a theory. Hence, I will briefly go over actor-network theory in the methodology chapter. I see actors in these networks as socialization agents. Describing the networks and identifying the actors could help us determine the source of norms and values that affect the work of scientists in LDCs.

Another aspect of dependency theory that works on explaining the failure of western science to perform developmental functions in LDCs is the issue of the contrast between the alien western science and local systems of knowledge¹. The area of local knowledge and western science and technology in LDCs is complicated. However, relevant to this study is the assumption of dependency theory that third world nations are more creative when approaching nature, or solving technical problems, through their own local knowledge than when they use western science to do so.

A simple example of this is the comparison Goonatilake (1984) makes between two types of knowledge production in the Philippines—local knowledge and western science. The first type is the knowledge produced by rural people through local knowledge systems; different rural Filipino groups have remarkable abilities to create knowledge appropriate to face new health problems, such as malaria, make use of new objects, such as new plants, and update current classification systems. Examples Goonatilake provides about these people indicate that they have not only rich knowledge systems but also dynamic ones that are able to face new problems and exploit new items. The second type of knowledge production is introduced through the R&D in a national Filipino firm that produces medicine through contracts with western firms. The firm's R&D is regarded as a “big” research center in the Philippines. However, the Filipino scientists, who are physicians and Ph.D.s, work in routine research, with most of the research

¹ Although developed by dependency theory, studies of local knowledge are currently not limited to dependency theory and development literature. The problem is discussed in constructivist and cultural studies of science as well. However, concepts of local knowledge in relation to western science were formed first by social anthropology in the early twentieth century (Leach and Scoones 2003).

focusing on taking samples and monitoring the quality of products. The same research has been done on these products in the United States previously, and results are well known; the research lacks creativity. Goonatilake concludes by stating that the production of modern science in these countries is static and uncreative, in contrast with the dynamic and flexible production of local knowledge in the same society at the same period of time.

The problem Goonatilake did not discuss is that the knowledge produced through traditional ways, despite its creativity, is not legitimized by the international organization of science, while the knowledge produced by the Philippine scientists gains legitimacy but lacks creativity. In other words, the authoritative manner of international science, combined with its ignorance of local problems, could be part of the problem of the limited usefulness of the science produced in LDCs.

2.2.3 Institutional theory

Although it does not precisely address the role of science in national development, the institutional theory of social organization, also known as world polity theory, deepens the debate. The main concern of the theory, with regard to science, is why science became institutionalized and globally diffused in the years following WWII; the theory's broader concern is the determinants of institutional isomorphism, wherein non-western countries adopt certain western structural forms.

Since the early 1990s, papers, Ph.D. dissertations, and lately (2003) a book have been written addressing the question. This trend has developed primarily in the sociology department of Stanford University. The rapid and dramatic expansion of science in the modern world raises a significant sociological question; however, this question has not seriously been examined. Exploring this void, institutional theory argues that SND's domination of the discourse on national development has led to that discourse's inability to question the utility of scientific expenditure. Institutional theory submits the national usefulness of science to empirical investigation, which leads to results that contradict many assumptions of the dominant belief that science is economically useful. For example, Shenhav and Kamens (1991) argue that the degree of institutionalized science has no effect on the economic performance of LDCs, while it positively affects the economic performance of developed countries. On the other hand, Schofer et al (2000) note that state-sponsored scientific research has a negative effect on national GDPs, while a scientifically sophisticated labor force has a positive effect. Drori (1993) finds that the number of publications in the hard sciences has no effect on a country's economy. These findings have led institutional theory to reject the positive straightforward relationship between science and economic growth and develop new explanations for how science expands and why nations commit to it.

Institutional theory, I argue, has two different forms of explanation: an earlier one and a more developed one. The earlier one positions the theory closer to the assumptions of dependency theory. The later shifts it to the other end of the spectrum, the modernization view. Early publications on institutional theory studies of science examined the assumed

hierarchical relationship between science and national development to see if that explains why science globally expands. As I mentioned above, empirical studies of institutional theory challenged the modernization model of SND. The early works state that the findings support dependency theory (Shenhav and Kamens 1991). Thus, Shrum and Shenhav (1993) see institutional theory as complementary to the dependency perspective of science.

More recent works of institutional theory on science suggest a larger role for science than that allotted by the SND model. These views see science as a general culture model (Drori et al 2003). This explanation of the expansion of science is contrary to the SND model not because the model gives false promises for LDCs, but because it deemphasizes the social role of science by limiting it to just economic development. Shenhav & Kamens (1991) and Shrum & Shenhav (1993) focus on the expansion of science in LDCs as a measure of adherence to world-system requirements to secure external legitimacy. They also explore how this process may divert attention from task performance. That is a cautious view of science.

Although Drori (1997) rejects the SND model, she encourages broadening the role of science: she sees it as a means for improving human rights, increasing political engagement, enhancing national data collection, and standardizing governmental work. In her construction, science becomes a ritual of modern statehood. Frank et al. (2000) find that science positively impacts the public consciousness, societal regulation, and the organization of the environment. Schofer et al. (2000) argue that a scientifically

sophisticated work force (but not scientific research) positively effect economic growth. Drori et al (2003) see science's role in modern society as analogous to religion's role in traditional society. While Shenhav and Kamens (1991) warn of the cost of isomorphism, Drori (1997) writes that "science is no longer for national development, but rather science *is* national development" (112-113). This conclusion could be seen as an expansion of the modernization view of the role of science.

In regard to the question of why LDCs do not benefit from their scientists' input, institutional theory seem to provide some interesting theoretical points. First, institutional theory repositions the main function of science in LDCs as a means to gaining international legitimacy. Second, the theory, in its dependency form, emphasizes the role of the international organization of science in determining the agenda of prestigious and cutting-edge science. Third, it draws attention to the negative aspects of the isomorphism process, wherein a successful existing model of the science policy of science institutions in developed nations serves as a model.

This study is about why locally produced scientific research in a LDC, Saudi Arabia, is not locally beneficial, using DPEs as cases. Thus, it is important to review science studies in the Arab world, which Saudi Arabia is part of.

2.3. Science Studies Discourse in the Arab World

Is it possible or appropriate to place studies of Saudi science into an Arabic context?

Arab states differ greatly in some developmental indicators, such as GDPs, standard of

life, and literacy rate. For instance, some Arab states have among the highest incomes per capita in the world, such as Qatar. In contrast, others, such as Somalia, are among the lowest. Some Arab states are probably considered at the top of LDCs in terms of producing science, such as Egypt and Saudi Arabia. Others, including Yemen, Somalia, and Mauritania, are at the bottom. Some raise doubts about whether it is appropriate to frame the Arab world with one approach because of the inconsistency of economic indicators.

However, Arab countries share important features. Culturally, language, history, and (for most Arab people) religion constitute the glue of a shared identity. Structurally, Arab countries are brought together by a major regional organization, the Arab League, and its sub organizations. In regard to science, there are the Arab League Educational, Cultural, and Scientific Organization (ALECSO). International organizations, such as the United Nations and UNESCO, also deal with Arab countries as one unit. In addition, there are regional associations, conferences, and workshops that discuss the issue of science in Arab countries. These organization and their activities have produced a body of literature about science in a regional frame. I rely on that literature to present the problem of science in an Arabic developing country such as Saudi Arabia.

2.3.1. Main producers of Science Studies Discourse in the Arab region (SSDA)

Literature that deals with the issue of science in the Arab world is primarily produced by three actors: governmental institutions, international and regional organizations, and groups of civil society institutions, including individual scientists and intellectuals. Each

actor produces distinctive literature in regard to science studies in the Arab region. For instance, the governmental literature on science and technology tends to be technical reports and studies that target policy makers, experts, and academia. This type of literature is produced by centralized national institutions, such as ministries for science and technology, or smaller institutions, such as universities and research centers.

The international and regional organizations look at the status of science and technology through global lenses, wherein they provide quantitative data about the productivity of science for each nation-state in the region. This data compares individual states to one another or compares the regional averages to other regional averages. There are two major actors of this type: international organizations, such as UNESCO and the World Bank, and regional organizations, such as the Economic and Social Commission for Western Asia (ESCWA) and the Arab League Educational, Cultural, and Scientific Organization (ALECSO).

The third type of scientific literature is produced by individual Arab scientists, intellectuals, or civil society institutions (such as research centers that are independent of governmental control). This type is more critical of the status of science in the region than the previous types. It aims to construct public opinion in regard to important developmental variables, such as science. It also aims to affect policy makers, academia, and experts. Moreover, it sees the current situation of science in the Arab World in a larger context, as part of the general political, economic, and cultural situation of the

Arab states. For this group, regional scientific failure in science is a symptom of the larger failure of the so-called *al-nahda* project or intellectual awakening².

At the heart of this project is the question of progress. Mohamed Sid-Ahmed, an Egyptian intellectual, summarizes the central question when he writes, “[a] question that has for long troubled me is why Japan ‘made it’, so to speak, while Egypt did not, although the two countries were at approximately the same level of development at the time of the Meiji revolution in Japan and the reign of the Khedive Ismail in Egypt” (Al Ahram news paper, 2000). Writers of this type see the nation-state’s cultural and social organization as responsible for the current status of science in the region.

These three groups are institutionally linked through conferences, workshops, publications, citations, and job contacts. It is common to see intellectuals cooperating with national institutions or international organizations in discussing the status of science in the region. For instance, the main editors of the Arab region’s early report of the United Nation Development Program (UNDP) were intellectuals.

These actors are networked through sets of arrangements that take the form of cooperation, citation, conferences, and workshops. They all contribute in producing (or constructing!) what I call the Science Studies Discourse in the Arab region (SSDA).

Given the varied nature of its participants, there are considerable variations and perspectives within this discourse. Some participants are more critical of the current

² Al-nahda refers to an intellectual project that started in Egypt in the 19th century. It called for progress and development that would transform the regional societies, enabling them to become as developed as the Europeans.

situation than others. Some produce technical writings that only shallowly investigate the reasons underlying the Arab World's scientific evolution, as I will show later. In the coming section, however, I will go over the main characteristics of this discourse, focusing on how it sees the current status of science in the region, the developmental role of science in their societies, how it explains the current status of science in the Arab region, and where it stands in terms of the theoretical approaches discussed above.

2.3.2. SSDA: Some characteristics

The most obvious characteristic of SSDA is the philosophical consistency that frames its discourse. SSDA is epistemologically grounded in a very utilitarian view of science; it sees science as economically and socially useful and, hence, a desired expenditure. In essence, SSDA is based in a modernistic view of science, which gives science an unquestioned legitimacy, and praises its social and cultural role. This can be contrasted with the postmodern view of science, characterized by the constructionists of SSK, which can sometimes cynically analyze science through the lens of its actors' negotiations or interests. Also, there are not views that would discuss the authoritarian nature of western science and how that affects its interaction with local knowledge of developing societies, like that of dependency approaches. Moreover, there are no discussions of science as a source of legitimacy for nation-states, as the Stanford school of social organizations argues. That perspective, however, is to be expected from societies that are seeking development and perceive science as a vehicle for progress.

Even when SSDA intellectuals discuss the fears of some philosophers regarding the negative social role of science, they tend to defend science. Fergani briefly addresses Bertrand Russell's fear of the role of science in reinforcing the power of dominant groups, but concludes that "history also tells us that science has contributed to empowering the weak" (1999: 2). The language that dominates the SSDA usually focuses upon the promise that science holds for societies that succeed in producing and using it. Also, it is interesting to note that the language used to reinforce the legitimacy of science in these literatures usually uses the economic indicators of advanced societies (such as GNP or income per capita), comparing them to those of developing societies. This technique is aimed at associating these economic facts with the diffusion of production of science in advanced wealthy nations.

Another characteristic of SSDA is its emphasis upon providing a quantitative portrait of the position of science by using traditional quantitative measures of scientific activities, such as productivity (publications, citations, patents, and rewards), expenditure on R&D/GDP, number of personnel in R&D per 10,000 people, and average yearly productivity of individual scientists. SSDA supporters then compare these indicators to other regions and countries, particularly advanced nations. These statistics are published by national, regional, and international organizations that are known for their expertise in covering science activities, such as ESCOWA, UNESCO, UNDP, NSF, SAS, and so on. Thus, SSDA covers what is known as institutionalized western science. It is important to note, in this matter, the authoritative status of the ESCOWA and UNESCO reports of

science indicators in the region³. These reports, along with UNDP yearly reports, are the legitimized references on SSDA to assess the current situation of science in the region.

Since SSDA assumes the usefulness of science, and since production of science in the Arab world is low compared to that of advanced and newly industrial nations, one might expect that SSDA would be critical of the weak performance of science institutions in the region. The governmental documents criticize the situation by letting numbers speak for themselves. For instance, in 1996, the King Abdulaziz City for Science and Technology (KACST), the central Saudi department of science and technology, published a huge report titled “Studies of Current Situation of Science in Technology in Saudi Arabia.” When the report states the numbers of publications, citations, patents, and personnel in R&D/1000 of population, it repeatedly reminds the reader about averages in selected countries⁴.

Individual experts and intellectuals use harsher language. Fergani (1999) writes that “The dilemma, however, is that the institution of science tends to be grossly underdeveloped. . .It tends to be even less developed than other aspects of human existence. . .This should not be surprising. Science has generally been one of the ‘finer,’ and more expensive, facets of human societies. The ‘crisis’ of science in less developed countries is a frequent narrative” (2). It is important to note that Fergani is known as both an intellectual and an

³ Subhi Qasem prepared two reports (1995 and 1998) for UNESCO and ESCOWA titled “Research and development system in the Arab states: development of science and technology indicators.” These reports are usually mentioned as either the UNESCO report or the Qasem study.

⁴ The selected countries are the same countries mentioned in UNESCO reports. That would reinforce previous assumptions about the international organization authority in standardizing national or regional science and research activities.

expert in development. Thus, the language he uses to describe the situation reflects the intellectual side of SSDA. However, an important question is how the SSDA explains the current situation of science in the region. Why is the institution of science in the Arab world weak, according to SSDA?

2.3.3. How SSDA explains the situation

SSDA has a variety of explanations for the current situation of science in the Arab world. Mainly, the reasons provided are expenditure on R&D, education systems, science policy, key-turn mode⁵, and weak relations of universities and local productive sectors. In the coming section, I will show how SSDA introduces and analyzes these reasons.

2.3.3.1. Expenditure

The most common statistic that one sees in SSDA literature is the financial resources that states allocate to scientific research. In the Arab world, the average rate of R&D spending as a percentage of GDP is 0.2, compared to a world average of 1.4. Table 2.1 summarizes the situation.

SSDA strongly calls for increasing expenditure on budgets for scientific research. This suggestion emerges in national governmental reports (KACST), regional and international organizations' reports (ESCOWA & UNESCO; UNDP; World Bank), and individual scientists and intellectuals' writings (Zahlan, Fergani, and others). Hence, it is

⁵ Although the literature of SSDA usually mentions science policy as one of the reasons, the only complete work in science policy in the region was written by Zahlan. Key-turn mode is a factor that was developed by Zahlan. However, late works of SSDA start mentioning key-turn as a reason.

expected that any science policy, writings, lectures, and presentations about science in the region would see the shortage of expenditure as a main cause of the current scientific situation and recommend an immediate increase in national scientific expenditures.

Table 2.1: Rate of expenditure as a percentage of GNP and sources of R&D funding: Arab states compared with selected countries, 1990-1995

Region or group of countries	Average expenditure (% of GDP)	Average share of funding sources		
		Government	Industry	Other
US, Japan, Sweden	3.1	20-30	55-70	4-10
Germany, France, United Kingdom, Italy, Australia and Canada	2.4	38	52	10
Greece, Portugal and Spain	0.7	54	35	11
Turkey and Mexico	0.4	65-73	14-31	5
Arab states	0.2	89	3	8

Source: UNDP report, 2003.

With regard to the academic side of SSDA, Algahtani (2004) reviews 38 Arabic academic papers that consider funding for scientific research in Arab universities. All of them conclude that there is a shortage in funding for scientific research; all go on to note that this shortage is a factor in the low research output of faculty. A presenter in a regional conference on SCIENCE AND TECHNOLOGY in the Arab world states in one of his slides that “Arab countries shall target a minimum of 1% of their entire GDP for R&D by the year 2005-2010” (Badran 2003).

Even governmental plans aim to increase scientific research budgets. In 1996, the Ministry of planning and KACST in Saudi Arabia announced a 20-year national plan for

science and technology. The target of this proposal was to increase the country's R&D expenditure from 0.2% of the GDP to 1.6% of the GDP by 2020.

Interestingly, I found only one SSDA reference that argued against a large state expenditure on science. In 1978, a Proposal for Establishing an Arab Fund for Scientific and Technological Development (PEAFSTD) was presented to the CASTARAB follow-up committee. PEAFASTD warned that there was a "possible negative impact of a large expenditure on SCIENCE AND TECHNOLOGY if, given the many constraints in a backward society, a too ambiguous or simply inappropriate program led to the diversion of scarce resources, to indifferent results, to the accumulation of unused, and sometimes unusable, knowledge, or to the accentuation of the brain drain" (PEAFSTD 1978:16-17). This piece of literature goes against the common direction of SSDA. However, it is easy to see how dependency theory might frame such an approach.

2.3.3.2. Education

Another reason for the weak performance of the institutions of science, according to SSDA, is the educational system. The educational system has been accused of failing to prepare a skillful scientific work force. Literature on the subject has emphasized the relationship between education system and scientific capital, as mentioned above. Higher education is often seen as a direct factor in preparing manpower for scientific research and development. However, its success or failure in this goal relies on primary and secondary education, as the quality of this level of education determines the quality of higher education. Lundvall (1985) developed an approach for a National System of

Innovation (NSI) in LDCs, in which he regards the education system as one of the three required spheres for working NSIs; the other two are a production sphere and a research sphere. Zahlan (1999) sees effective educational institutions as the first element required for establishing a successful system of science and technology.

Education has greatly expanded in the Arab world during the past five decades. However, student averages in the Arab world are lower than world averages, although they are ahead of some regions such as sub-Saharan Africa. Illiteracy rates have decreased from 71.2 % in 1971 to 36.9% in 2000, compared to world averages of 36.6% in 1971 and 20.3% in 2000. However, some states, such as the Gulf States and Jordan, have had remarkable success in this matter, although their rates are less than the world averages (ALECSO 2004).

Higher education has expanded in Arab countries. In 1950, there were only 12 universities in the Arab world; by 1995, the number had increased to 175 (UNESCO, 1998). As a result, the enrollment of youth in higher education has increased. According to UNESCO's report (1995), the annual growth of student enrollment in higher education during the years of 1985 to 1991 was 4%; 37% of them majored in science and technology. In 1995, enrollment rates were 1,017/100,000 of population. The highest was Jordan, with 3,311; the lowest was Somalia, which had 99. By comparison, rates in Brazil were 1,074, in Mexico 1,552, and in Argentina 3,293 .

Because of its primary position in development discourse, the qualitative aspects of education form a critical component of SSDA. The 2003 UN human development report on the Arab world states that “the general condition of education is still unfavorable. . .” The report concludes that “Arab education falls far short of human development needs” (UNDP: 52). BouJaoude (2003) states that the two major problems facing science and technology education in the Arab world are access to and quality of education. In 1979, ALECSO developed a strategy for the education system in the Arab states. The strategy recommended re-writing education policies in light of national economic and scientific policies. According to Zahlan (1999), no Arab state implemented this suggestion. Moreover, Zahlan states that education policy makers were not aware of the relationship between education systems and work spheres. Therefore, Zahlan criticizes the weak coordination of education systems with the job market. However, some publications consider the weak expenditure on education as a factor in this matter (Fergani 1998, 1999).

In contrast, Shafik (1994) states that the Arab regional expenditure on education is the highest in the world. His argument is based on the fact that Arab states spent 5.2% of their GDP on education in 1990, compared to 4.9 % in industrial nations and 3.9 % in developing nations. According to Shafik, the problem lies in a weak linkage between education and the needs of job markets. To conclude, SSDA illustrates that the education system in the region does not produce a sufficiently skillful scientific workforce.

2.3.3.3. Science Policy

Many SSDA publications consider governmental science policy as the central explanation for the current situation. Although many Arab states have developed national science policies and built scientific institutions, and although many SSDA publications blame the absence of an effective science policy for the current science situation, there is, to my knowledge, only one book about science policy in the Arab world. This book, by Zahlan, is highly cited by SSDA and has had five Arabic editions. In his extensive works about science in the Arab world, Zahlan provides a theory that explains the situation I will review Zahlan's works, as they constitute a distinguished contribution to SSDA.

Zahlan thinks that the status of science in a certain nation depends on national science policies. It is important to note, however, that Zahlan defines science policy as not only policy for developing national scientific research, but also as a means of propelling societies into modernity, a source of economic wealth, and a means to translate the work of scientists into economic devices.

Zahlan focuses on two major components of national policy for science: institutions and strategies. In regard to strategies, Zahlan analyzes some Arab states' strategies, giving special attention to the Egyptian's, which was put forth by the Academy of Scientific Research and Technology in 1977. Zahlan describes the document, saying:

“The document in fact exhibits none of the basic items one expects to find in a strategy; the pathways that are selected to attain the policy objectives, the means and measures that are to be utilized, the inter-mediate phases in the unfolding of the strategy over the following two decades, and most importantly, the measures that have been adopted to launch this strategy, are all lacking. The document exhibits a popular style of expressing issues which one could call strategy-by-objective. For example, the document refers to the need for information, laboratory equipment and manpower. Yet it does not provide any information on how, when, by what means, to what extent and according to what priorities these needs are to be met” (172).

What Zahlan observed in the Academy's strategy was reflected in the actual work of scientific committees and teams. Fifty-three percent of committees either have no members or did not meet in 1977, the year after the policy was approved. Although the policy calls for developing the vertical development of agriculture through mechanization, the Academy has funded sixteen agricultural research projects, none of which studied the problems of mechanization. Such behaviors do not allow for the successful applications of science policies.

In regard to institutions, UNESCO, through regional organizations and conferences in the third world, has become the major molding force of establishing national Science Policy Making Bodies (SPMB) in the developing world. In the Arab world, SPMBs started spreading in the 1960s and 1970s, after regional conferences and meetings. In these gatherings, most of which were organized by UNESCO, UNESCO acts as what Finnemore (1996) calls a "teacher of norms." In some countries, independent institutions for science and technology had been established. These institutions differ from one country to another, and their titles vary, including ministry, counsel, foundation, and so on. In others, science policy is the responsibility of the ministry of higher education or the ministry of planning. Investigating cases of SPMBs in Egypt, Lebanon, and Syria, Zahlan states that they suffer problems that made it difficult for them to successfully develop efficient science policies. The most sophisticated experience in the region was the Egyptian; thus, the book offers a deep analysis of its SPMBs and their strategies. For instance, Zahlan observes eight major SPMB structural changes in Egypt between 1956 and 1976. These changes have negatively impacted the functional performance of these

institutions. For instance, “[p]rogram started under one SPMB may suddenly be terminated by a subsequent one... individuals and institutions become discouraged by the uncertainties of policy and support” (164). Moreover, the nature of the relationship between the executive authority in the Arab state and SPMBs weakens the role of SPMBs in national scientific activities. For example, Zahlan describes cases wherein the Egyptian president orders his personal scientific advisor to conduct executive scientific actions and national projects. According to Zahlan, such activities marginalize national SPMBs and make them irrelevant with regard to significant science policies issues. Zahlan concludes that establishing SPMBs according to the UNESCO model has failed in the Arab region, partly because of surrounding circumstances and low funding.

Zahlan suggested two main reasons for the current state of science in the Arab world: the low expenditure on science and the dependency on foreign firms in the Arab world for building and consultation. He named the later factor the turn-key mode in most of his works and developed it in his latest book, *Science and Technology in the Arab World: Progress Without Change*. In the coming section, I will go over Zahlan’s theory, which I see as the most developed theoretical contribution of SSDA.

2.3.3.4. *The Turn-key mode*

Zahlan (1975, 1980, 1984, and 1999) sees the turn-key mode as the main cause of the failure for developmentally useful science and technology systems to emerge in the Arab world. By “turn-key mode,” Zahlan means the continuing tendency of local governments and investors to give their projects to foreign firms, or to keep them locally owned but use a foreign workforce to build them. This process is a historical one. According to

Zahlan, since the time of the Egyptian governor Mohammed Ali in 1810, policies for achieving modernity and development in the region have focused on *importing*. For example, Arab countries have imported foreign equipment, workforce, technicians, consultants, and so on. This method of development has had a devastating impact on the development of a useful system of science and technology. The story starts with governments' wishes to benefit from European advancement in the 19th century. However, Arab governments did not work to develop a national work force that would produce what the advanced nations had. Instead, they kept relying on foreign services and products, through the turn-key method. This created technological and economical dependency. Zahlan writes:

“When either a government or an individual investor wishes to erect a dam, construct a harbor or a sugar plant, or establish a modern army, the methodology for doing so is self-evident. Officials appear to assume that those in the know are the best experts to contract for the job. Science and learning are too slow and appear to be marginal processes totally divorced from the task at hand. In some Arab bureaucracies one repeatedly hears that they are tired of studies and plans; they want turnkey projects, they want results. . .technical institutions often merely specialize in compiling ideas generated by consultants; and after securing approval for an idea, foreign firms are either invited to prepare a feasibility study or asked directly to execute the project on a turnkey basis. Foreign firms have visible or invisible local agents who perform the necessary public relations work. Between this world of development and the community of science there is virtually no transaction of communication whatsoever. University professors of chemical engineering and biology are not informed or consulted” (18-19).

The above text illustrates some important points. First, there is a mentality of doing things, a culture of how to accomplish the highest efficiency. This culture represents itself every time a country decides to conduct projects that require a working system of science and technology. Remarkably, this mentality has reproduced itself for two

centuries. In later works, Zahlan developed his theoretical frame, in which he explores how this behavior links with the rentier political economy. Second, the text points out a very important mechanism of this reproduced process. The turnkey mode produces complicated social forces (local agencies) that specialize in and benefit from trading and transformative technology. In another book (1984), Zahlan points out that some Arab countries in the 1970s and 1980s changed their laws several times to raise the share of their local agencies of foreign firms from governmental contracts with these firms.

Meanwhile, no serious laws were adopted to require the sharing of jobs or the development of a national work force in these contracts. These agencies work as bridges between the state and foreign firms. It is obvious that the local agencies are powerful enough to influence the state to recognize their interests during the phase of building infrastructure. These interests reinforce the turnkey mode, work against the local acquisition of technology, and discourage the growth of a local scientific work force.

It seems that, in the past three decades, some Arab countries have experienced dramatic positive changes with regard to the production of science. Although science has been expanded in the relatively rich Gulf Arab states, there were no links between locally produced science and the national economies of these states because of their heavy dependence on *buying* technology, with its workforce and projects, from abroad. Zahlan (1999) predicts that production of science in these states would exceed that of Asian tigers countries. The real challenge for this produced science, he states, is linking it with national and regional economies. In his latest book, Zahlan attempts to frame the

continuation of the turnkey method theoretically. He sees that method as a product of the rentier political economy in the region. The liberation of Arab countries from the turnkey situation can occur through the development of an effective policy for science and technology. These policies must build upon an accumulated knowledge of the nature of the regional political economy.

In conclusion, Zahlan provides a theory for science and technology in the region. Simply, his theory states that the problem is not the scientists' fault, nor is it a failure of international science organizations. Rather, the shortcoming lies in the mistaken definitions of development. The current attitude sees development as *buying* technology, not *transferring* it. Thus, Zahlan's works are obviously built on the modernization theory approach toward science's role in development. However, for Zahlan, this role is conditioned by effective science and technology policies. Some of the major questions that this study will investigate concern the role of the turnkey mode in the weak relationship between science and the productive sectors in the region. Thus, it is important to review the SSSA literature on that relationship.

2.3.3.5. Weak relation between national universities and local productivity sectors

The core question of this study, which uses Saudi Arabia as a case study, is why science produced in the Arab world contributes little to local needs. Most of the science produced in the region takes place in universities. Hence, it is important to review the literature that investigates the relationship between university research and the larger society.

In the literature, there is a consensus regarding the relationship between universities and the productive sectors in the region; all studies in this matter conclude that the relationship is weak (Alsultan 1994; Alghatni 2004). This is a known fact, and regional universities are aware of it. When surveyed in 1992 about serving their communities, most presidents of the Gulf State universities saw their institutions' top priorities in that regard as providing technical assistance and applied research (AlSenpel & AbdulJawad 1993). Despite that perspective, current writings emphasize the weak relationship. In the coming section, I will go over these studies⁶, focusing on what they see as reasons for that weak relationship and how to strengthen it.

Although some of these studies discuss the issue in the whole region, most of them are limited to Saudi Arabia. Minfikhey (1988) found that faculty members at King Saud University felt that they suffered a weak relationship with public institutions and national firms. Thus, he recommended that the university establish a department for facilitating cooperation between the productive sectors and the local scientific community. Fhmmei (1993) studied the research, consultations, and training offered by Gulf States' universities to the service and industrial institutions in the area. His results indicate that cooperation between the two is weak and limited to training programs. There are few consultation and research activities. Meanwhile, universities do not attempt to benefit from expertise in these institutions. Hence, he recommends that universities should adopt open systems that link universities with their surrounding environment and allow them to address local needs. Such a system would emphasize useful applied research. Moreover, he urges universities to cooperate with economic and industrial institutions to benefit

⁶ All these studies (except KACST's) are taken from Alsutlan (1994) and Alghatani (2004) dissertations.

from these institutions' abilities and help them through solving their technical problems. Obviously, Fhmmey's analysis indicates that universities are partially responsible for the weak relationship.

Furthering the exploration of the university/society relationship, Alsenpel & AbdulJawad (1993) studied the roles of Gulf States universities in serving societies. This study produced important results. It found that most faculty consultation services (72%) in Gulf States universities go to governmental departments. Sixty-six percent of applied colleges (such as agriculture, medicine, and administration) do not conduct research with service and industrial institutions. Big national firms prefer to seek consultation from foreign institutions.

Saeg and others (1995) evaluated the academic work in King Saudi University. They found that the university research centers do not do enough work to strengthen their relationship with institutions in the universities, nor do they work to develop science policies that focus on bridging the gap between scientific research and local needs. Also, they stated that the university lacks strategies to link scientific research with society developmental issues and to coordinate scientific research with national universities. Furthermore, academic departments do not announce or market their scientific achievements to the local environment. On the other hand, they are not effective and serious in providing consultations to local institutions, which make these institutions seek foreign consultations. Alsharouk (1997) recommends that Arab universities should make use of and market their scientists' patents. Almutrif (1996) finds that 78% of industries in

his sample do not have any idea of what scientific researchers are doing. Eighty-seven percent of the faculty in his sample expressed a desire for scientific research centers to announce and market their activities among industrial, agricultural, and service institutions. According to Aldbasi (1998), university scientific research was not linked with national development plans.

Turkistani (1998) studied the experiences of the scientific research council in King Abdul Aziz University. He found that the council does not conduct any kind of activities to market university-funded research. Also, he indicates that the university has no department or efforts to explore local problems in order to direct funded research projects. One of the problems facing universities in their aim to be open to society is the bureaucratic limitations and centrality in administration. Turkistani offers an interesting recommendation: that the university establish a center for marketing research. Such a center would be academically and financially linked to the university. Ukasha (1999) studied the problem of funding scientific research in the Arab world. Among his most important findings was that the funding projects of scientific institutions (central scientific institutions and universities) do not correspond with the needs of local productive sectors.

In 1990, the Saudi Council of Treasure (SCT) published a study about its experiences with research centers. The study illustrates that the relationship between SCT and research centers suffers a lack of cooperation and integration in regard to the exploitation of produced research. SCT suggested a number of factors that influenced this problem,

among which was the weak communication between the two and SCT's lack of trust in the abilities and expertise of national research centers. Nuaimy (1999) suggested that the low level of non-governmental funding for scientific research is partly due to the weak ties between the producers of scientific research and those who supposedly benefit from it. Fayed (2000) indicates that there are enormous bodies of applied research conducted in Arab universities that nobody makes use of because there is no coordination between offers and demands. Also, he finds that there is no centralized effort for planning and preparing research projects in Arab universities. Moreover, economical arrangements for scientific research are absent. Thus, universities keep producing research for which there is no demand.

KACST (2001) conducted a huge survey of science and technology indicators in Saudi Arabia. The survey found that 38% of R&D centers had a mechanism to measure the societal benefit of their work. The survey comments, "that mean[s] 60% of these centers have no clear vision of what their role in the society is" (54). The reasons for the weak relationship between these centers and universities are no different from what has previously been stated, but one cannot underestimate the influence of firms' preference for foreign consultations.

Al-Zahrani (1997) questioned faculty members at Saudi Arabia's Umm Al-Qura University about the factors that negatively influence their productivity. Some members complained about the low demands, underestimation, and sensitivity of the society toward scientific research.

Other group of studies emphasized various patterns of problems at universities that negatively effect the research mission of the university in Saudi Arabia. Alsalem (1999) and Khateeb (1996) state that there are coordination and network difficulties among Saudi universities. Turkistani (2002), Mahboob (2001), Sane, (1996), and Munifikhey (1989) state that faculties point to difficulties in getting opportunities for attending conferences and workshops abroad or lack of encouragement to do so as obstacles for being networked with global science. Weakness of universities' library systems in terms of updating, supplying with books and periodicals, linking with national and global data bases have been emphasized by Turkistani (2002), Kana'an (2001), Khudair (1999), Lal (1998), and Alsulimani (1996). The low funding of universities to research activities is a common problem that many studies point to such as Alghatani (2004), Kana'an (2001), Seam (2001), Aisawi and Dakheel (1999), Alsalem (1999), Khudair (1999), Aldawood (1996), Alsulimani (1996). The lack of appropriate environment is also mentioned by some studies. Seam (2001), Khudair (1999), and Ageeley (1984) found that there was lack of competition among universities and faculties or absences of scientific societies are factors on weakling the research activities within universities. Ageeley (1984) also point to the low translation from foreign languages into Arabic as barrier of research activities for some faculties. The universities weakness of marketing their faculties' researches has been also studied, Nuaiemi and Numan (2000), Turkistani (1999). And, the lack of research assistances and labs technicians were also mentioned by some researchers such as Turkistani (2002), Seam (2001), Alsalem (1999), Khudair (1999), Munifikhey (1989).

Two things can be said about the above studies. First, it seems that consciousness about the issue, both individually and institutionally, has gained increasing importance recently. Obviously, there is a growing number of articles on the issue. In 1994, Alsultan found only two studies that discussed the relationship between university and industry. Ten years later, Alghatni reports thirteen studies that have touched on the issue. That is not surprising, as both higher education institutions and the profession of science have developed in the country and have started seeking broader roles and greater social significance. In 2000, KACST started working on developing national science and technology policy for the country. During the process of preparing the policy and after announcing it, KACST hosted many forums to discuss the developmental role of local science. These activities have raised the profile of the issue and transformed it into a topic for academic research.

Second, it is possible to identify three root causes of the weak relationship: 1) the tendency of firms to seek foreign consultations for their technical problems, due to their distrust of the ability of the national scientific force; this is what Zahlan calls the turnkey mode; 2) the weak efforts of universities in marketing their scientists' work to local productive sectors, coupled with their failure to direct their scientists' research to address local needs; 3) the alienation of scientists and isolation of their professional capital, which Al-Zahrani noted (1997).

Third, all these studies are built in the epistemological base of SSDA, which believes in the efficacy of "science for development." The question that these studies focus on is

how to make use of locally produced science; they do not discuss institutional theory or cultural studies, nor do they consider the relevance of theories about the role of science in developing countries. Therefore, when these studies investigate reasons for the weak relationship between locally produced science and local needs, they look for factors in the arrangement of local institutions, in productive institutions' lack of confidence in the local scientific work force, or in research institutions' failure to market their science and communicate with local productive institutions.

These factors are, surely, important. However, there have been no studies questioning the organization of international science and its relevance to the problem. No studies have considered the institution of global science's criteria for evaluating "good" and "bad" science and whether or not these criteria produce a value system among scientists that marginalizes the local needs of developed societies. No single study asks why states are committed to science, as institutional theory does. Also, none of the above studies research factors outside the realm of scientific and productive institutions, as Zahlan does when he studies the turnkey method for evaluating governmental and industry behavior.

2.3.4. Critique of SSSA in light of dependency and institutional theory

As mentioned above, there are three actors who contribute in producing the SSSA—international organizations, governmental agencies, and individual scholars. All these actors take for granted the developmental usefulness of science. There were no doubts of the benefits of expanding scientific research or increasing expenditure on R&D, except the PEAFASTD study, which was formed based on the dependency approach of science

and was unique in SSDA. Interestingly, there have been no works accumulatively subsequently done based on that study. In other words, the study did not succeed in establishing a trend in SSDA, despite the fact that the low usefulness of science was clear and the problem was discussed in much literature. The reason might be the low influence of social science on SSDA.

However, international organizations, such as UNESCO, World Bank, and UNDP, seem to dominate the whole discourse and construct it. They set the evaluative criteria, such as number of publications, number of citations, expenditure on R&D, patents, number of personnel on R&D, and research productivity of personnel on R&D. The other two actors follow these criteria and evaluate the status of science based on it. That should not be a surprise. International organizations are powerful and act as norms creators and policy advisors globally, especially in developing countries. Finnemore (1993) shows the role of UNESCO in teaching states how to *successfully* establish a science system. However, Finnemore's study raises important questions about the ability of a model built according to external design to meet internal needs. Through its designs, advice, and evaluative criteria, UNESCO could be a main part of the problem, despite its huge efforts to help LDCs to build science systems. However, UNESCO, the major actor in producing SSDA, is a legitimized actor in such a way that no study would consider it as a factor in the failure of science policy in the region⁷.

⁷ Zahlan (1980) briefly mentioned that the UNESCO model of central planning for science activities was the reason for acceptance by Arab states of that model. Had UNESCO advice, Zahlan states, concentrated on quality of research institutions, scientific activities, and academic freedom, the advice may not have been adopted.

The SSDA emphasis on scientific activities indicators makes the discourse focus on questions such as why scientists' productivity is low, or why the expenditure on R&D is weak. I do not doubt the importance of these questions. Neither do I doubt the significance of the above indicators in explaining the situation of science. What I am critical of is the dominance of these indicators. They dominate the SSDA literature to the extent that other aspects of science have been ignored, including the usefulness of science. Focusing on such indicators makes SSDA appear to blindly believe in what Hill (1987) calls the "cargo cult of science," where one believes that more science leads to development and growth. Even studies of science/industry relations do not, as I mentioned, question the usefulness of local science. Zahlan (1980) mentions that some sociologists say scientists of LDCs prefer to publish their works in international journals; thus, they select problems of advanced societies. However, he rejects this statement, arguing that even when LDCs scientists produce locally useful science, their nations do not use it, focusing on the turn-key as the reason for the limited usefulness of locally produced science. Zahlan's opinion could be due to two factors. First, he does not want to blame science and scientists, as that might make him seem anti-science. Second, he believes that the cause is located outside the science arena; it is the turn-key mode.

However, here a question arises. Why do the two actors follow the criteria of international organizations⁸? It is easy, based on institutional theory, to understand the behavior of governments. Institutional theory states that science is an important component of the modern state. It is one of the credentials of the current nation state in

⁸ I should exclude Zahlan from such tradition since he mentioned the challenge of linking local science with national economies.

the modern world system. Since science was promoted through global normative pressure and not based on internal demands, the advice of international organizations would be followed and would be seen as appropriate.

In regard to intellectuals, the answer is not clear. However, Arab intellectuals see themselves as an enlightening force in less developed societies. But the situation of Arabic science, based on these indicators, is dismal. Relying on these indicators to determine the low contribution of science to local development allows the avoidance of questions about the usefulness of the already produced science. However, Drori (1997) indicated that the SND model, which appears in international organizations' views of science, is powerful and persuasive. I think the isolation of science from local needs and the ignorance of modern science toward local knowledge are factors affecting the current situation of science in the Arab region.

2.3.5. Conclusion about SSDA

In presenting the problem of science, SSDA's focus on low productivity, low expenditure on R&D, and ineffective science policy has marginalized the question of connectivity of locally produced science. However, studies that address the point state clearly that locally produced science makes only limited contributions to local development. Such science is not connected with the local economy. These studies tend to locate the causes of this phenomenon in 1) the weak abilities of local universities (as major sites for producing research) in marketing their scientists' works and 2) the tendency of local firms to seek foreign help. Despite its significant importance, the latter point has not been theoretically

developed; neither has it been empirically investigated. Moreover, the theoretical works of Zahlan in this matter do not investigate specifically the situation of university/industry relations. That local productive sectors rely on foreign services has not actually been demonstrated.

The studies of SSDA that examine the weak relations between university and productive sectors suffer the lack of three related factors. First is the role of the international organization of science in the problem and how, by concentrating on the state of the art as a major criterion by which to judge scientific works, it marginalizes the applied problems of developed societies. Second, and related to the first point, is the type of technical norms (in Mulkey's definition) scientists in LDCs adhere to when choosing their research problems and how these norms may separate the potentially gifted contributions of these scientists from their surrounding environment. Both points were illustrated in the dependency theory section of this chapter. Third is an empirical investigation of Zahlan's assumption about the turn-key mode, or what most studies call the tendency of local firms to seek foreign help. Although most studies of SSDA that aimed to research the problem of connecting science to local needs have mentioned productive sectors relying on foreign technical services, I found no empirical investigation of this reliance. Further, I found no attempt to use (and develop) Zahlan's theme of the turn-key mode as not only a limit to the development and use of the local scientific work force but also as a culture that governs the behavior of decision makers. In this study, I intend to investigate the above three points, the first two through questioning scientists and the third through

interviewing related personnel in local industry. In the coming chapter, I will illustrate how I will approach such questions methodologically.

2.4. The sociological approaches to science

There are two main sociological approaches to studying science, the institutional sociology of science and the sociology of scientific knowledge. Both these sub-disciplines were developed in the west, mainly in the United States, the United Kingdom, and France, where science is produced in great abundance and plays vital social roles. But science in LDCs has unique sociological problems that distinguish the scientific field in these societies from that in advanced nations. These problems have not received the attention of both sub-disciplines. In fact, the issue of science in LDCs has been sociologically investigated by another discipline—the sociology of organization, through institutional theory. The dependency theory also has produced an interesting approach to science in LDCs. In the coming section, I will briefly review the two traditional sociological approaches to studying science.

2.4.1. Institutional sociology of science

Robert Merton is widely considered as the founding father of the sociology of science. Merton concentrates on studying the social structure of science instead of focusing on “social contexts that influence its substantive output of knowledge” (Storer, 1973). The first work in studying the social structure of science, or in the institutional sociology of science, was Merton’s article “A Note on Science and Democracy,” which was published in 1942 (titled in more recent printings “The Normative Structure of Science”). Merton succeeds in developing a framework of concepts, tools, and a program of research for the

sociology of science. As one of the leaders in the development of American functionalist sociology, Merton developed the research agenda of the field of the sociology of science from this theoretical perspective.

Functionalism is rooted in Durkheim's work in solidarity, Weber's work in legitimacy and religion, and nineteenth century utilitarian philosophers. Some of Merton's contributions to the sociology of science are his works in Puritanism and the rise of institutionalized science, normative structure in science, the reward system in science, and the Matthew effect. Merton's program in the sociology of science emphasizes the institutional environment of science, such as norms, values, and the reward system.

Hess (1997) distinguishes between two groups in the sociology of science. First is the Columbia school, which includes Merton, Zuckerman, Cole, and Cole. This group looks at science as a social institution that "worked well." The other group was a network of different schools--Wisconsin-Berkeley-Cornell. This network included Collins, Hagstrom, and Hargens, who developed a critical view of the institution of science emphasizing the race and gender inequalities within it. Nonetheless, a major area of the sociology of science is the reward system of science.

While this study does not investigate the reward system per se, I use Merton's work on the reward system to provide a description of the motivations for producing science in Saudi academia. I will go over some of the features of reward system studies in the sociology of science.

2.4.2. The sociology of scientific knowledge (SKK)

Since the late 1960s, a new trend in the sociological study of science has emerged, later named the sociology of scientific knowledge or SKK. While the sociology of science is concerned with the institutional arrangements and contextual aspects that enable science to exist and function effectively, the SKK is concerned with the content of scientific knowledge. It aims to open the “black box” of science. (“Black box,” in science, means any device for which its input and output are investigated while its content is not.) SKK is one of the most interdisciplinary subfields in sociology; history and philosophy contributed heavily to the development of SKK.

The story of SKK is like the story of postmodern studies, where fields are highly controversial and theoretical trends go in different directions. Unlike the sociology of science, there was no founding father for SKK, but multiple founders who differ in their views and methods. SKK emerged as a result of European writings that attacked the institutional sociology of science. While the institutional sociology of science examines the structure and development of science, SKK focuses on the social construction of scientific knowledge. However, SKK is highly controversial; four major different theoretical trends have emerged within the subfield of SKK. These trends are actor-network theory (ANT), strong program, discourse analysis (DA), and social construction of technology (SCOT).

Elements of both major theoretical traditions are being used in this study, as I will explain later. In the following section, I will go over the theoretical pieces of the sociology of science and SKK that frame my study.

2.4.3. Ben-David and the social organization of science: A Weberian-Mertonian approach

Ben-David is a sociologist of science who has a modified Mertonian approach to the sociology of science. Ben-David's theoretical frame is influenced by the work of both Merton and Weber (Shapin, 1992; Mann, 1993). Barber (1979) says that the uniqueness of Ben-David's analysis is in his ability to combine concepts of both structure and process. Some sociologists, like Freudenhal (1991) and Fuchs (1992), think that his work could serve as a bridge between the two sociological approaches to science—the institutional sociology of science (the Mertonian approach) and the sociology of scientific knowledge (the constructionist approach). I disagree with this view; I do not see Ben-David as close to constructionists since he advocates a view of science as an institution that produces objective knowledge or theories for universal characters of scientific norms.

Ben-David is known for his emphasis on the social organization of scientific institutions as a key to understanding the growth and development of science. For instance, he opposes Khun's theory of scientific revolutions, as this theory explains revolutions within science based on internal mechanisms within the content of scientific knowledge.

According to Khun, scientific revolutions occur when a governing scientific paradigm becomes unable to explain more and more phenomena within a scientific field. The

accumulation of unexplained phenomena causes a crisis within the field. A shift to a new paradigm becomes a matter of necessity. Hence, a new paradigm emerges and scientific reevaluation proceeds.

Ben-David rejects this theory because it ignores the institutional factors that shape and affect the content of scientific knowledge. Ben-David instead suggests that scientific revolutions occur based on both knowledge mechanisms (the disability of the existing paradigm) and institutional mechanisms (the social organization of science). For Ben-David, changes in the organizational structure of a scientific field facilitate scientific revolution. The rejection by Ben-David of Khun's theory is an example that illustrates the significance Ben-David assigns to social organization in the growth and production of science. In the coming section, I will lay out the key elements of his theory of the social organization of science and its relationship, according to Ben-David, to the advancement of science.

Ben-David's scheme of analysis gives great importance to the professionalization of science. The professionalization of science includes the creation of the role of scientist as a career and the emergence of different scientific disciplines. Institutionalizing the role of the scientist meant that the society would allocate individuals whose job is to produce innovations. Meanwhile, the emergence of new disciplines is an organizational step that allows for such innovations. These two elements are shaped by a distinctive social system—the research university.

Studying the German universities in the mid-nineteenth century, Ben-David theorizes that the university, as an institutional frame of scientific practice, allows for a key factor in the growth of science--the separation of scientific activities from the larger society. The German universities that led the growth of science in the mid-nineteenth century developed subsystems that enjoyed so much autonomy that they basically were left to be developed according to their own laws. There was no central system for managing these universities. The autonomy of universities and the decentralization of the system led to competition among these universities for achievement and fame in science, which resulted in productive research institutions.

The two basic elements in Ben-David's approach to the advancement of science are a decentralized system of higher education and a competitive environment for universities. He used this analytical framework to compare scientific growth among nations, applying it to the case of Germany, France, the United Kingdom, and the United States; France and the United Kingdom experienced declines in scientific productivity due to the failure of their higher education system to decentralize and compete compared to German and U.S. universities. Ben-David emphasized the importance of decentralization and competition in his scholarly writings as well as in his advisory capacity as a science policy expert.

The significance of Ben-David's work to this study lies in his emphasis on how the social organization of universities is a key to understanding and explaining scientific productivity. In his paper "Scientific Productivity and Academic Organization in Nineteenth-century Medicine" (1991), Ben-David introduces the university as a

significant factor in analyzing scientific productivity. According to Ben-David, the university was the institution that effectively professionalized the role of scientist. Turning science into a professional career within the university has transformed the university to include research as one of its missions. This led to other organizational developments, such as the creation of research labs within universities. Ben-David, however, emphasized an important point in this matter. Steps such as the professionalization of the role of scientists and the transformation of the university were not achieved due to the planning of policy makers. They were unplanned developments achieved through the competition among universities in an uncentralized system.

This point is extremely significant to this study, especially when it is combined with the contribution of world polity theory to the phenomenon of the institutionalization of science in non-western nation-states in the post-WWII era. Shenhav and Kamens (1991), of world polity theory, state that the institutionalization of science in most LDCs did not affect national development because such institutionalization was of isomorphism with the existing science institutions in the west. Ben-David's work fits into investigating the low outcomes of scientific institutions in LDCs when it is framed with the world polity contributions.

2.4.4. Social constructivism

Social constructivism is a social theory that was developed by Berger and Luckmann through their famous book *The Social Construction of Reality* (1966). The main claim of the theory is that people and groups participate in creating their reality. It is concerned

with uncovering how people create social phenomenon, institutionalize them, and put them into practice. Reality, according to Berger and Luckmann, is socially constructed through an ongoing process. Reality, then, is re-produced by people, actors, through acting on their interpretations and knowledge of the reality. The knowledge people hold of their reality is the product of their social interactions. Institutions, as they exist in the reality, are shaped by the shared interpretations and knowledge of actors.

There are multiple directions in social constructivism in science studies, some of which are relevant to my study. For instance, Collins (1985), Pinch & Bijker (1984), and Pickering (1984) came up with the concept of interruptive flexibility, which sees scientific results or technological designs as an open process that could result in different outcomes depending on the social environment in which they developed. While this concept had been developed within science studies, scholars of SCOT apply it to technological artifacts (Klein & Daniel, 2002). Another concept in the constructivism approach is relevant social groups. Members of certain social groups share sets of meanings and knowledge about their reality.

These two concepts, interruptive flexibility and relevant social groups, are what I use from the constructivism approach for this study. Social constructivism allows for understanding why the university, as a scientific institution, is unable to link the scientific production of its faculty members to national needs, as shown in my third theme.

2.5. Theoretical model(s) of this study

The two different approaches to science greatly differ in their research agendas. They are so different that it seems as if the researchers in each do not talk to each other. However, some sociologists call for mutual benefits between the two traditions (Collins, 1983; Hess, 1997; Ben-David & Sullivan, 1975). Zuckerman (1988) attempts to combine the two traditions by listing studies from both traditions as if they belong to one tradition—the sociology of scientific knowledge. However, in my opinion Zuckerman does not succeed in her attempt to combine them. She fails because she ignores the contradistinction of the epistemological roots of each tradition. The sociology of science was based on a functional-structural approach that believes in one objective truth while the sociology of scientific knowledge was based on a phenomenological approach that sees truth as relativist and socially constructed.

Investigating the connectivity between produced scientific knowledge and national needs in a less developed country could be both an opportunity and a challenge to use these two very different approaches simultaneously. In this study, I use both sociological approaches, institutional and constructivist traditions, as theoretical models to analyze how nationally produced science connects with national needs in a third world country.

The two approaches are useful as different lenses in viewing the story of connectivity between nationally produced science and national needs. For instance, the institutional sociology of science, especially the work of Ben-David in the social organization of the university, is a great tool in understanding why an academic DPE in one university could succeed in breaking the walls of isolation while a similar department in another

university could not, as illustrated in my first theme. The constructionist approach is the appropriate one in explaining the process through which the national universities were constructed (third theme). While the sociology of scientific knowledge is primarily concerned with the actual content of scientific ideas, I am concerned with the fates of these ideas within a national frame. Thus, the constructionist approach is used in this study to explain how certain social actors construct academic institutions in a way that does not help them to connect produced knowledge with national needs. It also is used to investigate how the whole structure affects the actions of faculty members and constructs the identities of their professional roles. My use of the two approaches can be seen as an attempt to use both structure and action to analyze a social phenomenon, inspired by the work of Giddens in his work on structuration (1986).

By using the two theoretical traditions, I hope to provide a deeper understanding of the problem of this study. A more ambitious goal is to contribute to the Science and Technology in the Society (STS) field. Such a task is extremely difficult; calls for such a goal began some thirty years ago and have been continued by great contributors to the field, such as Ben-David & Sullivan, 1975; Collins, 1983; Hess, 1997. Few attempts, such as that of Zuckerman, have been made. While Zuckerman attempted to mix works from the two traditions together, I use them in parallel, with one tradition in one theme and the other in another theme. By doing so, I show how both traditions are useful in providing a more holistic approach in studying science, especially in societies where science has not yet been investigated sociologically. While I hope to succeed in my

attempt at contributing to the field, I also hope that simply making this new attempt not to combine the two approaches but to use them simultaneously in one study is worthwhile.

2.6. Conclusion

This is a chapter of relevant literature in which I went over the three main components of the problem of science and national needs in an Arab country—science and development, SSDA, and sociological studies of science. In the first part, I showed how the issue of science and national development is controversial. In the second part, I went over different types of science studies in Arab countries. This section provides the reader with the state of science in Arab countries, problems of science there, and how a certain discourse about such problems has been developed, constructing certain sets of beliefs about the issue of science. Also, I showed how sociological studies of such problems are lacking. In the third part, I went over the sociological contributions to science studies, focusing on the contradictions between the two sociological approaches to science studies—institutional sociology of science and sociology of scientific knowledge.

I have framed my study relying on elements from the two contradicting traditions, believing that using them both would provide an investigator with effective tools in approaching and explaining a previously unexplored problem such as the connectivity between nationally produced science and national needs.

Chapter III: Methodology

3.1. Introduction

The main research question of this study is why locally produced science in LDCs makes little contribution to local needs. I focus on Saudi Arabia and investigate the connectedness of science produced by faculty members at two academic departments (DPE) at two Saudi universities, Alpha and Beta⁹. This study is a case study.

3.2. Case studies

The case study is a qualitative method with a long history of practice in sociology, especially in the Chicago school during the first three decades of the 20th Century (Tellis, 1997). A distinctive feature of the case study is that it must have boundaries (Stake, 1995). The case study is bounded by time and place. The research may investigate a single program (within-site study) or more than one program (a multi-site case study) (Creswell, 1998). The research can be a study of one case (single case study) or multiple cases (collective case study). There is a risk, however, when investigating multiple cases, of lacking depth. Usually, case study requires in-depth data collection through multiple sources of data, such as interviews, documents, observation, and audio-visual materials (Creswell, 1998). The analysis of data aims either to analyze the entire case (holistic analysis) or certain sides of the case (embedded analysis). If the study is for more than one case, the analysis could be applied to one case (within case analysis) or to more than one case (cross case analysis). According to Tellis (1997), many researchers, such as

⁹ These are pseudonyms.

Yin, Stake, Feagin, and others, state that case study is not a sampling research method. But others, such as Creswell, mention the issue of purposeful sampling in case study. Stake (1995) and Yin (1989) distinguish between two types of case study based on the focus of the researcher. If the research focuses on the case itself, it is called an intrinsic case study. But if the research is on an issue through a case, then the study is an instrumental case study.

This is a bounded study. It is bounded by academic organizations, the DPE at two Saudi universities. Since it is a study of two cases, it is a collective case study. I am not focusing on the cases themselves but using them to investigate the issue of connectivity between science and needs in Saudi Arabia. That makes my study an instrumental case study. I use in-depth taped interviews, documents, and observation as sources of data. As for data analysis, most themes are cross-case analysis, although there is one within-case analysis, the second theme. In sum, this is a collective instrumental case study of the problem of connectedness between science and local needs in Saudi Arabia.

I chose Saudi Arabia as an example for two reasons. The first one is subjective. Saudi Arabia is my country, and I feel responsible for making my knowledge, experience, and academic work relevant to Saudi Arabia's problems. The second is rational. Saudi Arabia is one of the LDCs. In terms of scientific publications, Saudi Arabia is one of the "big producers" of science in the LDCs¹⁰. Yet, as previously reviewed, science produced in Saudi Arabia is isolated from the local productive sectors.

¹⁰ I intend to provide a more comprehensive description of Saudi Arabia in Chapter 4. The chapter will focus on the status of science, the scientific workforce, and the economy in Saudi Arabia. I will also

3.3. The Cases

To investigate the problem of the low connectedness of science in Saudi Arabia, I focused on one scientific field--petroleum engineering. Science related to petroleum has a significant legitimacy in Saudi Arabia, as explained in Chapter 1.

Nevertheless, sciences that are related to the oil industry vary. At the university level, they are divided into different academic departments. Universities differ in how they organize and locate these academic majors. For instance, some tracks within geophysics concentrate on petroleum geophysics. Some universities, such as Texas A&M, locate their petroleum geophysics faculty within engineering departments. In other universities, independent departments for geophysics are located, along with engineering departments, within a college of petroleum science. In Saudi Arabia, geophysics faculties are located within geology departments, which are not part of engineering colleges. In some cases, geology departments are located within the college of science, like the case of Beta University. In others, the geology department is part of the college of earth science, which is the case with Alpha University. Therefore, petroleum geophysics is not an organizationally bounded system, which is a very significant aspect of case study tradition. Hence, for this study I excluded faculty who are interested in geophysics and produce science about it in Saudi universities.

provide descriptions of the institutions where this study will be done: ARAMCO, SWCC, KAAU, KSU, and KFUPM.

In addition to geophysics, there is chemical engineering. Within chemical engineering departments, there are some faculty who specialize in petrochemical engineering. Petrochemical is advanced in Saudi Arabia as an industry. The Saudi Company for Petrochemical (SABIC) is considered one of the global giants in the industry. There is a problem with choosing petrochemical engineering departments as the cases for this study similar to that of geophysics; there is no bounded system for petrochemical concentration. Also, the share of petrochemical engineering in the standard of living of Saudis is not close to that of the petroleum industry. Oil sales in 2006 benefited the state of Saudi Arabia about \$156 billion, according to the country's Ministry of Finance. By contrast, the selling of petrochemical products of SABIC (70 percent of which is owned by Saudi Arabia) benefited the state only \$4 billion, according to SABIC's 2006 report of budget revenue.

The DPEs in Saudi academia contain faculty members who are professionally trained to do research on petroleum reservoir engineering, engineering of oil production, and engineering of the transfer and storage of oil, according to descriptions of the concentrations of the two departments. These departments and their faculty deal with technical and environmental aspects of the processes that gained the country of 80 percent of its income for the past 35 years; see Chapter 1. Therefore, DPEs are ideal for investigating the issue of connectedness between produced science and local needs in Saudi Arabia.

There are nineteen universities in Saudi Arabia; sixteen are state universities, and three are private. Among these universities only two contain DPE. I include both departments in my study.

3.4. Gaining entry to the sites

The main source of data for this study was the interview. Documents were also collected and used in describing the sites as well as in data analysis. Observation has helped in providing more description. The first step in collecting data was gaining entry to the sites.

Gaining access to participants is a key issue in qualitative studies. In case study research, access is usually gained through gatekeepers (Creswell, 1998). For gaining entry to my study sites, I used two types of consent, institutional and individual. The institutional consent was a letter of introduction written in Arabic on college stationery from the college of Art & Humanities at King Abdul Aziz University (KAAU), where I work, and was signed by the dean of the college of Art & Humanities. The letter stated that I had a scholarship from the university and that I was at the stage of collecting data for my dissertation on the sociology of science. The letter asked whomever it concerned to cooperate with me to finish my work. KAAU, Alpha, and Beta all are state universities and are networked through the Ministry of Higher Education and the Council for Higher Education.

I felt the need to provide participants with more details about myself as well as my project. Bailey (1996) suggests that researchers explain who they are and why they are

doing their studies. Explaining such things to potential participants provides them with a more clear idea of what the project is about and, hence, allows them to make a better judgment about whether they agree to participate or not. Therefore, in addition to the letter signed by the dean, I wrote and signed another letter of introduction explaining more precisely who am I, what was I doing, and the need of tape-recorded in-depth interviews for my work. I promised the confidentiality of the participants. However, “I may use quotes of the interview in my dissertation,” I added. Copies of both letters were handed to each interviewee; see Appendix A. As an ethical matter and to gain the trust of participants, I verbally told each participant that he had the right to refuse to answer any question, to stop the interview at any time, to ask for stopping the tape recorder at any time, or to not permit me to use the data generated from the interview. Some interviewees assured me that what they say in the interview is to be said in other situations. None of the participants asked to stop the interview or asked me not to use it. However, one informant asked me to stop the tape recorder while illustrating an issue. I did not take notes of what he said since I regarded that as off-record. Therefore, I did not use what he said during the stopped recorder. The main difficulty I faced while arranging for the interviews, in both universities, was the instrument of data collection I used—the recorded interview. An hour seemed too long for most interviewees. They preferred a questionnaire. Taping the interview was a source of hesitation for some interviewees and the cause of refusal to do the interview for others. I used the letter I wrote to convince interviewees of the confidentiality of the interviews, which helped.

In Beta University's case, I was asked by the department head to gain approval from the dean of the college of engineering to conduct the interviews, which was easily achieved, having the letter from KAAU. The department's head was my main gatekeeper in the department; he introduced me to some faculty members as well as going over the dean's approval in an official department meeting.

The internet played a role in data collection. In the case of Alpha University, the internet was designed to be an effective source of communication; the chair and every faculty member had email and a personal web page that contained research interests, publications, and biographical information. Thus, I used the internet as a tool of communication; I sent email to the department chair and followed it by a phone call. In this way he acted as a gatekeeper as well. He suggested that I send emails to the rest of the faculty and speak to them as I arrived at the department. I sent emails to every faculty member in the department, asking to conduct interviews, prior to going physically to the site. The emails explained who I am, the purpose of the research, the fact that I had official letters of introduction, and the expected time of interviews. Only one faculty responded, giving me an appointment to conduct the interview. When I arrived at the site, I visited every faculty member to follow up on my email and to ask to conduct an interview. Most faculty members agreed. I wonder if the fact that I was doing a Ph.D. dissertation in a remote country may have helped in gaining the cooperation of participants in both sites or whether the participants liked the idea of making their departments cases for a doctoral project. The personal web pages of faculty members at Alpha helped me get biographical information about informants before starting

interviews. I printed copies of the publications of each participant to use during the interviews.

3.5. Interviewees

Interviews for this study were made with university professors at the two Saudi universities Alpha and Beta. Most of the interviews were with faculty members of the two cases—the DPEs at Alpha and Beta.

Some of the participants were still at work; a few had already retired. In addition to the faculty members of the departments, I interviewed current and former deans and vice-deans, as shown in Table 3.1.

Table 3.1: Interviews and interviewees

	Alpha	Beta
Current or retired faculty of petroleum engineering departments	5	11
Current or former administrators	2	4
Total	7	15

I completed 22 interviews for a total of 1,411 minutes of interview time. The average length of an interview was sixty-four minutes; see table 3.2. Except for two interviews conducted in English, all interviews were conducted using the Arabic language. All interviews were made at interviewees’ offices except one at an interviewee’s home and one at a department lab. The interviews were taped with a digital recorder and downloaded to a computer. I conducted the interviews at the two sites simultaneously, going back and forth between sites. At the beginning, I did two at Beta’s department and

then two at Alpha's. I consider this as the first phase of the interviews. Based on this phase, I started realizing difference between the two sites in terms of the research question—the connectedness of produced science with local needs. The realization was not based on transcription of interviews but rather on observing the attitudes, tones, and level of satisfaction of the interviewees in regard to cooperation with the country's oil industry.

I continued conducting interviews. All interviews were conducted during the fall and spring semesters of the academic year of 2005/2006. All the interviews were completed after five months and four days, from October 4, 2005, to March 8, 2006. During that period, there were seven weeks of breaks and exams¹¹, which slowed down my data collection. I also worked to collect more documents about the two cases as well as about the national oil company, ARAMCO. The information about ARAMCO was gathered to enrich my understanding, and hence my analysis, of the two cases, as explained in Chapter 5.

I transcribed most of the interviews during the period of data collection using the language in which the interview was conducted. The Word software was my tool of transcription. I began reviewing the data, interviews, documents, and observation to make meaning of them. Many themes emerged from these data, especially from interviews and observation. I start opening word files for each theme and saved them all in one folder called 'themes.' In each file, I supported the stated theme with the parts of interviews to

¹¹ The two holy Islamic rituals, Ramadan and Hajj, were during the fall semester. These rituals are treated as breaks, two weeks for each added to the two weeks of exams and one week of break between the two semesters. The fall semester lasts from September 10 until February 1.

be used when writing the theme. In addition, I wrote my notes about the theme.

Constructing themes and reconstructing themes again and again was a kind of unending process. The data said many things, and the challenge was to combine these small ‘results’ into big themes. The more time I spent with the transcripts of interviews, the greater abilities I developed to see how parts of different narrations and experiences fit into one theme. The time spent in reading these transcripts and making notes of them gave me a familiarity of interviewees’ ‘voices.’ In a sense, I was concerned not only with how to construct themes but, more importantly, with how to allow interviewees’ experiences and narrations to construct ‘a’ reality of produced science in terms of local needs. I am scholarly trained and interested in sociological approaches to science. That gave me an advantage over my interviewees in terms of interpreting sociologically the problem of relations between locally produced science and the country’s productive sectors. Meanwhile, my interviewees had a deeper recognition of the reality of this problem than I do. Making sense of what I learned from the interviewees in the context of sociological traditions of science was a challenge of a special nature.

After reading the transcripts many times and constructing a large number of themes, I started the process of mixing some themes together and developing main themes out of some smaller ideas and results. The twenty-some themes were combined into four themes, presented in the data analysis chapter. I opened a folder for each one where files of Word, Excel, and Acrobat Reader were stored. I supported each theme with the needed parts of interviews. At this point, I started translating these parts into English, except for the two interviews that were originally conducted in English. However, in almost all

interviews, interviewees used English words, phrases, and even sentences during the interviews. They shifted from Arabic to English and visa versa. When the interviewees used English words, phrases, or sentences in parts that are quoted in this study, I used them as expressed by the interviewees, except in one case where I changed the word ‘classical’ to ‘traditional’ (this was used in a sentence that was otherwise in Arabic, and the interviewee obviously was reflecting a negative evaluation of national research outputs).

Table 3.2: Number of interviews and their lengths

	Number of interviews	Length of interviews, in minutes	Average length of an interview, in minutes
Alpha	7	443	63.3
Beta	15	968	64.5
Total	22	1411	64.1

I used two types of interviews, semi-structured and unstructured. I conducted semi-structured interviews with faculty members of the two cases. Participants of the two departments were asked two questions. The first question was, “Using all or some of your publications, would you describe how do you choose your research problem when you want to write a paper?” I was able to obtain printed sheets of the publications of the faculty members of Alpha’s department. In Beta, some participants provided me with their own publications. In both cases, I asked participants to narrate the story of the research problem of each or some of his publications. If the interviewee had less than twelve publications in refereed journals, I asked him to go over the story of the research problem of each paper. If he had more than twelve papers, I asked him to randomly select papers and narrate the story of their research problems. The objective of this question was to explore whether the Saudi Arabian productive sector (the country’s petroleum

industry) acts as a resource for writing science. In other words, through this question, I hoped to locate networks that act as sources of written and published science; are they literature, colleagues, students, or actual needs of the petroleum industry? While some informants went over their publications paper by paper, some of them categorized their work and explained how they got involved in each category.

During the answers to that question, some questions emerged as the faculty narrated the stories of their papers. Some questions were clarifications to make sure the interviewee and the interviewer shared meanings. Other questions were to gain more details of a story or an experience narrated by the participant. If the interviewee narrated what seem to be experience related to the research question, I asked more questions to get as many details of the story or the experience as possible.

The second question was, “Would you describe in detail the nature of your relation with the national industry of oil?” The question, I hoped, would reveal the nature of ties and networks that link the faculty of the DPEs with the Saudi petroleum industry and the shape these ties take. In all cases, there were relations between the faculty and the oil industry. However, the types of these relations varied; they were centered on the teaching mission in some cases but broader in others. Even when the relations were merely centered about training students, such as field trips, participants gave rich details, such as how these relations developed, who they met at the industry locations, the types of topics discussed with industry officers, attempts to open avenues for research cooperation or seeking funds, and, if these attempts failed, details about how they did.

Interviews with administrators were unstructured. I used a guideline to ask questions that would help exploring some aspects of two issues. The first issue was the production of science within a university, such as reward systems and means the university uses to put that system into practice and how the system transforms itself into a determinant of social interaction within the university, or college, realm through creating status and roles. In other words, I was interested in knowing whether doing science is a factor in the stratified system of the university. The second issue was the institutional efforts of the university to link its faculty with the country's productive sectors, focusing as much as possible on petroleum.

3.6. Informants' characteristics

Twenty-two persons were interviewed in this study. All of them hold faculty positions, except for one interviewee who holds an administrative position. Because this research is a collective case study project done about two cases—the petroleum DPEs at Alpha and Beta universities—I will provide more details about the characteristics of the interviewed faculty of these two departments. I will not include characteristics of the interviewees who have not served as a faculty member in petroleum engineering. Interviews with non-petroleum engineering faculty were done not to investigate the research activities of these interviewees, which is the central research question of this study, but to collect organizational, historical, and administrative data about research production at the two universities. While interviews with petroleum engineering faculty allowed informants to speak of their own research productivity in light of linkage with the country's needs, interviews with non-petroleum engineering faculty explored how organizational,

regulatory, and administrative realities of colleges and universities shape the research productions of faculty in the entire Saudi academia. Although they occupied faculty positions, interviewed deans, vice deans, and center chairs were not asked about their own research experience because they simply are not part of the two cases—the Alpha and Beta DPEs.

I will characterize these interviewees in terms of nationality, country of academic training, professional experience after getting the Ph.D. (did they work in academia only or in both academia and industry?), and source of funding for the Ph.D. project. However, the ways these characteristics are introduced are limited by an ethical challenge.

3.7. Ethical considerations

Ethical considerations face researchers while collecting data or writing analyses. Interviews are a major form of data collection in qualitative methods. The researcher knows the informants and can easily identify them. It is an ethical imperative that he/she not divulges the identities of these interviewees. Citing Glesne & Peshkin, Creswell (1998) states that the American Anthropological Association sets up certain standards for researchers to follow to protect the anonymity of the informants. For instance, he/she may assign numbers or aliases to individuals. Other procedures may be required if the topic appears to be sensitive, which is not the case with this study.

I was faced by a critical ethical issue in preparing this study. Because there are only two DPE in Saudi Arabia, it is a simple matter for a reader to identify the two academic departments being studied. Because of this, I felt the need to use a more complicated procedure to mask the identities of informants. I combined the categories of the non-petroleum engineering faculty under one category—administrators. “Administrators” refers to interviewees who were former and current deans, vice-deans, and center chairs at the college of engineering, the deanship of scientific research, and the research institutes at both universities. There were six interviewed administrators at both universities; see Table 3-1.

All of them but one held teaching positions while working as administrators. I assigned these interviewees with numbers (administrator 1, administrator 2, all the way to number 6). Also, I combined the current and retired faculty into one category and assigned them with numbers as well. I categorized the country of Ph.D. as United States, United Kingdom, and Other, instead of specifying all other countries; this was done to mask the identity of interviewees.

As Table 3.3 indicates, the faculties of the DPEs at the two universities are of different nationalities. Seven are foreigners, or ‘comers,’ according to official description. Again for the purpose of confidentiality, I divided the nationalities into two groups—Saudis and non-Saudis--instead of listing all non-Saudi nationalities. All of the faculty in the two departments, participants and non-participants, come from Arab countries.

Table 3.3: Nationality of interviewed faculty of DPEs at Alpha & Beta

	Alpha	Beta	Total
Saudi	4	5	9
Non-Saudis	1	6	7

The hiring system for faculty in Saudi Arabia, as well as all governmental positions, differentiates between Saudis and non-Saudis. For Saudis, once a person gets an academic position, such as assistant professor, he/she has a secure job; it is a lifelong position, with no contracts to be renewed. For non-Saudis, a faculty member works with a contract for a certain period of time, usually two years, and may get renewed. However, there are no institutional differences between Saudi and non-Saudi faculty in terms of promotions or funding research projects. For instance, the only research project funded by KACST¹² to the DPEs during the duration of this study was being done by an Egyptian faculty in Beta with a \$300,000 grant.

Table 3.4: Country of Ph. D.

U.S.	UK	Other countries
9	3	4

Another characteristic of the informants is the country of academic training for the Ph.D. Two-thirds of the informants got their Ph.D.s from American universities; see Table 3.4. Most of them graduated from the highest prestige universities in petroleum engineering, such as Texas A&M and Stanford. The United Kingdom was second for academic training, with three faculty members. The rest got their Ph.D.s from other countries. In sum, three-fourths of the informants came through an Anglo-Saxon academic tradition. Generally speaking, the United States, the United Kingdom, Germany, and Egypt are the

¹² KACST is the equivalent of NSF in the U.S. and has annual grants; see Chapter 4 for more details.

main countries for academic training in Saudi academia. While the United States and the United Kingdom are preferred in Saudi universities for sending young teaching assistants to become faculty, Germany is a potential location for medical specialties. Egypt, on the other hand, is a source for hiring non-Saudi faculty members in case of shortages of Saudi faculty members.

Table 3.5: Professional experiences after getting the Ph.D.

University & Industry	University only
4	12

In terms of professional experience, most informants (twelve out of sixteen) had not worked in industry after getting their Ph.D.s; only four of them had (see Table 3.5). However, the Saudi oil company, ARAMCO, offers Alpha's faculty summer training programs to provide them with field facts for the courses they teach. The four who worked for the petroleum industry had occupied technical and executive positions. None of them worked at an R&D department at the industry. And none of them had published any papers during their work in industry. However, their positions in industry allowed them to attend conferences and symposiums.

Table 3.6: Source of funding for Ph.D.

Funded by national governmental agency	Scholarship from the university where Ph.D. was obtained
13	3

The source of funding is important in terms of science and connectivity. According to Zahaln (1999), part of the weakness of science productivity of university faculty in Arab universities is the lack of experience in doing research for real needs of the productive sectors during graduate training. Academic training of faculty member would be take the

shape of taking courses at the master's and Ph.D. levels, then doing the Ph.D. dissertation, and then coming back immediately to his/her mother university to teach. Since he/she is funded by his national university and does not seek a scholarship from the department where he/she does graduate work, the advisor does not feel the pressure to make such a student work on a funded project. Such a student typically ends up doing an abstract or theoretical project for the dissertation. This organization does not allow the graduate student to work on a project that is designed for actual needs of the productive sectors. It is reasonable to hypothesize that if a faculty member was funded by his national university or government, he would work on an abstract or theoretical project for the Ph.D. dissertation. In regard to the participants of this study, thirteen of them had funds from their countries' universities to complete their Ph.D.s, as shown in Table 3.6. Only two of these informants had worked for petroleum industry after getting their Ph.D.s.

Chapter IV: Saudi Arabia: demography, economy, and science

Saudi Arabia is the nation-state of the two cases of this study. Hence, it would be necessary for making sense of the data analysis that some descriptive data are introduced to the reader about the country in general and science in particular. There are many ways to do so. However, I will concentrate in this chapter on the socio-demography, economy, and science in the country and how the first two aspects affect the third—science.

4.1. Socio-demographic

Saudi Arabia is regarded as one of the major Arab and Islamic countries. Its size is about 856,356 sq miles, making it the fifteenth largest country in the world. In 1999, the Saudi Central Department of Statistics declared that the population in the country was 20 million (Central Department of Statistics). In 2005, it is estimated that the population to be 24.6 million (World Bank), 5.6 million of whom were resident foreigners. Three quarters of these foreigners are part of the local labor force (Saudi Arabian General Investment Authority [SAGIA]). The country's annual growth rate has significantly dropped recently (UN, World Bank, UNICEF, SAGIA). According to a UNICEF report, it went from 5.2 percent for the years 1970-1990 to 2.7 percent for the years 1991-2004. The main reason for this change in demographic structure was the large number of Saudi women entering the labor force; the fertility rate in Saudi Arabia went from 6.3 in 2000 to 4.05 in 2005 (CIA).

The majority of people are young in Saudi Arabia. According to the Saudi Central Department of Statistics, 50 percent of the Saudi population in 2000 was under the age of

20. This predominantly young society brings obvious future development challenges, especially in the education and employment sectors. The employment sector is influenced by the nature and type of education system; effective educational output would help in replacing the foreign labor force with a national one.

4.1.1. Labor structure and unemployment: the question of culture

The labor force structure in Saudi Arabia shows a high representation of foreigners. Table 4.1 indicates that more labor-force participants are non-Saudis than are Saudis.

Table 4.1: Labor force in Saudi Arabia 2000-2005

	2000	2001	2002	2003	2004	2005
Saudis	2,844.1 39.7 %	2,991.5 39.5 %	3,108.1 37.7 %	3,303.3 39.9 %	3,536.3 42.7 %	3,695.0 44.5 %
Non-Saudis	4,311.5 60.7 %	4,591.2 60.5 %	5,136.6 62.3 %	4,974.8 60.1 %	4,745.5 57.3 %	4,599.3 45.5 %
Total	7,155.6	7,582.7	8,244.7	8,278.1	8,281.8	8,294.3

Source: Central Department of Statistics, Saudi Arabia

Table 4.1 also shows the increasing nationalization of the labor force (“Saudization”) in the last two years for which we have data. Two factors explain this increase. First is the increasing recognition of the problem of unemployment among youths, where unemployment becomes a serious problem for the society. Second is the increasing price of oil, the main source of budget revenue, in the past three years.

In regard to the first factor, the Saudi labor department was separated from the ministry of social affairs and became an independent ministry in 2004 which indicate more institutional care for the problem of unemployment among citizens.

The high representation of non-Saudis in the labor market is not simply due to a lack of workers in the native population, as is the case in some other Persian Gulf countries. As mentioned above, Saudi Arabia faces an unemployment problem. Unemployment became a serious and complicated issue in Saudi Arabia over the past two decades. Contributing to unemployment in the native population are wages (most Saudi private businesses prefer manpower from low-income societies because it is cheap labor) and education outputs (Saudi education is accused of not preparing well new generations for the labor market).

The actual size of the unemployment problem is not precisely known. Estimates vary widely, as shown in Table 4.2; government estimates are very different from those made by non-governmental groups.

Table 4.2: Estimation of unemployment among citizens in Saudi Arabia

Source	Estimation	Year
The International Federation of Training and Development Organization (IFTDO) Source: Khaleej Times newspaper. 19 Feb. 2006.	15 %	2005
Ministry of labor Source: SAMA	9.66%	2002
Central Department of Statistics Source: Central Department of Statistics	8.66%	2004
Ministry of labor Source: Al-Madeena Newspaper	5% among males	2005

No matter which estimate is correct, the fact that nearly half the Saudi work force is foreign makes any unemployment among Saudis a matter of concern. Unemployment among Saudis is a challenge to the educational system in general and to higher education structure and intuitions in particular. What factors prevent the education system from preparing Saudi manpower to replace foreigners in the labor market?

The fact that half of the labor market is made up of foreigners while Saudi youth face an unemployment problem is interesting for this study. Just as much of the country's labor goes to outsiders, when Saudi productive sectors need advice or research from scientists they seek help from foreign consulting institutions while ignoring the country's own scientists. The question raised here is about the elements embedded in organizational and work cultures that make it easier to look for outside human resources to accomplish jobs while neglecting an unused Saudi labor force and Saudi scientists. The analogy between the non employed Saudi work force and non used national scientists may deepen our understanding of the phenomenon of isolated science from national needs in Saudi context.

Zahlan's (1980, 1984, 1999) theory about turn-key mode and rentier mentality could help in analyzing such phenomenon. In general, the labor structure and unemployment rates in Saudi society could help us discover cultural factors behind the phenomenon of Saudi scientists' research being isolated from local needs.

4.2. Economy

The Saudi economy is an oil-based economy. Three actors participated in forming the current structure of Saudi economy. These are the establishment of the nation state of Saudi Arabia in 1932, the discovery of oil in 1938, and the rebuilding of Europe after World War II and its need for a reliable source of oil. Since then, the petroleum sector, which is owned by the state, has played a significant role in the Saudi economy. Oil is the main source of the country's income; there is no taxation system, and the petroleum

sector is the main component of the country's GDP. Table 4.3 shows the importance of the petroleum sector for the Saudi economy.

Table 4.3: Economic indicators of Saudi Arabia

	2000	2001	2002	2003	2004	2005
Nominal GDP	706.7	686.3	707.1	804.6	939.6	1,152.5
GDP growth %	17.1	2.9-	3.0	13.8	16.8	22.7
Crud Oil production (Million b/d)	8.1	7.9	7.1	8.4	8.9	9.6
Average price of light Arabic crude oil (\$/b)	26.81	23.06	24.32	27.11	34.53	49.67
Petroleum export (billion Riyal)	265.7	224.2	271.7	349.7	472.5	677.1
Non-petroleum export (billion Riyal)	24.8	30.7	32.4	41.1	57.2	71.2

Source: Central department of statistics.

According to Table 4.3, GDP growth is clearly affected by the amount of oil production and the price of oil in any given year. It also shows the significant gap between petroleum and non-petroleum exports, although non-petroleum exports are increasing annually. The selling of crude oil, as a raw material, is the main engine of the Saudi economy. When oil prices or production goes down, the whole economy is negatively affected.

The state is considered the major player in the country's economy. In the eras of high oil prices, the state increases its expenditures through expanding the infrastructure, providing more jobs, increasing salaries, and so on. Such behavior significantly influences the private sector, where projects provide new opportunities for construction, operational, and maintenance institutions while increasing salaries lead to more consumption. In general, the income from selling oil is distributed through the state bureaucracy in the form of salaries, job positions, services, projects, and so on. The heavy dependence of the Saudi economy on selling oil as a raw material makes it a rentier economy.

4.2.1 Rentier economy

Developed by Mahdavy (1970) in his study about Iran, the rentier economy is a concept used to describe a nation-state economy that relies on “substantial external rent in the form of sale of oil, transit charges (Suez Canal), or tourism”. (Moaddel, 2002: 377). The rentier economy does not depend on domestic taxation (Moaddel, 2002). A rentier state economy is not an industrial economy; the industry sector is not the major engine of the economy. However, there is a difference between high-income rentier countries, which are rich in natural resources sold as raw materials, and middle- and low-income rentier states, which do not enjoy the feature of the first group of having and selling natural resources.

According to Mahdavy (1970), Beblawi (1987), Shafer (1994), Noreng (1997) and Amuzegar (2001), the rentier economy has political, social, and cultural effects. Beblawi (1990) argues that a rentier economy creates rentier ethics and mentality. According to Beblawi, there is an obvious contradiction between rentier ethics and production; the rentier mentality is associated with a break in the causal relation between work and reward. In a rentier economy, reward is not necessarily related to the effort of work but rather to a situation. Reward is not the result of the process of a long systematic and organized production circuit, as it is in a productive economy. This organization of the distribution of rewards destroys the motivation for production, which significantly affects the developmental process. The annual report of UNDP (2002) warns of the negative influence of the fact that the main societal rent does not require big efforts or hard work but investing one’s status in the society.

4.2.2 Rentier economy and science

Zahlan (1980, 1984, 1999) attempts to link the situation of science in the Arab world with the rentier mentality. According to Zahlan, the rentier mentality is embedded in the action of decision makers in these societies. Such a mentality does not include the long range vision to develop the country's own work force, especially in more skilled jobs such as science and industry. Hence, when it comes to building manufacture, roads, hospitals, and so on, the people in charge tend to look toward foreign firms and institutions for help, which Zahlan calls the turn-key mode. The turn-key mode has been the base of developmental efforts of nation states in the Arab world since the mid-19th century, when the Egyptian ruler planned to catch up with European modernity.

As I mentioned in the literature review chapter, Zahlan uses the turn-key mode to explain the phenomenon of productive sectors seeking foreign research or consulting institutions while ignoring those at home because they cannot provide the same standards or work as that of the foreign. The productive sectors do not have the motivation as well as the required patent to train their own country's workforce. According to Zahlan, this considerably slows the development of national institutions of science and prevents the country's own scientists from participating in development.

4.3. Science in Saudi Arabia

Like most of world countries, science in Saudi Arabia is produced mainly by universities' faculties. According to ISI data base, 74 per cent of publications done by scientists in

Saudi Arabia during 1996-2005 were conducted by universities' researchers¹³. However, I will go over some aspects of science in Saudi Arabia concentrating in science policy-making bodies, funding, reward system, and publications in the coming sections.

4.3.1. Science policy-making bodies in Saudi Arabia

Qasem (1998) differentiates between two organizational modalities of R&D in the Arab states. In the first, there is one central institutional arrangement for R&D, the Ministry of Higher Education and Scientific Research. In the second, two institutions are responsible for R&D. The first is the Ministry of Higher Education, which is primarily concerned with the teaching function of universities and is in charge of policy making for institutions of higher education. The second is a science policy institutional body that has a ministerial status. Saudi Arabia uses the second model, with the Ministry of Higher Education responsible for higher education and King Abdulaziz City for Science and Technology (KACST) acting as the science policy body. Such a model has the advantage, according to Qasem, of having an R&D funding unit as part of the science policy-making institution. In addition, such a model allows for decentralizing the relationship between universities and ministry-governed R&Ds.

4. 3.1.1. KACST

KACST was established in 1977 and was meant to be the national science policy body of the country. It is governed by a supreme committee that is chaired by the prime minister (which is the king) and composed of fourteen members, the prime minister, ministers of

¹³ During that period, there were 16641 published articles by researchers who work at Saudi Arabia. 12353 of them were conducted by researchers who work for universities over there. These data reflect the journals monitored by ISI.

defense, interior, higher education, agriculture, industry, planning, finance, petroleum and minerals, head of general intelligence, and three members that are appointed by the prime minister. According to its mission statement, KACST supports and funds scientific research for applied goals and coordinates the activities of scientific institutions to serve the developmental needs of the country. It also coordinates with related bodies to set up the priorities and national policies of science and technology to build a base of science and technology that would serve development in the country's sectors of agriculture, industry, minerals and so on. KACST also aims to develop the country's human resources in science and to attract them to work at KACST. The main mission of KACST is to fund scientific research and to set up a science policy, with a very clear emphasis on science for applied goals and developmental needs.

4.3.1.1.1. Funding at KACST

In regard to funding, KACST has established a department called the General Directorate of Research Grants Programs (GDRGP). The GDRGP aims to direct and follow up scientific research in Saudi Arabia through its multi-phase research grants programs (KACST website). The GDRGP at KACST funds research annually through seven programs. These programs are the Annual Research Grants Program (ARP), the national grants program (should you capitalize that one?), the National Traffic Safety Committee, the National Education Committee, the Postgraduate Student Grants Program, the Limited Grants Program, the Humanities Grants Program, and the Production Sectors Grants Program.

Although the funding for these programs started relatively late, in 1980, it has been maintained annually since then. The government seems to be committed to the programs; the total expenditure of the programs has exceeded \$137 million. However, the GDRDP seems to be facing the problem of how to make the funded projects usable nationally and how to ensure that they are done to serve actual needs of the country's production sectors. Table 4.4 provides brief descriptive information about these programs.

Table 4.4: Programs of funds at KACST

Program Name	Program scope	Starting year	Number of funded research projects	Total expenditure (in U.S. dollars)
Annual Research Grants Program (General) (ARP)	Research in science, engineering, and medical, with emphasis on applied projects	1979	455	101,022,933 (1980-2000)
National Grants – General Program	Research designed according to a request of a governmental agency to seek scientific solving of a technical problem	2000	-----	-----
The National Traffic Safety Committee	Traffic problems, transportation safety	1982	-----	-----
The National Education Committee	Improving scientific and technological education	-----	87	30,100,000 (1980-1998)
Postgraduate Student Grants Program	Support MS theses and PhD dissertations in science, engineering, and medicine	1991	25 (1991-2000)	2,378, 965 (1991-2000)
Limited Grants Program	Small research projects (one year and not more than \$26, 600)	1996	192	4,136, 205 (1996-2000)
Humanities Grants Program	Social, educational, and economic studies	1998	2	359,226
Production Sectors Grants Program	Applied research that aims to solve specific problems of production sectors	-----	-----	-----

Source: KACST's annual reports of 2000-2005.

The establishment of the national grants general program in 2000 and the establishment of the production sectors grants program later indicates, I argue, that the general annual research grants program (ARP) failed to connect its outcome with actual national needs.

Observing the behavior and outcomes of these two later grants programs is essential to my project; do they really bring changes in connecting the research output of scientists to actual needs in Saudi Arabia? Moreover, investigating KACST executives' discussions that led to the launching of these two grants programs would uncover the extent of these executives' consciousness in regard to how to make use of the already produced science in the country.

The GDRDP has established a section that focuses on utilizing the funded research projects. It does so by two means: 1) publishing results; and 2) organizing symposia, workshops, and conferences that discuss the already completed research projects. Obviously, these remain at the intellectual level of scientific research. They may help in getting results utilized, but they are not a defined strategy to make funded projects consumable by local production sectors. Both KACST and the GDRDP focus on applied research and science for serving national needs, but KACST has not set up an effective policy that ensures that its funded scientific research serves its major mission.

There is another means by which the GDRDP tries to help in making use of the science produced in Saudi Arabia. The GDRDP defines the priorities of funded projects according to recommendations from scientific working groups formed by the GDRDP. These working groups are medical, engineering, agricultural, industrial, and environmental. Each group has representatives from KACST, universities, government, and private sectors. The GDRDP announces the KACST annual research grants

according to the recommendation of these working groups. This mechanism allows for selecting topics that have the potential to be used within the country.

However, there are no specific mechanisms to match the funded projects to specific technical problems in the production sector. The working group scientists who set priorities are not those who seek scientists' help in the production sectors. In Saudi Arabia, where science suffers by being isolated from Saudi consumers, KACST-funded research would be more connected if it were done on a contractual basis to solve actual technical problems of local production sectors, as some of my findings show. KACST could function as the legal and financial umbrella of scientific research produced by Saudi scientists for Saudi consumers as well as for science policy body who could face the problem of the gap need to be bridged between science produced and actual needs in the notational contexts.

4. 3.1.2. Ministry of Higher Education

The Ministry of Higher Education (MHE) is the other major institution responsible for regulating and advancing scientific research in Saudi Arabia. As is the case with KACST, the MHE is relatively young, established in 1975. The MHE is the authority responsible for regulating higher education, including education in Saudi universities and community colleges and getting higher education abroad, along with the supreme council of higher education. A very important point in this study with regard to the MHE is the very centralistic nature of the higher education system in Saudi Arabia and the role the MHE plays. Every university has a council that is supervised by the minister of higher

education. The faculty hiring, salary, teaching loads, and promotion systems are all unified by the MHE and are the same for all Saudi universities. Until recently, all universities were state universities. Their annual budgets come through the government. Their presidents are appointed by a royal declaration. Selection of colleges' deans and academic departments' heads are regulated by one central system for all state universities, more descriptive of this point would be offered in third theme. According to Ben-David (1991), decentralization is a very important component of the advancement of science.

Such organization does not mean that Saudi universities are similar. They vary in their emphasis, size, and identity. For instance, there are two universities that focus mainly on religious education, Imam University and Islamic University. One is well known for specialized in engineering science, King Fahd University for Petroleum and Minerals (KFUPM). Others are known for providing education in most specialties.

4.3.1.2.1 Funding higher education

There are nineteen universities in Saudi Arabia; sixteen of them are of a state nature. Eleven of these universities were established during the last decade. The state universities have a unique funding system. The education in these universities is totally free, as is room and board. In addition, students get a monthly income once they get admitted¹⁴, more detailed description is presented in third theme. Every state university has an annual budget that covers the expenditures. However, the supreme council of higher education

¹⁴ Students who study science, engineering, or medicine get \$266. Students of social science, arts, and religious studies get \$220.

agreed in 1998 to allow universities to seek non-governmental sources of income. The governmental income of state universities should cover the four main segments of the institution's annual budget—salaries and allowances, maintenance, projects, and operational expenses. The non-governmental income comes through two main sources—donations and income that resulted from conducting research for costumers outside other than universities. This research income has a very significant impact on connecting research with Saudi needs, the research problem of this study, as I will illustrate in the first theme.

4.3.1.2.2. Enrollment in higher education

Due to the demographic structure of Saudi society, as described above, an increasing number of youth finish high school and seek a higher education degree. Table 4.5 shows the continuous increase in students enrolled in higher education institutions, where the number of enrolled students in higher education has increased 159% in one decade.

Table 4.5: Enrollment in higher education

Year	Community college diploma	Bachelor	Post-bachelor diploma	Master	PhD	Total
1996	29,233	197,698	325	5253	1291	233,800
1997	27,142	225,345	586	5485	1167	259,725
1998	27,175	264,484	851	5811	1176	299,497
1999	27,790	299,456	1112	6605	1416	336,379
2000	38,252	324,423	1580	5774	1439	371,468
2001	55,611	367,512	1406	6005	1814	432,348
2002	58,092	377,438	1285	6424	1561	444,800
2003	68,982	445,419	1400	7542	2001	525,344
2004	79,106	483,036	1961	7836	1797	573,736
2005	84,992	505,932	1670	9141	2032	603,767

Source: Ministry of higher education

The yearly increased demands for enrollment in higher education cause pressure on the current universities. Both the upswing of state income in the past few years and the need for more institutions of higher education have led to a large increase in the establishment

of both universities and community colleges. Eleven universities and tens of community colleges have been established in the last decade.

4.3.1.2.3 Research funding in Saudi universities

Research is funded in Saudi universities in three ways:

- 1) Contracted research: This research is produced through contracts between the university and a governmental or private institution, with the latter funding the research.
- 2) Grants from national institutions that provide grants for Saudi scientists. KACST and SABIC are the only two Saudi institutions known for having annual grants programs.
- 3) Research funded through the annual budgets of scientific research within each university (Alzahrani, 2004).

It is important to mention that the first is a relatively new source of funding, while the third is the oldest. The main difference between the three is that the first aims to fund research designed to solve a specific problem facing a production institution. The second is composed of announced grants programs, while in the third, the faculty member comes with his/her own idea of research and seeks funding through the research center at his/her college in some universities or through the deanship of scientific research at other universities. My interviews with deans and faculty members indicate that the third avenue of funding is the weakest of the three, with only small amounts allocated for funding research. The average amount of research money for each researcher in Saudi Arabia in 1996 was \$175,000 (Haitee, 1999). Alzahrani (2004), Alghatani (2004), Kana'an (2001), Seam (2001), Aisawi & Dakheel (1999), Alsalem (1999), Khudair (1999), Aldawood (1996), Alsulimani (1996) have all emphasizes that research funding in Saudi universities

is not consistent with the goals of developmental plans, which provide obvious guidelines for the role of research in developing the country. In general, expenditure on research in Saudi Arabia is considered weak; the whole expenditure is about 0.15 percent of the GDP, compared to an average of 2.2 percent in industrial nations (Al-gahtani, 2000).

4.3.2. The reward system and research in Saudi universities¹⁵

The reward system in science is a main concentration of the institutional sociology of science. It is away to examine the institutional function of science. The reward system would be easier to described if the institution of science is working actively. Merton (1973) states that once science grows and become more professionalized the reward system gets more elaborated and accelerated rate. The reward system takes various forms such as job positions, publications, and prizes¹⁶.

The reward system of science in Saudi Arabia requires deep investigation. However, I will concentrate on providing some description of reward system in Saudi universities and how it works, aiming to show how the reward system functions in advancing science.

The hiring system in higher education does not require publication; however, promotion does. Once a person gets a fulltime job as a faculty member, he/she is not institutionally required to publish to maintain his/her job status. Despite that, Saudi academia has a reward system that encourages faculty to produce science. The MHE regulations of

¹⁵ Most information in this section was gathered through interviews, especially with deans.

¹⁶ Ben-David and Sullivan (1975) have warned from the misleading of the word reward, “since it may imply the purpose of scientific activity is to obtain honors and material rewards” (Ben-David and Sullivan, 1975:206). However, since science now is a profession, honors and material rewards are major mechanisms of such profession, as any other profession, in addition to interest in research and discovery.

faculty promotions give sixty percent of needed points to promote to publishing, twenty-five to teaching, and fifteen for community service. An assistant professor needs to publish four papers in refereed journals in order to be promoted to associate. For an associate to be promoted to full professor, he/she needs to publish six papers. Further, the scientific council in the university, which is the department responsible for promotion, sends the published papers to three referees to decide if the works are worthy to serve as a basis for promotion or not. Despite the lack of an official policy on publishing for the maintenance of job status, publishing is definitely required for promotion.

There are few journals in Saudi Arabia to publish in. That is the case of countries with small population, small number of universities, and/or low productivity of science. Thus, scientists in Saudi Arabia tend to publish in international journals. Like the profession of science, international journals are highly stratified. There are the prestigious journals and those who have low prestige. For science and applied science in Saudi context, the highest prestigious journals are those who are monitored by ISI. The emphasis to build stratification of journals using such ISI as a drawn line might be due to the phenomenon of 'Indian journals'. India is one of the largest publishers of science. In India, there are high levels scientific institutions and journals. Yet, there are journals that are less strict in their criteria of publication. Hence, sizable number of universities faculties in LDCs may publish in such journals to get promoted. For maintaining certain level of technical norms and prestigious status for their institutions, some universities and departments request articles published in journal monitored by ISI to be considered for promotion. According to one of my interviewee from Alpha, Alpha University has restricted application for

promotion regulation of MOE in which only articles published in ISI monitored journals would be accepted for promotion. More about Alpha University and its institutional identity would be explained in the next chapter.

The higher education system had developed more formal and informal institutional care to encourage faculties to do research. Various mechanisms have been lately developed encourage faculty to publish. For example, although this is not officially stated, a faculty member needs to be at least an associate professor to be a department head or a college dean. It is easier for associate and full professors than for assistant professors to get membership in prestigious committees and councils at universities. Hence, the system makes association between publication and prestigious positions within the institution where scientists work. Publication also is an essential factor for increasing income for faculty members. The MHE regulations for faculty members in Saudi Arabia allow them to have consulting positions with outside agencies. Typically, a faculty member would serve as a consultant for a governmental or private agency in which he/she spends one day a week with that agency. It is like a part-time job, in addition to the fulltime job at the university. Faculty academic status and vita play significant roles in marketing him/herself in this regard, and publication is needed both for academic status and building reputation. The scientific council of a university financially rewards faculty members if it approves their work of authoring textbooks or translating books from a foreign language. Contract research, through the research institutes of universities or through getting grants from KACST, is another way of increasing monthly income. In contract research, the faculty member gets paid by the university, which signed a contract

with an outside agency to do research for a specific problem. In research funded through grants program, the faculty member him/herself signs a contract with the funding agency to conduct the research. In such research, the faculty member gets a monthly payment during the research period, which varies from several months to five years. Those who have published, who show interest and capabilities in producing science, are more likely to get such contract research or funding from grant programs.

Hence, for an active Saudi faculty member, especially in engineering, medicine, or science, publication can be a practical means of increasing income. Things tend to snowball: the more you publish, the more prestigious your status; the more prestigious your status, the more you can increase your income. According to one of my interviewees, who acts as administrator at engineering college, a very active faculty member could get a monthly income more than his/her salary by doing consulting, publication, and research.

As with global universities system, publication is source of prestige for faculties; hence, source for stratification within academia system. However, such point needs more investigation to determine the share of publications in constructing one's status among colleagues compared the share of administrative skills, power relations and such factors to measure the function of reward system of science within Saudi academia.

The reward system of the global community of science also affects the national reward system of Saudi science. The national scientists who have their contributions to the

advancement of science institutionally rewarded by scientific communities, such as gaining international patent, have been rewarded by the Saudi state with national recognition through granting them with national medal orders. So, the nation-state honored the scientists who gain prestigious rewards from the global institution of science. When Merton (1973) lays out the structure of reward system, he puts at the very top what he called 'eponymy' category. Eponymy refers to high status prize that is given to a relatively small size of scientists. The prize takes the shape of new products, artifacts, tools, schools, or theories are named after the discoverers or first describers within the scientific field. In DPE at Saudi academia, there is one national scientist who fits such category. Al-Marhoun, a faculty member at Alpha, developed a correlation formula to describe the physical characteristics of different types of crude oil in Saudi reservoirs. He, thus, got the correlation named after him. Amazingly, he got small national recognition. The simple reason is that the patent is more nationally recognized as a scientific reward than a formula name, although things for Merton go the opposite way.

However, the reward system of science within Saudi context does not include other forms of honors like what Merton described of naming new products, artifacts, tools, or schools after scientists. That is a very distinctive feature of the shortcoming of the institution of science in an LDC.

4.3.3. Saudi scientists and publications

Saudis publish significantly less than their peers in advanced nations, but they publish more than their peers in other LCD. Table 4.6 compares Saudi publications to those of scientists in selected countries.

Table 4.6: Science &Engineering articles for selected countries

Country	1990	1995	2000
Worldwide	508,795	580,809	632,781
United States	191,559	202,887	196,221
Germany	32,295	38,100	43,440
Bangladesh	116	170	160
China	6,285	9,261	18,142
India	9,200	9,591	10,047
Indonesia	104	133	165
Japan	38,570	47,603	55,413
Malaysia	233	373	470
South Korea	1,170	3,806	9,386
Egypt	1,254	1,359	1,376
Iran	94	271	825
Saudi Arabia	644	781	595
Ghana	40	65	95
Nigeria	815	464	428
South Africa	2,406	2,364	2,237

NSF statistical book (2006).

Differences are significant between Saudi Arabia and advanced nations such as the United States and Japan. But Saudi Arabia is considered as a major science producer among LCDs, such as Egypt, Iran, Ghana, Nigeria, Malaysia, Indonesia, and Bangladesh. Saudi scientists produce more science than their peers in Malaysia and Indonesia, which are making rapid progress in shifting their economies to be productive and knowledge-based economies. The fact that Saudi scientists publish more than scientists in less rentier and more industrial economies, such as Indonesia and Malaysia, illustrates the real need for making national use of these scientific efforts. For instance, the two countries of

Indonesia and Malaysia experience deep economical changes during the last two decades which have been shifting the society to be more good producer through varies means including developing national work force to participate in the new knowledge-based economies. Meanwhile, their scientists gradually produce more science, as shown in table 4.6. In other words, the developments of science production in these two countries have been accompanied by the development of their economies¹⁷. In a rent economy, like Saudi Arabia, research activities appear to be isolated from changes in national economy. Significant changes in annual budget revenues, illustrated in table 1.1, chapter 1, and GDP, shown in table 4.3, is not accompanied by changes in research activates of these years.

It is important to examine the fields that scientists in Saudi Arabia tend to publish in. Table 7.4 shows publications in various fields for some selected countries. For Saudis, clinical medicine appears to be the largest scientific field of publication, with almost 41 percent of publications occurring in this field. Saudis publish more than the worldwide average in that field, and Saudi Arabia is among only six countries whose publication in clinical medicine is more than 40 percent (the others are Ethiopia (54%), Tanzania (53%), Lebanon (48%), Uganda (46%), and Turkey (44%). Except for Turkey, which publishes more than 4000 articles, the rest of these countries publish significantly fewer than Saudi Arabia. The domination of clinical medicine field has very significant point for the connectivity point. Clinical medicine is an applied science. In Saudi context, it is

¹⁷ This is not assumption of connectivity between nationally produced science and national economy of these two countries. It is just observation. However, it motivates for deeper investigation of the institutional links between producer of science (individual scientists as well as institutions) and national productive sectors.

connected with national needs. Medical colleges in Saudi academia establish educational hospitals where faculties provide medical service to public¹⁸ as they teach and do search. For instance, Medical College at KSU established two hospitals. In addition, faculties of medical college could work as consultant at non-university hospitals. Hence, the medicine as science is not isolated from the larger society and national needs in Saudi context.

Table 4.7: Regional and country portfolio of Science & Engineering articles, by field: 2001

Country	Articles	Clinical medicine	Biomedical research	Biology	Chemistry	Physics	Earth/space sciences	Engineering/technology	Mathematics
Worldwide	649,795	28.4	14.2	6.8	11.9	13.4	5.4	9.0	2.2
United States	200,870	31.7	16.9	6.2	7.1	8.7	5.6	6.9	1.8
Germany	43,623	30.9	14.1	5.2	12.7	16.3	5.0	8.5	2.2
Bangladesh	177	21.5	8.0	12.2	17.4	14.0	4.8	8.7	0.3
China	20,978	10.7	8.0	3.8	26.3	23.4	4.4	16.3	3.9
India	11,076	14.3	13.4	6.5	25.5	18.6	5.2	13.0	1.2
Japan	57,420	28.7	14.0	6.1	14.9	19.1	3.0	11.6	1.4
Malaysia	494	20.4	7.6	15.1	28.4	6.4	2.9	12.1	1.0
South Korea	11,037	17.9	11.3	3.3	17.7	22.4	3.0	20.7	1.7
Egypt	1,548	20.2	5.1	6.4	29.9	17.7	3.6	15.4	0.5
Iran	995	19.5	3.7	3.7	39.6	13.5	2.9	12.3	3.9
Saudi Arabia	580	40.8	5.9	4.7	12.3	10.1	2.8	17.2	4.0
Nigeria	332	29.7	11.5	29.9	3.9	2.4	4.0	4.6	2.1
Senegal	62	33.8	9.8	30.1	2.7	5.4	4.4	1.9	1.6
South Africa	2,327	24.5	12.7	18.0	8.9	5.9	10.3	6.8	1.7

NSF statistical book (2006).

The second highest publishing field for Saudis is engineering and technology, with 17.2 percent, almost two times of world wide average. That may give indication of the status of engineering within Saudi society in general and Saudi academia in particular. The data above do not provide descriptive information about the sub-categories fields within engineering the Saudi faculties tend to publish in. Such information is important due to

¹⁸ The state provides free medical services for public through medical centers and hospitals of ministry of health and educational hospitals of universities.

the nature of Saudi productive sectors that related to engineering fields. For instance, the industry of petroleum, which is related to petroleum engineering, or the industry of petrochemical, which is also related to petrochemical engineering, are active components of Saudi economy as well as the construction and architecture. But the first category of engineering in Saudi Universities is electric and electronic engineering, see next chapter, although there are no advanced industries of electric or electronics in Saudi Arabia.

4.4. Conclusion

In this chapter, I have presented general description of Saudi Arabia focusing on demography and economy characteristics linking them to science and research activities at the country. Also, I have gone over science in Saudi Arabia focusing on science policy-making bodies, reward system within science institution, and publications. The main theme of the chapter is that Saudi Arabia has a young society and a rentier economy. The rentier economy has created a mentality that negatively affected the use of national forces through relying on foreign resources, for both work force and scientists. Such cultural character either effect of accompanied by social organization of science in which the science policy-making bodies suffer the lack of creating affective link between national productive sector and nationally produced science as the case of KACST, or creating regulations that do not allow for autonomy and completion among national universities, like the case of ministry of higher education.

In the coming chapter, I put the two cases of this study in organizational and historical contexts. That would reveal mechanisms of producing science. For instance, I will show how social organization of science practice effects, both positively and negatively, the

production of science as well as the connectedness of science and national needs. The data analysis chapter will illustrate how institutional arrangements could lead to more or less connectedness.

Chapter V: Historical and organizational contexts of the two cases

5.1. Introduction

This is a study of two academic departments, DPEs, at two Saudi universities, Alpha and Beta. These departments are the only academic departments of petroleum engineering in the whole Saudi academia. In this chapter, I will provide a description of the two universities and the DPEs (the two cases) as well as of the national oil company, ARAMCO. ARAMCO is not a site for my study, but it plays a vital role in determining the identities of the two academic departments and the nature of the roles each department could play in Saudi Arabia's petroleum industry. Because ARAMCO and the two departments are actors in the education and science of petroleum engineering in Saudi Arabia, in this chapter I will show how they are networked. By doing so, I hope to situate the two cases in their larger context. According to Merriam (1988), situating the case(s) enriches the data analysis. This chapter should allow for better understandings of the data analysis, which follows in the next chapter.

5.2. The two universities

Modern institutionalized higher education began in Saudi Arabia in the early 1950s, taking the form of colleges. Beta was the first university in Saudi Arabia, established in 1957 with two colleges, arts and science. Organizationally, Beta was attached to the Ministry of Education when it was established; when the Ministry of Higher Education was established in 1975, Beta and all other Saudi universities were gathered under the umbrella of the Ministry of Higher Education. Beta has been and still is regarded as the

largest Saudi university in terms of size, number of students, number of colleges, number of faculty members, and even budget revenue, 3 billion riyals (\$800 million) in 2005.

During the academic year 2005/2006, Beta had 18 colleges, 3 community colleges, two educational hospitals, 3,009 faculty members, and more than 60,000 students. Its colleges provide education in various academic fields in the humanities, science, social science, and applied science such as engineering and medicine.

In contrast, Alpha appears to be a university that concentrates on fewer academic fields, such as engineering, computer science, science, and industrial management. During 2005, Alpha had 5 colleges, 3 community colleges, 728 faculty members, and 12,600 students¹⁹. Alpha does not have colleges such as art, medicine, pharmacy, or education.

A historical factor may play a role in Alpha's concentration on engineering and industrial management areas. Alpha was established in 1963 as a community college. Its bylaw at that time assigned it with a specific goal: "to provide the country with specialists in the different forms of petroleum and mineral industry." The minister of petroleum and minerals acted as the head of the board of directors for the college. The board included three foreign members, the president of American University in Cairo, a member from the French Petroleum Institute, and a member from MIT. A very important point about the establishing of Alpha is that it was freed by a royal decree from following the administrative and finance regulations that govern the governmental system; it was given the opportunity to develop according to its internal laws, a factor in university progress, according to Ben-David (1991). Such autonomy gave Alpha more freedom than other

¹⁹ These numbers represent graduate and undergraduate, full time and part time students in both universities.

universities in terms of hiring faculty and staff and admitting students²⁰. ARAMCO, the Saudi oil company, donated part of its land to the new college and shared in building the campus. The campus was literally next to ARAMCO's campus²¹. Its academic program was composed of three years, the first year for learning English, and the second and third years for learning math and science through the English language. Students then would be given scholarships to finish their bachelor degrees at American universities. In 1966, Alpha became a college that specialized in petroleum and minerals. In 1975, it was made a university and attached to the newly established Ministry of Higher Education. Interestingly, a dignity among faculty, staff, and students could be easily observed on Alpha's campus. For some, Alpha is the MIT of the Middle East. This identity is informally taught to students to maintain their achievement motivation.

We keep telling our students: you are the best, you are the best (Scientist 1 at Alpha).

In general, the two universities occupy distinct positions within Saudi academia, Alpha for its quality in engineering education and Beta both for being the country's largest academic institution and for playing the historical role. A rough generalization about the two universities in Saudi society is that while Alpha is known for its high quality of education in engineering, Beta is known for being the center of public intellectuals and the largest producer of professionals and various kinds of professions. In publications, the two universities appear to be at the top among Saudi universities. Beta's faculty

²⁰ That was changed in 1975 when a Ministry of Higher Education was established and all Saudi universities, which all were governmental, were attached to it and its regulations. This change led to the the loss of the previous autonomy, which led to loss of an important factor of scientific growth; see third theme for more details.

²¹ This historical formulation would affect the relation of Alpha and ARAMCO forever and, hence, would ease the academic-industry relation of Alpha and ARAMCO, in contrast to other Saudi universities.

members publish more than Alpha's; see Table 5.1. As mentioned above, Beta has more faculty members than Alpha and that may explain the phenomenon²².

Table 5.1: Monitored Published articles by ISI of Alpha and Beta, 1975-2006

University	Number of articles
Alpha	5721
Beta	7613

The top subject categories of the publications of each university may explain the differences in research activities and concentration among them. As Table 5.2 indicates, engineering and science are the top 10 categories of publications of Alpha's faculty members during the time from 1975 to 2005.

Table 5.2: Top subject categories of publications by faculty of Alpha, 1975-2006

Number of published papers	Subject category	% of whole university publications
Engineering, electrical & electronic	628	10.97
Energy & fuels	387	6.76
Mechanics	349	6.10
Engineering, chemical	333	5.82
Materials science, multidisciplinary	330	5.76
Thermodynamics	327	5.72
Chemistry, physical	287	5.02
Multidisciplinary science	285	4.98
Engineering, mechanical	250	4.36
Mathematics, applied	231	4.04

The first two categories of publications at Beta are medicine and pharmacology, as shown in Table 5.3, with a considerable gap between the first two categories and the third one.

²² If the count is based on publication per faculty, Alpha may be higher than Beta. However, ISI is an English-centric web of science; it concentrates on journals in the English language. Most papers in the humanities at Arab universities are published in Arabic. Hence, the numbers in Table 1 most likely do not include publications by Beta's faculty in the humanities.

Table 5.3: Top subject categories of publications by faculty of Beta, 1975-2006

Subject category	Number of published papers	% of whole university publications
Medicine, general & Internal	955	12.54
Pharmacology & pharmacy	713	9.37
Chemistry, analytical	287	3.77
Mathematics	286	3.76
Engineering, electrical & electronic	275	3.38
Multidisciplinary science	275	3.38
Biochemistry & molecular biology	239	3.14
Engineering, chemical	230	3.02
Mathematics, applied	213	2.78
Surgery	212	2.78

Tables 5.1 and 5.2 indicate that the predominant disciplines in both universities are applied science first and then pure science. In regard to publications in engineering, electrical and electronic engineering is the first engineering subject category at both universities, with 11 percent for Alpha and 3 percent for Beta. Energy and fuel, which overlap with petroleum engineering, comes as the second category at Alpha and is not among the top 10 categories at Beta. However, Alpha is known for concentrating in petroleum and minerals. Finally, Tables 5.2 and 5.3 show that while research in engineering is Alpha's concentration, research in medicine is Beta's.

In regard to research and publications in petroleum engineering, Alpha's faculty have accomplished more than Beta's in both numbers of publications and citation rates, according to ISI and as shown in Table 5.4. That may suggest greater differences between the DPEs of Alpha and Beta. More descriptive data of these departments follows.

Table 5.4: Publications and citations in the subject of petroleum engineering in both universities, 1975-2006²³

	Alpha	Beta
# of articles	115	79
Times been cited	331	75
Citation per article	2.88	0.95

5.3. The two departments

The two departments were established the same year, 1974, but in different ways. The DPE at Beta was established through the efforts of the Minister of Education, who was the senior president of the university. He contacted a young faculty member who was working at a regional university and assigned him the task of establishing a department of petroleum engineering. There was no contact or coordination with ARAMCO.

In contrast, the DPE at Alpha was established by one of ARAMCO's officers, who had transferred from ARAMCO to Alpha. His previous job at ARAMCO provided him with connections that helped him in arranging educational field trips for the students to petroleum reservoirs of ARAMCO. However, the research cooperation between ARAMCO and Alpha had to wait for twenty years.

The two departments represent different realities of petroleum engineering as a profession and as a science as well as in the Saudi academia. The most noticeable difference between the two departments is the outcomes of their graduates in terms of

²³ Results generated from ISI web site. ISI classifies articles by subjects, not by academic department. Hence, these numbers do not reflect publications of petroleum engineering departments, since some of these articles were written by faculty from different departments and some of the petroleum faculty's papers might be classified with other subjects. However, these numbers give an indication of the petroleum engineering publications for each university.

getting jobs. The job market for DPEs in Saudi Arabia is limited. The potential institutions for hiring these engineers are the Saudi oil company, ARAMCO, and local branches of multi-national petroleum service firms such as Halliburton and Schimberg, the small national petroleum service companies that do business through getting contracts with ARAMCO. The public sector does not have specific classifications for petroleum engineers but it hires them as environmental specialists. Even environmental engineering, as criteria, suffers limited demands as well. The GPA is the essential factor in hiring petroleum engineers in petroleum companies; it has to be 3 or above²⁴. Empowering students with communications skills such as the ability to give professional presentations and lead meetings also seems to be important, at least for ARAMCO. According to one of my informants, the ARAMCO administration is not happy with Beta's DPE graduates in that sense.

Finding jobs for graduates became a serious problem for the DPE at Beta. Many of my informants at Beta stated that the problem was their main issue when contacting ARAMCO. Those who served as department chairs found themselves involved deeply in the problem, which consumed their time and energy and even became a public issue. The largely distributed newspaper, Al-Riyadh, covered it more than once. Al-Ekbariyah, a governmental national TV station, hosted the department chair and some of his graduates to cover what appeared to be a dilemma for both the department and the graduates. The problem does not seem to be that ARAMCO, the larger market, avoids hiring the department graduates; rather, the department's graduates often fail to meet ARAMCO's

²⁴ That is in the case of ARAMCO and the global petroleum services firms. The national petroleum services companies tend to hire non-Saudi manpower due to the fact that foreign manpower is cheaper.

standard for a GPA of 3 or higher. During the collection of data for this study, the DPE at Beta was developing a new curriculum and seeking accreditation of EPT to modify their standards.

A low GPA is not a characteristic of all the graduates of Beta's college of engineering. It is a problem in petroleum engineering only and has been for a long time. The interviewees of the department who ever served as department chair all kept mentioning finding jobs for their graduates as the main problem facing them during their service as department chair.

What accounts for this problem? An administrator at Beta stated that there is a real problem in the department. Historically, the department suffered a lack of institutional attention, which led to deeper structural problems.

We at the university and at the Ministry of Higher Education did not have the level of consciousness to give the kind of special institutional care to the petroleum engineering department that it deserved since petroleum is the main engine of our economy. A regional university²⁵ named the college of engineering as 'college of engineering and petroleum' and centered the college's identity on petroleum science. We did not do this. The department was left with no institutional guiding. Another factor [of the status of the department within the college] is that the people who founded the department and worked on it during its early years were non-Saudis. They were there for a limited period of time. They perhaps did not intend to trouble themselves by going beyond teaching. They did not pay attention to the department's place in any larger context; they were busy with teaching only. When a new Saudi generation of faculty members graduated from U.S. schools and came back to teach²⁶ and lead the department, they were faced by the isolation of the department and obstacles ARAMCO put against their graduates; some of these are real and some are just artificial. Meanwhile and maybe because of the obstacles in the job market against petroleum engineering graduates, there developed a policy within the college of engineering that students who do not get into other academic departments are sent to the

²⁵ Regional does not have a specific meaning. Sometimes it is used to refer to the six members of GCC (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and UAE). Sometimes it is used to refer to the Middle East as a whole.

²⁶ These were among the early graduates of the departments. They were chosen to receive scholarships to go to western universities to finish their graduate studies and come back to teach at the department.

petroleum engineering department. So the department became the place for the lowest qualified students of the college²⁷ (Administrator 1 at Beta).

The interviewee presents an honest and coherent description of the department's main problems, which have accompanied it through its entire history and consumed its leaderships' time and energy. The lack of institutional care, difficulties facing its graduates, and the low number of Saudi faculty members²⁸ all contributed to making the department occupy the lowest rank within the college. There has not been a dean or vice dean of the engineering college from the DPE throughout its entire history. But the low number of faculty members may become the most significant factor; low numbers mean lower representation within the college's leadership, committees, and other circles of decision-making. With its low faculty numbers, the departments suffer a real lack of power within the college²⁹. The number would have been increased had the department attracted more students, which is unlikely to happen with a narrow major such as petroleum engineering.

The problem of finding jobs for graduates may have influenced the production of connected science at Beta's department in an indirect way. The resistance of ARAMCO to open avenues with Beta's DPE could be due to the negative attitude ARAMCO developed about the department based on the performance of the department's graduates. In other words, ARAMCO may have made judgments about the faculty members' abilities based on the fact that many of Beta's DPE graduates do not meet its standards,

²⁷ All used parts of interviews were translated from Arabic to English, by researcher, except interviews with scientists 3 & 4 at Alpha University.

²⁸ During the study, there were three Saudi faculty members versus more than one hundred faculty in the civil engineering department and forty-some in the electrical engineering department.

²⁹ This point deserves ethnographical study of how power is distributed within academia.

making cooperation between industry and academia in terms of doing research less likely to occur.

In contrast, the PED at Alpha has not suffered from such a problem. During the time of this study, oil prices were at their peak. ARAMCO was planning to expand its exploration for and production of oil, which was reflected in the job market for petroleum engineers. ARAMCO was searching for qualified students at Alpha's DPE to offer them scholarships³⁰. ARAMCO has a scholarship program through which the company sends students to various western universities for academic degrees. The program considers Alpha as the only Saudi university to send students to. Typically ARAMCO offers 50 scholarships per year to all Alpha's departments. During the time of this study, ARAMCO was planning to offer 45 scholarships to just the DPE at Alpha. This program made the department more attractive for freshman students of the college of engineering at Alpha. The large number of freshmen who wanted to major in petroleum engineering led the department to be more selective in accepting new students; unlike at Beta, Alpha's DPE was accepting only the most qualified students among freshmen.

In both cases, the giant potential employer, ARAMCO, appears as an active actor in placing the departments within their college ranking. However, the historical relations between Alpha and ARAMCO may have facilitated the hiring of Alpha's DPE

³⁰ Higher education is free in Saudi Arabia. Moreover, students are given a monthly income of \$264; see the fourth theme in Chapter 6. With a scholarship, students get a higher monthly payment and the security of a job at ARAMCO after graduation.

graduates³¹. It might be that Alpha's standards of education meet ARAMCO's standard. It is important, however, to notice that the curriculum of Alpha's DPE is accredited by EPT. Alpha has focused on the mission of providing the country with qualified manpower for the petroleum industry since it was a community college, and this may have helped the DPE at Alpha to gain the institutional care missing at Beta. But the fact that the DPE at Alpha has not faced the problem of finding jobs for its graduates has helped the department to maintain a good reputation both inside the university and outside it, and has saved the energy and time of its leaders. The graduates of the DPE at Alpha who work for ARAMCO play a role in connecting the research activities with the actual needs of ARAMCO, which will be analyzed at the end of this chapter.

Another difference between the two departments of petroleum engineering is the achievements of the PDE at Alpha. One of its members has been working for twenty years to develop mathematical models that predict viscosity of different kinds of Saudi crude oils based on its gradients. As part of the reward system in science institutions Merton described, that faculty member got the correlations he developed named after him. ARAMCO uses his correlations and equations to program software used in calculating oil production. Prior to these correlations, ARAMCO was using equations that were developed based on oils from America or the North Sea, which may have different components. The Society for Petroleum Engineers (SPE), a global organization of petroleum engineers, named this scientist 'best petroleum engineer in the world' for 2005. Additionally, two Alpha faculty members developed an important formula to

³¹ If that was the case, it is important to notice that such historical relations did not help in creating cooperation in research between ARAMCO and Alpha's DPE faculty until a decade ago; see data analysis for more information.

control sands in reservoirs for which they gained a patent and wide national recognition. ARAMCO funded the research project during its lab phase and was allowing the team to experiment at two reservoirs during the data collection for this study. Another faculty member of the DPE at Alpha was nominated for the prize of best teaching skills in Alpha during 2005. Finally, the 2006 president of the global organization of SPE, an ARAMCO engineer, got his bachelor's and master's degree from Alpha.

The graduate programs of the two departments also differ. Both of them have a graduate program; Beta's offers master's degrees while Alpha has both master's and Ph.D. programs. The activation of the RI at Alpha allows the department to have Ph.D. students work in research labs suitable for Ph.D. research. While the master's program does not require residency, the Ph.D. program does. One of the major scientific achievements of Alpha's DPE, the patent for controlling sands in reservoirs, was accomplished through the work of two faculty members and a Ph.D. student. It is known that a Ph.D. program, or at least a full-time master's program, is an important component for an academic research department.

I noticed an interesting phenomenon at Beta's DPE. Many Saudi faculty leave the department, either through early retirement or working temporarily for other institutions outside the university. This could be seen as part of a phenomenon facing Saudi academia known as "the leak of faculty members." Because the private sector offers higher salaries for qualified Ph.D.s, especially in medicine, engineering, and business, some faculty leave academia early. At the DPE of Beta, two faculty took early retirement and two

others had been working temporarily for the private sector during the period of data collection for this study. This does not seem to occur at Alpha. Income is not a factor, since public universities are all governed by one regulatory body that applies a unified salaries table (see the third theme for more details). The attrition could be linked to the rank of the department within the college or to the lost ties with the oil industry in terms of research and funding opportunities. Alpha's DPE suffered a lack of faculty members during the duration of this study for different reason. Two Saudi faculty had passed away and one non-Saudi had found a new opportunity at a Canadian university.

5.4. ARAMCO

ARAMCO is not a site for this study. However, providing the reader with some descriptive data about it is important because of its vital role in making use of the science produced by faculty of the university DPEs.

ARAMCO is the Saudi national oil company. It is owned by the state. ARAMCO dominates and manages all the Saudi oil reserves. Because Saudi Arabia has the largest amount of crude oil and is the largest producer of oil, ARAMCO is the largest oil company in the world (ARAMCO annual report, 2005). Its recoverable crude oil reserve was estimated to be 259.8 billions of barrels in 2005; the second largest reserve in the world is located in Iran with 132.5 billions of barrels. In 2005, ARAMCO produced 3.3 billions of barrels of crude oil, with a daily production of 9.1 million of barrels.

In 2005, ARAMCO had 51, 843 employees, 87 percent of them Saudis. With such a huge operation, one would logically assume that petroleum engineering, both as a profession and as a field for research activities, is an active field for Saudi university researchers. In reality, as we have seen, there are only two academic department of PE, one of which suffers from isolation and marginalization. The data analysis will investigate why a department is isolated and how it could be connected.

ARAMCO gains much recognition for playing positive roles in national development. For instance, in 2004 it was selected as the best institution in the Arab world for training its employees. It has built schools and offered scholarships, conditioned minimum rate of Saudization³² of national companies to give them contracts, even offered free training programs for the employees of small Saudi companies. It donates scholarships for Saudi universities to send their teaching assistants to western universities to earn their Ph.D.s and become part of the teaching staff.

However, ARAMCO's generosity has not extended to the research activities at Saudi universities. ARAMCO does not have funding or grants programs for Saudi universities. Universities allocate little money for funding research. The main funding sources for research activities within universities are the National Institute of Science and Technology, King Abdulaziz City for Science and Technology (KACST), and the national firm of petrochemical industry, SABIC. While none of my informants at Beta had ever gotten funding from ARAMCO, a few of them had gotten big grants from

³² Saudization is a term used nationally to mean subsidizing foreigners with citizens in labor market (see chapter four for more details on labor structure in Saudi Arabia).

KACST and all of them were working, or had worked, on research funded by SABIC³³. Those grants, however, were not designed to solve technical problems or to address actual needs. Indeed, they were grants to facilitate scientific research within universities.

ARAMCO has not participated in such efforts, despite its positive image as an active player in developing both national institutions and local communities; this deserves deeper investigation. Almost every informant in this study states that ARAMCO is highly practical in supporting research; it supports research that is designed to meet actual and current needs of the firm. In sum, ARAMCO does not have any program to support basic research.

5.6. The relation between DPEs at Alpha and Beta

The two universities of Alpha and Beta are networked through various institutional links. Both of them are members of the Council of Higher Education³⁴ and they both belong to the Ministry of Higher Education. The colleges of engineering at Alpha and Beta are also linked through a regional institution, the committee of engineering college deans in the Gulf Cooperation Council (GCC). However, the two academic departments of PE at Alpha and Beta seem to be isolated from each other and not institutionally linked. There is no professional organization or scientific society that brings them together and hence, no social ties, meetings, or personal interactions that distinguish their relations. They are connected through regional conferences or publications in journals. The lack of personal interaction between the two departments creates gap in the research efforts of faculty at

³³ For more detailed information about grants at Saudi universities, see Chapter 4. It should be noticed, however, that SABIC provide small grants to help faculty do research.

³⁴ See more description about it in the forth theme.

the two departments. One of my informants at Beta's DPE has published 15 papers on controlling sands in reservoirs, a very serious problem for oil industry. All of these papers were mathematical models developed in the department's labs. Meanwhile, two faculty at Alpha's DPE were working on inventing a new technique to control sands. The technique got ARAMCO funding, an international patent, and national publicity. They published several papers based on the work. None of the two parties cited the other, cooperated, or exchanged information about their area of expertise related to the problem. Neither department invited faculty from the other department to give presentations about his input to the problem.

It should be noted again that there are only two academic departments of petroleum engineering in the country. Further, the research activities of these departments are lower than the capacity of the national industry. It might be that the lack of communication between the two departments is due to the lack of a culture of research as an institutional activity, not only as an individual one. However, the two departments differ in their relation with ARAMCO. In the coming section, I will provide some description of how each department is networked with ARAMCO.

5.7. ARAMCO and Alpha's DPE

The DPE at Alpha is linked with ARAMCO through various means. These means allow for social interaction between faculty members of the DPE at Alpha and ARAMCO's engineers and managers. The social interactions ease communication between academia and industry and increase familiarity among members of both. ARAMCO does not have a

program to announce its funding for research, which makes this social interaction play a particularly critical role. Because there is no formal means by which faculty members can determine the actual problems facing the oil industry and/or what ARAMCO needs research help with, informal means are critical. There are three means by which the faculties of Alpha's DPE are connected with ARAMCO. They are the Society for Petroleum Engineering, the department graduates, and the geographical location.

5.7.1. The Society for Petroleum Engineering

Among the factors that ease connectivity between Alpha scientists and the Saudi oil industry is membership in and attendance of the activities of a professional organization that bring academicians and industry officers together—the Saudi section of the Society for Petroleum Engineering (SPE).

SPE was established in the United States in 1957 as part of the American Institute of Mining Engineers (AIME) and then incorporated separately in 1985. Currently, the SPE is a global professional organization. It is described as the largest network for professional managers, engineers, and scientists in the oil and gas industry, with more than 69,000 members in 110 countries. SPE organizes more than 70 events per year around the world at which information in the field of petroleum and gas industry is exchanged. The SPE publishes a monthly peer-reviewed journal, the *Journal of Petroleum Technology* (JPT), in addition to four quarterly peer-reviewed journals, books, and online articles; their e-library contains more than 40,000 papers to which 1,700 papers are added annually. Their e-library experiences one million downloads a year (SPE web site). The SPE organizes its

branches into sections and chapters. Sections are for professionals and chapters are for students, and chapters are always named after the universities where they are located. The SPE has more than 150 sections and 160 student chapters around the world. Interestingly, the elected president of the SPE for 2006 was a Saudi petroleum engineer who works at ARAMCO and got his BS and master's degrees from the DPE at Alpha University. ARAMCO is represented in the 2007 board of directors roster by two persons, the president and the Middle East regional director. Obviously, the SPE is strongly linked with the giants of the petroleum industry. Halliburton pays student memberships and BJ, an oil service company, underwrites university e-library subscriptions.

In Saudi Arabia there are one section and two student chapters. The student chapters are located in both DPEs, Alpha and Beta. Unlike the Beta chapter, the Alpha's has a website that contains some information and activities of the students of the DPE at Alpha.

Some countries have more than one section. For instance, Australia has nineteen sections. Although it is the largest producer of oil in the world, Saudi Arabia has only one section of SPE. However, the Saudi section seems to be active, large in size, and advanced. According to its website, the Saudi section won many awards in 2006, as a regional distinguished section, and some of its board members have gained the annual award of regional distinguished personnel of the SPE. One of its directors is the Middle East regional director of the SPE; he is a member of the general board of directors of the SPE. The Saudi section is hosted and run by ARAMCO personnel. Alpha's DPE is represented

in the section, where a faculty member serves on the board of directors. Beta's DPE is not represented.

The Saudi section of the SPE run a monthly meeting in which a technical presentation is offered. Alpha faculty members participate in SPE activities. They attend the monthly meeting of the Saudi section of the SPE. Officers, among them high-positioned leaders and engineers of ARAMCO, also attend.

When you go to the monthly meeting of SPE, you see all the top management attending: VPs and General Managers (Scientist 1 at Alpha).

The meeting facilitates the exchange of knowledge.

You get information about the latest technology, the latest developments in the field by attending these [meetings] because there are basically general technical presentations. Sometimes they are focused. Sometimes they are general. But the benefit that you get is that it exposes you to new technological developments (Scientist 4 at Alpha).

What is significant about the SPE monthly meeting is not only the shared knowledge but, more importantly, the social ties that are being built and maintained through these meetings.

I keep going to the monthly meetings of SPE. It helps me maintain contacts with ARAMCO people. As a matter of fact, we are being represented in the local section (Scientist 3 at Alpha).

Technical presentations given in these meetings motivate general discussions in which questions, answers, and comments are exchanged. These meetings could be seen as social rituals that bring together the people of industry and the faculty of the DPE on a regular basis. Knowledge and expertise about petroleum technical issues are shared and exchanged as part of practicing the rituals. Dinner is offered during each meeting, which reinforces the social nature of the meeting. These rituals of exchanging knowledge around shared meals familiarize the people of the Saudi oil industry and the faculty of

Alpha to an extent where a shared consciousness of the technical issues in petroleum engineering is constructed. When describing the source of the research problem of two of his papers, scientist 1 at Alpha says

There is a problem that we, I mean by we ARAMCO and the engineering community here [in the department].

The usage of the 'we' pronoun to include both industry and academic people indicates the feeling of shared identity that bring the two segments together. This identity is created through constructing a shared list of problems and developments in the field, which emerges through joining the activities of the SPE. In other words, the monthly meetings of the SPE, as social rituals, create a communal sense among industry and academic people of the problems being faced in the field, how they should be solved, and, more importantly, who is who within each problem or technique in the local community of petroleum engineers. This shared sense of problems and solutions means that Saudi scientists are not only more exposed to the actual problems of industry but also are more likely to produce connected research.

The second means [of getting a research contract from ARAMCO] is mutual visits, they visit us and we visit them, or through technical presentations and conferences. They [ARAMCO] are close to us. There is continuous collaboration, continuous research (administrator 2 at Alpha).

In contrast, Beta faculties do not have the privilege of such social rituals that bring them together with the petroleum engineers of ARAMCO.

We need to travel [to contact people of petroleum engineering management at ARAMCO]. When you arrive there, you find people waiting and ready for you. You are planned what to see and what not... Friendly meetings may ease communicating process. If people of Alpha meet once a month with ARAMCO, compared to us, the ratio reaches two to twelve (Scientist 3 at Beta).

The two meetings the scientist talks about are regular field trips that are part of educating the undergraduate students of the department and not for the sake of seeking research

funds or looking for consulting opportunities. One could feel the complaining tone of Beta scientists when they talked about the barriers between them and industry. When asking Scientist 2 at Beta about the source of research problems he writes about, he says:

They are supposed to come through contacting oil companies. [But] one does not meet with people of oil companies regularly.

The SPE monthly meetings offer the Alpha faculty a regular means of meeting ARAMCO people. Thus it serves, for Alpha, to provide a social network for the two segments of petroleum engineering—the industrial and the academic—with each other, which helps the academic scientists to produce connected science. This means of interaction is missing in Beta’s case, which reinforces the isolation of the department from industry.

5.7.2. The graduates and geographical location

The relations between ARAMCO and Alpha, as a research institution, had been weak until the activation of the RI a decade ago; see the first theme in the next chapter. In contrast, ARAMCO has maintained a strong relationship with Alpha as an educational institution. The historical conditions of establishing Alpha, presented above, details part of that strong relationship. ARAMCO has treated Alpha as a place for preparing qualified engineers and managers. The university was established to play such a role; see the third theme. Large number of Alpha’s graduates have found jobs at ARAMCO. Some of them have reached high positions within the giant petroleum industry. These Alpha graduates know the qualification of Alpha’s faculty and may have biases and loyalties toward their school. My informants at Alpha mention the positive role the Alpha graduates play in easing connections with ARAMCO. As they become decision-makers within ARAMCO,

some of those graduates start using Alpha as a potential location for research. They play a role in changing ARAMCO's vision of Alpha as merely a teaching institution to include Alpha faculty members' abilities as researchers. The graduates thus ease networking the university with their company.

Geographical location also is a factor in connecting Alpha's faculty with ARAMCO.

ARAMCO donated part of its headquarter land to Alpha to build its campus, when it was established in 1963. Alpha and ARAMCO are separated by only a fence. Some of my informants at Alpha point to this physical proximity as a factor in easing communication with ARAMCO. The closeness makes people's movement between the two spheres a matter of daily activities. While on the Alpha campus, I noticed ARAMCO cars on the university campus. One of my interviews was disturbed by the early arrival of some ARAMCO officers to the interviewee's office.

The geographical factor is mentioned by informants at Beta as the default reason for the cooperation of ARAMCO with Alpha; hence, geographical isolation is used to legitimize the isolation of Beta from ARAMCO. Beta's faculty may think of it because of the difficulties they face when planning to visit ARAMCO headquarter. One of my informants at Beta stated that a visit to ARAMCO may take months of arrangements, in addition to the travel needed to reach ARAMCO headquarter.

The SPE, Alpha graduates, and geographical location all serve as mechanisms for networking Alpha's department with ARAMCO. These networks take the shape of social

interactions which allow industry and university scientists to become familiar with one another and facilitate both Alpha faculty members' understandings of actual field problems faced by the Saudi oil industry and industry decision-makers' knowledge of the research abilities of faculty members.

Chapter VI: Data Analysis

6.1. Introduction

The purpose of this study is to investigate the problem of connectivity between locally produced science and national needs in a third world country, Saudi Arabia. The study led me to generate four main themes about the problem of connectivity. The themes are institutional arrangement, positive attitude, social construction of university, and rentier mentality.

6.2. Connectivity needs institutional arrangements

The study led me to two different academic realms in terms of the rate of connectivity between the scientific output of faculty members and national needs. While faculties at Alpha institution were involved in research projects for the national petroleum industry, the research output of faculty at Beta seemed to be completely isolated from the country's industry. Every faculty member at Alpha University was involved in a research project that was funded by and contracted with ARAMCO. In Beta, not only was no faculty member involved in such research, but no one had ever done so.

What are the factors that allow Alpha to connect the scientific output of its faculty members with the national petroleum industry and that prevent Beta scientists from doing so? What isolates the Beta scientific output from Saudi industry? It is important to note that even the Alpha scientists still suffer, and aware of, in their relation with the national industry. Compared to their peers at Beta University, Alpha scientists are very connected with Saudi industry, but they are still not nearly as connected as they could be.

The answer to this crucial question lies in the appearance of certain institutional arrangements at Alpha and the absence of such arrangements at Beta. By institutional arrangements, I mean a complex set of structural mechanisms that interact to provide a base for the usage of Alpha scientific output by the Saudi petroleum industry. I will introduce these mechanisms through both descriptive data and interviews. They include the research institute, the industry advisory committee, and the summer program faculty.

6.2.1. Research institute

Both universities have a research institute (RI). However, there are differences between the two in terms of organization, philosophy of work, mission, objectives, and experience. First I will describe each RI. Then I will explain how the RI at Alpha serves as a mechanism for linking the scientists in the DPE with the national petroleum industry while the RI at Beta does not.

6.2.1.1 RI at Alpha University

With its six-story-high huge building, the RI at Alpha University introduces itself as an independent body and complicated organization. The RI is chaired by the university vice-rector for applied research and was established in the early 1970s. It contains six research centers. They are the Center for Refining and Petrochemicals, the Center for Engineering Research, the Center for Environment and Water, the Center for Petroleum and Minerals, the Center for Applied Physical Sciences, the Center for Communications and Computer Research, and the Center for Economics and Management Systems. Every center is

managed by a faculty member from an academic department that is related to the center's focus. For instance, the Center for Petroleum and Minerals is supervised by a faculty member of the DPE.

The main function of the RI is contract research at the university in which the RI signs contracts with clients who need the research service of the university. In other words, the RI markets the research services of the university to clients in the larger society. The RI has 150 fulltime researchers. It also cooperates with university faculty members to conduct contract research. According to the 2004 RI book, 24 percent of the research team is composed of faculty members, compared to 36 percent fulltime researchers; the rest are technical support and managerial services. During the past five years, the RI conducted 90-110 research projects and 420-480 laboratory services annually, which were done for the benefit of 180-210 clients annually during the same period. These projects rewarded the university with 30 to 50 million Riyal (\$8 to 13.3 million) a year. The Petroleum and Minerals Center (PMC) was second after the Center for Refining and Petrochemicals in terms of project values during 2003 and 2004. The PMC is the unit within the RI that links the DPE with research consumers.

The PMC has its fulltime researchers, Ph.D and master's degree holders, and part-time researchers. Some of the fulltime researchers help in teaching in the DPE. However, the RI is the institution that makes it possible for Alpha faculty members to conduct research for the Saudi petroleum industry:

The RI is the marketing arm for the university. They have full time researchers but most research is done by the faculty. RI is the promotion, they push, and they bring us business. For example, [RI realizes that] a certain company is interested in solving their problems. They [RI] announce it

at the university. Two or three faculty approach the RI. The RI then writes a technical memorandum that would be sent to those [industry]. If it is promising for them, they ask for a proposal. Then, we start the commercial process (Scientist 1 at Alpha).

The administrator 2 at Alpha describes the center job and how the PMC selects a research problem:

Research teams prepare a research idea. Then we approach the client about it. Mostly, we find someone at ARAMCO who is interested in funding this research or that. Once they like the research idea, ARAMCO sends a 'request for proposal' ... there are other means [of generating ideas for research contract]: mutual visits, conferences, sometime ARAMCO approaches us seeking our input to solve a certain technical problem...there are two sources for research problems: the research teams and the client...we have full time researchers and the faculty members, mostly faculty of the petroleum engineering department, participate either as project managers or as members of research teams (Administrator 2 at Alpha).

The above text illustrates how the RI approaches external actors to "sell" them research. It also illustrates that the client for the PMC is the national oil company, ARAMCO. The administrator uses the words "the client" and "ARAMCO" interchangeably. The faculties of the DPE participate in contract research with ARAMCO. Interviews at the petroleum department indicated that every faculty member was involved in a research project, or more than one, with ARAMCO through the PMC of the RI.

We work here as full time in the department. We work as part time in the research institute... as a matter of fact we are managing projects through the research institute. RI is used as the umbrella for the contractual research projects (Scientist 3 at Alpha).

Things sometimes go through an informal stage at the beginning, especially if the research idea comes through the faculty member himself and not through the industry.

Either the chairman of the PMC contacts the industry to seek research opportunities or individual faculty would do so. For example, I am a faculty member at the department. I have relations with 500 petroleum engineers at ARAMCO. I know what they do and I have an idea [of research that fits the ARAMCO needs]. But I need pushing. I go to the chairman of the PMC. I talk to him: 'I need you to talk to the VP.' Things are still informal at this stage. We do not start written things, documents and contracts, unless we receive a request from the company [ARAMCO]. But things in the beginning need pushing, through phone calls, or you take advantage of meetings, conferences, dinner, and lunch (Scientist 1 at Alpha).

It is clear that the RI is the institutional link between the faculty members and the Saudi industry. Meanwhile, the faculty members are part of the research teams at the RI. The differences between the research work of the fulltime researchers at the RI and faculty members is that the fulltime researcher conducts research that is designed and managed by the RI while faculty member may choose the research problem themselves and work on it or they may participate in contract research with the RI.

Normally, faculty tends to do basic research. They have the freedom of intellect to study and investigate, explore, broaden the scope of research. Faculty members are not restricted. He determines the research frame based on his research interest (The administrator 2 at Alpha).

Faculty members at Alpha feel the differences the RI has made in regard to their relation with the Saudi petroleum industry.

The department was very small. We were a small group, even. When the department started, we did not have the excellent facilities to handle big projects. But after the RI was equipped and they had all the labs prepared for research, we invited ARAMCO. We had several meetings with them back and forth (Scientist 3 at Alpha).

The RI has facilitated the interaction with the industry (Scientist 1 at Alpha).

The RI is a source of contract research for faculties at Alpha.

The RI is the marketing arm for the university. They have full time researchers but most research is done by the faculty. RI is the promotion, they push, and they bring us business (Scientist 1 at Alpha).

It seems that there are general impression among national productive sector about the nature of faculty research at Alpha is that it is for intellectual challenge more than it is for solving technical problems that face industry, although faculty members do participate in research for the Saudi oil industry. This impression is a product of historical construction of faculty research in Saudi context. Most of faculty members' publications were product of isolated activity, as I will show in coming sections of this chapter. The cooperation with local industry seems to be a newly developing phenomenon. However, while

faculties at Alpha do enjoy a sort of cooperation with local industry in terms of producing science, the picture at Beta is totally different.

6.2.1.2. RCI at Beta University

The Research and Consulting Institute (RCI) at Beta University is relatively new. It was established in 1997. The first three years were used to establish the institute and went with no achievement, according to the administrator 1 at Beta. It is different from that of Alpha in terms of size and organization. Unlike the RI at Alpha, the RCI at Beta is located in a small part of a management building at the university. The RCI at Beta does not have centers, labs, and full time researchers. It functions to market the university faculty's research skills to the larger society; its stated mission is to allow society to benefit from the research and consulting skills of the faculty members at Beta University, according to administrator 1 at Beta. By doing so, RCI is able to create connection that would bring more resources for the university.

The RCI at Beta is organizationally simple compared to that at Alpha. The RCI is managed by a dean who is aided by a vice dean. It has fewer than twenty managerial staff in a department for marketing, a department for following up, a department for consulting services, and a department of support.

The RCI aims to bridge the gap between the university and society. "The university before [the establishment of the] RCI was described as an educational, academic institution that is away from the reality and the concerns of people... Its activity is nothing more than a high school or a little bit more than a high school... There was real

desire to have connection with the society... the university was not playing the expected role in terms of research and development. Hence, a main goal of this institute is to bridge the gap with the productive sector,” said administrator 2 at Beta.

The RCI does not conduct research but introduces researchers to the productive sector in society:

In the beginning, we [at RCI] were linking individual faculties with client. The demand was for individual faculties who could do consultations. [we receive] requests for a consultant on this issue or that. We search among the university’s faculties and nominate the right person for the client (administrator 2 at Beta).

The RCI develops its work later on. Instead of just linking individual faculties with external client, it organizes the work through forming teams of faculty members, mostly from different academic departments, to work on certain research projects or consulting jobs. The RCI signs the contract with the client and manages the project to make sure products are delivered according to the contract. The RCI gets contract in different ways:

We hunt for consulting opportunities. They come through different sources. Some of the consulting opportunities come through a faculty member or open competition. We form a scientific team to study the project. [Also], opportunities may come from the client itself, which is usually a former client... once we are attracted to a project, we start building our team that would conduct the work (Administrator 2 at Beta).

The main difference between the RI at Alpha and the RCI at Beta is the way research is conducted. While the RI does not rely exclusively on faculty members, where full-time RI researchers constitute the majority of the research teams, the RCI intends to rely completely on university faculty members, aiming to achieve two goals, training faculties and serving society. Such difference is supposed to benefit of faculty of DPE at Beta, but it does not. None of the department faculties has ever conducted a consulting or research project for ARAMCO. Why does the RCI not help in this matter?

The engineering services are widely demanded except the petroleum engineering. Its potentiality is high but it is still inactive. We are trying to make it more active; we gather information about research interests of our faculty, arrange visits, and contact the client (Administrator 2 at Beta).

The interviewee mentioned some methods to connect the faculty of the DPE with the local giant industrial firm, ARAMCO. However, none of these methods have been exercised yet. Therefore, one can conclude that the faculties of the DPE at Beta suffer the lack of the institutional link with Saudi industry. Interviews with faculty members in petroleum engineering at Beta illustrate that they have not attempted to use the RCI as a link. They are eager to conduct contract research for Saudi industry; they are enthusiastic about producing connected science. But they have not been able to accomplish the first step.

The issue is the first step. If they (Saudi industry) give you one research project, that is it; it means the road has been opened. But how can you get the first step done?! (Scientist 4 at Beta).

Faculty members tried to contact the local industry themselves.

We have made big efforts just to establish simple relations with ARAMCO. You know ARAMCO is a huge firm. You may build relations with one part of the firm but you cannot build relations with many other parts because of the distance.³⁵ You have to travel for two or three days just to meet a person for two or three hours there. They are busy. You have to make an appointment a month or six weeks in advance just for a two- or three- hour meeting... they contact [us] when they face a shortage in manpower and are in need of engineers but not for research projects... we have sent them proposals, which was not enough. We had to travel there and present the proposal and talk to the person in charge (Scientist 1 at Beta).

It seems that faculty members at Beta have just begun attempts to contact Saudi industry about their research projects. Two faculty members mentioned a trip to ARAMCO headquarters to present a research project proposal and were still waiting for an answer from the giant national firm. The door had not opened for them yet, but they were hoping and waiting. During this waiting they did not want to give more information about what might be their single visit.³⁶ However, interviews with them uncovered the lack of basic knowledge about to whom such a proposal should be presented.

³⁵ ARAMCO headquarter is 250 miles away form the location of Beta.

³⁶ Faculty at Beta make visits to ARAMCO on a regular basis for student training. The singularity here is about a visit for the sake of presenting research project.

Since our proposal is about scientific research, we targeted the research department at ARAMCO, which is the R&D (Scientist 1 at Beta).

But R&D is not the right department to contact. When I asked Scientist 4 at Alpha if he sent his proposals to R&D at ARAMCO he replied:

[laugh] they are our competitors (Scientist 4 at Alpha).

Administrator 2 at Alpha explains the role of ARAMCO's R&D:

Our work is with the petroleum engineering department at ARAMCO. It is our main customer. The petroleum engineering department is part of the business line in ARAMCO, called petroleum engineering and development... The R&D at ARAMCO is part of another business line called engineering service, which deals with other aspects of engineering such as civil and mechanical (Administrator 2 at Alpha).

The differences among Alpha's and Beta's interviewees in knowing the structure of the national industry reflect the degree of connectivity between the two departments and the national industry.

6.2.2. Industrial Advisory Committee (IAC)

Saudi universities suffer isolation from the country's productive sectors. It is a known fact supported by the literature in the field, as I illustrated in the literature review. Aiming to bridge the gap, Alpha University has come up with an institutional arrangement that could help in linking the Saudi oil industry with the university, the Industrial Advisory Committee (IAC). A faculty of Alpha narrates the story, work mechanism, and function of IAC.

We solved the problem [of being isolated from industry] through involving the industry in our business...every academic department [in the engineering college] has an IAC where major companies in the country who are specialized in the field [of the academic department] are involved. The department was the first one that established such a committee, although it did not take action until later. Currently, we have the committee running. It contains [the companies of] ARAMCO, Schlumberger, and Halliburton³⁷... We did not invent the idea. When we were in

³⁷ Schlumberger and Halliburton are multinational firms in the petroleum industry.

Stanford University, they had such a committee for more than 90 years... I mean us as a department who suggested such a thing for the engineering college...Now the model is working and functioning very well... The idea started in the 1980s. The university agreed to the idea but it had not been applied in our department until lately for unknown reason. Some departments within the college have activated the committee for fifteen years now. Ours just started recently... It advances our relation with industry. We select members [of the committee] from the industry. We select people who perform technical works, not people from management, not a personnel director [of a petroleum company] but a person such as the petroleum technical manager. The goals of the committee are to review our curriculum; sometimes they ask for reviewing some courses or textbooks. They give us advice. [They review] our labs. We see if they are going to support us [with equipment] or not. Also, they review research work of the faculty. The committee suggests for us avenues in field research which companies are in need for. They put us in the frame [of what kind of research they need]... The university felt isolated [from industry]. Thus it starts pushing academic departments to get involved with the industry in their business. As a result, the IAC has emerged (Scientist 1 at Alpha).

The testimony indicates the consciousness the university has about its isolation from the Saudi oil industry and its attempt to remedy the situation through the IAC. The important thing about the IAC is that industry representatives are from technical parts of the firms, not administrative; comments and suggestions would emerge from field needs of the industry. Also, because of being formed by people from the field and not from the management, the IAC facilitates the connection between academicians and those in the field. When describing the curriculum revision process, a faculty member commented:

We do not go through the administration. We know the key people who can contribute to this (Scientist 3 at Alpha).

From the name and aim, the IAC would appear to be a way of generating answers about what the industry needs from its country's universities. However, it seems industry is concerned more about preparing the future workforce. Other faculty members mentioned the role of the IAC in curriculum revision:

They [industry] are members of the IAC. When we need to develop the curriculum, we consult them because the student eventually will work for them after graduating. What are their interests and the topics they want to be covered? (Scientist 2 at Alpha).

The petroleum engineering curriculum has gone through several revisions. In order to graduate good students, you need to have an excellent program that will meet industry needs ...We always consult with ARAMCO when we revise the curriculum... We deal with the people in the petroleum engineering department [of ARAMCO] directly (Scientist 3 at Alpha)

Beta University lacks such an institutional arrangement. However, several informants from Beta University mentioned that they consult the DPE at ARAMCO when revising the curriculum and consider their comments about it. But there are qualitative differences between the two consultations with ARAMCO. For instance, at Alpha case, the industry representatives visit the department and review text books and labs. In the case of Beta, some faculties discuss the issue when visiting ARAMCO. None of the Beta faculty mentioned that ARAMCO representatives had visited the department to discuss the curriculum or to check textbooks or labs. However, the IAC at Alpha serves as an institutional mechanism of cooperation between academia and industry that involves the oil industry in the departments' programs, eases communication between ARAMCO and Alpha, and increases familiarity between the two.

The RI, and IAC serve as mechanisms of institutional arrangement that connect Alpha University with the country's industry. This connection would not emerge as a result of personal efforts of this active scientist or that; neither would it emerge simply because there are institutions that produce science and institutions that need science. The main key in building a bridge between the producers and consumers of science is the institutional arrangements that link the producer and the consumer. Such arrangements should originate with the producer of science, the university, and they should include serious efforts to provide the consumer with a good product along with the consumer's desire to buy the producer's good product. In the case of Beta, the institutional link, the RCI, has not arranged for linking the DPE with ARAMCO yet. That might be due to the way the RCI is structured, since it lack labs and full-time researchers, and to the short life

of the institute. However, the relation between scientific institutions and productive sectors, in terms of research mission of the university, could be described using Weber's concept of exchanged relations. The university in this very special arena is the seller of national scientists' research skills and the productive sectors are the buyers. The seller has to get rid of thoughts that grant him privileges over foreign sellers due to its national nature. In other words, the university as research institute should expect to be exempt from basic duties such as reliability, efficiency, and delivering on time just because they are national institutions. The mutual expectations of national productive sectors and national research institutions are framed by the cultural characteristics or rentier mentality in which the productive sector expect the national scientists' research to be free service and the research institutions expect to enjoy privileges of being 'national' (see theme four for more details).

Alpha and Beta, in terms of connection with the country's industry, make up a tale of two institutions. Their differences allow us to see the basics of connectivity. In terms of research products, I found a partly connected department and a completely isolated one. The most obvious mechanism connecting the academic and industrial worlds was institutional arrangements that are more powerful than individual scientists' efforts, desires, and will.

The faculty members of both departments got their academic training in advanced research universities (see Chapter 3 for the characteristics of interviewees) and were appointed as faculty members. But that by itself was not enough to produce science that

would have highly rewarded nationally and globally. Nevertheless, the production of connected science led to gaining the highest rewards from the institution of science, in the forms of patents and of naming formulas after a scientist's name; see Chapters 4 and 5. The production of connected science would not have been possible without institutional arrangements, through the RI in the case of Alpha. The RI at Alpha was equipped with labs, technicians, full-time researchers, and administrative and legal services to link faculty members with the productive sectors of the larger society beginning in the 1990s. Hence, the department faculty at Alpha could work on research conducted for the direct benefit of the oil industry. The RI, then, played the role of what Ben-David calls the institutionalization of the role of professional scientists. According to Ben-David (1991), the institutionalization of science requires the transformation of the university to be more research-oriented through equipping faculty with research labs. The case of the RI at Alpha indicates that not only research labs are needed but also an organizational development through a complex set of administrative, legal, and regulatory mechanisms that allow for an effective link between scientists and the productive sectors.

The institutional arrangement to connect produced research with actual societal needs puts an individual scientist into a network of meanings and purposes consistent with the fundamental motivations of the individual scientist in a developing society, in which the society raises ambitious expectations from its cultural elites. The institutional connection establishes a mechanism to transform the progressive meanings and ambitions inside the individual scientists into sequences of procedures that lead his/her research effort to be

organized and produced such that it can be sold to a local consumer, who contracts to buy it to solve a technical problem or gain improvement in the work environment.

6.3. Connected science leads to positive attitude and self-confidence

A factor in the relatively successful institutional arrangements at Alpha University was the hard work of faculty members to develop a positive attitude about their professional commitment in the Saudi oil industry, which led to gaining ARAMCO's trust in regard to the research abilities of Alpha faculty.

The traditional expectation of Saudi productive sectors about Saudi academic departments is that they are institutions to teach and prepare manpower for the job market only. Saudi universities have not been seen as centers to produce reliable research for quite a long time. Indeed, there is a negative stereotype of the research abilities of faculty in Saudi academia.

The industry in Saudi Arabia, especially big firms, somehow they do not have trust in the abilities and capabilities of Saudi universities or Saudi researchers to come up with solutions for problems. They have an image that these people (academicians) are just governmental employees. They just want money, over-time payments, travel, and so on. Their knowledge is not worthwhile. The last thing in a faculty's head is what he gained during his graduate studies in the United States twenty or thirty years ago. They are just gaining weight and doing nothing (Scientist 1 at Alpha).

Goonatilake (1984) narrated the story of the prestigious Philippine R&D center at a drug factory where PhD researchers write and publish papers based on samples taken from patents who use the factory products to observe the effects. All effects are already known because all the products were produced in the United States. Hence, there was "nothing new the local scientists could come up with." Doing such research would just reinforce the negative stereotype about local scientists and spread the belief about them not being capable of solving actual problems and being innovative.

Years ago if you talked to some people they don't really have confidence in their local people, in the Saudis, that they can produce research, that they are capable of doing something similar to what other people do in other countries... Before, even if one of us says that he is capable of doing reliable research, he would not get support because of the beliefs that were governing us (Scientist 4 at Alpha).

The last testimony is especially significant. It indicates that there was a negative attitude toward local scientists despite their continuous efforts to produce science and to publish papers in refereed journals. It implies that a positive attitude would not be gained through publication or writing abstracted knowledge. The positive attitude would be gained through producing knowledge that can successfully approach actual problems in the country in which it is produced and come up with creative solutions. Research that is done by those who are called researchers because they adhere to certain methodological procedures may not be enough to build a positive attitude.

The sources of the negative stereotype may be found in the social construction of academic institutions in the national context, where they are constructed as teaching institutions, as I will illustrate in the third theme, social construction of university.

Another source for such a stereotype is the work ethic in general and how it governs work performed by academicians, which I will also illustrate in the theme of rentier mentality.

The work ethics in Saudi academia have somehow contributed to the negative stereotype held by those in the Saudi productive sectors.

Industry should not be completely blamed [for having a negative stereotype]. Part of it was built upon previous experiences with researchers in national universities. The [work delivered] was insufficient. Researchers do not deliver on time; their work is mediocre, nonsense. [Such work makes industry people say] an ordinary engineer in ARAMCO is more knowledgeable than you. What did you come up with that I see as new? You did not solve my problem. Or, they [researchers] make all their work theoretical; all are traditional experiments, no innovation (Scientist 1, Alpha).

ARAMCO is not an exception to this mentality. Historically, ARAMCO was not used to seeing the country's universities as a place for doing practical research that may help in solving actual problems. For ARAMCO, it was taken for granted that the needed research services would be contracted with foreign research centers.

They [ARAMCO] used to send business, we call it [research] business. They used to give research contracts to foreign [research institutions]... in the 1980s, when we go to ARAMCO, they just give us money [to help doing research]. We did not want money to conduct whatever research we want to. No, we wanted to solve their problems (Scientist 1 at Alpha).

A lack of trust among those in the country's academic scientific community contributed to the lack of trust in the industry.

We used not to trust ourselves in the past. We didn't have the feeling that we are confident in ourselves... If you don't have confidence in yourself, how can you convince the others to have confidence in you? (Scientist 4 at Alpha).

Interviews signify that the traditional attitude of ARAMCO has experienced some changes during the past decade.

Since 1990s, the attitude has changed. They [ARAMCO] started funding us. [If] you visit them, they welcome you, hear from you. Sometimes, they send you [work], you and others. They give you a chance: 'I have a problem, give me a proposal [of] how to solve it.' They send [the problem] to us. [Meanwhile] they send it to FPI (French Petroleum Institute) in Paris or ... (not clear) in the United States (Scientist 1 at Alpha).

After the RI was equipped and they had all the labs prepared for research, we invited ARAMCO. We had several meetings with them, back and forth. In the beginning, they were giving projects to the university here. Basically, when I say the university I mean the CPM at RI. The projects were handled mostly by faculty members. Meanwhile, they were sending the same projects to outside to compare results. They found out that the results coming from us were reliable and cheaper. And, at the same time, it gives the chance to the people here to develop themselves and their expertise. So, they started changing their attitude (Scientist 3 at Alpha).

The RI helps gradually in gaining trust of the industry in our abilities. We deliver on time; we are cheaper [than research centers abroad] (Scientist 1 at Alpha).

Now we are getting support from Saudi ARAMCO from the level of top management all the way to the level of engineers. They definitely are supporting the research activities at the university (Scientist 4 at Alpha).

The quotes above indicate many important points. First, the role of the activation of the RI in changing the attitude of ARAMCO was crucial. Second, measuring the reliability of university research through comparison with the results of known and trusted research centers helped to build confidence. Third, the attitude of the country's productive sectors toward the country's academic scientists is evolving. Small steps could lead to a major change in the attitude of national consumers of science.

After carrying out several project for them, and delivering the results to them, I think they were very happy with the results, which gave them some sort of trust in this institution that reliable work can be generated from here (Scientist 3 at Alpha).

Here is a real story. There was a contract research between ARAMCO and RI in which a local scientist, faculty member of the electrical engineering department, was involved. He came up with a specific application of a well known assimilation that was developed by a live non-Saudi scientist. ARAMCO people rejected the application and returned the work but the scientist did not accept to change his application and a controversy emerged. ARAMCO then sent the job to the assimilation inventor to consult with him about the controversy. He validated the Alpha scientist's opinion, stating that he was doing the right job. ARAMCO then got to trust that person and heavily relies on him in matters of his research interests (Scientist 2 at Alpha).

Years ago we did not prove to them [the industry] that we are capable of doing research that they can benefit from. Maybe now they see the research results that we can do inside the country are reliable; they can use it to solve their problems. It is not just that they want to give the money. If they do not see that they are benefiting they will not give us projects...When at least some people know that you can deliver, you have the capability, you have background, they trust you. Of course, they are going to deal with you (Scientist 4 at Alpha).

The descriptions by Alpha faculty of the changing attitude of the Saudi industry imply that the faculty had themselves adopted the general negative attitude. The Saudi academic science community lacks self-confidence because of the negative stereotype held by the country's productive sectors about their research abilities.

Through hard work we have proved [it]. First we have proved to ourselves, we convinced people among ourselves, that we have the capability to do the level of research that other people can produce. When you have confidence in yourself then you can present yourself to the outside. We have gone through that period. Now we feel that the Saudi faculty can produce good quality research. The industry also has the confidence that we can deliver good quality research results (Scientist 4 at Alpha).

Another lesson to be learned from the above testimonies is that the connected science helps in providing academic scientific communities with self-confidence. Scientists

correlate the self-confidence not with scientific productivity but with science produced to approach actual problems facing the country's productive sectors. This point is significant for the sociology of scientific knowledge.

6.4. The social construction of the university leads to isolated science

Previous studies of the state of research in Saudi universities have uncovered the weakness of the research mission of these universities (Mandeeley 2001, Sane 1966, Munifikhey 1989, Alsalem 1997, Mahboob 2001, Fhmmey 1993, Seroor 1999, Aldbasi 1998, Khateeb 1996, Turkistani 2002, Kana'an 2001, Khudair 1999, Lal 1998, Alsulimani 1996, Alghatani 2004, Seam 2001, Aisawi and Dakheel 1999, Alsalem 1999, Aldawood 1996, Ageeley 1984, Nuaimi and Nuaiman 2000, Turkistani 1999). Some of these studies point to the universities' concentration on the teaching mission as an obstacle to research productivity either directly, such as assigning faculty with heavy teaching loads, or indirectly, such as not equipping libraries with updated resources or providing low funding. (See Chapter 2 for more detailed analysis of these studies.)

According to these studies, Saudi universities all seem to be teaching institutions. In this theme, I illustrate how certain actors socially construct the university to be a teaching institution and how such construction excludes connected science from the list of social expectations of the university. These actors, or social groups, interacted based on shared meanings of what the university is about and, hence, were able to construct it the way it is. The social construction of the "university" in Saudi Arabia, and maybe in most LDCs,

has led to the ignorance of the research mission of the university and has given greater attention to the teaching mission.

In terms of social groups that participate in the social construction of the university in Saudi Arabia, I identify four actors: the state, the universities' leadership, the productive sectors, and the larger society.

6.4.1. The state

Higher education in Saudi Arabia is relatively new; it began in the early 1950s with some colleges. The structure of higher education, especially the financial and regulatory structure, illustrates how the university is seen by the state—an institution to educate new generations and prepare them for job market. While teaching is only one of a modern university's missions (the other two are research and serving society), it becomes almost the exclusive mission in such an arrangement. The state's vision of the university in the Saudi context is extremely significant knowing that the state is the most powerful actor in constructing the university. Until a few years ago, there were no private universities and colleges in Saudi Arabia; all were state ones. Up to the present day, when we talk about higher education in Saudi Arabia, we talk about governmental universities and community colleges; the private ones are a new phenomenon and small in both numbers and sizes.

Universities in Saudi Arabia are organizationally linked with the state. They are linked to the government through the ministry of higher education and the council for higher education. The council of higher education plays the role of the legislative body of the

higher education system in the country. It is chaired by the chairman of the council of ministers (the equivalent of a prime minister), and the minister of higher education acts as the deputy chairman of the council. Members of the council include ministers of education, finance, planning, work, social affairs, and rectors of universities. It is located within the ministry of higher education. The ministry of higher education is the executive part of higher education policy. It directs universities, supervises them, and makes sure that higher education policies are practiced by higher education institutions.

Every university has its own council. The minister of higher education is the chairman of every university council. Universities are managed by the university council and the rector. The council meets monthly to make important decisions for the university. The university rector is assigned by a royal declaration, based on a nomination by the higher education minister. A university's annual budget revenue comes mainly from the state. High officers of the university prepare the budget and negotiate it with the ministry of finance. The university's annual budget is announced with the declaration of the state budget.

The higher education system in Saudi Arabia is a centralized one. There are specific regulations for hiring, promoting, salaries, job description, and teaching loads of faculty members, which govern all governmental universities.³⁸ In general, the reward system in Saudi academia is framed by central regulations that are written by the council of higher

³⁸ The private universities are a new phenomenon in Saudi Arabia.

education³⁹ and observed by the ministry of higher education. The centralized organization of the higher education system in Saudi Arabia has not allowed for the rise of different types of universities, teaching versus research ones. They are all the same in terms of the teaching mission; they might, however, differ in fulfilling this mission. Hence, some researchers conclude that the higher education system in Saudi Arabia has no mechanism for competition among Saudi universities.

In regard to my assumption that the nation state in Saudi Arabia participates in the social construction of national universities to be teaching universities, there are some specific regulations and structures the state maintains that concentrate and reinforce this mission. For instance, the written mission, objectives, and goals of the university in Saudi Arabia are no different from those of western universities in regard to research missions and objectives. According to the first article in the regulation of the council of higher education, universities “offer undergraduate and graduate education, promote scientific research, perform writing, translating, and publishing, and serve the society according to their own specialties” (Daleel Al-Taleem Al-ali, 1996). The regulation of Scientific Research in Saudi Universities (UPSR) emphasizes the research function of the university. In its second article, the UPSR calls for encouraging faculty and students to conduct unique and distinguished research that contributes to enriching specialized knowledge and serves society.

³⁹ The council of higher education and universities is chaired by the chairman of the council of ministers (equivalent to the prime minister) and the minister of higher education acts as the deputy chairman of the council. It is located within the ministry of higher education.

However, there are no specific policies that would put the research mission into practice as there are for the mission of teaching. The regulation of faculty members of Saudi universities does not include the “publish or perish” policy. The system requires publication for promotion but not for maintaining one’s job position as a faculty member.

In other words, publication has nothing to do with having the position.

If the faculty is a foreigner, you may not renew his contract if he does not publish. But if he is a citizen, you cannot fire him for such a reason. You may, however, keep insisting that he publish (Administrator 1 at Alpha).

No one can force the faculty member to do research (Administrator 1 at Beta).

But if the faculty member is absent from his/her job for fifteen continuous days with no legal excuse, he/she could be fired. It is the same regulation for any job in the state’s bureaucracy. The job description of faculty members emphasizes the teaching mission.

The regulation of faculty members in Saudi universities indicates directly that the main function for faculty members is teaching (Scientist 2 at Beta).

The teaching load of Saudi academia, shown in table 6.1, indicates the nature of the professional role the state expects from faculty members.

Table 6.1: Teaching load at Saudi universities

Status	Teaching loads, academic hours per week
Professor	10
Associate professor	12
Assistant professor	14

In terms of students, there are some structural characteristics that indicate the teaching nature of Saudi universities. Students attend university for free, no tuition at all.

Moreover, students get a monthly allowance. Dorms are free.⁴⁰ Meals are offered at low rates. And the ministry of higher education puts pressure on universities to increase their capacity to offer admission to as large a number of high school graduates as possible.

The problem that we are facing currently is that there is enormous pressure on the university to accept a larger number of students (Scientist 3 at Alpha).

The ministry would not follow the same practice of exercising pressure when it comes to research activities of national universities. The financial regulations of universities provide another example of the emphasis of the teaching mission of the university. The higher education regulation specifies four sources of income for the university: 1) state, 2) donation, 3) renting university properties, 4) contract research. But these regulations do not include mechanisms either to encourage or to exercise pressure on universities to expand their income from doing science through contract research. Universities could expand their sources of income, but they are not required to do so. Hence, the contract research makes up a very small amount of university income. For instance, the annual budget revenue of Beta University that comes through the ministry of finance was 2,500,000,000 S.R. (\$660,000,000). The RI income of Beta the same year was 65,000,000 S.R. (\$16,300,000), which means the university income from research activities is 2.6 percent of the state support. At Alpha University, income from research activities constitutes about 8 percent of state support. However, the situation is improving gradually. The RI of Alpha was equipped and started in the mid-1990s, while the RI of Beta was started a few years later. In other words, there was no income from

⁴⁰ There some requirements for getting a place within the dorm such as having graduated from high school in another city than the location of the university. There is competition over dorms, but there is no fee for such service.

research activities ten years ago in either university. The university getting income from research activities is a new phenomenon in Saudi academia.

The state construction of the university as a teaching institution is supported by regulations of the university. Despite the fact that the research mission of universities appears on documents of the council of higher education, the ministry of higher education, and universities, there are no specific strategies, regulations, or arrangements that would facilitate the performance of such a mission. Indeed, some regulations appear as if they were obstacles to such a mission or in direct contradiction to it.

Two faculties of our department came with new technique to control sands within petroleum reservoirs. Oman's petroleum fields suffer such problem. They (the oil company) heard about the newly technique through a presentation one of our faculties gave in Bahrain. They contacted us [the department] and said we need you to come and perform a test over our fields. We met with them and discussed the idea with them; then we agreed to perform the field test over there. We informed the RI about the idea to raise a contract with the Oman Oil Company, since the RI is the responsible body of research contracts with costumers. The RI told us that they would have to get approval from the government to sign a research contract or to do research for the benefit of a costumer outside the country. 'We have to send papers to the ministry of higher education,' [they said]. It (the request for approval) stayed there for a year and a half until the minister of higher education was able to put the request in the agenda of the weekly meeting of the council of ministries. Finally, the approval came indicating that Alpha University is allowed to perform a research contract for the benefit of Oman Oil Company in Oman. We did not even get an open umbrella to conduct research with any oil company in the Gulf States, for instance. The approval was so restrictive. Imagine! The Omanies were dying, emails and so on [saying], 'Hey guys, we need you please!' [We answered them] the approval has not come yet (Scientist 1 at Alpha).

The negotiations between the founder of the DPE at Beta University and the minister of education illustrate how the teaching mission was the objective of establishing the academic department.⁴¹

The minister of education, who was the senior president of Beta university at that time, preferred that we not involve ourselves with ARAMCO business and vice versa. 'We do not want you to deal with their matters so they don't form a negative attitude about you,' he said. We did not want

⁴¹ At that time, Alpha University was a college that belonged to the ministry of petroleum and minerals while Beta University belonged to the ministry of education. There was no ministry of higher education yet.

to enter their territory so that they would not get mad at us. It was like ... every side does the work it wants to (Scientist 5 at Beta).

Relations with industry for solving technical problems or getting funds from them for research were not in the picture. The academic department was arranged when founded to perform a certain mission.

The objective [of establishing the department] was very clear, to graduate people who could occupy high positions within ARAMCO...Saudi engineers who could work at reservoirs (Scientist 5 at Beta).

It is the same objective Bahgat (1999) talked about when he mentions that universities in Gulf region⁴² were created for the sake of preparing citizens for employment in the expanding bureaucracy. With such objectives, the university would be constructed around the mission of teaching to prepare citizens for the job market and produce a work force that could meet the demands of modernizing traditional societies. The university, with such a construction, serves as a vehicle of social mobility for transitional societies, equipping citizens with the requirements for getting professional positions in public or private sectors. Citing Lin and Younger (1975), Ramirez and Meyer (1980) state that education has a stronger effect on occupation in LCDs than in developed countries. Such a role would reinforce the societal role in constructing the university around the teaching mission, which I will discuss later.

6.4.2. Leadership of universities

The universities' leadership was one of the social actors responsible for the social construction of universities in Saudi Arabia. How did leadership contribute to

⁴² It should be noted, however, that universities main mission in most LDCs are the same in regard to concentrate on teaching mission.

undermining the research mission for the benefit of the teaching mission? Universities' leadership includes the university council⁴³, university rector, vice rectors, and deans. Historically, university leadership was concerned with the teaching mission. Even when university leaders consider or regulate for research, they do so because the university has to have publications, not for getting funds or marketing their faculty members' skills to the productive sectors of society.

However, things seem to have begun to change recently. First, universities have changed during the past decade in regard to the research mission of universities. University leaders emphasize now more than before the research mission of the university. Second, the establishment of the RCI at Beta and the activation of the RI at Alpha have helped in creating a recognition of the societal benefits of faculty members' research among university leaders. The spread of this understanding acts as a factor in reinforcing the research mission of the university.

My interview with some of senior faculties of the DPE at Beta University reveals how university leadership traditionally focuses on the teaching mission of their institutions. More precisely, they focus on the university as an institution to prepare citizens for the job market.⁴⁴

The object was clear from the beginning: you have Saudis who make their own decisions about petroleum. They need to be involved in the decision making about what to do with the reservoir and how to produce oil (Scientist 5 at Beta).

⁴³ Constituted of the minister of higher education, the university rector, vice rectors, and deans.

⁴⁴ That does not mean the goal of preparing graduates for the job market has always been achieved. Indeed, the weakness of output is a known problem of some departments. But the point here is the goal that justifies establishing and running a higher education institution.

The object of preparing citizens for the field has framed the department's relationship with the giant national industry of petroleum, ARAMCO.

Our relations with ARAMCO took the shape of field visits for the sake of training our students (Scientist 5 at Beta).

The industry was seen as a training device and job market for graduates only, not as a potential customer of the research outputs of faculty members.

My contact with ARAMCO was for the sake of arranging field trips or to get summer training...I have visited ARAMCO with students during field trips only (Scientist 5 at Beta).

Hence, the institutional contact with ARAMCO was not with the department that may consume research of faculty members, such as the DPE at ARAMCO, but with a department that deals with the larger society.

We used to deal with the public relations department at ARAMCO (Scientist 5 at Beta).

There were no attempts to do contract research for ARAMCO or to seek funding for research from them because

We knew that they were not interested. They never wanted to talk to us (Scientist 5 at Beta).

Such a perception has perhaps emerged from negative experiences.

We needed data from them (ARAMCO), data about oil shields. Our students should work on something in their own country rather than for me to go and get U.S. data, but it was very difficult to get. We used to order samples of rocks for our students to study and get to know; they [ARAMCO] got very hesitant (Scientist 5 at Beta).

It might be that negative experiences have been used to justify the undermining of the research mission of the department.

They [ARAMCO] did not open any area of communication. You are there to do whatever you want to do. They did not want to cooperate much. [The department has] faculty at very high levels. They [ARAMCO] never picked up the phone, no one ever said could you tell us something about this or that...We could have helped them a lot but they were not open (Scientist 5 at Beta).

Hence, when he did his only funded research project⁴⁵ during his academic career, he did not contact ARAMCO either to seek funding or to approach them regarding results, despite the fact that the research project had practical possibilities⁴⁶.

After ten years of failed attempts, I had no intention of contacting them (Scientist 5 at Beta).

With perceptions such as these accumulated by the faculties of DPE at Beta about their relationship with the Saudi oil industry, it is reasonable that they focus the department on the teaching mission.

Our objective in establishing the department was preparing a work force that could work at the oil fields, and later on they would be representatives at the high management level of ARAMCO. But doing consulting? There were no possibilities. There was no hope that our faculty would be consulted or contacted by ARAMCO. We concentrate, then, on the students. That was the most important objective for us (Scientist 5 at Beta).

Scientist 5 at Beta summarizes the vision of universities' leadership in regard to their institutions' missions. But is it true that the faculties focused on teaching because they lost hope of being consulted by the industry? Building ties with the Saudi oil industry to produce science or to participate in solving local technical problems requires institutional arrangements and positive attitudes that would be built gradually, as the previous themes illustrate. Were faculty members really waiting for a phone call from the ARAMCO seeking their help in scientifically approaching a technical problem that faced the industry? If that accurately reflects faculty members' expectations and perceptions of reality, that would give greater significance to my study, since it identifies structural mechanisms for tying faculty research to the country's productive sectors. Nevertheless,

⁴⁵ Funded by the National Center for Science and Technology, later on King Abdulaziz City for Science and Technology (KACST).

⁴⁶ It was about using some chemicals to treat oil recovery to reduce the negative effect of salty water in reservoirs on equipment, a problem ARAMCO was facing.

the absence of the Saudi oil industry from the research activities of Saudi university faculty is not the fault only of the industry or only of the faculty. The missing university arrangements could be largely to blame. Universities have not, for years, attempted to create such arrangements either because they were busy with the teaching mission or because they lack the appropriate knowledge of what kind of arrangements are needed to link faculty with the country's productive sectors. Some faculty of Beta have recognized, after several attempts to convince ARAMCO to sign research contracts with them, that getting their research networked with the industry's needs requires the efforts of their university leaders.

You need a university rector who leaves the campus and talks to industry, visits them, negotiates with them. He has power. We do not. We are just faculty (Scientist 1 at Beta).

The lack of universities' leadership to set appropriate arrangements does not mean that universities were not aware of research at all. Indeed, regulations for faculty promotions emphasize research as a major qualification for promotion. Faculty are encouraged to do research to get promoted. Promotion and publications lead to an improvement of one's status among colleagues.

The university's mission becomes teaching only, graduating physicians, engineers, and so on. Meanwhile, we do research but this research is for the sake of promotion; I get promoted from assistant to associate but not for the sake of benefiting the world (Scientist 1 at Alpha).

Most university positions and opportunities are associated with academic status. Most colleges, especially engineering, medical, and science, require the status of associate professor to be considered as dean, vice-dean, department chairman, or a member of most councils and committees, as I explained about the reward system of Saudi academia in Chapter 4. Therefore, doing research is required for status competition within Saudi academia.

But research has remained an internal activity of the university. For instance, faculty are not expected to generate funding. They are expected to publish in refereed journals to be promoted and then nominated for positions and so on, but citations are not part of the evaluation process of faculty research. Hence, there is no systematic way to differentiate between high quality and useful publications and those that are less so.

In all Saudi universities, there is no real reward system that honors scientifically distinguished work (Administrator 1 at Beta).

In this sense, it seems that universities encourage their faculty to do research just because university faculties are expected to so; it is just isomorphism activity, using Shenhav and Kamens (1991) and institutionalists' arguments. Some interviewees justified research for the sake of linking the faculty member with updated developments in his/her field, which would be reflected in his/her teaching abilities. In other words, the teaching mission justifies research activity. Research activity has not gained any autonomy in such an arrangement. Research was done as small projects funded by research centers within colleges, which lack the financial ability to offer big grants.

Research was [ten years ago] individual efforts. We did not have any organizer; although the RI was already established it was doing nothing (Scientist 1 at Alpha).

As I mentioned earlier, the universities leadership's role as actors in the social construction of universities as teaching institutions has been experiencing change during the past few years, with increased emphasis on the research mission. That is true in both Alpha and Beta universities, with different progress being made. While the DPE at Alpha is actively engaged in these changes, Beta's department seems to be isolated from changes taking place at Beta University. The most obvious indicator was the complete isolation of the department from the newly activated RCI at Beta University. For this

reason, the DPE at Alpha should provide insight into the significance of the leadership's role in the social construction of the university.

Testimonies of Alpha faculties and leaders indicate two main things in this regard. First, the activation of the RI had a dramatic effect on the research activities of Alpha faculty. Although the RI is meant to run contract research and is designed for such an aim, it also has provided faculty with labs equipped for conducting research. In Latourian language, well-equipped labs have expanded the Alpha scientists' networks, allowing them to produce more science.

The department was very small. We were a small group, even. When the department started, we did not have the excellent facilities to handle big projects. But after the RI was equipped and they had all the labs prepared for research, we invited ARAMCO. We had several meetings with them back and forth (Scientist 3 at Alpha).

The RI has facilitated the interaction with the industry (Scientist 1 at Alpha).

The RI was founded in the early 1970s but was not equipped with labs and a clear plan of how to do research until the mid-1990s, according to testimonies.⁴⁷ The fact that there was an RI with no clear object or work agenda for two decades indicates how the university's leadership perceived the research mission of the university. Either the leadership was busy with the teaching mission of the university for two decades or they simply did not know how to activate the research mission. Given the approach that I heard from faculty at Beta—waiting for years for a phone call from the oil industry asking them to engage in their business--not knowing how to activate the research mission seems a plausible explanation. However, had the university's leadership been as

⁴⁷ I was not able to get annual reports for the RI for earlier than 2002.

concerned with the research mission as they were concerned with the teaching mission, the research mission would not have remained inactive for such a long period.

Second, many interviewees mentioned the personal role of the current university's rector on emphasizing the research activities of the university. The interviewed administrators of Alpha have all mentioned the rector's role in pushing the whole university to be more active in producing research and, hence, in being more research-oriented. Literature on organizational studies demonstrates the importance of the leadership role in activating institutions' missions and reinforcing them.

Nevertheless, leaders of Saudi universities have traditionally been concerned more with the teaching mission than with the other two university missions. In this sense, the leadership participated as an actor in the social construction of universities as teaching institutions. Using their legal authority, leaders have reinforced society's perceptions and meaning of the university as a teaching institution.

6.4.3. The productive sectors

By productive sectors (PS), I mean various types of formal organizations that would potentially seek consultation services from a local or foreign provider. The PS would, then, include industrial, service, and agricultural arenas in both the private and public sectors. Therefore, ARAMCO and government agencies are part of and representatives of PS in the Saudi context.

PS could consume two types of university products—graduates, who could serve as qualified manpower, and research, which could help in solving problems, improving productivity, and so on. The PS in Saudi Arabia has traditionally focused on consuming only one product of the universities—the graduates. Saudi PS has seen Saudi universities as a location for qualifying citizens for the job market. The image of the university for PS is viewing it as teaching institution.

Productive sectors may not think that there are national universities that could do consultation services. They see the university as if it is only teaching institution; institution that do not practice larger role than teaching (Administrator 2 at Beta).

In this sense, Saudi PS serve as one of the actors that has participated in the social construction of universities as teaching institutions. Examining the relation of ARAMCO and DPEs would reveal such process.

The kind of relation and networks ARAMCO had established with the DPE at Alpha for twenty years⁴⁸ or with Beta's since the foundation of the department until the current date uncovers the type of perceptions and meanings ARAMCO had about Saudi universities. Testimonies of faculty at the DPE at Beta reveal the type of relation with ARAMCO that had been developed. Beta's department is networked with ARAMCO only for the sake of teaching and training purposes.

My contact with ARAMCO was for the sake of arranging field trips or to get summer training...I have visited ARAMCO with students during field trips only (Scientist 5 at Beta).

They [ARAMCO] do not seek scientists [in our departments]; they may seek engineers [when they need] (Scientist 1 at Beta).

Our visits to ARAMCO are to investigate problems they face with our graduates (Scientist 2 at Beta).

⁴⁸ From the mid-1970s until the mid-1990s. Many testimonies from Alpha's faculty indicate that research cooperation with ARAMCO started only a decade ago, as shown in the previous theme.

Meanwhile, ARAMCO is networked with foreign universities for the sake of conducting research projects at a very high cost. The fact that ARAMCO never attempted to use Beta's department as a potential location for research activities exemplifies the image ARAMCO has of the academic department. In some operations, ARAMCO sends samples to be analyzed by research centers, some of which are university research centers. Usually ARAMCO follows a procedure where they send samples to more than one lab at a time to measure reliability. They never attempted to test Beta's reliability through this procedure, even though not all the research centers ARAMCO dealt with were always trusted.

ARAMCO sends rock samples for analysis to more than one research center at the same time to make sure of reliability. I was working on my PhD in the UK when this happened. ARAMCO sent a sample to X University and another sample to Y University, both in the UK. Y's lab was down (not working) at that time, so they sent their sample to X University. Thus, X University did the same test twice (Scientist 1 at Beta).

The scientist narrated the story to explain why he and his colleagues wonder, "Why do not they try us?" The simple answer is that decision makers at ARAMCO do not see Beta's department as a location for research. Making them consider a Saudi academic department as such would require an institutional arrangement (explained in the first theme) by the university. In other words, it does not seem that the productive sectors hold a mission to develop national scientific institutions and national scientists by integrating them through activities that related to the actual productivities of the organization—producing oil, in ARAMCO's case. Developmental objectives would be accomplished through separate activities such as financial support, training students, and so on, but not through relying on an untested academic department to solve technical problems in the field. I will discuss the mechanisms that isolate Saudi productive sectors

from Saudi universities as locations for research activities in the section on the “rentier mentality”.

By dealing with the universities as locations for preparing manpower only, in ignorance of the research abilities of these universities’ faculty members, the productive sectors have participated in the social construction of the university as primarily a teaching institution.

6.4.4. The public

Although the public as a social group had not played an obvious role in the social construction of the university as a teaching institution at the beginning, they became more powerful later as the demographic structure of Saudi society changed, combined with the successful role of the university in changing class structure. Mandeeliey (2001) argues that the continuous annual increase of high school graduates who seek higher education puts pressure on the country’s universities to offer opportunities for these new generations. This challenge acts as a mechanism that reinforces the teaching mission of the university and hence negatively affects the research mission.

Mandeeliey’s statement looks more reasonable in the light of two facts about Saudi Arabia. First, the Saudi society is a young one. Half of the society is under the age of twenty years old, which means more high school graduates every year, see chapter 4. Second, higher education is seen as a tool for distributing wealth among the population through providing new generations with the qualifications required for getting middle class positions. As I mentioned in chapter 4, higher education is free of fees in governmental universities. Moreover, students get paid for attending universities; they

receive a fixed monthly allowance--\$266 for students of science and applied science studies and \$220 for students of humanities. These facts create societal expectations of universities as institutions similar to public schools—teaching institutions. Providing students with a free education and paying them to attend university generates a public image of the university as part of society's school system rather than as an institution with a threefold mission—teaching, research, and serving society.

For the public, the practical, proven, and measured benefit of the university is its significant ability to move people up in the social mobility process through the awarding of its certificates, mainly BSs and BAs. The obvious role of the university is its powerful ability to publicize status and professions of the middle class such as physician, lawyer, judge, engineer, teacher, banker, and so on. The university has played a significant role in the social mobility of citizens whose parents were farmers, small shop owners, or simply had no specific occupation a few decades ago. The university provided them with the tools to get professions in both the public and private sectors. Hence, expectations for the public have centered on the teaching mission.

Universities become a hot topic of public media and public discussions when their abilities to admit new high school graduates have been slowed. The decade of the 1990s was one of wide societal worries about the universities' relatively low abilities to provide high school graduates with admissions. The university's research mission has never been the center of hot debate in Saudi Arabia. The public that have raised many concerns about

the universities' teaching mission do not get upset because university scientists are not participating in solving developmental problems.

It is important, however, to take Mandeeliey's point precisely. The demographic expansion that caused increasing societal pressure on universities to keep concentrating on the teaching mission during the past two decades did not play the role of transforming universities into institutions that only teach. In fact, they have always been so. The increasing demand for higher education and the relatively low number of universities has strengthened the societal role in the social construction of the university as a teaching institution. It reinforces the teaching mission and delays the research mission that has not been activated before. In other words, the significance of Mandeeliey's study is its illustration of how demographic developments of Saudi society have prevented Saudi universities, especially the large ones, from transforming themselves into teaching and research institutions.

Table 6.2: The increase in undergraduate enrollment in Saudi Universities, 1996-2006

Academic year	Number of admitted students of Bachelor degree
1996/1997	197,698
1997/1998	224,345
1998/1999	264,484
1999/2000	299,456
2000/2001	324,423
2001/2002	367,512
2002/2003	377,438
2003/2004	445,419
2004/2005	483,036
2005/2006	505,932

Source: Saudi Money Agency (SAMA)

Table 6.2 illustrates how the demographic developments of Saudi society have created more demands for expanded higher education services. In ten years, the number of undergraduate students in Saudi universities has increased 256 percent.

Such demographic developments keep the public interested in one function of the university—to provide education and expand admission capacities. Such societal expectations create problems for universities that delay the development of their commitment to the research mission of the university.

The problem that we are facing currently is that there is enormous pressure on the university to accept larger number of students (Scientist 3 at Alpha).

The demand for higher education became a hot topic of public media, especially during the 1990s, when the number of high school graduates tremendously increased while the number of universities remained the same. With such demands, the public become a more powerful social actor in constructing the university around the function largely demanded—teaching. With the increasing demands for higher education, the government has established more universities in the past few years; the number has increased from seven universities in the mid-1990s to nineteen currently, sixteen of them governmental.

In conclusion, the state, university leadership, productive sectors, and the public all have participated in an ongoing process of producing perceptions and meanings of the university as a teaching institution. This raises a question: was the attitude of these four social groups toward the university (as merely a teaching institution) a conscious state that reflects the production of scientific knowledge or was it just the result of negotiations of the four actors? The answer is beyond the concentration of this study; it is a valid

investigation for the sociology of knowledge. But the productive sectors, represented by ARAMCO in the current case, suggest the negotiation factor. When the leadership of ARAMCO was more foreign, ARAMCO was less likely to consider Alpha University as a location for research. But with more Saudization of the management, more cooperation has emerged.

However, when the universities were ready to commit more resources to their research mission, two social groups, the state and the public, slowed such transformation due to demographic developments and thus continued reinforcing the teaching mission of the university. The greater concentration by Alpha's rector on both the research activities of faculty and contract research may indicate an evolution of university leadership's perception of university missions. The leadership of universities may have the privilege of being the most powerful social group in reconstructing universities to include the research mission, but it requires getting the other social groups to see the benefits of the research activities of their institutions.

The relevant social groups mentioned above have been engaging in ongoing flexible interpretations of what university is about. Such process favors the teaching mission of the university over the research one due to the direct needs of these groups from the university—educates young citizens and prepares them form job market. The social construction described above, thus, has turned the research activities of university faculty into individualistic behavior and internal activity. Universities consider the number of publications of the faculty in their reward system, but they do not question faculty or

evaluate them based on the contract research they bring to the university. Contract research is the teamed and collective research that has developmental meanings for the country; it would help in reconstructing the university to focus on its research mission, since other social groups would see the practical benefit of the country's scientists' research. However, a relevant question for the sake of this study is how the social construction of the university as a teaching institution acts as a justification mechanism for faculty to produce isolated science. The social organization of the university as a teaching institution, I assume, creates a certain culture in academia that affects the role, the status, and, more importantly, the role identity of the faculty member in such a way that he/she does not feel institutional pressure to produce developmentally meaningful scientific knowledge, connected science. Societal expectations and the bureaucratic organization of universities in LDCs would produce certain role identities among faculty members that legitimized the production of isolated and abstract science. Unfortunately, I did not ask my interviewees questions about their role identities to allow them to tell how they see themselves as faculties, more as scientific knowledge producers or as teachers. How the two roles play together and organized inside the self of faculties of an engineering department. However, interviewees that had occupied leadership roles within the department of Beta have explained how the kind of problems they either discuss or wanted to discuss with ARAMCO in regard to their department. These problems were merely about employing the department's graduates, see chapter five. They did not see the complete isolations of the department faculties from the national industry, in regard to research, as *real* problem that needed to be negotiated with national industry. That could be due to how these faculties/leaders see their role identities. Also, few informal chats

with some interviewees clarify how the institutional reality of universities as teaching-oriented universities has been embedded in the self of the faculty member and constructed the role identity of a faculty member as a teacher and researcher for the sake of being a good and updated teacher. Specific question and systematic investigations of such point may uncover a process similar to what Giddens called structuration (1986), where the structure frame and limit the action of the agency, while the continuous repetition of the action reinforces the structure.

6.5. Rentier Mentality

Zahlan (1975, 1980, 1984, and 1999) presents a unique explanation of the slow development of science and technology in the Arab world. He approaches the phenomenon with the concept of the turn-key mode, which is based on a rentier political economy, as a major part of his theoretical system. According to Zahlan, the continuous *act* of the productive sectors relying on foreign firms either to achieve complicated tasks such as building petrochemical factories or just the simple consultation of experts is a product of a certain mental mode, the turn-key mode, that needs things to be state-of-the-art and, thus, seeks out foreign experts--institutions or individuals—to make progress. In sum, the productive sectors see technology, and a system of science and technology, as something that is bought rather than transformed. (See Chapter 2 for more details on the turn-key mode and Chapter 4 for more details on the rentier mentality). This mentality prevents the development of national systems of science and technology. Paraphrasing Zahlan's theory in sociological language, using Giddens's theory of structuration, the low connectivity between national science and national needs in the Arab world is due to a certain economical structure, the rentier economy. A rentier economy produces what

Beblawi (1990) calls a rentier mentality. The rentier mentality, then, legitimizes and reproduces a continuous cycle—the turn-key mode, the *buying* and *importing* system of science and technology instead of a system of science and technology developed within the nation. Developing a system of science and technology needs, on average, twenty-five years of continuous hard work, according to Zahlan (1999).

Some observations and data generated in the field support Zahlan's theory, within limits. The fact that the DPE at Beta is completely isolated from the national petroleum industry and that the DPE at Alpha had been isolated for more than twenty years is support for Zahlan's explanation. Some of the experiences of some of the faculty and administrators I interviewed shed light on how a rentier mentality is an obstacle to the production of connected science. Some of the testimonies reveal that the rentier mentality is more complicated than just the turn-key mode. It includes attitudes toward national scientists and their outcomes as rent also, as I will show.

In this theme, I will go over different aspects of the rentier mentality, based on experiences described by the interviewees. I will also discuss the concept itself and suggest a broadening of it, as some stories reveal more complexity about how the rentier mentality creates perceptions and attitudes among the decision-makers in the productive sectors toward national scientists.

6.5.1. Rentier mentality: turn-key mode

One interviewee narrated a story that is a classic example of how the turn-key mode shapes the actions of decision-makers in the productive sectors toward national scientists.

I remember one time we approached the minister of petroleum and we talked to them about sponsoring a project to develop a commercial simulator. At that time we were very enthusiastic about establishing our own simulator, software used for simulating the reservoir [you establish it] and then you put it in standards, like any other simulator being published around the world. We submitted the proposal. We went and met the guy there [in the ministry]. At that time, they had a simulator that was (produced) by Inter-come [a foreign manufacturer]. They pay for using it. There were also some other simulators in the market. [So,] the answer we received from them was, “Why should we re-invent the wheel?” In other words, these simulators already exist. We just buy them and use them. So, they declined the project. This is the way they sometime deal with your proposals. Just to give you some information about the simulation they used: They have no access to the code, they cannot do any modification, and they have to pay a lot of money for using that simulator... This is something that we suffered a lot because of this kind of--I mean, you know. If that project had been at least sponsored, we could maybe now have our simulator that can be used (Scientist 3 at Alpha).

The experience is evidence of how the turn-key mode acts as a mechanism that works against connecting national scientists efforts with national needs. The answer the scientist got, “Why should we re-invent the wheel?”, not only indicates a turn-key mode but also shows how such a mode legitimizes itself. The decision-makers at productive sectors deeply believe that technology is bought, not transferred. They have sets of negative beliefs and attitudes toward national scientists’ abilities in building national technology. It is a negative stereotype about national scientists. However, such a mentality is an obvious obstacle to developing a national system of science and technology.

Meanwhile, many things could be generated from the above testimony in regard to the effects of the productive sectors’ rentier mentality on national scientists. The interviewee mentions it not as a unique experience but as an example of the pervasive attitude of the productive sectors. The repetition of such actions creates expectations within the scientific community of resistance from the productive sector toward scientists’ inventions and efforts to come up with national products that would replace imported ones. If national scientists internalize such perceptions and expectations about the productive sectors, they would not waste time and effort in working on connected

science; they would not be rewarded for doing so. They would, thus, focus on rewarded products such as published papers in refereed journals, regardless of the content of such papers and regardless of their relevance to local needs. The turn-key mode, as one aspect of the rentier mentality, not only prevents connectivity between national scientists and national productive sectors but also creates an environment in which scientists find it more rational and beneficial to produce work that meets publishing requirements even if the work produced is abstract and isolated from national needs.

The experience described above reflects a typical form of rentier mentality, the turn-key mode. While Zhalan emphasizes the turn-key mode, rentier mentality, I argue, may take different forms. Interviews generated another aspect of such mentality—national scientists' efforts as free rent.

6.5.2. Rentier mentality: scientists' scurvies as free rent

Interviews with faculty members who occupy administrative positions revealed the complexity of the rentier mentality. The productive sectors usually look to foreign experts to solve technical problems. When approached by university leaders to seek solutions to their technical problems within national universities, these men expect to consult with national scientists free of charge. They develop such expectations as a result of their image of the university as a governmental institution that provides teaching services for free; it seems reasonable to conclude that it would also provide consultation services for free.

The consultation culture is still strange and new for the productive sectors. A leader in such a sector may sign a contract with consultation service agencies, paying a high price for the contract.

But when it comes to the university, he would say no. It is your [as a university] mission. You should perform this mission voluntarily (Administrator 2 at Beta).

Productive sectors see the efforts of national scientists as free rent because they see the whole academic institution, the university, as free rent. They act in such a way either because they lack the culture of approaching R&D as exchanged goods or because they lack trust in national scientists and do not want to waste their money. Whatever the reason, other forms of behavior of the productive sectors toward the university as a source of consultation services uncovers the image of the university as free rent. The interviewee explains:

Many leaders at productive sectors seek the consultation services of the university when their institutions lack the finances to consult with a foreign house of expertise. When they face a shortage of money, they would think, why don't we try the university? (Administrator 2 at Beta).

The testimony reveals some mechanisms of the rentier mentality. First is the turn-key mode—the preference of foreign experts when possible. Second is the attitude toward the consulting services of a national university. However, in the second theme, connected science leads to positive attitudes, I showed how the productive sectors change their attitudes toward the efforts of national scientists in a positive direction after dealing successfully with national universities and receiving high-quality results. However, the aspect of the rentier mentality of expecting free consultation services is an interesting one.

In 1990, a governmental agency had cracks in their building, which had been built by a Korean firm. The agency wrote to the civil engineering department at Beta explaining their problem and seeking cooperation. The department replied, telling them the department had faculty members who specialized in concrete and geotechnical issues who were willing to visit them and investigate the problem. Three faculty members of the department went to the location, investigated the problem, and wrote a reasonable report that proposed a detailed study that would cost 400,000 S.R. (\$107,000). To our surprise, the manager of the agency called the department condemning the idea that the department would charge for such a service. His idea was simply that the university was established for serving society. The chair of the department replied to the manager, stating that the project cost more than one hundred million and was done by a foreign company. Yet when

national experts would study its problems in detail and would suggest solutions step by step for only 400,000, the agency rejects (Administrator 1 at Beta).

The narration illustrates certain expectations of the productive sector in regard to university services. The client could not accept the idea that a national university would charge for consulting. Productive sectors may see the university as a location for free services because higher education is free. Consultation services, just like teaching services, should be free, too. However, if such services would be provided free, as part of the public sector, clients might think such services would not be high quality. That might explain the fact that when the productive sector has the money, it seeks foreign consultation.

However, the rentier mentality, as it seeks foreign services and views national universities as a source of free services, is not a static state. Communicating with the productive sectors and providing them with high-quality results would cause changes in this mentality, as illustrated in the second theme. Two stories from the engineering petroleum department at Alpha reveal the dynamic nature of the rentier mentality and how it could change in a positive direction with regard to national scientists. Such a change would represent a significant shift in the mentality.

6.5.3. Productive sector mentality: from rentier to productive

Production of oil is an extremely complicated problem within the oil industry. Sand mixed with oil in reservoirs destroys expensive drilling equipment in a short period of time when production runs at its optimum rate. The simple technique used by ARAMCO to face the problem was using a certain operation run by the global company of

Schimberg, which throws chemical materials into the reservoirs to control sand and slow the production process to lower the rate of mixed sand and oil. The chemical materials are costly, because of the huge amount needed in every operation, and slowing production leaves oil in the reservoir without being exploited. Two⁴⁹ faculty members at Alpha's DPE thought of a new technique to control the problem. They developed a device using very basic tools, due to a lack of funds for buying advanced equipment. After testing their device successfully, the two scientists contacted the reservoir management at ARAMCO (the department that deals with the problem), telling them that they had come up with a new technique to solve the sand problem and proposing that ARAMCO fund their work. The department invited them to give a presentation to its engineers, at which the presenters showed a sample of their invention that succeeded in turning loose sand into solid rock without losing its permeability, which is very important for the production process.

ARAMCO's engineers were fascinated by the invention and asked the presenters to write a proposal and send it, which the scientists did. They then waited six years, after which ARAMCO contacted them and told them that the company would fund the project but would need results within six months. Six months was too short a period to run tests with the modified lab equipment that the scientists needed to buy with the ARAMCO funding and to then try it in the field. The reservoir management department insisted on the six-month period because ARAMCO had begun working in new reservoirs where the oil was

⁴⁹ Information about the new technique of controlling sand was generated through interviews and documents. I decided not to use certain quotes of interviewees about the issue for ethical reasons.

so massively mixed with sands that the old techniques would have been too costly and production would have been very low.

The reservoir management department at ARAMCO looked for a solution from foreign companies with no success. They remembered the presentation and contacted the DPE at Alpha. ARAMCO finally funded the research project with three million Saudi Riyal (\$ 800,000). A Ph.D. student worked with the two faculty members on the project's lab phase for some years. After the lab tests were completed, ARAMCO allowed the team to field test the technique on two of its reservoirs, which was being done during the data collection for this study. The whole story indicates a new era of cooperation between the giant national petroleum industry and national academia. There are no similar cases yet.

Typical diagram for research in our academia would be ideal and theoretical. There are no applications (Scientist 1 at Alpha).

The story of sand control generates many meanings for this study; I have mentioned it in the social construction theme. Here I will concentrate in its relevance to the rentier mentality. ARAMCO did not interact with the idea and the proposal although it was facing significant sand control problems. ARAMCO, or the reservoir management department at it, seemed not to take the university faculty's idea seriously. That might be due to the negative stereotype about the abilities of national universities and their scientists, which is a core characteristic of rentier mentality. According to the narrative, ARAMCO contacted the national scientists only when it faced the problem in a way that the old techniques were not useful and the company could not find a solution from a foreign provider. It might be that the attitudes of ARAMCO personnel toward Saudi scientists had changed during the time between the presentation and the reply six years

later. It is known that ARAMCO has developed a positive attitude toward the faculty of the DPE at Alpha during the last decade; see second theme.

If the DPE of Alpha was finally considered as a potential source for solutions to technical problems, that means the rentier mentality, as mentioned above, is not static. A story of the faculty at Alpha reveals more on that point.

The story of the last two papers⁵⁰ is different from the previous ones. ARAMCO talked to us. They contacted the RI, stating that they have a technical problem that is related to injectivity of ... [not clear]. The chair of PMC at RI talked to me, since I am interested in the subject. We went to reservoir management at ARAMCO and they explained to us that they had a problem and they needed us to investigate it. They wanted the main cause of the problem, not the solution. The solution would come later. We agreed to do the work. People at reservoir management told us that there is a British company that does the investigation but they (at ARAMCO) did not want to give the problem to that company because they want to involve the university to transfer technology and so on. "So when we face the same problem in the future in other reservoirs you at the university would be able to do it (Scientist 1 at Alpha).

The testimony above came when the interviewee was describing the research problems of his publications as he responded to the first question of the interview; see Chapter 3.

While the research problems of his previous publications had been isolated from the needs of the Saudi oil industry and were based on theoretical problems, the last two were based on an actual problem that was facing the industry. The significance of this matter is not only that he produced connected science but, more importantly, that such connected scientific research was done and published because of a conscious decision of personnel in the Saudi oil industry. The story of these faculty publications provides evidence for the shifting and changing reality of the connectivity between produced science and actual needs of national productive sectors; it also shows the significant impact of the changes in mentality and attitudes of decision-makers of the productive sectors toward Saudi scientists on the issue of connectivity. The testimony also reveals a radical shift of

⁵⁰ The interviewee was describing the research problems of his publications.

ARAMCO in regard to national scientific institutions, not only because ARAMCO contacted them to investigate the problem but, more importantly, because ARAMCO wanted to develop the nearby national scientific institution, the RI at Alpha, and the national scientific community, and purposefully did not send the job to a foreign company.

This supports my idea that the rentier mentality is a dynamic state. As a concept being applied by Zahlan to the status of science and technology systems in non-industrial societies such as the Arab countries, the rentier mentality serves as an ideological belief that organizes the productive needs for scientists' outputs in which national scientists are ignored. The assumption, I argue, could be true if it means that the default action of decision-makers in productive sectors would be to directly seek a foreign experts to solve technical problems, which is supported by the testimonies of the administrators of Beta University. However, evidence from the experiences of the DPE at Alpha with ARAMCO, such as the above two stories and more detailed stories in the second theme, indicate that effective organizational structure, such as the RI at Alpha, and hard work from the national scientific community could change the rentier mentality.

The rentier mentality reproduces itself among leaders of the productive sectors simply because of the lack of university efforts in marketing the skills and abilities of their faculty. Administrators at Beta University, which had its RCI activated recently (see first theme), explain how the absence of knowledge in the productive sectors about the

abilities of Saudi universities to do scientific research was a reason for seeking scientific services abroad.

There are agencies [in the productive sectors] that do not know that there are qualified researchers at the university [Beta University] (Administrator 1 at Beta).

Some leaders in productive sectors, once they need consultation, they directly seek foreign experts. When we discussed the issue with them, they said they did not know that such a thing was available at [national] universities (Administrator 2 at Beta).

These testimonies support my assumption that a rentier reality could be changed. The rentier mentality contains, in regards to a national system of science and technology, both the turn-key mode and the assumption of rent-free—and therefore potentially low-quality--university services. However, the hard work of establishing effective institutional arrangements (see first theme) leads to positive changes in attitudes (second theme). Seeking foreign scientists' services does not have to be the default action of the productive sector.

In this theme, I discussed the concept of the rentier mentality as it is applied by Zahlan to science and technology systems in the Arab world using the turn-key mode to show how such a mentality is an obstacle to the effective development of a national system of science and technology. Some data and observations from my interviewees supported the concept as it is introduced by Zahlan. However, the emergence of an institutional link between the university and the productive sector, such as the RI at Alpha and the RCI at Beta, changes the way people in the productive sectors think about and act toward the national institutions of science and national scientific community, which leads to more connected science.

Serious efforts by Saudi universities to develop their research missions could result in changing the rentier mentality of the productive sectors, instead of waiting for the productive sectors to change themselves. It is true that positive changes in the productive sectors in regard to national scientific institutions are greatly effective. But small steps at the national universities may lead to such positive changes, as the above story of Scientist 1 at Alpha indicates. Steps taken by national universities and the national scientific community to connect with Saudi productive sectors would facilitate changes in the productive sectors.

Chapter VII: Summary and discussion

7.1. Introduction

In this chapter, I will summarize the study and discuss it. In the first part, I will go over the problem, placing it with the literature of science studies in the Arab world. Second part will be information about how I conducted the study. The third part is about results. In this part, I mix summary of themes with discussion of each one. Then, I generally discuss the problem in light of this study. Finally, I mention weakness of this study and suggestion for future studies.

7.2. The problem

Saudi Arabia is part of the Arab world and one of the LDCs. The problem of science and technology in LDCs is approached by most studies as if features and characteristics, such as low rates of research productivity or the low effectiveness of national scientific institutions in the development process of these societies, are similar in all such countries. In the Arab world, international institutions (such as UNESCO and UNDP) and regional ones (such as ESCWA and ALECSO) study the issue of science and technology using all countries as a single category. Well-known scholars in the Arab world have built their reputations studying the issue of science and technology in the Arab world, again using the whole region as one category, including Zahlan (1975, 1980, 1984, 1999) and Fergani⁵¹ (1998, 1999).

⁵¹ Fergani is also the main editor of the NUHD report (2000, 2003) about human development in the Arab world, which gives special attention to the issue of science in the region.

Studying the issue of science and technology as if all Arab countries are the same has its own legitimacy. Arab countries have common factors, such as language, history, and culture, and are similar in the way modern institutions, such as the nation state and its institutions and regulations, have been built. It is legitimate to assume that there is one general discourse about the issue of science and technology in the Arab world. This discourse is produced by international and regional institutions, well-known public intellectuals who have concentrated on science and technology (such as Zahlan and Fergani), and specialized academic work such as papers published in refereed journals, Ph.D. dissertations, and M.A. theses that focus on the problems in a particular country, such as those academic works that study the problem of scientific research in Saudi Arabia (reviewed in Chapter 2). The three producers of such studies participate in producing a certain discourse on science studies in the Arab world—SSDA.

The SSDA concentrates on one main central issue—the weak production of science and the feeble research mission of national universities. In finding reasons for this problem, the SSDA emphasizes funding as the main obstacle to the performance of research missions by academic and scientific institutions. The SSDA compares research funding in the Arab world to that in other countries and regions of the world to show how weak funding of research activities is. However, the SSDA has not investigated the reasons for this weak funding of research activities.

Another point the SSDA emphasizes is the matter of science policies and their roles in preventing the rise of effective and productive scientific institutions and the emergence of

a dynamic scientific community. Some major producers of the SSDA, such as UNESCO and Zahlan, have contributed greatly in this area (see Chapter 2 for details). Some SSDA studies mention an important aspect of the problem, the responsibility of the productive sectors for the weakness of science in the region (both qualitatively and quantitatively) due to their continuous tendency to ignore national scientific institutions and approach foreign suppliers when needing the help of scientists to solve their problems. This tendency isolates national universities and their faculty members from the developmental processes of these societies.

For the most part the SSDA does not address important questions such as why the funding of scientific activities is weak in the region. For example, the SSDA does not discuss the impact of low usefulness of nationally produced science on the phenomenon of low funding of research activities. This point is a major component of this study; although it does not address this question directly, it attempts to contribute to our understanding of the phenomenon examining the relationship of already-produced science to actual needs.

Some works of the SSDA mention the subject indirectly by concentrating on the ignorance of the national productive sectors about the national scientific community. For instance, Zahlan (1980, 1999) links the low effectiveness of national scientists with the rentier mentality and the turn-key mode. And some purely academic works that do not find their ways to the public, such as papers published in refereed journals, Ph.D. dissertations, and master's theses, discuss the weak relationship between universities and

productive sectors. In Saudi Arabia, many studies related to this point have been done (Mandeeliey, 2001; Sane, 1966; Munifikhey, 1989; Alsalem, 1997; Mahboob, 2001; Fhmme, 1993; Seroor, 1999; Aldbasi, 1998; Khateeb, 1996; Turkistani, 2002; Kana'an, 2001; Khudair, 1999; Lal, 1998; Alsulimani, 1996; Alghatani, 2004; Seam, 2001; Aisawi and Dakheel, 1999; Alsalem, 1999; Aldawood, 1996; Ageeley, 1984; Nuaimi and Nuaiman, 2000; Turkistani, 1999). A general characteristic of these works is that they are quantitative studies. Usually such studies distribute questionnaires to universities' leaders, universities' faculty members, or officers at productive sectors to investigate opinions about the relationship between universities and productive sectors. These studies, which were done in different universities and different productive sectors such as industry or service sectors, agree on the weak relationship between national universities and national productive sectors. Nonetheless, they all are macro studies.

As I reviewed previous studies of science in Saudi Arabia, I was unable to find a micro study of the problem. Further, these academic studies were done by researchers of three academic fields: education, library studies, and management. None were sociological investigations of the problem. I undertook this study to fill that gap.

This study is designed to approach the problem of the connectedness between the science produced within an Arab country and the actual needs of the productive sectors in that country--Saudi Arabia. A major aim of this study is to examine another aspect of the problem of science in a LDC. While the SSDA concentrates on the three big elements of the picture (weak production of science, low funding, and the weak relationship between

universities and scientists and national productive sectors), I wanted to shift to another level, the connectedness of already-produced science with national needs, the usefulness of produced science. I hoped that this might help us to understand the continuous reluctance of the larger society (governments and productive sectors) to increase funds or consider the national scientific community when seeking scientists' advice or input.

In this study, I investigated conditions under which produced science would be connected with or isolated from the actual needs of the society within scientific institutions and scientific communities. I was interested in factors that might encourage or discourage more consideration of national scientists by the productive sectors. What is it in the social organization of Saudi academia that affects connectedness? And how does the whole society frame the universities in ways that make them less likely to connect the science produced by their faculty to actual needs? I designed a micro level study by concentrating on one academic field in Saudi academia, petroleum engineering--which should be, theoretically speaking, highly related to the Saudi oil industry.

As I mentioned above, I am not aware of any sociological investigations of science production or of the relationship between universities and the productive sectors in Saudi Arabia. Approaching the issue from a sociological perspective is a contribution in itself. However, conducting a sociological study of science and society in an LDC is a real challenge. The heritage of sociological studies of science is controversial. There are two main approaches: the functional structural approach (institutional sociology of science) and the constructivist approach (sociology of scientific knowledge). While the two

traditions differ significantly, I used aspects of both traditions to approach the problem of connectedness. Ben-David's (1991) works on the social organization of scientific practice, the decentralization of the academic system, and competition of scientific institutions were central to this study. The works of Collins (1985), Pinch & Bijker (1984), and Pickering (1984) on the social construction of scientific practice and the social construction of technology were important in understanding the resistance of national universities to becoming research institutions; I will discuss these points later.

7.3. How the problem was studied

The academic field of petroleum engineering is a narrow specialty, focusing only on petroleum reservoirs and oil production. In Saudi academia, there are two academic DPEs, one at Alpha University and one at Beta University; both were included in this study. Saudi Arabia is known for having the largest amount of crude oil, 25 percent of the whole world's crude oil; for being the world's largest producer of oil; and for having the largest oil company—ARAMCO. Thus, the field of petroleum engineering is highly suited for investigating the issue of connectedness between locally produced science and local needs.

I designed my study as a collective case study. I studied the two academic departments of petroleum engineering in Saudi Arabia to investigate the connectedness of the science produced by the faculty members of these two departments with the actual needs of the Saudi petroleum industry. By concentrating on one academic field that is highly theoretically related with this advanced national industry, I attempted to determine the degree to which nationally produced science is connected with or isolated from national

needs. My main tools were in-depth interviews with the faculty of these two departments as well as interviews with administrators of each university, documents, and observation.

Interviews with faculty of the DPEs focused on two main points. First, I wanted to know how they selected the research problems of their published work; interviewees described the research problems of all or selected published works. Research problems could originate in scientific literature, scholarly discussions with colleagues and students, real problems of industry, and so on. I also wanted to let interviewees discuss the world they are involved in when deciding to investigate a problem scientifically and to determine whether the needs of the Saudi oil industry are present in such a world.

Second, I wanted to discover the relationship of university faculty to the national oil industry. A faculty member in a DPE would most likely have some form of ties to the petroleum industry. However, the nature of such a relationship is important. Is it for the sake of teaching, such as arranging field trips and training sessions for students, or does it include research cooperation? It was important to let faculty members explain the nature of their relationship to the petroleum industry.

While interviews with the faculty of the two departments focused on the networks faculty find themselves in when producing science and on their relationship with the national oil industry, interviews with administrators of the two universities gathered data about the social organization of Saudi academia. Interviews with administrator of engineering schools focused on the expectations from faculty. Were these expectations focused on the

teaching mission or did they include research? I also asked administrators about the tools they use to encourage faculty to do science, hoping to gather descriptive data about the reward system in Saudi academia. Interviews with administrators at scientific research deanships focused on how university leaders see the university in terms of teaching and research missions and on the locations, sources, and activities of the deanship within the university system. I wanted to find out how much importance the university placed on its research mission. Administrators also were asked about how they evaluate the production of science by faculty. So they focus on quantifiable measures, such as publications and citations, only, or do they include the relevance of produced science to actual needs of Saudi Arabia?

The third category of interviews was with administrators of the research institutes and centers at both universities. On these interviews, I gathered information about how these institutions, the RI at Alpha and the RCI at Beta, are organized, how they perform work, their achievements, and their ways of linking university faculty with the productive sectors, with special attention given to the DPEs at each university.

In addition to the interviews, I gathered documents about both universities, Alpha and Beta, both departments, and the national oil firm, ARAMCO. Observation played a role in the study as well, such as recognizing the physical differences between the RI at Alpha and the RCI at Beta, between labs of the two departments, the systematic use of the internet as a tool of communicating with the “outside” by the two departments and their

faculty, and the presence of ARAMCO vehicles on the Alpha campus versus the absence of them at Beta.

7.4. The results

As I studied the two cases, the DPEs at Alpha and Beta universities, the field data collected have led me to an unexpected and interesting result: the different realities of the two departments in regard to the degree of connectedness with the national productive sectors. As mentioned in the literature review, studies of scientific research in Saudi Arabia, and in the Arab world in general, agree on the issue of the weak relationship between universities and national productive sectors. Despite the fact that this study was not built on causal relationships, and thus has no hypothesis, I assumed that the two cases I would study were both not very connected with the Saudi oil industry and its needs.

In fact, they differed greatly. The DPE at Beta suffers literally a complete isolation from the national industry in regard to its faculty members' scientific outputs. During the 33 years of the department's existence, none of the faculty have conducted a single research project for the national petroleum industry, namely the national oil company, ARAMCO. It clearly is a typical case of disconnected science, an ideal type case.

On the other hand, the DPE at Alpha has been experiencing a more active relationship with the national industry. At the DPE of Alpha, I found that every faculty member was involved in a research project funded by ARAMCO. Some faculty were running more than one such research project. Obviously, I was dealing with different levels of connectedness. At the beginning, this situation was confusing. Later I discovered that the

different realities of the two cases would enhance my study. They would enrich the outcome, allowing for the narration of a tale of two academic departments. One is isolated; the other enjoys some degree of connection. Assessing the two departments allows for identifying the conditions under which an academic department is connected with or isolated from national needs.

Historical and geographical factors strengthen the relationship between Alpha University and ARAMCO. For example, when Alpha was established by royal decree, it was freed from following governmental regulations in terms of hiring employees, faculty, and so on. This reinforces Ben-David's point about the importance of scientific institutions' autonomy to develop according to their own laws. Beta had no such opportunity.

However, both universities were governed by one central regulation when the ministry of higher education was established in 1975. In regard to the historical factors, Alpha was established as a community college to serve the national oil industry, while Beta was established as a university to provide the whole newly rising nation state with educated and trained manpower. The establishment of each department also plays a role in the stories of their connectedness with ARAMCO. Beta's was established through the decision of the ministry of education by a young associate professor of petroleum engineering. Alpha's was established when it was a college under the supervision of the ministry of petroleum and minerals, in which the minister was the senior president of both ARAMCO and Alpha. These factors fostered the connectedness between Alpha and ARAMCO that appeared in the mid-1990s. Other factors played roles in networking the DPE at Alpha with ARAMCO. These factors, department graduates and the SPE, were

provided as descriptive data and discussed in Chapter 5, historical and organizational contexts of the two cases.

The data analysis of this study includes four themes. Themes were constructed from the data, based on the literature and research question.

In the first theme, institutional arrangements, I analyzed the phenomenon of the isolation of the DPE at Beta from the Saudi oil industry versus the connection of Alpha's, using the works of Ben-David on the effect of the social organization of science on science production. Each university has an institution that was established to market the research skill of its faculty to productive sectors, the RI at Alpha and the RCI at Beta. The RI at Alpha University acts as an institutional link between the faculty of the DPE and the oil industry. The way the RI is organized and its work have helped faculty to adapt their research practices to address real problems in the oil industry. It contains six research centers, among which is the Petroleum and Minerals Center (PMC). The RI has fully-equipped labs and full-time researchers who work as team members of research projects that are run by faculty. The RI got underway a decade ago and started playing an effective role in bringing research projects to university faculty. The RCI at Beta, on the other hand, is more modern than the RI, started just five years ago. It is organized differently. It is administrative institution that works to link university faculty with productive sectors, but has no labs or full-time researchers. Moreover, the RCI has not yet done any work with the DPE at Beta, perhaps because of the short life of the institution.

In sum, the RI at Alpha effectively connects the faculty of the DPE with ARAMCO while the RCI at Beta has not yet managed to do so. The faculty of the DPE at Beta struggle on their own to open research avenues with ARAMCO. They do not use the RCI to bridge the gap. With the lack of an institutional link with the Saudi oil industry, the faculty of the DPE at Beta find themselves isolated from ARAMCO and unable to convince ARAMCO officers to engage them on research projects.

Another institutional arrangement at Alpha is the Industrial Advisory Committee (IAC). The IAC includes representatives of oil companies, both the national one (ARAMCO) and the multi-national ones that work in Saudi Arabia such as Halliburton and Schlumberger. Through the IAC, the DPE at Alpha investigates the needs of the industry in regards to educational curriculum and research avenues. Beside its function of familiarizing the department with the needs of the industry, the IAC strengthens the social ties of the DPE faculty with industry. The DPE of Beta lacks such an institutional link with the oil industry.

Ben-David's emphasis on the social organization of scientific institutions, such as universities, as a way of understanding the effectiveness of scientific practice seems to be significant in answering one of the classical questions of the SSDA—how to build ties between universities and productive sectors in regard to scientific research. The SSDA contains studies and reports addressing this issue. Through conducting a micro level study, the sociology of science contributes in answering the long-standing question.

In the second theme, positive attitude, I intended to monitor the changing relationship of the DPE at Alpha with the oil industry in terms of scientific output of the department's faculty. Interviews with the faculty of the DPE at Alpha indicate that the relationship with ARAMCO was confined to teaching issues until the mid-1990s, when the RI was started and ARAMCO began to send research problems to it. Since then, ARAMCO has increased its consideration of Alpha's DPE as a source of science. Interviews revealed that the positive experiences of ARAMCO with the faculty and the RI, including such things as delivering results on time and performing high quality research, have gradually changed the attitude of ARAMCO toward the scientific abilities of Saudi scientists. This has resulted in ARAMCO sending more research work to the RI, which has led to the involvement of all the faculty of the DPE in research projects funded by ARAMCO.

While the literature review of this study does not include the concept of attitude, Zahlan's works in rentier mentalities touch the role of perceptions and stereotypes held by national productive sectors about national scientists in isolating these scientists from participating in solving the problems of their societies. The increasing consideration by ARAMCO of Alpha's faculty has led to increased self-confidence of the faculty in their abilities to conduct research that address the actual problems of industry.

None of the SSDA discusses the impact of the weak relationship between national universities with productive sectors on the self-confidence of national scientists.

Interviews with faculty who have experienced both the era of isolation and the time of greater connectedness, the faculty of Alpha's department, indicate that the issue is

consciously recognized by these faculty members as they succeed in proving to themselves and to their customers that they are reliable producers of science. It is clear that the isolation from the national oil industry caused a lack of confidence in their abilities to produce useful scientific knowledge. Such a consciousness would, I assume, play a part in constructing the professional identity of these faculties. However, none of the isolated faculty of Beta discussed the issue of self-confidence. It seems that the issue is either not recognized or kept under wraps.

In the third theme, social construction of the university, I discuss how society constructs the university as a teaching institution. Four actors, the state, the universities' leadership, the productive sectors, and the public, participate in sharing meanings about the university that focus on the teaching mission. The research mission has been undermined. This theme is built theoretically on a constructivist approach, especially on the works of Collins (1985) on social construction of science and Pinch & Bijker (1984), and Pickering (1984) on social construction of technology (SCOT). I relate these works to academic institutions and show how they are socially constructed to concentrate on one mission, teaching, and marginalize another, research. The need of the relatively new systems of bureaucracy to prepare citizens was behind the state's and productive sectors' perceptions of universities as teaching and training institutions. The universities' leadership, thus, concentrates on this mission. When these actors were ready to consider the research mission, the public was experiencing new needs. The demographics of Saudi society, with half of the population under the age of 24, has led to a population of high school graduates who have no jobs or places in higher education institutions. That

increased pressure on universities to concentrate more on the teaching mission and increase admission dramatically, 256 percent in one decade.

The social construction of the university in Saudi Arabia has marginalized faculty research activities. They are encouraged to do research but are not required to do so. Moreover, the university does not expect a faculty member to bring funding; it does not affect his professional status within the university. Thus, faculties do not feel the urge to seek funded research projects. This contributes to the role identity of faculty as teacher more than as producer of science.

For the last theme, rentier mentality, I discussed the concept in light of the data. Zahlan (1975, 1980, 1984, and 1999) applied the concept to the science and technology system in the Arab world. Rentier mentality, according to Zahlan, expresses itself in regard to the issue of science and technology through the turn-key mode. By turn-key mode, Zahlan refers to situations in which a governmental agency or productive sector institution needs advanced services of skillful and reliable scientists or advanced and up-to-date technological services and seeks it from well-known foreign providers. This negatively affects the national scientific community because it limits their opportunities to develop themselves. My data provided support for Zahlan's theory. For example, a Saudi scientist sent a proposal to the ministry of petroleum for developing a technological device, a commercial simulator used to simulate petroleum reservoirs. His proposal was rejected because the people in the ministry did not want to "re-invent the wheel," an ideal type of the turn-key mode.

But other stories suggested different forms of rentier mentality other than the turn-key mode. For example, administrators of the RCI and the engineering college at Beta told stories of the early stages of university cooperation with the productive sectors in which potential customers assumed that the services of university scientists would be free of charge or at least very cheap. That assumption, I argue, is a form of rentier mentality. The productive sectors deal with university services as if they are free rent. This attitude could be due to the fact that universities are state one (part of the public sector) and are seen as institutions that should not charge for their services; in that case the point is related to the way the political economy is organized. Another possible explanation could be that these productive sector institutions believe that the university and its scientists are not worth paying as much money as foreign providers are paid because of hidden assumptions about the low work quality of national scientists. With both explanations, the rentier mentality is active in constructing a public image among officers of the productive sectors in regard to national science institutions and national scientists.

Interestingly, the changing reality of Alpha's department in terms of connectedness during the past decade adds a layer of complication to the concept of rentier mentality and how it acts or changes. As I explained in the second theme, faculty at Alpha noticed a change in the attitude of ARAMCO toward their abilities as reliable producers of practical science. ARAMCO has changed from dealing with Alpha's DPE as a reliable location for preparing future petroleum engineers to seeing and using it as an institution that contains skillful scientists. ARAMCO has gradually increased cooperation with the

department at a rate such that all faculty of the department were handling at least one research project for ARAMCO at the time of this study. This change occurred within just a few years, according to my informants.

The story of sand control, told in this theme, provides a typical portrait of a mentality in its transitional stage. The proposal of two Saudi scientists for a new technique to control sand in reservoirs was ignored for six years. But later on, it was reconsidered due to the discovery of new reservoirs with massive amount of sands and was funded in its lab-testing phase and then tested in actual reservoirs. The shift from total ignorance to generous funding and then allowing actual tests in reservoirs represents a significant change in ARAMCO's perception of what national scientists can do. However, and in regard to the concept of rentier mentality, the stories of dealing with national scientists as free rent uncover other mechanisms of this mentality that would add to the turn-key mode. The changing attitudes of ARAMCO, as illustrated by the story of sand control, show how a productive sector can transition from ignoring national scientists to working with them to solve local problems, from acting based on the rentier mentality to a productive way of thinking.

7.5. General discussion

This is a study of the problem of the connectedness between the science produced in Saudi Arabia, as an LDC and Arab country, and national needs. I performed it at a micro level and studied two cases, DPEs at Alpha University and Beta University. Conducting a micro level sociological study of the problem resulted in locating mechanisms of connectedness as well as that of isolation within scientific institutions and scientific

communities. The two different realities of the two cases in terms of connectedness was a bonus for my study. While this study was not designed as a comparative one, the different cases allowed me to determine some of the factors affecting when scientists practice and produce science for national needs and when they do not.

The different realities of the two departments raises an important question: what if my study had been designed as a single case study, in which I studied just one of the departments? I assume if I had studied one case I would have concluded that I had located the mechanism of connectedness or of isolation. In other words, had I studied the DPE at Beta, I would have found a story of complete isolation, emphasizing the missing mechanisms of connectedness, such as institutional arrangements, the role of the way the university had been established and developed, the social construction of the university, and some structural mechanisms such as that of political economy organization--the rentier mentality. The positive attitude and self-confidence, however, would not have been presented.

On the other hand, had I taken Alpha's DPE as my case, I would have found a story of connectedness, but the recent changes in level of connectedness may have let me construct similar themes. The different realities of the two cases supported the validity of the themes and how they fit into the connected case versus their actions in the isolated one. The two cases also allow us to see the importance of historical and regulatory factors in facilitating connected science, as mentioned above. Moreover, studying the two cases

provided examples of institutional situations in which scientists connect their scientific output with national needs or do not.

In general, the two cases allow us to see the importance of institutional environments in framing the type of produced knowledge. Scientists with no appropriate institutional arrangements, such as in Beta's case, should not be blamed for low production of science or for producing scientific knowledge isolated from local needs. Connected science needs institutional efforts at the level of the university. Scientists are not actors in producing connected science without well-organized networks supporting them. The SSDA should not blame national scientists for their low productivity or for the limited usefulness of their already-produced science. Neither should the blame target the productive sectors alone. The key is the way in which universities are regulated and organized. Somehow universities need to support and promote more effectively the research mission.

Another point to be discussed is the theoretical frame of this study. As I mentioned in the second chapter and above, I used parts of the two primary sociological approaches to science. I do not use them as a mixed theoretical frame. Instead, I use them as a railway to carry my train, this study. Ben-David's institutional analysis forms one rail line while the Collins (1975), Pinch & Bijker (1984), and Pickering (1984) constructionist approach forms the other line. These approaches constitute the main themes of this study, institutional arrangements and social construction of the university. As I worked in the field, both approaches were useful in constructing the results and, later, analyzing the

data. I hope this study makes a contribution to sociological studies of science in benefiting from the different sociological heritages of studying science.

Zahlan's work on rentier mentality also was useful in analyzing data. Zahlan, the scholar well known for his studies of science and technology systems in the Arab world, applied the concept of rentier mentality to the issue of science and used it to explain how productive sectors in the region could reproduce their habit of ignoring national scientists and seeking the services of scientists abroad. Zahlan applied the concept developing the term "turn-key mode," which I see as a mechanism of rentier mentality. However, Zahlan's term and the whole concept were used by Zahlan himself (1975, 1980, 1984, and 1999) only with macro level studies. I examined it in this study with micro level cases. The data suggest adding another mechanism, national scientists as free rent. Some of the stories of my interviewees allowed me to observe changes in the attitude of the productive sector toward national scientists from a rentier mentality to a productive one. Based on this study, I suggest that Zahlan's work added to the sociological studies of science in LCDs.

7.6. Weaknesses of the study

When analyzing the data, I found some weaknesses of this study. For example, I wish I could cover the issue of role identity by asking faculty of the DPEs precise questions about how they see themselves in terms of teachers and scientists. This might reveal how the production of isolated scientific knowledge legitimized and reproduced itself. As I discussed at the end of the social construction theme, if faculty see themselves as teachers

and trainers, the research they do is legitimate if it serves such a role identity, since research in this case would connect the faculty with updated trends in the field. Moreover, if publishing papers allows the faculty to meet institutional requirements for promotion as well as providing personal fame and prestige among colleagues, that would legitimate the isolation of research from national needs. The Saudi university system does not create institutional pressure on faculty to bring funds to their universities. These mechanisms work together to isolate the faculty from the productive sectors. How such institutional and organized reality is reflected on the self of the faculty members is a point that I wish I had covered.

Another point that I wish I had covered with the faculty of Beta's DPE was the issue of self-confidence. Faculty of Alpha's DPE described their increasing self-confidence after strengthening their research ties with the national oil industry. Faculty at Beta did not touch on the issue. It would be interesting to know how the faculty in an environment isolated from national needs feel about their abilities.

7.7. Future studies

As I was gathering data or analyzing them, many questions arose in regards to how the national oil industry makes decisions about the selection of researchers for scientific research on technical problems. A complementary work for this study would an ethnographic study within the reservoir management and engineering department at ARAMCO. Such a study could observe the way decisions are made about seeking the services of scientists outside the firm. It is important to know the structure of decision units; are they committees, individual persons, or departments? It also is important to

gather information about the academic and training backgrounds of members of such units. Did they earn their degrees from national universities or western ones? Do their academic backgrounds affect their decisions? In other words, are they biased in regard to national scientific institutions and scientists because of their educational backgrounds? The more important point is to know whether there are certain perceptions that affect their decisions. The complete isolation of Beta faculty from the national oil company, which is the largest one of its kind in the world, makes it worth knowing how the people at ARAMCO responsible for selecting which scientific institution to seek help from justify such complete and continuous rejection of the national academy. The complete isolation of Beta's department from the national industry could be due to the experiences, inherited ways of conducting work, or perceptions of small units in the giant oil industry.

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Appendix A

Appendix A contains two letters. First letter was used as introduction of the researcher to interviewee. Second letter, which is written in Arabic, was a letter signed by the dean of college of Arts and Humanities at King Abdul Aziz University, Jeddah, Saudi Arabia asking potential interviewees to cooperate with the researcher and telling them that I work as a teaching assistance at the sociology department at King Abdul Aziz University.

The problem of connectivity A sociological study of links between academia and productive sectors in Saudi Arabia

October, 4, 2005

Dear Sir,

You are invited to be in a research study of the social order of producing and using scientific knowledge in Saudi academia, focusing in petroleum science as a case. You were selected as a possible participant because you work as I ask that you read this form and ask any question you may have.

The purpose of this study is to complete a Ph.D. dissertation in social studies of science at the sociology department in Virginia Polytechnic institute and State University, Blacksburg Virginian, US.

I work as a teaching assistance at the sociology department, King Abdul Aziz University, Jeddah. Currently, I am in the process of collecting data for my dissertation. Your participating is going to be great and appreciated help for my project. Since the research project I work on as a qualitative study that aims to gather as much as possible about faculties' experiences and stories, I use in-depth tape-recorded interviews. Interviews may last for one hour long. I know how valuable your time and how busy your schedule is but your cooperation is critical for this project.

The records of this study will be kept private. Research records will be stored securely and only I (the researcher) will have access to the records. However, I may use quotes of the interview in my dissertation. In any sort of report I might publish, I will not include any information (like scientist's name or university name) that will make it possible to identify a subject.

Sincerely,
Abdusslam Assuliman
Sociology Department
King Abdul Aziz University



Ref.
Date
Encl.

الرقم ٤٠٦/١٤٥
التاريخ ٤٠٦/٤١٥
المرفقات جواز سفر بحلي

إلى من يهمه الأمر

نفيد سعادتكم ان المبتعث / عبدالسلام بن وائل السليمان مبعوث قسم
الاجتماع بكلية الآداب والعلوم الإنسانية بجامعة الملك عبدالعزيز إلى
الولايات المتحدة الأمريكية لتحضير درجة الدكتوراه في علم الاجتماع (علم
اجتماع المعرفة العلمية) يقوم حالياً بزيارة إلى المملكة لجمع المادة العلمية
لرسالته .

نرجو التكرم بمساعدته بتسهيل مهمته في جمع المادة العلمية الخاصة
لرسالته تشجيعاً للعلم وطلابه .

شاكرين ومقدرين تعاونكم سلفاً .

وتقبلوا خالص تحياتي وتقديري ،،،،

عميد كلية الآداب والعلوم الإنسانية

د. محسن بن أحمد منصور

٤١٥

AZ-W2330