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MULTINATIONAL URANIUM ENRICHMENT IN THE MIDDLE EAST: ECONOMIC AND POLITICAL PERSPECTVES

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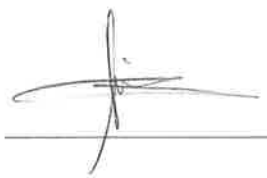

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AN ABSTRACT OF THE THESIS OF

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The Joint Comprehensive Plan of Action (JCPOA), a multinational agreement signed in 2015 between Iran and the P5+1 countries (the United States, China, Russia, France, the United Kingdom and Germany), represented a successful step towards achieving international cooperation within the Middle East. However, most of the physical restrictions imposed by the deal on Iran's enrichment capabilities will be lifted in 10 to 15 years after which Iran intends to resume enrichment to supply its nuclear reactors. Meanwhile, other regional powers are moving forward with their own nuclear power programs. One proposal that could offer a long term solution to regional security is the conversion of Iran's enrichment program to a multinational one where regional countries and some members of the P5+1 act as stakeholders. This dissertation examines the economic and political factors that could influence the proposal for multinational enrichment in the Middle East. It will use a discounted cashflow methodology to estimate the total levelized cost of enrichment for national enrichment plants and a multinational enrichment facility in the Middle East. The dissertation will also present an analysis on the international enrichment market and projected prices. Finally, the paper will also conduct a comparative analysis to identify potential political, policy and economic factors that could influence Iran and Saudi Arabia to move forward with a multinational enrichment venture. Findings show that multinational enrichment holds an economic advantage – in the form of capital and operational costs - compared to national enrichment due to economies of scale. Also, market enrichment prices are projected to remain low due to an oversupplied market and the projected downturn in global nuclear capacity. With the current political tension, mistrust and heightened regional rivalry coupled with the limited political capacity for cooperation, Iran and Saudi Arabia will have to reach some political understanding before moving forward with nuclear rapprochement and multinational enrichment.

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CHAPTER I

INTRODUCTION

The Joint Comprehensive Plan of Action (JCPOA), a multinational agreement signed in 2015 between Iran and P5+1 countries (the United States, China, Russia, France, the United Kingdom and Germany), represents a successful step towards achieving international cooperation within the Middle East (Joint Comprehensive Plan of Action, 2015). It allowed the international community to rebuild trust and transparency with Iran in regards to its nuclear cycle activities, and more importantly it paved the way for the removal of economic sanctions imposed upon Iran which were adversely affecting the country's economy and population.

However, the physical restrictions placed by the JCPOA on Iran's enrichment activities will expire within a period of 10 to 15 years, after which Iran has expressed its desire to resume enrichment to fuel its Bushehr-1 reactor as well as expand its enrichment program and install additional advanced centrifuges at Natanz (Heinonen, 2016). Meanwhile, with increasing demand for electricity in the MENA region, nuclear power is gradually gaining momentum as multiple states within the region – Egypt, Jordan, Saudi Arabia, Turkey and United Arab Emirates – began moving forward with their own nuclear power programs. Some of these regional countries, such as Saudi Arabia and the United Arab Emirates, have expressed concerns regarding Iran's capabilities to acquire a nuclear weapon and require further assurance of the nuclear program's peaceful nature (Einhorn & Nephew, 2016). According to Reuters (2014), Prince Turki al-Faisal, former chief of

intelligence, was quoted saying “preserving our regional security requires that we, as a Gulf grouping, work to create a real balance of forces with [Iran], including in nuclear know-how.”

Pursuing such nuclear know-how will once again raise security concerns among the international community as nuclear cycle facilities involving uranium enrichment and reprocessing would supply countries with the intrinsic ability to produce nuclear weapons. One proposal that would allow Iran to pursue its domestic enrichment plans while maintaining its improved relationship with the international community suggests a long term solution that opts to convert Iran’s current national enrichment program into a multinational one where regional countries with civilian nuclear power programs and P5+1 countries could be potential shareholders (Mian et al., 2015).

According to Mian et al (2015), such an arrangement would allow for further transparency of Iran’s current and future enrichment operations while containing proliferation concerns using adequate extensive safeguard arrangements. This long-term approach suggests opting for regional alliance structures instead of resorting to the strenuously familiar line of accusations and economic sanctions previously imposed on Iran. Moreover, Mian et al (2015) also state that, when it is politically possible, further transparency could come if regional countries decide to form a “nuclear inspectorate to supplement IAEA safeguards” (p. 1321) similar to the one formed between Argentina and Brazil in the 1990’s.

This paper will rely on a previously coauthored publication titled “Multinational uranium enrichment in the Middle East” in which a discounted cashflow methodology

developed by Ahmad, Salahieh and Snyder (2017) will be used to estimate the total levelized cost of enrichment incurred by a multinational enrichment plant and by indigenous enrichment plants in countries with a civilian nuclear power program in the Middle East. Such quantitative assessment will allow for a comparison between enrichment costs and show whether a multinational enrichment plant holds an economic advantage over national enrichment plants. The paper will provide an analysis of the current international enrichment market and the foreseeable trend in enrichment prices. In addition, the paper will undertake a new approach and present a preliminary comparative study to identify the potential political, policy and economic factors that could influence Iran and Saudi Arabia to move forward with the multinational enrichment venture.

CHAPTER II

NUCLEAR POWER AND ENRICHMENT CAPACITY IN THE MIDDLE EAST

Currently, six countries in the Middle East have planned nuclear power programs; Saudi Arabia has well-developed plans but its commitment is pending, Egypt and Jordan have committed plans and are developing their legal and regulatory infrastructure, Turkey has signed contracts with reactor vendors, UAE is currently constructing its first rector and Iran has the only operational program in the region. See Figure 1.

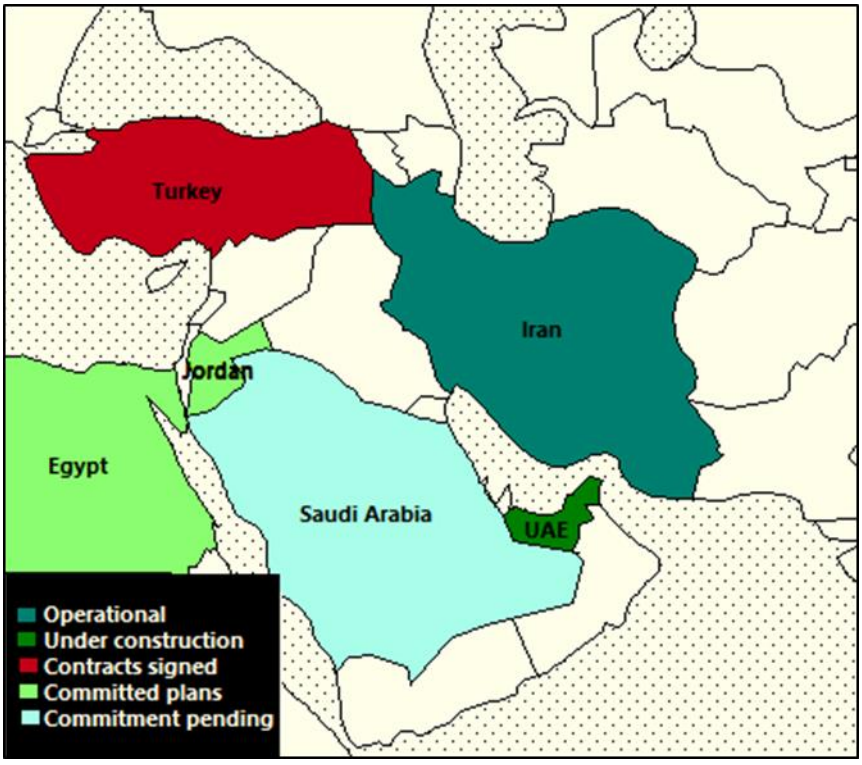

Figure 1: Nuclear power reactors in the Middle East

Nuclear power capacity can be defined as the amount of electricity generated by a nuclear reactor per year, while enrichment capacity is the amount of energy, measured in Separative Work Units (SWU) per year, required to separate different isotopes of uranium into enriched and depleted streams. Uranium enrichment is one of the main processes within the nuclear fuel cycle which involves isotope separation to increase the percentage of uranium-235 (the fissile isotope), usually to 3-5%, in natural uranium ("Uranium Enrichment", n.d.). The enriched product then undergoes fuel fabrication processes in order to produce nuclear fuel suitable for commercial reactors.

Among other variables, a country's nuclear power capacity plays an important role in determining the enrichment capacity required to produce enough fuel for its reactors. A preliminary study conducted by Ali Ahmad and Ryan Snyder (2016) calculated the high and low projected enrichment capacities for countries with civil nuclear programs in the Middle East. The low projections are based on the assumption that not all planned reactors are finished while the high projections are based on the assumption that all planned reactors are built and completed. Their results are shown in Table 1.[1]

[1] As noted by Ahmad & Snyder (2016), estimated enrichment capacity is based on the following assumptions: Fuel burn-up equals 45 GW-day per metric ton. Plant capacity factor is 90 percent. Thermal efficiency is 33 percent. Product, feed and tails assays equal 3.5, 0.71 and 0.25 percent respectively.

		Projected enrichment capacity (million SWU/yr)	
Country	**Year**	**Low**	**High**
Egypt	2030	0	0.5
Jordan	2026	0	0.2
Iran	2030	0.2	0.3
Saudi Arabia	2040	0	1.8
Turkey	2030	0.4	1
United Arab Emirates	2020	0.6	0.6

Table 1 Ahmad and Snyder (2016) projected enrichment capacities for countries in the Middle East

A. Iran

Iran is the only country in the region with an operational nuclear reactor, the Bushehr-I. According to the World Nuclear Association (WNA, 2016a), the country is expected to install additional units by 2030 and their nuclear power capacity is estimated to reach 2000 to 3000 MWe. Iran's Atomic Energy Organization (AEOI) declared the need to add power plants at the Bushehr site in order to cut down on operating costs per unit and make nuclear power more economically suitable (Mousavian, 2014). Moreover, Mousavian argues that the expansion of Iran's nuclear power program seeks to reduce the country's dependency on oil for domestic electricity production as well as improve its overall energy security. Iran signed contracts with the Russian national nuclear cooperation, Rosatom, for the supply of two additional 1000 MWe units at Bushehr (WNA, 2016e). The foundation stones for both units were laid in 2016 while the project is expected to take 10 years to finish and cost around $10 billion ("Iran and Russia celebrate", 2016).

Moreover, the World Nuclear Association (2016a) states that Rosatom is currently supplying Bushehr I with nuclear fuel and will be involved in the future fuel supply and take back options for planned reactors.

B. The United Arab Emirates

The United Arab Emirates has the second most advanced nuclear power program in the Middle East with the Barakah-1 reactor expected to enter commercial operations in May 2017 (WNA, 2016b). The plant's national operator, Emirates Nuclear Energy Cooperation (ENEC), signed contracts with a South Korean consortium to build a total of four reactors by 2020 each with a capacity of 1400 MWe. The first fuel shipments will be supplied by South Korea while the IAEA is coordinating with the plant's national operator, ENEC, to ensure proper safeguards, surveillance and control measures are being implemented (Malek, 2017). The IAEA's Director General, Yukiya Amano, recently declared that "we will continue to work closely with the UAE as they complete all four units at Barakah, and throughout the operating life of the facility and beyond" ("Positive future for nuclear", 2017). Back in 2009, the UAE clarified its position on non-proliferation and signed the "123 Agreement" with the United States in which it renounced any plans to reprocess or enrich nuclear fuel in return for the transfer of nuclear material and equipment ("USA signs 123 Agreement with UAE", 2009). According to the World Nuclear Association (2016b), the other three units will be gradually installed such that the country's projected nuclear capacity is 5600 MWe by 2020.

C. Turkey

Turkey has signed contracts with Rosatom for the construction of four reactors each with a capacity of 1200 MWe (WNA, 2016c). The project is financed by Russia government using a build-own-operate (BOO) model and the plant is expected to enter operations in 2023 ("Turkey to nationalise grid lines", 2016). A preliminary license to initiate investment and permit other related procedures was signed in June 2015 by the Russian-owned company responsible for the plant ("Turkish regulator issues", 2015). However, political tension between the two countries escalated in November 2015 when a Turkish fighter jet shot down a Russian aircraft (Kramer, 2015). Certain claims were made regarding the suspension of the power plant construction yet other sources refer to the deputy director general of the Akkuyu Nuclear Company stating: "the work at the site is underway as scheduled" (Kramer, 2015; Russia Today, 2015). At a joint news conference in 2016 in which the Russian and Turkish presidents met, pledges were made to amend relations among both countries while Erdogan specifically reassured the international community of Russia's commitment to continue mutual contracts including the construction of Turkey's first nuclear power plant (King, 2016). Moreover, a second power plant with four reactor units is also being planned at the city of Sinop by a French-Japanese consortium (WNA, 2016c). Turkey's projected nuclear power capacity is between 3350 MWe and 9400 MWe by 2030 (Ahmad, & Snyder, 2016). According to the World Nuclear Association (2016c), nuclear fuel for the first plant will be provided by Russia.

D. Jordan

Jordan signed an intergovernmental agreement with Rosatom on the cooperation for the construction of two reactors at Qasr Amra, each with a capacity of 1000 MWe (WNA, 2016d). Moreover, nuclear fuel is also expected to be supplied by the same company. According to the IAEA (2015), the country still needs to develop its nuclear regulatory and legal infrastructure. The country could also benefit from improving its grid capacity which would require an upgrade to accommodate the two potential reactors (Ahmad, & Ramana, 2016). In 2016, Rosatom's general director, Sergey Kirienko, claimed that a feasibility study on the construction project should be prepared in the first half of 2017 ("Russia expects feasibility study", 2016). Moreover, the chairman of the Jordan Atomic Energy Commission (JAEC), Khaled Toukan, stated that the country would be able to operate its reactor by 2025, if adequate financing is secured. Currently, the country imports more than 95% of its energy and aims to integrate nuclear power within it energy mix in order to supply 50% of its electricity by 2030 (WNA, 2016d). Jordan's projected nuclear capacity is 2000 MWe by 2026 (Ahmad, & Snyder, 2016).

E. Egypt

Since the 1960's, Egypt has sought to develop nuclear power and research technology but its plans have been repeatedly hindered by political and economic obstacles (Acton & Bowen, 2008). Nevertheless, the country was able to seize an agreement with Russia in 2015 for the construction of four reactors each with a capacity of 1200 MWe at a site knowns as El Dabba (Fahmy, Alsharif, Baker & Lawson, 2016). The agreement also

includes collaboration on future fuel supply and resource training. In 2016, Russia announced that it will loan Egypt $25 billion to finance 85% of the project which will be paid back over 35-year period (Alsharif, & King, 2016). Currently, France, China and South Korea have entered an international bidding platform for Egypt's second nuclear power plant (WNA, 2017). Moreover, Egypt's nuclear power regulator, Nuclear Power Plant Authority (NPPA), is working with the international consulting firm, Worley Parsons, on a two-year project to identify a suitable site for the second nuclear power plant, possibly at the Nabila area. Nevertheless, the first reactor is expected to enter commercial operation by 2024 while Egypt's overall projected nuclear capacity for 2030 is 4800 MWe (Ahmad, & Snyder, 2016).

F. Saudi Arabia

With the collapse of oil prices, the Kingdom of Saudi Arabia (KSA) is currently emphasizing the need to diversify its energy mix. Back in 2011, the country announced an ambitious plan to construct 16 nuclear reactor units that would be able to provide 20% of the country's electricity by 2032 (WNA, 2016e). Later in 2015, the date was further pushed till 2040. The King Abdullah City for Atomic and Renewable Energy (KA-CARE) signed an intergovernmental cooperation agreement with Rosatom in June 2015 for the development of the country's nuclear power program which is expected to be implemented ("Russia ready to build", 2016). In 2016, KSA's energy minister, Khalid Al-Falih, declared that the country was ready to begin construction of its first nuclear power plant within a 12 months period ("Saudi Arabia to start building", 2016). The minister further

emphasized the country's motivations behind its nuclear program which aims to generate electricity, power desalination plants and alleviate domestic dependence on oil consumption and allow for more oil exports. KA-CARE also signed an agreement with Kazakhstan in 2016 for potential fuel supply and has signed other nuclear cooperation agreements with Argentina, China, Finland, France, Hungary, Indonesia and South Korea ("Kazakhstan and Saudi Arabia agree", 2016). The Kingdom's projected nuclear capacity is 17000 MWe which could be an optimistic estimate (Ahmad, & Snyder, 2016).

CHAPTER III

THE JOINT COMPREHENSIVE PLAN OF ACTION AND MULTINATIONAL ENRICHMENT

The Joint Comprehensive Plan of Action (2015) signed between Iran and the P5+1 set certain restrictions on Iran's nuclear program in return for the lifting of oil and financial sanctions. These restrictions directly and indirectly constrain Iran capabilities from assembling a nuclear weapon or even a dirty bomb.

Iran will not separate plutonium from spent fuel for 15 years and "does not intend to thereafter," it also agreed to limit its enrichment capacity in Natanz by dismantling two thirds of its total centrifuges and only keep 5,060 centrifuges for the next 10 years (Joint Comprehensive Plan of Action, 2015). The deal also limits Iran's stock of Low Enriched Uranium hexafluoride to 300 kg to be kept at an enrichment level of 3.67% U235 for the next 15 years. These limitations prolonged Iran's breakout time, - the time required to assemble a nuclear weapon, - from 3 months, as previously calculated before the deal, to about 12 months (BBC News, 2016a). Moreover, no more enrichment will take place at Iran's Fordow enrichment facility which will turn into a research center while two thirds of its centrifuges will be dismantled.

According to Mian et al. (2015), Iran intends to resume enrichment after sanctions are removed to be able to supply its Bushehr reactor which would produce at least 27 tons every year of 3.5% enriched uranium. (p.1321). The amount of enrichment capacity needed

to produce enough enriched fuel for Bushehr is around 100,000 SWU per year which would give Iran the ability to produce approximately 50 nuclear explosive devices per year – if it uses 3.5% enriched uranium (Mian, et al, 2015). Once Iran starts re-enriching uranium, the international community as well as regional countries within the Middle East, would require further assurance of the peaceful nature of Iran's activities.

In 2003, Mohammad El Baradei (2003), the previous Director General of the IAEA, suggested new approaches with considerable security advantages that would allow for strengthening the global nonproliferation regime. One of his proposed approaches stated: "it is time to limit the processing of weapon-usable material (separated plutonium and high-enriched uranium) in civilian nuclear programmes, as well as the production of new material through reprocessing and enrichment, by agreeing to restrict these operations exclusively to facilities under multinational control. These limitations would need to be accompanied by proper rules of transparency and, above all, by an assurance that legitimate would-be users could get their supplies."

El Baradei further emphasized that these measures would not simply add to the non-proliferation control of weapon-grade fissile material but also allow for a wider global population to properly and safely benefit from nuclear technology.

Glaser et al. (2015) argues that current Middle Eastern countries with civilian nuclear power programs should use the next decade, - approximately the same period under which the Iran deal is expected to remain in force, - to agree on regional restraints inspired by the JCPOA's key obligations to be used as preliminary steps towards establishing a Middle Eastern Nuclear Weapon Free Zone (MENWFZ). The restraints would include a

ban on plutonium separation, restrictions on enrichment levels, placement of enrichment facilities under multinational control, gradual elimination of Israel's nuclear arsenal and reduction of its stocks of fissile material (p. 14). The proposal further emphasizes the need for robust regional safeguards, monitoring and verification regime which would ensure the compliance of Middle Eastern countries and their nonproliferation commitments. Specifically, Glaser et al. suggested the establishment of a working committee between Iran and the P5+1 on the multinationalism of Iran's enrichment program to which regional partners would be invited to join and work together to set a 5 year deadline to reach agreements (p. 17).

Iranian policy maker, scholar, and former Ambassador to Germany, Hossein Mousavian (2017), recently called for the establishment of a sub-regional security and cooperation arrangement in the Persian Gulf which would include security, economic and political cooperation measures inspired by principles of the JCPOA. According to Mousavian, the multilateral enrichment venture could be an element of this new cooperation structure.

Multinational enrichment ventures have been achieved in the past. In his article, "Multinational Alternatives and Nuclear Nonproliferation," Lawrence Scheinman (1981), discusses the different aspects of multinational institutional arrangements related to nonproliferation. He argues that there is no single formula for such arrangements and the actual success of implementing a multinational model will be determined by the flexibility of its application. He further states that multinationalism alone is not enough to prevent proliferation but rather the arrangement "must be part of an integrated regime which covers

not only the facility itself, but the material produced" (p. 81). Specifically speaking, for a multinational enrichment facility that produces enriched uranium, there needs to be specific control arrangements covering the storage, release, use, and disposition of the product. More importantly, Scheinman emphasizes consensus and political acceptance as the main prerequisites to multinationalism: "An institutional arrangement can only be as strong as the foundation upon which it is built. . . Multinationalism cannot substitute for consensus; it can only reflect and reinforce that consensus." (p.82).

Urenco is an example of a multinational enrichment venture which currently produces a third of global enrichment capacity and shares a multinational board of directors, as well as an oversight body, with three governments: The United Kingdom, The Netherlands, and Germany. Originally, the company was based on the 1970 Treaty of Almelo[2] and currently owns and operates enrichment facilities in the three countries and ensures shared areas for collaboration and oversight in regards to the development, protection and peaceful use of enrichment technology (Carlson, 2015). Moreover, the major policy committees, the facility management and operation, and the operating staff involve nationals from those three countries that operate Urenco (Goodby, 2008).

Another multinational enrichment arrangement is the International Uranium Enrichment Centre (IUEC) at Angarsk, Russia, which aims to allow interested states access to enrichment services for their civilian nuclear power programs without transferring proliferation-sensitive technology and information (IAEA, 2016). This center was

[2] Also known as the Agreement between the United Kingdom of Great Britain and Northern Ireland, the Federal Republic of Germany, and the Kingdom of the Netherlands on Collaboration in the Development and Exploitation of the Gas Centrifuge Process for Producing Enriched Uranium

multinationalized using enrichment contracts with Russia and current participant states, Kazakhstan, Armenia and Ukraine, have access to enrichment services through agreements with the Russian government after meeting specified non-proliferation conditions and agreeing that the material supplied is only used for peaceful purposes (Loukianova, 2008). Since 2011, the facility includes a Low Enriched Uranium (LEU) Guaranteed Reserve which is under IAEA safeguards and available for IAEA Member States.

Both Urenco and IUEC are multinational arrangements that hold important technical and security characteristics that could be further assessed and developed when considering multinational enrichment in the Middle East.

CHAPTER IV

A MODEL FOR NUCLEAR COOPERATION: THE CASE OF ARGENTINA AND BRAZIL

Argentina and Brazil, as highlighted by Mian et al. (2015) in their proposal for multinational enrichment, were involved in the formation of a regional nuclear inspectorate in the 1990's which allowed both countries to build and maintain nuclear and regional security in Latin America. Such bilateral nuclear cooperation could be useful to understand before assessing the potential factors that could influence certain regional countries to join a multinational enrichment venture in the Middle East.

Between the 1970's and 80's, the international community had various reasons to fear that both Argentina and Brazil were planning to develop nuclear weapons. By then, both countries had refused measures put by the international nonproliferation regime; they did not sign the Treaty of Tlatelolco which called for a nuclear-weapon-free zone in Latin America, nor did they concede to joining the NPT. More importantly, they were simultaneously able to acquire proliferation sensitive technology which, theoretically speaking, would have given them the inherent capability to develop nuclear weapons. Nevertheless, by the 1990's, both countries managed to sign and ratify the Treaty of Tlatelolco and the NPT as well as multiple other agreements that allowed for the establishment of the Joint System of Accounting and Control of Nuclear Materials (SCCC) and the creation of its implementing body, the Brazilian-Argentine Agency known in

Spanish as ABACC. During that period, there were various factors that promoted bilateral cooperation and others that hindered it, however, they all played an important role in shaping Argentina and Brazil's nuclear relations. It is critical to understand these factors given their time and context as they offer additional insights into assessing how bilateral cooperation can be galvanized and even restricted when it comes to modern day nuclear diplomacy.

Argentina was the first country in South America to produce a fission chain reaction, develop uranium enrichment and fuel reprocessing technology, as well as export a nuclear reactor (Poneman, 1985 as cited in Reiss, 1995, p. 46). On the other hand, in 1975, Brazil had signed the "nuclear deal of the century" with West Germany which promised the largest transfer of nuclear technology to a developing country (Wonder, 1977, as quoted in Reiss, 1995, p.49). Fears regarding their proliferation capabilities were tied to the fact that they were developing sensitive technology such as uranium enrichment and fuel reprocessing, without consenting to international safeguard regimes (Mallea et al., 2015, p. 1; Reiss, 1995, p.46).

Moreover, these fears were amplified by the countries' history of rivalry, mistrust and competition fueled by their desire to lead South America and dominate export markets (Carasales, 1995, p.40; Redick et al., 1995, p.110). Nevertheless, they shared common incentives to develop the capacity of their nuclear programs. According to Poneman (1985) and Myers (1985), both countries had strong political motivations as well as underlying security and economic motivations to pursue a complete nuclear fuel cycle. Their political motivations were fueled by the desire to achieve prestige and independence; they both

sought the independent supply of nuclear materials and did not want to depend on nuclear supplier countries to run their own nuclear power programs (Poneman, 1985, p. 93; Myers, 1985, p. 123). At the time, Argentina and Brazil were run by military regimes who, according to Poneman (1985), considered nuclear technology as an indicative element to securing national political support and claiming regional leadership (p.94-95).

According to Myers (1975), in the context of the early 1970's oil crisis, Argentina and Brazil considered nuclear power to be the next dependable energy source able to support their growing economies. Brazil's endeavors to enter the export industry of nuclear reactors were driven by the desire to earn foreign exchange and break the "industrial North's monopoly" that forced developing countries to depend on technology provided by developed countries (p. 125). Similarly, Poneman (1985) argues that Argentina's nuclear power program was also framed as an economic development strategy that would enhance the capabilities of the Argentinian economy through promoting engineering skills deemed useful for a variety of its sectors (p.96). Moreover, Argentina pursued a full nuclear fuel cycle as it would allow for the recycling of nuclear materials to be reused in reactors and ultimately provide services and compete among other nuclear suppliers in the international market (p. 103).

Although the last armed conflict between Argentina and Brazil was in 1825, there still remained a prevalent "culture of competition" which was partly translated in their attempts to acquire nuclear know-how and technology in which Brazil was always a step behind Argentina (Reiss, 1995, p.52; Carasales, 1995, p.40). However, certain efforts initiated by political leaders were able to curb these antagonistic relations and set the

platform for nuclear cooperation. In 1980, Brazil's military leader, Joao Figueiredo, visited the capital of Argentina and held nuclear talks with the Argentinian president General Videla after which they both signed the "Agreement on Cooperation for the Development and Application of the Peaceful uses of Nuclear Energy" (Brigagão & Fonrouge, 1998; Carasales, 1995; Reiss, 1995).

Brigagão & Fonrouge (1998) argue that this agreement – which included cooperation mechanisms covering nuclear research projects and experiments as well as the exchange of technical and scientific information and nuclear materials – was among the founding elements of mutual understanding between the two nations in regards to their nuclear programs (p.102). Carasales (1995) claims that the agreement was significant as it portrayed the containment of 30 years of nuclear rivalry while policy-makers from both nations realized that the field of nuclear development held promising ground for future cooperation (p. 40). Moreover, Reiss (1995) states that the agreement allowed for the strengthening of personal relationships and mutual trust while alleviating suspicion (p.54). He further explains that both leaders resorted to collaboration rather than competition as a way of resisting the obstacles set by the nonproliferation regime which had adopted a technology-denial strategy. Spektor (2015) states that both countries considered the U.S denial strategy as more provoking ad threatening than the risks perceived from each other's nuclear programs.

Thus, a driving factor for nuclear cooperation between the two countries was their shared positions on the international nonproliferation regime which was perceived as discriminatory and dismissive of their own sovereign rights to nuclear technology (Reiss,

1995, p.53; Redick et al., 1995, p.111). During the 1970's and 1980's, the U.S had pressured nuclear technology suppliers to cut supplies to other countries, while in 1974 it announced the suspension of future enrichment contracts to both Brazil and Argentina (Kassenova, 2016; Reiss, 1995, p. 47-50; Spektor, 2015). Both countries were then denied the supply of advanced nuclear technology which caused their nuclear power programs to suffer both technically and financially. Thus, according to Wrobel (1993), Argentina and Brazil's shared resentment towards nuclear supplier countries prompted them to "coordinate and exchange ideas on the best way to resist the pressures constantly exerted by the nuclear states to join the regime" (as cited in Reiss, 1995, p.80). This enabled both countries to see each other as allies rather than enemies. Furthermore, Oscar Camilión, the previous Argentinian Ambassador to Brazil (1976-1981), was quoted saying:

> The spirit of the 1980 agreement was precisely to look for concrete exchanges: heavy metallurgy parts from the Brazilian side and the loan of zircaloy pipes on the part of Argentina . . . It was understood that once cooperation between Brazil and Argentina in the industrial field started, the gates would be open for the two countries to become as transparent as possible in communicating their respective nuclear programs to the neighbor so that the fear of an armaments race would be dispelled (Mallea et al., 2015, p.64-65).

After the 1980 agreement, certain external and domestic events influenced the progression of nuclear cooperation. The 1982 Malvinas-Falklands war between Argentina and Britain ended with an Argentinian defeat and eventually led to the collapse of the military regime, the introduction of the first popular elections and the rise of civilian rule ("Falkland Islands War", 2014). Similarly, Brazil's military government had also transitioned into a civilian nation by 1985 and Jose Sarney was elected president (Mainwaring, 1986). Although both those events had temporarily halted the momentum of the 1980 agreement, they eventually set the stage for accelerated cooperation.

According to Redick et al. (1995), the newly elected Argentinian president, Raul Alfonsín, wanted to reverse the economic and political isolationist attitude adopted by the military government and to place the nuclear program under civilian control. Brigagão & Fonrouge (1998) state that both countries' nuclear commissions were remodeled and demilitarized after the re-establishment of democracy. According to Spektor (2015), Alfonsín considered it wasteful to direct resources for military purposes, let alone a nuclear arms race, as it could destabilize the country's democratic transition. Essentially, Reiss (1995) claims that nuclear cooperation was enhanced when civilian governments were introduced into the process as they managed to renew the momentum and infuse bilateral relationships. Carasales (1995) further adds that the rise of civilian leadership promised the improvement of relations between the two countries.

At the end of 1985, both presidents met in Foz do Iguaçu and signed the "Joint Declaration on Nuclear Policy" which reiterated both countries' commitments to the peaceful use of nuclear energy and their willingness to cooperate together within the nuclear field.[3] It also mentioned an inspection system which would ensure the peaceful nature of nuclear facilities, equipment and material across the two countries. The declaration also formed a joint working group responsible for proposing cooperation measures to be supervised by Argentina and Brazil's Foreign Ministries which, according to Reiss (1995), specifically enhanced efforts as it helped "institutionalize bilateral nuclear cooperation" (p.55). Carasales (1995) further confirms that the involvement of the Foreign

[3] See the "Brazil-Argentina Foz do Iguaçu Joint Declaration on Regional Nuclear Policy." (November 1985). History and Public Policy Program Digital Archive, Department of Energy and Mineral Resources of the Ministry of External Relations, AHMRE. Retrieved from http://digitalarchive.wilsoncenter.org/document/117521

Ministries was “a significant factor contributing to the success of the bilateral nuclear nonproliferation effort” (p.41).

After 1985, nuclear cooperation was further enhanced by several protocols and declarations signed by both presidents which acted as additional confidence building tools. Some of these included the 1986 Brasilia Declaration, the 1987 Viedma Declaration and the 1988 Ipero Declaration which all paved the way for legal and technical transparency and verification measures between the two nuclear programs (Brigagão & Fonrouge, 1998). The two presidents also started to frequently visit each countries’ sensitive nuclear facilities (Reiss, 1995; Brigagão & Fonrouge, 1998). Carasales (1995) states that these high level visits were not simply social gestures but also “confidence building measures” (p.41). Moreover, according to Reiss (1995), they “demonstrated unprecedented high-level political support for the process” (p.55). Another confidence-building measure was when Brazilian President, Sarney, personally notified Alfonsin of the successful completion of Brazil’s enrichment facility in 1987 before publicly announcing the news (Redick et al., 1995). These interactions and the subsequent presidential visits to each enrichment plant were critical as they eliminated suspicion. According to Mallea et al. (2015) the face-to-face meetings with then-Brazil and Argentina’s presidents played a significant role in building trust among both nations as their relationship made the progress of mutual nuclear inspections possible. Both presidents, Alfonsín and Sarney, are described to be main actors who were able to turn the beginnings of rapprochement into sustained cooperation (Mallea, Spektor & Wheeler, 2015, p. 8).

When new presidents were elected by the end of the 1980's in Argentina and Brazil, they too declared their strong and firm support of nuclear cooperation as, according to Carasales (1995), they "not only kept the effort going but also intensified it, soon showing that the new vision had solid roots and was not based on the political will of a few individuals" (p.42). According to Redick et al. (1995), Argentina's new President, Carlos Menem, and his advisors sought a pragmatic approach to reform Argentina's economy; they regarded the country's resistance towards the international nonproliferation regime as "counterproductive" and resorted to improving Argentina's foreign relations with Western countries (p. 113). Moreover, according to Goldemberg (1994, as cited in Reiss, 1995, p.58) the newly elected Brazilian president, Fernando Collor de Mello, strongly disapproved of nuclear weapons and insisted on achieving complete civilian control over Brazil's nuclear activities. More importantly, Redick (1995), further argues that both presidents aimed to reshape their nuclear policies in ways that achieved economic development and maintained national interests and thus decided to reintegrate their countries within the international community's nonproliferation framework. Reiss (1995) states that both administrations aimed to rejoin the global economy. Argentina suspended its ballistic missile program in 1990 as part of their attempt to reestablished relations with Britain and the U.S (Reiss, 1995, p.60; Nash, 1991). On the other hand, Saraiva (2012, as cited in Mariano, 2013) states that Brazil had reshaped its foreign policy strategy at the end of the 1980's; Brazil's Foreign Ministry advocated the idea that regional integration was necessary to achieve economic and industrial development as well as global engagement. Furthermore, this concept was reiterated within the new constitution which promoted

building partnerships with neighboring countries as a way of enhancing trust (Mariano, 2013, p.120).

In 1990, both president met at Foz do Iguaçu and signed another landmark "Joint Declaration of Common Nuclear Policy" whose commitments were codified the following year in The Guadalajara Accord when the two presidents met again in Mexico to sign the safeguard agreement (Reiss, 1995; Carasales, 1995; Redick et al.; 1995). The Accord established the Common System of Nuclear Materials Accountancy and Control (SCCC) and its complementary supervising body, the Brazilian-Argentinian Agency for the Accountancy and Control of Nuclear Materials (ABACC). The aim of the system is to verify the peaceful nature of all nuclear activities, materials and equipment while the implementing body, ABACC, is the bilateral agency that would have international jurisdiction to ensure the proper application of the system in keeping both nuclear programs pacific. The Accord also pledged to negotiate a safeguard arrangement with the IAEA which would enable the ratification of a revised Treaty of Tlatelolco while it also renounced both countries' right to peaceful nuclear explosions.

By the end of 1991, four parties – Brazil, Argentina, the International Atomic Energy Agency (IAEA) and ABACC – came together to sign the Quadripartite Agreement which allowed for the application of comprehensive safeguards on all nuclear materials and activities within both countries and ensure their peaceful use ("IAEA Safeguards Agreement", 1991). According to Redick et al. (1995), the ratification of the agreement went smoothly within Argentina's congress but proved more difficult with Brazil's congress due to lack of political leadership of the interim president, Itamar Franco, and the

opposition of certain members who opposed IAEA interference and involvement in Brazil's nuclear affairs (p.115). Redick et al. (1995) further states that these obstacles were eventually settled after visits by IAEA's general director, Hans Blix, who reassured officials of the protection of propriety information and after heavy lobbying carried out by the Foreign Ministry, academic scientists and the nuclear energy commission. Reiss (1995) adds that advocates of the agreement were driven by economic development and energy goals which would have been hindered by certain nuclear supplier nations, such as Germany, had Brazil refused to ratify the Quadripartite Agreement (p. 64).

Kupchan (2010) states that the rapprochement that took place between Argentina and Brazil at the time was "at least in part a produce of elites who, albeit members of a military junta, understood the importance of institutionalized restraint at home and pursued strategic restraint abroad to further domestic reform and re-engage civil society" (p. 132). He further argues that the civilian presidents pushed for nuclear cooperation as well as economic integration as a strategy to limit military jurisdiction, establish strong relations with commerce entities and widen their countries' political engagement and participation (p.133).

During the 1990's, the two countries were motivated to coordinate and work closely in regards to their non-proliferation policies. By 1994, Argentina and Brazil ratified the Tlatelolco Treaty for the establishment of a Nuclear Weapon Free Zone in Latin America, and joined the NPT by 1995 and 1998 respectively (REF) .

Eventually, Argentina and Brazil's interpersonal talks and face-to-face diplomacy were strong diplomatic tools that enabled the two to establish confidence and build mutual

trust among each other. Moreover, Hymans (2014) states that the nuclear rapprochement between Argentina and Brazil was "more of a symptom than a cause of the growing trust between the two states" (p. 372). Carasales (1995) argues that it was not the nuclear safeguard system that built trust, but rather it was the "combination of visits, exchanges of technicians and students, commercial relations, complementary activities of nuclear industries and similar actions" (p.42). Brigagão & Fonrouge (1998) further argue that there was a political will for both countries to build trust which was not solely for the sake of regional security but also for the sake of building credibility in regards to their own nuclear programs. It is evident that, not only did both countries share common incentives to develop a nuclear program in the first place, but they also shared strong incentives to sustain their programs especially under the pressure of the international community.

Nevertheless, although the direct applicability of the Argentina-Brazil model to other contexts would require further assessment, the evolution of their nuclear relations could offer some important insights to the nature of nuclear cooperation and could potentially assist in assessing the current case of Saudi Arabia and Iran.

CHAPTER V

OVERVIEW OF POLITICS, ECONOMICS AND ENERGY POLICIES IN IRAN AND SAUDI ARABIA

This dissertation also aims to identify some of the political, policy and economic factors that could potentially influence Iran and Saudi Arabia to join multinational enrichment and will thus provide a brief overview of the current contexts of their political structure, economic condition and energy policies. Such an overview will provide some important background information for the preliminary comparative analysis to be discussed.

A. Iran

The Islamic Republic of Iran is a theocracy whose constitution is based on Islamic law (Sharia) (Central Intelligence Agency [CIA], 2017a). According to the constitution, the supreme leader, currently Ayatollah Ali Khamenei, is elected by the Assembly of Experts and is considered the most powerful man in the country as he has major influence over the legislative, executive and judiciary branches of government as well as the armed forces (Constitution of Iran, 1982a).[4] The Assembly of Experts is a group of popularly elected clerics responsible for appointing and dismissing (if found unqualified) the supreme leader – even though there are no constitutional mechanisms for his dismissal (Borden, 2016).

[4] See article 110

Nonetheless, the presence of popular elections in Iran does not necessarily indicate the presence of a democracy. Although the Assembly of Experts, members of Parliament and the President are directly elected by the people, the nominees for these positions must first be vetted by the Guardian Council - a 12-member body of 6 theologians picked by the supreme leader and 6 jurists approved by the existing parliament (BBC News, n.d). According to the BBC, this council, which is currently dominated by conservatives, is considered to be the most influential body in the Iranian government as it has the ability to pass and veto laws drafted by parliament according to their constitutional compliance.

According to the International Crisis Group's senior analyst on Iran, Ali Vaez (2016), the mainstream political parties in Iran can be split between two major camps, the theocratic (conservative or principal-ist) camp and the republican (reformist or moderate) camp. The essential distinguishing point among the two lies in their beliefs regarding the source of government legitimacy; the theocrats believe it to stem from "divine providence" while the republicans believe it to come from popular will. Vaez (2016) also argues that both parties can be further divided into radicals and pragmatists.

According to Mahmoud Sadri (2016), Iranian scholar and sociologist, the conservatives have power over security, media, supervisory bodies and the judiciary while the reformists are concentrated in the parliament and the presidency. The current president, Hassan Rouhani, whose constitutional responsibilities include nominating ministers and supervising their work as well as being in charge of "national planning and budget and state employment affairs," [5] is a pragmatic reformist who ran an election campaign under the

[5] See article 117, 126 & 128

slogan “moderation and prudence” (Constitution of Iran, 1982b; Naji, 2015). Nevertheless, although his duties make him responsible for the country’s domestic and foreign economic policies, the general guidelines are in fact determined by the supreme leader (Buchta, 2000). The same applies to nuclear and foreign policies as well as on matters regarding defense and security (Bruno & Afridi, 2009).

Rouhani pledged to reverse the aggressive isolationist attitude adopted by the previous government and start a new era that promised to end sanctions and reengage Iran with the world market (Bruno & Afridi, 2009; Milani, 2013). Throughout the last decade, Iran’s economy had shrunk under economic sanctions imposed by the United Nations, United States and the European Union. Most of these sanctions were enforced after the National council of Resistance of Iran, an exiled group of Iranians that opposed the Islamic Regime, exposed details of hidden nuclear facilities at Natanz and Fordow in 2002 (Davenport, 2016). The sanctions targeted Iran’s export and import industries as well as its foreign investments sector which further worsened existing economic conditions within the Iranian economy (Johnson & Hakimian, 2012). The Iranian currency further depreciated and inflation rates further increased along with food prices while unemployment grew to 11.5% in mid-2015 (CIA, 2017a; Trading Economics, 2017; BBC, 2010). Nevertheless, Rouhani’s promises were made more concrete when Iran and the P5+1 countries signed the JCPOA in July 2015 in which Iran’s enrichment program would be restricted under certain terms in return for the lifting of sanctions.

Iran’s economy is the second largest in the Middle East and North Africa (MENA) region and its GDP of US $394 billion in 2015 is mainly supported by its hydrocarbon,

agriculture, services and manufacturing sectors (World Bank, 2016a). According to the World Bank (2016a), Iran's current 5-year development plan for the period of 2016-2021 mainly focuses on market-based reform policies. The plan aims to achieve an average yearly economic growth of 8% by boosting efficiency growth, utilizing the latest technology and modernizing Iran's infrastructure (Khajehpour, 2016). It also stresses the importance of foreign direct investments (FDI) as it aims to attract $12 billion of FDI per year.

Moreover, the concept of a "resistance economy" is promoted as a major pillar of the development plan in which the supreme leader calls for Iran's economy to become more resistant to foreign pressure and enhance its self-sufficiency (Reuters Africa, 2017). Following this logic, budget dependency on oil revenues will be reduced from the current 31.5% to 22% by 2021 (Khajehpour, 2016). The plan also aims to reduce and keep inflation to single-digit figures, curb unemployment to 7% and increase the share of tax revenues in GDP from the current 6.5% to 11.5%. As for Iran's military spending, it is expected to increase from 2 to 5% of the annual government budget (Reuters Africa, 2017).

Back in 2015, Reuters predicted that a signed deal between Iran and the P5+1 could potentially lead to creating billions of dollars among local and foreign investors (Reuters, 2015). It further claimed that such a deal could cause a shift of economic balance in the Gulf, one disfavoring Saudi Arabia and the United Arab Emirates (Reuters, 2015). However, one year after the JCPOA was signed, there is still uncertainty regarding the extent to which the deal has benefitted Iran's economy. After the JCPOA's implementation day arrived in January 2016, most of the nuclear-related sanctions imposed by the UN, US,

and Europe were lifted. However, certain unilateral US sanctions targeting financial transactions linked to the Iranian Revolutionary Guard Corps remained enforced (Handjani, 2016). These sanctions directly forbid US citizens and companies from conducting most forms of business in Iran and also indirectly force other countries that trade with the U.S to hesitate from investing in Iran. According to the Economist (2016b), big banks are hesitant to invest as they worry of being charged gigantic fines and refuse to take the risk of falling foul to the remaining U.S sanctions.

On the other hand, Iran has been able to capitalize on the deal through its oil and gas productions. According to the U.S Energy Information Administration (2013), the Islamic Republic is among the top 10 oil producers and top 5 natural gas producers in the world. The country also has the fourth largest proved crude oil reserves and the second largest natural gas reserves in the world. Nevertheless, Iran's energy sector has been previously experiencing both declining and slow growth due to international sanctions. In 2012, certain sanctions targeted Iran's oil sector as they restricted many European countries from purchasing Iranian oil, a commodity that covered 80% of government revenues (EIA, 2013). However, after the JCPOA was signed oil production had rebounded faster than expected while exportation almost doubled (Glenn, 2016). Nonetheless, although oil exports have increased from 1.3 to 2.3 million barrels per day in 2015, export revenues were lower than those generated in 2011 as oil prices have plummeted since then (Clawson, 2016).

Oil and natural gas exploration, production and distribution is under the control of the National Iranian Oil Company (NIOC), the second largest state-owned oil company in

the world, the first being Saudi Arabia's ARAMCO. The NIOC is directly controlled by the Ministry of Oil whose minister is Bijan Zanganeh, a reformist appointed by President Rouhani in 2013 (Mohamedi, 2015). More recently, Cameron Glenn (2016) from the Iran Primer states that the company has announced its intention to increase oil production from its average production in May 2016 of 3.5 million barrels per day to 4.8 million barrels per day by 2021. Nevertheless, such a move would require significant foreign investments which the ministry plans to attract using its new Iranian Petroleum Contract (IPC) that allows for investors to become engaged in all phases of the oil field's life cycle (Glenn, 2016). However, certain hardliners within the government have expressed opposition to these contracts while the supreme leader announced that they will not be signed until they are assessed to fit within the "framework of national interests" (Sharafedin, 2016).

Iran's total electricity production in 2013 was approximately 270 million MWh while total demand was around 210 million MWh (WNA, 2016e; EIA, 2015a). According to the EIA (2015a), the country also exports electricity to countries like Armenia, Afghanistan, Iraq, Pakistan and Turkey. Electricity demand in Iran is increasing at 4% per year and is expected to be met by generation from natural gas, renewables and nuclear power (EIA, 2015a). Iran's current gross nuclear power capacity stands at 1000 MW supplied from its Bushehr-1 reactor. The reactor is supplied with nuclear fuel imported from Russia's TVEL which is also responsible for taking back the spent fuel (McAuley, 2015).

B. Saudi Arabia

According to the CIA World Fact Book (2017b), the Kingdom of Saudi Arabia, named after al-Saud ruling family, is an absolute monarchy. The Basic Law of Governance, issued in 1992 by royal decree, acts as the Kingdom's constitution-like charter and is based on the Salafi interpretations of Islamic Sharia (CIA, 2017b). The law has been criticized for not including basic rights such as the freedom of belief or even political participation (U.S Library of Congress, 1992a). According to the Economist Democracy Index (2010), the Saudi Government is the seventh most authoritarian regime among 167 ranked countries. The King, currently Salman bin Abdulaziz Al Saud, is both the head of the government and the chief of state and has power over issuing and implementing legislation, appointing ministers, senior government officials, foreign diplomats, ambassadors and governors, as well as senior military officers (U.S Library of Congress, 1992b)

There is also the Consultative Council, also known as "Majlis al-Shura", which acts as the 150-member advisory body to the King on governmental affairs but has no legislative authority (U.S Library of Congress, 1992c). According to the U.S Library of Congress (1992c), the Council of Ministers is the executive organ of the government that issues ministerial decrees that have been approved by the king, where many ministerial positions are headed by members of the al-Saud family. As for political parties, they are banned in the Kingdom. Municipal elections were introduced in 2005 where only half of the municipal council is elected, while women's right to vote in these elections was granted only recently in 2011 (National Public Radio, 2015).

According to the World Bank (2016b), Saudi Arabia's economy was ranked 20th largest in the world with an annual GDP of $646 billion in 2015. The economy is highly dependent on its oil and gas sector which makes up almost 50% of GDP and 85% of export earnings (OPEC, 2016). The Saudi economy's lack of sufficient economic diversification has made it susceptible to facing major difficulties when oil prices collapsed in 2014. The government announced its 2016 budget deficit at $79 billion which is projected to decrease to $53 billion in 2017 (Rodionova, 2016). The Kingdom utilized 20% of its international reserves by March 2016 and its credit rating has been lowered by agencies such as Moody's and Fitch which has increased its cost of borrowing (Kerr, 2016). Nevertheless, efforts to bring up oil prices are being discussed. Being one of the largest oil producers among OPEC members, Saudi Arabia exercises tremendous power within the organization and has recently, with the support of Russia, pushed for a freeze on oil production in the hopes of raising market prices (BBC News, 2016b).

Moreover, in order to cushion itself from the adverse economic effects of the oil price crash, the government has also adopted domestic reform measures including cutting spending, introducing taxes and privatizing its oil conglomerate, ARAMCO (World Bank, n.d.). Announced in mid-2016, the National Transformation Program (NTP) is Saudi Arabia's plan for 2020 that aims to reshape and diversify its economy and boost non-oil revenues to $141 billion - more than triple its current amount (Al Omran & Margherita, 2016). Parts of the plan include cutting subsidies to the water and electricity sectors which will in return raise their domestic prices.

On the other hand, the government has also considered diversifying its energy mix supply. In 2013, the Kingdom generated around 293 million MWh of electricity while domestic consumption was around 270 million MWh (CIA, 2017b). The percentage share of electricity generated from fossil-fuel was around 99.9%. According to the EIA (2014), demand for electricity in the Kingdom is expected to rapidly grow due to population increase, low electricity prices, high consumption during the summer months and ongoing expansion of industries. The government plans to increase total installed capacity to 120 GW in order to meet demand in 2032 (EIA, 2014). According to the King Abdullah City for Atomic and Renewable Energy (KA-CARE) (n.d.), the Kingdom has plans to supply half the projected installed capacity using non-fossil fuel sources such as nuclear power and renewables. Generation capacity will include renewables and nuclear energy to free up more oil and natural gas for exports.

In 2011, plans were announced for the construction of 16 nuclear reactors by the year 2032. Later on, the date was further extended till 2040 (WNA, 2016a). By then, nuclear power is expected to cover 20% of the Kingdom's total electricity production while costs are estimated to be more than $80 billion (Heinonen, & Henderson, 2014). More recently, the Saudi Energy Minister, Khalid al-Falih, announced plans for a renewable energy program expected to bring in between $30bn to $50bn of investments by 2023. Al-Falih also confirmed the start of feasibility and design studies for the first two reactors (Reuters, 2017). Moreover, according to Reuters (2017), the Minister declared his country's willingness to collaborate and connect with Yemen, Jordan and Egypt in regards to their renewable energy programs. The Kingdom plans to finance its projects through private

partnerships with domestic and foreign companies able to bear associated costs and risks (Reuters, 2017).

CHAPTER VI

METHODOLOGY

This dissertation will estimate the total levelized cost of enrichment incurred by a potential multinational enrichment plant and by potential national enrichment plants in countries with civilian nuclear power programs in the Middle East. It will also include a projected trend in international enrichment market prices. Finally, the dissertation will identify some political, policy and economic factors that could influence Iran and Saudi Arabia to join a multinational enrichment venture. The quantitative analysis of this dissertation will be based on a previous coauthored paper in which the economics for multinational enrichment is estimated using a discounted cash-flow methodology developed by Ahmad et al. (2017). This methodology will be used to estimate the total levelized cost of enrichment entailed by national enrichment plants in each country and by a multinational plant in the Middle East. This methodology uses a microeconomic cost-engineering model developed by Rothwell (2009) and adds to the different parameters related to the enrichment plant and the project finances to calculate the capital, energy, labor and depreciation costs of enrichment which are summed up to equal the levelized cost of enrichment, measured in US dollars per Separative Work Unit (units of enrichment). See Table 2.

Parameters	Unit
Enrichment Plant Parameters:	
Plant annual capacity	tSWU/yr
Electricity consumption	kWh/SWU
Electricity price	$/MWh
Staff capacity	employee
Annual salary per employee	$
Project Financing Parameters:	
Overnight capital cost	$
Discount rate	%
Inflation adjustment	%
Interest During Construction & Contingency	%
Loan payback period	years
Total Levelized Enrichment Cost components:	
Capital and investment costs	$/SWU
Energy cost	$/SWU
Labor cost	$/SWU
Depreciation cost	$/SWU

Table 2: Parameters used to estimate total levelized cost of enrichment and its components

The model estimates the overnight capital cost and the labor capacity of enrichment plants using functions developed by Rothwell (2009).

The overnight capital cost represents the costs incurred by building an enrichment plant overnight and is estimated using Rothwell's function:

$$ln(k_i) = -0.09 + 0.76 \times ln(SWU_i)$$

Where k_i is the overnight capital cost measured in billion in 2008 dollars and SWU_i is the plant's annual enrichment capacity measured in million SWU. The plant

annual enrichment capacities for each country were previously determined in a study authored by Ahmad and Snyder (2016). See Table 1. For the purpose of this thesis, the high projections will be used.

Ahmad et al. (2017) model estimates annual capital costs using the overnight capital costs and a capital recovery factor which is based on a discount rate and loan payback period. Discount rate, in this case, refers to the annual return on investments for the whole loan amortization period. These will vary according to the credit rating of each country. Since Saudi Arabia and UAE have high credit ratings then a discount rate of 5% is assumed. As for Egypt, Jordan and Turkey, their low credit ratings assumes a discount rate of 10% while Iran will be assigned a discount rate of 7%. The loan payback period is set at 30 years as assumed by Rothwell. Moreover, the model assumes a contingency rate – the cost estimates that deal with uncertainties and overrun risks – as 10% and interest during construction (IDC) – which discounts the construction expenditures to the start of the commercial operation of the plant – as 7.5%. Rothwell also assumes the depreciation cost of enrichment to be 1 % of overnight capital cost.

The energy cost of enrichment is determined using two values: the electricity consumption of enrichment and the price of electricity. Based on Rothwell's findings the electricity consumed during enrichment is around 62 kWh/SWU while the electricity price will be assigned a constant value of $100/MWh. Since results show that energy costs account for a small percentage of the total levelized cost of enrichment (8%), changing this variable to electricity prices of each Middle Eastern country will not make much of a difference.

The labor cost of enrichment is determined using the fully burdened average annual salary of highly skilled employees in the Middle East and the estimated staff capacity of enrichment plants. The fully burdened average salary of employees was calculated by first estimating the ratio of average annual salaries of highly skilled employees in the US to Rothwell's estimated burdened annual salary in the US of $120,000. This ratio was then multiplied by average annual salaries of highly skilled employees in each of the studied countries.

The staff capacity is estimated using Rothwell's function:

$$ln(L_i) = 0.65 + 0.43 \times ln(SWU_i)$$

Where L_i is the number of employees in 100's and SWU_i is the plant annual enrichment capacity in millions SWU.

Finally, an inflation adjustment rate of 10% will be used to make up for the inflation of the U.S currency since 2008, the year of Rothwell's publication of the model.

As part of the economic analysis, this dissertation will also calculate the projected global enrichment capacity based on the projected global nuclear power capacities till 2030 published by the IAEA (2014) biannual report "International Status and Prospects for Nuclear Power". This report contains low and high projections for projected global nuclear capacity in which the low projections assume that global economic growth is slow, global demand for electricity is low and policies and laws for climate change mitigation are delayed and not yet put in force while the high projections assume the opposite. The projected enrichment capacities will be calculated using similar assumptions used by

Ahmad & Snyder (2016) in their calculations for projected enrichment capacity in the Middle East.

As for the qualitative analysis, the paper will undertake a new approach and use a case study approach in which two countries with civilian nuclear power programs in the Middle East will be chosen and a preliminary comparative analysis will be conducted to essentially identify the potential political, policy and economic factors that could influence these countries to join a multinational enrichment venture. Moreover, their political structure, current economic condition and energy policies will be examined.

According to Yin (2014), the case study tool is considered more effective than other forms of social science research under certain conditions: when the research question is a "how" or "why" question being asked about a contemporary phenomenon over which the researcher has little control. Yin (2004) defines a case study as "an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-world context." (p. 16). Furthermore, one of the distinguishing characteristics of the case study tool is its ability to gather data from a variety of sources and integrate them in a "triangular fashion" bringing different perspectives to the issue at hand (p.17).

For the purpose of this case study, the two countries chosen are Iran and Saudi Arabia due to reasons related to their regional influence and resource capabilities. Iran will play a key role in a multinational enrichment venture in the Middle East since it has the most advanced nuclear power program and existing enrichment facilities. On the other hand, Saudi Arabia is Iran's main regional rival who is interested in matching Iran's nuclear know-how as it deems it necessary to balancing its own regional power ("Saudi

Prince Urges Mideast", 2014). The Kingdom also has the largest planned nuclear power program which aims to build 16 reactors by 2040 making it an important stakeholder in a multinational enrichment venture as it holds the largest potential demand for enrichment services in the region (WNA, 2016e).

Also, as part of this research, the case of Argentina and Brazil's nuclear rapprochement in the 1980's will be studied in order to understand the different factors that led to the evolution of nuclear cooperation and eventually to the establishment of their regional nuclear inspectorate agency, ABACC. Their case is chosen because the binational arrangement for implementing transparency and safeguard measures is very similar to the multinational arrangement required by the proposed venture in the Middle East. Also, similar to Iran and Saudi Arabia, Argentina and Brazil shared a history of rivalry and competition. However, they were both able to initiate nuclear talks in the 1980's leading up to the institutionalization of their nuclear cooperation. Such a previous model could provide important indicators to assess for discussing at the current case of Saudi Arabia and Iran.

The comparative analysis will include some discourse analysis and will use information sources such as interviews, newspaper and journal articles, official government documents and statements, press releases and policy reports released by experts, academic institutions and international organizations.

CHAPTER VII

RESULTS

A. Estimated Enrichment Costs in the Middle East

The estimated levelized cost of enrichment for a multinational facility in the Middle East are expected to be lower than for individual national enrichment programs mainly due to economies of scale. See Figure 2. This entails an economic advantage for multinational enrichment.

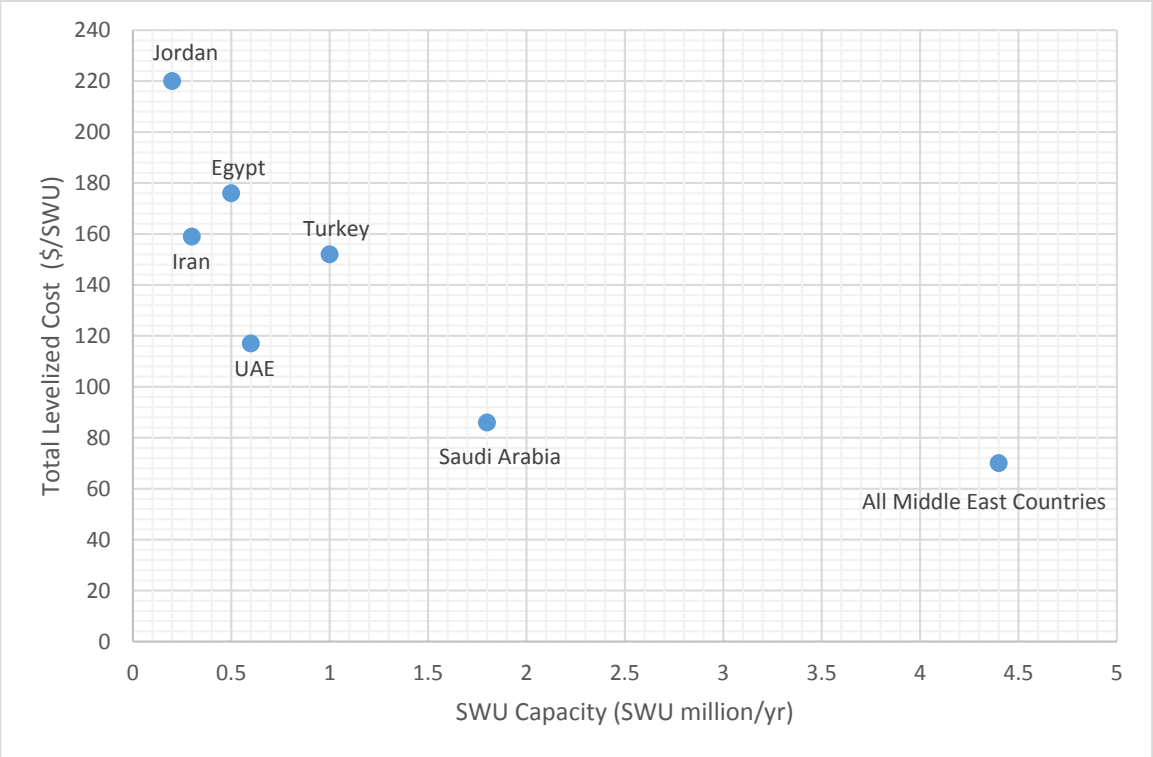

Figure 2: Estimated levelized cost of enrichment for countries in the Middle East based on the high projections of enrichment capacity

Results show that the SWU cost for indigenous enrichment is expected to be relatively high for countries with low enrichment capacities and high discount rates. Jordan is expected to have the highest cost of enrichment at around $220/SWU as it has the lowest enrichment capacity (0.2 million SWUs/yr) and a high discount rate (10%). The cost of enrichment in Egypt, Iran and Turkey is estimated to be $176/SWU, $159/SWU and $152/SWU respectively. Moreover, although UAE's projected enrichment capacity (0.6 million SWUs) is close to Egypt's (0.5 million SWUs), its levelized cost of enrichment is expected to be $117/SWU which is lower than Egypt's due to UAE's low discount rate (5%).

Saudi Arabia's levelized cost of enrichment is estimated to be the lowest out of all countries at $86/SWU since it has the highest expected enrichment capacity (1.8 million SWUs) coupled with a low discount rate (5%). As for a multinational enrichment facility which combines the enrichment capacity of all the studied countries, the cost of enrichment would range from $70/SWU, under a 5% discount rate, till $110/SWU under a 10% discount rate.

The average percentage share of the different cost components of the levelized enrichment costs were calculated. See Figure 3. The capital and investment costs are expected to cover the highest share of enrichment costs, 81%, since enrichment is a capital-intensive process. Moreover, capital and investment costs increase as the discount rate increases. For a multinational enrichment facility that combines all countries' enrichment capacities, the capital and investment costs accounted for 84% of enrichment costs under the 10% discount rate, while under the 5% discount rate they accounted for 75% of enrichment costs. Energy costs, on the other hand, are expected to account for the least

share of enrichment costs (5%) as major energy savings were achieved by the centrifuge-based technologies. Labors and depreciation costs cover approximately 6% and 8% of enrichment costs, respectively.

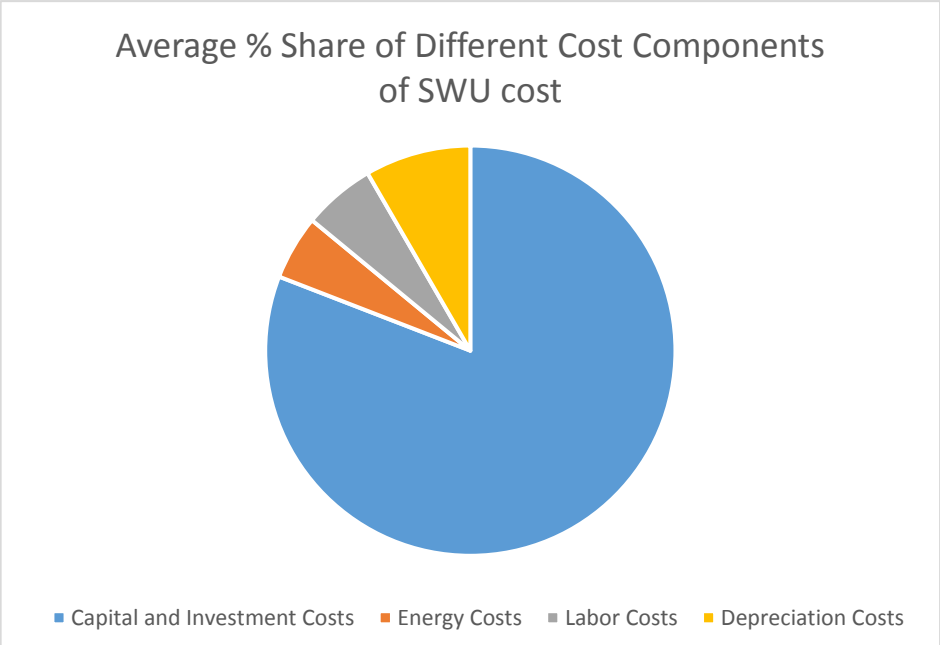

Figure 3: Average percentage share of different cost components of SWU cost

Nonetheless, although multinational enrichment may have a competitive edge within the region compared to national enrichment, other economic, political and policy factors could influence the proposal, specifically relevant to Iran and Saudi Arabia. These factors will be discussed in the following section.

CHAPTER VIII

DISCUSSION

This analysis aims to examine the potential political, policy and economic factors that could influence Iran and Saudi Arabia to move forward with the proposal for multinational enrichment in the Middle East. The analysis does not, however, provide a comprehensive analysis of the prospects of multinational enrichment in the region but simply provides a brief overview of some of the relevant issues.

A. Shared Challenges towards Regional Security in the Middle East

Iran and Saudi Arabia ratified the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) in 1970 and 1988 respectively.[6] The NPT is a global treaty that seeks to limit the spread of nuclear weapons; under it, the nuclear weapon states commit to pursuing disarmament while the non-nuclear weapon states forgo acquiring or developing nuclear weapons.[7] The treaty also calls for a review conference to be held every 5 years. Moreover, Iran and KSA also signed and ratified the Biological Weapon Convention (BWC) and the Chemical Weapon Convention (CWC) both of which prohibit the development, production

[6] UN Office for Disarmament Affairs. "Treaty on the Non-Proliferation of Nuclear Weapons". Retrieved from http://disarmament.un.org/treaties/t/npt

[7] The Arms Control Association. "The Nuclear Non-Proliferation Treaty at a Glance". Retrieved from https://www.armscontrol.org/factsheets/nptfact

and stockpiling of biological, toxin and chemical weapons and call for their destruction.[8] [9] Nevertheless, when it comes to the Comprehensive Test Ban Treaty (CTBT), a legally binding ban on nuclear explosive testing, both countries fall short; Iran signed the CTBT in 1996 but failed to ratify it while KSA never signed the treaty (Arms Control Association, 2016).[10]

The head of the U.N Comprehensive Test Ban Treaty Organization, Lassina Zerbo, recently declared that both Iran and Israel were close to ratifying the CTBT which would pave the way for other regional countries to ratify the treaty while simultaneously bringing the region closer to a nuclear-test-free zone in the Middle East (Financial Tribune, 2016). Moreover, Mr Zerbo emphasized that a nuclear-test-free zone would act as an encouraging step towards achieving the MENWFZ. He was quoted saying, "You can't jump and get a weapon-free zone in the Middle East if the CTBT isn't ratified" ("Iran, Israel could ratify", 2016). Nevertheless, it was back in 2014 that Iran stated its reasons for not ratifying the CTBT: "lack of progress towards nuclear disarmament, upgrading and modernization of existing nuclear weapons, rejection of the CTBT by major nuclear weapon states, and acknowledgment of the possession of nuclear weapons by Israel" ("The

[8] UN Office for Disarmament Affairs. "Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction". Retrieved from http://disarmament.un.org/treaties/t/bwc

[9] UN Office for Disarmament Affairs. "Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction". Retrieved from http://disarmament.un.org/treaties/t/cwc

[10] See Comprehensive Test Ban Treaty Organization, "Status of Signature and Ratification". Retrieved from https://www.ctbto.org/the-treaty/status-of-signature-and-ratification/

NPT Action Plan", 2014, p. 66). Most of those facts still stand true today, thus whether Iran is actually closer to ratifying the CTBT is unclear.

At the 1995 NPT Review Conference, NPT signatories agreed to extend the NPT treaty indefinitely as long as efforts to establish a Middle East Nuclear Weapon Free zone were promised under the Middle East Resolution 1995 (UNODA, 1995). In 2015, twenty years after the resolution and during the NPT Review Conference, both Iranian and Saudi officials denounced the lack of progress on the establishment of the zone.

Iran's Foreign Minister Javad Zarif called for all parties to take urgent steps for the establishment of the zone and demanded that Israel dismantle its nuclear arsenal and join the NPT and place its nuclear facilities under IAEA safeguards while all States should refrain from transferring any nuclear related information, material or technology to Israel (Zarif, 2015). Moreover, Saudi Arabia's Ambassador to the United Nations, Abdullah Al-Mouallimi, reiterated Iran's concerns regarding the delay on implementing the 1995 resolution and stated that the lack of progress on establishing a nuclear free zone "may lead towards a nuclear arms' race." (Al-Mouallimi, 2015, p.2). Al-Mouallimi also stated: "It is really unfortunate that international consensus and a region's urgent desire to make the Middle East a zone free of nuclear weapons have been thwarted by Israel" (p.2).

Israel has never signed the NPT and is believed to have assembled around 80 nuclear war heads (Kristensen, & Norris, 2013). Since the 1970's, Arab countries, including Iran and Saudi Arabia, have long pressured Israel to dismantle its nuclear war heads and allow for real progress on the establishment of a Middle East nuclear-weapons-free zone (Bahgat, 2015). According to Bahgat (2015), Iran and Arab countries share

certain common perceptions regarding the path to a nuclear free zone in the Middle East which conflict with Israel's current policies.[11]

For Iran and most Arab capitals, denuclearization comes as a prerequisite to achieving regional peace and a nuclear free zone; the dismantlement of Israel's nuclear arsenal, which they consider a key factor in the region's instability, would eliminate "nuclear intimidation by Israel and would lead to broad regional arms control measures and lay the foundations for lasting peace." (Bahgat, 2015, p.34). As for Israel, regional peace is a prerequisite for denuclearization and for agreeing to join a nuclear weapon free zone; only after all its neighbors recognize it and normalize relations by establishing mutual diplomatic and commercial ties will they agree to eliminate their "last line of defense" (p. 32).

Similar obstacles could be expected for the case of a multinational enrichment venture in the Middle East. Iran may not be willing to give up certain sovereign rights and accept permanent transparency and safeguard measures that come with a multinational enrichment structure if Israel continues denying any transparency regarding its own nuclear arsenal. Iran may consider the venture as further imposing the discriminatory double standard held by the international community that allows for the persistence of Israel's nuclear monopoly within the region while demanding other countries make concessions. The involved transparency and verification arrangements of multinational enrichment would actually allow Israel, as it would allow world powers, to confirm the peaceful nature

[11] According to a study by the UN Department for Disarmament Affairs (1991) commissioned by the UN General Secretary, the zone encompasses "all States directly connected to current conflicts in the region, i.e., all States members of the League of Arab States. . . , Iran, and Israel." (p. 15).

of nuclear activities in Iran. However, Iran may not be willing to provide such transparency until Israel shows similar efforts to nonproliferation or even denuclearization.

B. Political Consensus before Multinationalism

Iran and Saudi Arabia share a history of politically strained relations which, according to Fisher (2016), are currently reflected in wars taking place in Syria and Yemen as well as political disruptions happening in Iraq, Lebanon and Bahrain. Their struggle for regional dominance is fueled through Sunni-Shiite sectarianism which further contributes to the region's instability. In 2016, a sharp escalation in tension was triggered by the Saudi execution of Shia Cleric Sheikh Nimr al-Nimr, an outspoken cleric who criticized the Al-Saud family and supported pro-democracy sentiments, after being charged with terrorist-related charges (Slawson, 2016). This prompted furious Iranian protestors to storm and set fire to the Saudi Embassy in Tehran which further prompted Saudi Arabia to sever diplomatic relations with Iran (Hubbard, 2016; Chulov, 2016). Shortly after, the Swiss Foreign Ministry announced that it would represent the interests of Saudi Arabia in Iran, and those of Iran in Saudi Arabia via a protecting power mandate ("Switzerland confirms protecting", 2016).

Under current turbulent political relations, Iran and KSA would first need to share some political consensus before they could consider joining a multinational enrichment venture. As previously mentioned by Scheinman (1981), successful multinationalism, in the context of uranium enrichment, is not a tool for political consensus and acceptance but rather a reflection of both. Iran and Saudi Arabia cannot be expected to move forward with such a venture unless they first share a certain degree of mutual political understanding.

As it is explicitly mentioned in the Glaser et al (2015) proposal, multinational control of enrichment is just one of the "intermediate steps to a nuclear-weapon-free zone that would establish strong, new technical and political barriers to any future attempts by countries in the region to seek nuclear weapons capability" (p.14). Bahgat (2015) stated that the two criteria needed for the successful establishment of the five currently existing nuclear-weapon free zones: "a common historical understanding among regional states and a manageable relationship with the five recognized nuclear-weapons states" (p. 29). To a similar extent, these two criteria were not only needed for the successful ratification of the Treaty of Tlatelolco by Argentina and Brazil but also for the successful evolution of their nuclear relations.

Similar to Saudi Arabia and Iran, both Argentina and Brazil shared a history of rivalry, mistrust and competition which was fueled by their desire to lead the continent and dominate export markets. Also, they shared similar incentives for developing their nuclear power programs which included strong political and security motivations as a nuclear program was considered indicative for regional leadership. According to Guzansky (2015), Saudi Arabia's declaration for pursuing nuclear power was a contingency plan to keep pace with Iran's nuclear program.

However, the factors that galvanized nuclear rapprochement and diplomacy between Argentina and Brazil are lacking and limited in capacity in the context of the Middle East, specifically between Iran and Saudi Arabia.

One of the factors that enabled Argentinian and Brazilian leaders to curb their antagonistic relations and sign their first nuclear cooperation deal in 1980 was their shared

resistance to the obstacles set by the U.S and the international nonproliferation regime which adopted a technological denial strategy. They perceived these obstacles as more threatening than they perceived each other's nuclear programs (Spektor, 2015). This allowed them to perceive each other more as allies rather than enemies.

Another factor that allowed for further improvement in nuclear relations was the rise of civilian leadership and the vision adopted by civilian leaders (Carasales, 1995). After the democratic transition of both nations in the early 1980's, the Argentinian President, Alfonsin, considered it wasteful to direct funds for military purposes as it would destabilize the country's democratic transition (Spektor, 2015). He also wanted to reverse the political isolationist attitude adopted by previous military government and place the nuclear program under civilian control. In 1985, both nations signed a second agreement on nuclear policy which formed a joint working group supervised by their Foreign Ministries responsible for proposing cooperation measures. This institutionalization of bilateral nuclear cooperation also helped enhance and strengthen nonproliferation efforts between both countries (Carasales, 1995).

Afterwards, Argentinian and Brazilian presidents initiated frequent visits to each others' nuclear facilities and held face to face meetings which further played a role in establishing trust between both nations. Essentially, in the late 1980's, both presidents wanted to enhance economic development and boost national support through global engagement and thus considered reshaping their foreign policies and reintegrating their countries within the international nonproliferation framework.

Such political capacity for cooperation in the Middle East could be limited as the factors that once existed for Brazil and Argentina are currently lacking between Iran and Saudi Arabia.

C. Political Capacity for Consensus and Regional Security

Unlike the case with Argentina and Brazil who were able to see each other as allies rather than enemies, the prospects for nuclear rapprochement and collaboration between Iran and Saudi Arabia seem crippled by the heightened sense of tension, rivalry and mistrust.

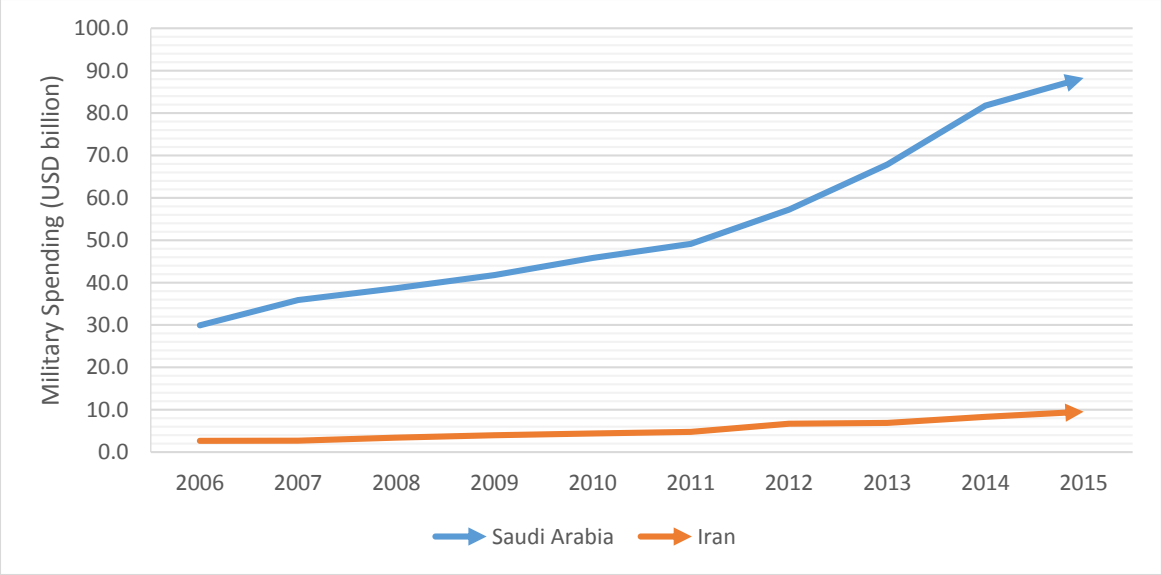

Figure 4: Military Spending by Saudi Arabia and Iran (2006 – 2015)

Both nations dedicate enormous amounts of their government budgets to their militaries. Iran's is expected to increase its military spending from 2 to 5% of the annual government budget (Reuters Africa, 2017). Military spending by KSA and Iran has been

increasing during the past decade and with the current situation in the Middle East and strained relations between both governments it does not seem to be decreasing anytime soon. See Figure 4.[12]

Moreover, the lack of consensus and agreement between the two Foreign Ministries can be detected in the discourse used by the Iranian and Saudi Foreign Ministers at the World Economic Forum at Davos in 2017. During the 2017 World Economic Forum held in Davos, the Saudi Minister of Foreign Affair, Adel bin Ahmed Al Jubeir, was asked on KSA's position towards the Iran Deal to which he stated: **"**A number of countries, including Saudi Arabia, have concerns about the nuclear deal. What happens to Iran's enrichment capabilities after 10 to 12 years when the limits on enrichment and centrifuges are lifted? Do people trust the Iranian regime in not trying to acquire a nuclear weapon? I don't think they do" (Conger, 2017). When further asked whether he could see any areas in which cooperation with Iran is possible, such as joining the fight against ISIS, Al Jubeir replied: "It's not an issue of cooperation or no cooperation. We look forward to cooperate with the Iranians and others in fighting terrorism but the fact of the matter is, Iran has been single handedly the most important supporter of terrorism in the region."

During the same event, Iran's Foreign minister, Dr Javad Zarif took a different approach when describing possible relations between both countries: "I do not see any reason why Iran and Saudi Arabia should have hostile policies towards each other. We can in fact cooperate for future stability of our region. We can in fact work together in order to

[12] Source: SIPRI. (2015). Sipri military expenditure database. *Technical report, Stockholm International Peace Research Institute*. Retrieved from https://www.sipri.org/sites/default/files/SIPRI-Milex-data-1988-2015.xlsx

put an end to the miserable condition of people in Syria, Yemen and Bahrain and elsewhere in the region" ("Iran-Saudi cooperation possible", 2017). Citing an example of successful cooperation, Zarif then referred to the recent OPEC deal under which Saudi Arabia agreed to cut oil production while accepting that Iran would resume production: "Look at what happened with the oil crisis. Everybody was hurt. And now Iran and Saudi Arabia were able to accommodate each other and stabilize the market." Zarif also referred to Al Jubeir's remarks about Iran's support for terrorism and stated: "I think it [Saudi statements] doesn't help. I think we need to look at the realities of the region… And we need to understand that nobody can derive any benefits, even temporary benefits, from supporting extremism and terrorism and sectarianism."

Looking at both statements, it seems that the prospects of political consensus could be a long way ahead as the discourse on cooperation remains limited and crippled by terrorism-related accusations that highlight existing regional conflicts taking place between the two countries. Such limited discourse could be inhibiting the progress and the expansion of mutual relations. More importantly, this represents political challenges, present on the discourse level, for Iran and Saudi Arabia to establish mutual ground for holding nuclear cooperation talks.

Nevertheless, Zarif's statements indicate a political will for open dialogue and discussion with the Saudi's, while Al-Jubair tended to immediately highlight the mistrust present and focused on terrorist-related accusations rather than offer solutions for potential dialogue. Saudi Arabia may not be willing just yet to reciprocate and actually utilize diplomatic invitations for dialogue. Meanwhile Zarif recently stated "We see no positive

development in the political behavior of Saudi officials and they are still fueling tensions in the region through their policies and stances instead of taking advantage of the present grounds for dialogue and interaction" ("No positive change", 2017).

The path for nuclear rapprochement may first require diplomats to practice reconciliation and offer solutions to reduce current political tensions. Both states would at least need to rebuild their diplomatic ties before they could consider the proposal for multinational enrichment in the region. It took Argentina and Brazil a decade to progress from its first nuclear agreement signed in 1980 to eventually signing the Guadalajara Accord in 1991 which established the Common System of Nuclear Materials Accountancy and Control (SCCC) and its complementary supervising body, the Brazilian-Argentinian Agency, ABACC. Throughout the 1980's both nations were able to sign many nuclear agreements and protocols but these were mere tools and not the cause of nuclear rapprochement.

According to ABACC's current Secretary, Sergio Solmesky (2017), Argentina and Brazil's nuclear relations were fueled by "the backdrop of their historical friendship and the willingness of their people to advance jointly in the pacific use of nuclear energy." Moreover, he further stated that the agency is an instrument to guarantee this peaceful use and a safeguard for the rest of the world.

Hymans (2014) argues that the nuclear rapprochement between Argentina and Brazil was more of a symptom than a cause of the growing trust between the two states. Carasales (1995) argues that it was not the nuclear safeguard system that built trust, but rather it was the "combination of visits, exchanges of technicians and students, commercial

relations, complementary activities of nuclear industries and similar actions" (p.42). Brigagão & Fonrouge (1998) further argue that there was a political will for both countries to build trust which was not solely for the sake of regional security but also for the sake of building credibility in regards to their own nuclear programs.

It seems that progress in diplomatic relations may depend on Iran and Saudi Arabia's capacities to view regional integration and collaboration as mutual interests. Unless they start to view each other as potential allies with common interests their ability to hold solid talks involving regional security and a potential multinational enrichment venture could be limited. If they do not see such interests in mending relations, then their rivalry may continue to escalate and the prospects of nuclear rapprochement and multinational enrichment could be further suspended. Mutual understanding will depend on high level political will that would be able to set aside current conflicts, build trust and open up serious discussions regarding regional security.

D. Improving Relations with Saudi Arabia: Potential Opportunity for Moderates

During the World Nuclear News' Annual Symposium held in 2016, Dr. Ali Akbar Salehi, who was assigned by President Rouhani as the Head of the Atomic Energy Organization in Iran (AEOI), stated: "We would like to reiterate our readiness to share our valuable accumulated experience in the nuclear industry with our Persian Gulf neighbors through establishing a regional nuclear scientific contact group" (WNN, 2016a). He also referred to the JCPOA to be used as a potential template to resolve difficult regional and global issues.

Salehi's statement portrays a certain willingness to cooperate with regional states on nuclear issues. According to some Iranian news outlets, improving relations with Saudi Arabia might actually pose as an opportunity for reformist President Rouhani when it comes to domestic politics. According to Taheri (2017), the Iranian daily Entekhab states that Iran could benefit from reducing tensions with Saudi Arabia, especially at a time when the Trump presidency is creating new uncertainties. Analyst Nasser Zamani stated that Rouhani needs another foreign policy success since the hopes of improved relations with the U.S maybe postponed and the Iranian economy has yet to recover as promised: "Any sign of normalization with Saudi Arabia would be popular with Iranian voters and consequently helpful to Rouhani" (Taheri, 2017). Moreover, the daily Etemaad stated that "high-ranking security and political officials in Tehran welcomed the decline in tension" with Saudi Arabia.

After the JCPOA was signed in 2015, it signaled the improvement of relations between Iran and the United States. However, the newly elected republican president, Donald Trump, pledged during his campaign to "rip it up." Trump has not addressed the Iran deal since taking office and according to analysts is unlikely to break the deal (Sewell, 2017; Andelman, 2017; Khazani, 2017).

Rouhani and Zarif's efforts to improve relations and reach a successful nuclear deal with the U.S and the West were essentially fueled by the need to alleviate Iran's dire economic conditions caused by tough sanctions. However, even after two years from implementing the deal, Iran still suffers from the lack of foreign financial investments which has been attributed as a shortcoming by the United States to implement its part of the

bargain (Ziabari, 2016; “A Conversation With Javad Zarif”, 2016). If this disappointment is translated in the 2017 Iranian presidential elections held in May, and Rouhani fails to succeed in being reelected then this might give the chance for the conservative hardliners to take office. Back in 2015, the hardliners discouraged nuclear talks between Iran and the P5+1 and essentially opposed the JCPOA. According to Moussavian (2015), hardliners’ hostility during negotiations were very tense to the extent that one hard-line parliament member threatened to put Zarif and Salehi “in the ‘heart’ of Iran’s plutonium reactor and ‘bury’ them ‘in cement’.”

Nevertheless, if hardliners do win the presidential elections it would be difficult to say whether they would sabotage the JCPOA, since not even the president nor his appointed ministers have the final say on foreign and nuclear policy. The final say lies with the Supreme Leader, who essentially approved the Rouhani administration’s nuclear talks with international powers. However, the hardliners, who exploited public outrage for the Saudi execution of Sheikh Nimr al-Nimr as a way of undermining Rouhani’s government and gaining national support, could further pose challenges to improving relations with Saudi Arabia (Bozorgmehr, 2016; Myre, 2016).

According to Morevalli & Champion (2017), if the hardliners succeed in upcoming elections, they could very likely reverse Rouhani’s current efforts to welcome foreign investments and to improve relations with the international community: “the conservative establishment could push Iran back into open hostility toward the U.S. and its allies, scaring off investors and raising the risk of additional U.S. sanctions or even a

military confrontation." It seems that if hardliners take office they could limit the prospects of building consensus and initiating nuclear cooperation with Saudi Arabia.

On the other hand, it seems that Saudi Arabia may also be hesitant to move forward with initiating nuclear cooperation relations with Iran. When asked on the prospects of a multinational enrichment arrangement in the Middle East, Awadh Al-Badi, an expert on Saudi foreign policy and a current lecturer and faculty member at the Institute of Diplomatic Studies at the Ministry of Foreign Affairs of the Kingdom of Saudi Arabia stated: "It's a good approach. In order to safeguard your ambition, one must become transparent and regional especially with this enrichment program. Because this will be protective in the sense that no organized state would be able to direct accusations of illicit discreet activities. At the same time, it [the facility] would not represent one country. It would be many countries. This structure would be a kind of protection to the enrichment program. I think in the region there is acceptance for the idea and how to go about it. But when it comes to Iran now, I doubt Saudi Arabia would be open to discuss it yet."[13]

Al-Badi further elaborated by referring to the current mistrust present between Saudi Arabia and Iran: "We [Saudi Arabia] have a problem with Iran. No? The issue with Iran is its foreign regional behavior. We think it's a threat. So how can we deal together in this sensitive context? We should create trust because the issue between us is the mistrust. When the trust is there then there is possibility." In his recent article, Al-Badi (2017) describes "The Way Forward" between both countries by referring to the 1975 Helsinki Accords signed among European countries which he considers to be an important

[13] *Personal communication, March 2017, Beirut*

framework that governed relations among members and peacefully led the region out of a Cold War. He suggests that a similar institutionalized peacebuilding framework could be part of the solution to the region's challenges and help create trust among KSA and Iran.

Whether Al-Badi's proposed solution is viable is beyond the scope of this thesis, however, it is important to mention that before multinational enrichment could be established, it seems that at least some framework for cooperation would need to exist.

E. The Issue of Geography

One of the important determining factors that would influence Saudi Arabia's acceptance for a joint enrichment facility with Iran is its geographical location. Back in 2007, when tensions were heightened among the U.S and Iran, the Saudi Foreign Minister Prince Saud al-Faisal proposed a deal with Tehran to join a consortium of Arab Gulf States to jointly produce enriched uranium under the monitoring of international observers: "We have proposed a solution which is to create a consortium for all users of enriched uranium to do it in a collective manner that would distribute [nuclear fuel] according to need." (BBC, 2007). He further added that the location of the plant would need to be in a neutral third country, like Switzerland.

This further reinforces the notion that the Saudis simply do not trust Iran with having uranium enrichment capability within their own borders. It also shows that the Saudi's were willing to cooperate with Iran to see that Iran's enrichment program was dismantled and relocated which further highlights the danger and threat perceived towards

the program. The Saudi's could not accept having a multinational enrichment facility on Iranian soil for similar reasons.

Nevertheless, the Iranians would be reluctant to accept forgoing their hardly sought enrichment technology which they consider to be an "inalienable right." Some might argue that if Iran's original intention for keeping enrichment capabilities is to provide enriched fuel for its nuclear reactors and peacefully produce nuclear power, then it should not mind the idea of a joint enrichment consortium outside its territories. However, one of the reasons for why the Iranians would be reluctant to rely on foreign supply could be traced back to the 1990's when France refused to supply Iran with enriched fuel which the Iranians viewed as part of its justification to develop indigenous enrichment (Meier, 2006).

Iran did not respond to the Saudi proposal, however, their position seems adamant to develop their own indigenous supply of enriched fuel. It seems unlikely that Iran would accept a joint multinational venture outside its territories that would require it to let go of its own enrichment capabilities.

Aside from the political factors, it is important to identify the current economic conditions and policies that could play an important role in shaping the prospects of a multinational enrichment venture within the region.

F. Projected Trend in International Enrichment Market

Scheinman (1981) stated that neither of the previously established multinational enrichment ventures, Urenco and Eurodif, aimed to limit proliferation and yet both contributed to that purpose. Instead, their establishment was primarily motivated by

commercial, economic and technical factors instead of nonproliferation concerns. Scheinman (1981) refers to these factors as being the most important in persuading a nation to allow some form of restrictions on national control and decision making in regards to enrichment (p. 83).

Looking at the Middle East's total levelized cost of enrichment under the 5% discount rate, as shown in the results section, multinational enrichment in the region ($70/SWU) could be described as more economically viable than national enrichment in Iran ($159/SWU) or in Saudi Arabia ($86/SWU). By comparing both figures, it is evident that Iran would benefit much more than Saudi Arabia from the lower enrichment costs incurred by a multinational enrichment venture. On the other hand, Saud Arabia's enrichment costs are not so far off from those of a multinational facility and thus it may require more incentives to join the venture.

In addition, although the venture could be commercially appealing within the region, it could lose its competitive edge when compared to the projected prices of the international enrichment market.

The estimated average market spot price for enrichment since 1995 is $107/SWU while the market spot price for enrichment in 2016 averaged around $60/SWU.[14] During the past two decades, the uranium enrichment market has been volatile. Since the beginning of the 21st century, spot prices have increased until they peaked in 2009 at $177 in 2016 dollars. Since then, prices have collapsed at an annual average rate of 14% to reach the current $47/SWU (UxC Prices, 2017). Changes in enrichment prices are due to the

[14] The average was calculated using Historical Ux Price Charts of Spot SWU prices from The Ux Consulting Company, LLC. Retrieved from https://www.uxc.com/p/prices/UxCPriceChart.aspx?chart=spot-swu-full

developments in enrichment technologies and changes in demand and supply of enrichment services. The global trend in which gaseous diffusion enrichment technology has been phased out by the more efficient centrifuge enrichment technology has partly led to the rise in prices back in 2009 (Rothwell, 2009). Eventually, the disappearance of the less efficient commercial technologies has led to a decrease in SWU prices mainly due to their increased energy efficiency.

According to IAEA (2015), the global enrichment market currently supplies 65 million SWU/yr while the global enrichment demand is around 49 million SWU/yr. the added supply could be attributed to the commencement of new enrichment plants in the past few years Both URENCO's project in New Mexico and Areva's George Besse II plant in Tricastin have initiated commercial operations after enrichment prices reached their peak in 2009; their potential maximum enrichment capacities is around 4.6 and 7.5 million SWU/ yr respectively (Wise Uranium, 2017). Moreover, the demand for enrichment services has decreased especially after the recent downturn in global nuclear capacity which was triggered by the Fukushima disaster. According to Kidd (2014), the over-estimated supply could have contributed to the further reduction in enrichment prices since demand failed to meet expectations.

Future projections for uranium enrichment demand will rely mainly on the future prospects of nuclear power. The IAEA's latest report (2014) on the International Status and Prospects for Nuclear Power estimated the low and high projections of global nuclear capacity for the years 2020, 2025 and 2030 which were used to estimate the projected global enrichment capacity for those years. See Table 3.

	World Nuclear Power Capacity		World SWU Capacity	
Year	**Low Projections (Gwe)**	**High Projections (Gwe)**	**Low Projections (million SWU)**	**High Projections (million SWU)**
2020	390	464	41.5	49.4
2025	379	558	40.3	59.4
2030	401	699	42.7	74.4

Table 3: Estimated global enrichment capacity based on IAEA projections of nuclear power capacity till 2030

Results show that current global enrichment supply at 65 million SWUs is projected to meet high projections for global enrichment capacity till 2025 (59.4 million SWUs). This shows that the market will likely remain oversupplied for the next decade which indicates that current enrichment prices will remain low and stable. Whether global enrichment capacity will increase during this period will depend on the progress and expansion of nuclear power program around the world.

According to the IAEA (2015), each projection made since 2010 has been lower than previous projections. Moreover, it seems that nuclear power is losing its competitiveness to other energy sources. The renewables industry has recently been expanding and gaining increasing generation capacities as well as receiving the benefits of strong government and private sector support. Also, the collapse of oil prices due to the developments in the oil and gas sector is partly attributed to the recent development and expansion of the shale industry (IAEA, 2015). The Fukushima disaster has triggered a downturn in the demand for nuclear power around the globe where countries like Germany went as far as announcing the permanent shut down all their reactors by 2021 (Smedley, 2013). Nevertheless, IAEA data trends show that nuclear power capacity will expand

among developing countries, however, most of these countries might experience financial difficulties in completing their plans mainly due to high up-front investment costs and inflated cost over runs (Ahmad, 2015; Sukin, 2015).

Eventually, projected nuclear power capacities may in fact be lower than estimated indicating an even lower projected demand for enrichment capacity. Therefore, the oversupplied market and the expected downturn in global nuclear power capacity could lead to enrichment prices remaining low for some time. Consequently, the enrichment market could provide lower prices than a potential multinational enrichment facility in the Middle East and KSA may not have the economic incentive to join it. Instead the Kingdom and other regional countries may find it more cost-effective to purchase enrichment services from abroad.

G. Oil Crisis: Potential Challenges for Saudi Nuclear Power Plans

The OPEC deal signed in Vienna in November 2016 agreed to cut oil production by 1.2 million barrels/day over for the next six months (Wearden, 2016). Zarif referred to the deal as a sign of promising potential for political cooperation between Iran and Saudi Arabia.

Nevertheless, although KSA was able to reach a compromise and accept the deal, it was not motivated by the prospects of political cooperation but rather by financial gains. According to the Sydney Morning Herald, Russia played a pivotal role in mediating Saudi-Iranian acceptance for the deal. Putin communicated with the Saudi Crown Prince Mohammed bin Salman and held phone calls with Rouhani who further discussed with the

Supreme Leader. Eventually, the Saudi's agreed to oil cuts "as long as Iran didn't celebrate victory over the Saudis" (El Gamal, Hafezi & Zhdannikov, 2016).

According to the Economist (2016a), the Kingdom decided to act pragmatically and realized that its own gains would be higher than Iran's if oil prices improved. Thus, the deal was not actually a sign of easing tensions but rather a case of imminent priorities in which Saudi Arabia's financial incentives overshadowed its political views. Moreover, Saudi Arabia's current plans to restructure its economy and privatize its oil company, Saudi Aramco, are also dependent on the improvement of oil prices (Economist, 2016a).

The government announced its 2016 budget deficit at $79 billion which is projected to decrease to $53 billion in 2017 (Rodionova, 2016). Nevertheless, the country's economy is heavily dependent on oil and gas as it makes up 85% of export earnings and is responsible for 99.9% of total generated electricity (OPEC, 2016; CIA, 2017b). As a way of emerging from the low oil price era and transitioning towards a post-oil economy, the government has passed a reform plan known as the National Transformation Plan – "Vision 2030" – which includes restructuring strategies to diversify the Saudi economy. The diversification of energy sources for domestic electricity production is fueled by the predominant need to free up fossil fuel for exports and to reduce natural gas imports.

In 2011, the Kingdom announced plans to install 16 nuclear reactors expected to cover around 20% of the Kingdom's total electricity production by 2032 which are estimated to cost more than $80 billion (Heinonen, & Henderson, 2014). In 2015, the schedule for the nuclear program was further pushed till 2040 (WNA, 2016e). Saudi

Energy Minister Khalid Al-Falih recently confirmed the start of feasibility and design studies for the first two reactors (Reuters, 2017).

Nevertheless, in the context of collapsing oil prices, such plans could prove difficult to achieve. According to Anderson (2015), Saudi's nuclear program could face multiple challenges related to environmental and safety concerns as well as a shortage of local nuclear-engineering talents, but more importantly the program's high construction costs could be difficult to accommodate: "If oil prices are low, then financing the construction of 16 nuclear reactors at the same time, with potential cost overruns, might be an issue, even for a rich country like Saudi Arabia," stated Dr Ali Ahmad, Director of the Energy and Security in the Middle East program at the Issam Fares Institute in Beirut.

Saudi Arabia's credit rating has been lowered by agencies such as Moody's and Fitch due to: "the continued deterioration of public and external balance sheets, the significantly wider than expected fiscal deficit in 2016 and continued doubts about the extent to which the government's ambitious reform program can be implemented," as Fitch stated (Sharif & Nereim, 2017; Kerr, 2016). Such financial difficulties prove as financial risks that could directly affect and increase the discount rate used when calculating the total levelized cost of enrichment of a potential indigenous enrichment venture in Saudi Arabia. With increased discount rates, the total levelized cost of enrichment can also be expected to increase.

Ahmad et al. (2017) states that the level of investments required for a 4 million SWU/yr enrichment plant in the Middle East is around $3 billion which could be manageable especially with a project that includes multiple equity holders. However, if the

progress of the Kingdom's nuclear program is stalled and slowed by financial difficulties then the country's potential nuclear and enrichment capacity would be constricted accordingly. Saudi Arabia's potential enrichment capacity is estimated at 1.8 million SWU/yr, the highest among regional counties covering 41% of the total estimated enrichment capacity in the Middle East. As seen in the results section, as enrichment capacity increases, total levelized enrichment costs decrease. If Saudi Arabia's enrichment capacity does not reach the estimated expectations and is lower than the 1.8 million SWU figure, then the estimated enrichment costs of a potential national enrichment plant in Saudi Arabia and a multinational enrichment facility in the Middle East would be higher than previously calculated.

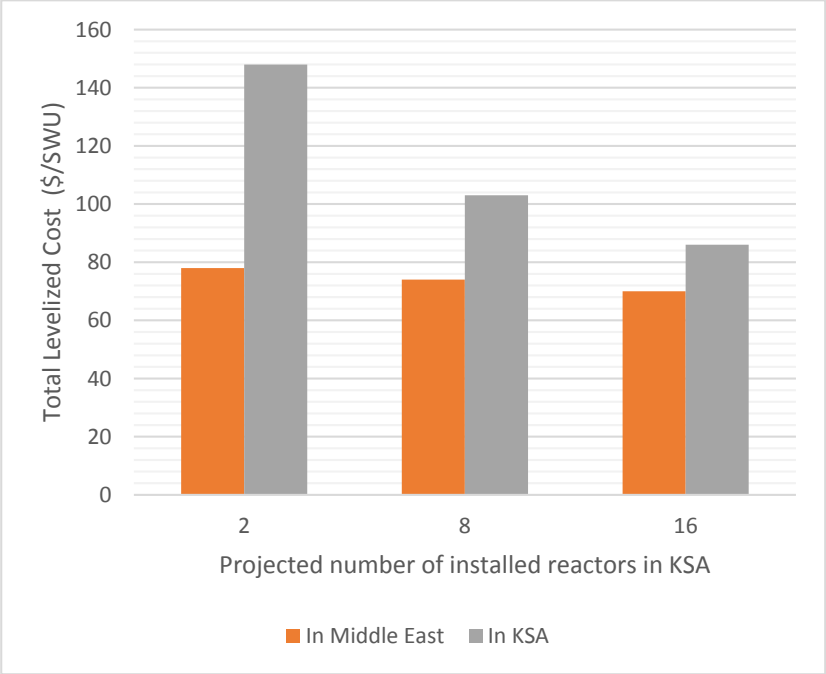

Figure 5: Levelized SWU cost for the Middle East and KSA based on projected number of successfully installed reactors in KSA

Figure 5 shows the total levelized cost of enrichment incurred by a potential national enrichment facility in KSA and a multinational enrichment facility in the Middle East based on the changing number of reactors expected to be installed by the Kingdom. Clearly, if the Kingdom manages to complete its current ambitious plans and install 16 reactors, the cost of enrichment in KSA and in the region would be lower than if the Kingdom only installs 8 reactors or even 2 reactors. If the Kingdom only manages to complete 8 reactors, then cost of enrichment is projected to increase to $103/SWU for national enrichment and $74/SWU for a multinational enrichment facility. If the Kingdom only manages to complete two reactors, then the cost of enrichment is projected to increase to $149/SWU for national enrichment and $78/SWU for a multinational enrichment facility. Consequently, this further shows that KSA would find it more cost effective to purchase enrichment services from abroad than develop indigenous enrichment capabilities or join a multinational enrichment facility.

The IMF (2016) recommended that the government begin expanding its private sector and control its public sector jobs which currently covers two thirds of the workforce. However, such private sector expansion plans could face political structural obstacles such as the lack of transparency and accountability currently present within the Kingdom (Chandran, 2016).

H. U.S Sanctions and Iran's Economy: Potential Obstacles

The Islamic Republic of Iran has also been experiencing financial difficulties even after the implementation of the JCPOA. After the JCPOA's implementation day arrived in January 2016, most of the nuclear-related sanctions imposed on the banking and energy by

the UN and Europe were lifted. However, certain unilateral US sanctions targeting financial transactions linked to the Islamic Revolutionary Guard Corps remained enforced (Handjani, 2016). These sanction have been a predominant challenge for foreign investors and banks wanting to invest in Iran; big banks, such as HSBC, have already been fined gigantic amounts of money for falling foul to US policies (Economist, 2016b).

The sanctions directly forbid US citizens and companies from conducting most forms of business in Iran and also indirectly force other countries that trade with the U.S to hesitate from investing in Iran. More recently, Chinese tech firm ZTE has pleaded guilty to using U.S manufactured equipment to build telecommunications networks in Iran and is expected to pay a $1.2 billion fine for violating US export laws (Riley, 2017). Evidently, the remaining sanctions are inhibiting Iran from collecting the financial benefits of the JCPOA and has placed the moderates, who pledged to alleviate the country's economic conditions, in a tight position.

According to Tett (2016), the resulting uncertainties are an example of Washington's uncoordinated policies. Although Kerry declared in 2016 that Washington would drop its opposition to non-American banks to invest in Iran and the U.S State department had released a joint statement that same year in which it pledged not to stand in the way of foreign investors as long "as they followed all applicable laws", they both failed to address the concerns raised by foreign banks and investors regarding the remaining sanctions. The joint statement has now been removed from the U.S Department of State's website. Under the Trump presidency, it is difficult to say whether such concerns will even

be addressed or recognized. Foreign investors and banks may not receive the required guarantees to feel confident enough to invest in Iran.

In his Nowruz speech celebrating the Iranian New Year, the Supreme Leader recently accused the U.S of removing sanctions only on paper and intimidating international banks and institutions from investing in Iran (Faghihi, 2017). He also reiterated the call for a "resistance economy" that is less sensitive to sanctions and more self-sufficient. According to Reuters, the Revolutionary Guards actually plan to play a significant role in Iran's resistance economy (Bozorgmehr, 2016). The IRGC is an army faction that also plays an influential economic role in Iran and has control over strategic industries and commercial services which could be threatened by competition coming from foreign investments (Bruno et al., 2014; Bozorgmehr, 2016). The Revolutionary Guards, who own and operate a share of Iran's nuclear program, were strong opponents to the JCPOA which they considered to have militarily weakened the country (Abedin, 2015). Similarly, they could also oppose a multinational venture that demands joint operation and ownership of Iran's nuclear enrichment facilities as the arrangement could conflict with their national and economic interests.

Moreover, if the revolutionary guards increase their economic participation they might make it more complicated and risky for foreign investors to invest in Iran (Bozorgmehr, 2016). This would not only restrict Rouhani's goals for reintegrating the Iranian economy within global markets, but it could pose as an additional factor that would influence future nuclear rapprochement and the financing methods for a multinational enrichment venture.

The way that the remaining U.S sanctions could potentially influence intergovernmental investments for a multinational enrichment facility located in Iran is unclear. For now, it is clear that U.S companies will not be allowed to directly invest and build the facility if it is located in Iran, this job will have to be taken by other regional states or P5+1 states. Nonetheless, whether these financing issues would remain prevalent before countries decide to go through with a multinational enrichment venture is uncertain. The political issues associated with the proposal for multinational enrichment in the Middle East would first need to be mediated during which the associated financing issues could also be discussed. Further assessment is required for the different payment methods available for central government banks when dealing with Iranian-related investments. Such assessment would require a better comprehensive understanding of the financing structure needed for the venture.

I. Other Stakeholders

Other external factors that could influence the multinational enrichment venture in the Middle East will involve the interests of certain stakeholders who benefit from Iran and Saudi Arabia's current rivalry, specifically their military spending. The incentives for such stakeholders to support the venture could be further assessed to understand whether they could conflict with their economic interests which might conflict with prospects of regional security within the Middle East. Moreover, Russia and other European countries who have enrichment contracts with regional countries may also find it conflicting to support a venture that aims to supply those very countries. It is important to understand the depth of

incentives for both types of stakeholders as they could shape the prospects of the venture and even the prospects for political consensus between Iran and Saudi Arabia.

CHAPTER IX

CONCLUSION

Results showed that the cost of enrichment incurred by a multinational facility in the Middle East is lower than enrichment costs incurred by national enrichment facilities in the studied countries mainly due to economies of scale. Moreover, capital and investment costs make up the highest percentage share of enrichment costs, while energy costs account for the lowest percentage share. The projected trend for enrichment market show that prices will remain low and stable for the next decade due to an oversupply of enrichment and a downturn in global nuclear power capacity.

Before multinational enrichment could be established in the Middle East, political consensus and understanding among potential members of the venture, such as Iran and Saudi Arabia, would first need to evolve. However, the current mistrust and rivalry as well as the limited political capacity for cooperation between Iran and Saudi Arabia could affect the progress of establishing the venture. Literature shows that high level political will for nuclear cooperation could enhance efforts for the establishment of nuclear relations and multinational enrichment within a region. Moreover, the location of the proposed multinational enrichment plant could be an important determining factor for Saudi Arabia and Iran to accept the venture.

KSA's current financial situation which is threatened by collapsing oil prices could delay the Kingdom's ambitious nuclear power program. If so, then enrichment costs for multinational enrichment could be higher than expected. Moreover, Iran could face

challenges related to the venture which could conflict with certain parties' national and economic interests.

Essentially, the political factors will play a more dominant and important role than the economic ones in the case for multinational enrichment in the Middle East. Iran and Saudi Arabia, would at least need to rebuild their diplomatic ties before they could consider the proposal and such progress will rely on their capacity to view each other as potential allies with common interests.

A. Limitation of Study

The model developed by Ahmad et al. (2017) is based on Rothwell's microeconomic cost-engineering model which uses information collected from just five different enrichment facilities in the U.S., France and Brazil. This creates uncertainties as his model is based on enrichment technologies found at those different facilities which could vary with their maturities and have different Separative capabilities than the centrifuges currently installed in Iran. These differences make it more difficult and uncertain to estimate actual capital costs involved in enrichment. Moreover, more accurate economic analysis could be developed when further information is collected. A more comprehensive analysis covering Iran and Saudi Arabia's motivations for rivalry and potential paths for cooperation could also add to the analysis presented in this dissertation. Moreover, the interests of external stakeholder who might benefit from sustaining the current rivalry in the Middle East would have to be a part of an extended analysis.

B. Future Studies

Future studies involving economics of enrichment facilities could be developed to improve the accuracy of previously developed models such as Rothwell's and Ahmad's since very little actual literature currently exists in this field of study. Moreover, the arrangement of the multinational enrichment facility in the Middle East should be further studied to include and accommodate the interests of potential shareholders such as Russia and other European counties which provide vendor contracts for enrichment services. Additional research could also go into understanding the associated transparency and safeguard arrangements that could accompany such a multinational enrichment facility in the Middle East. Such research could benefit the security motivations for regional states to join the venture and benefit from it.

A more comprehensive analysis is needed to understand the interests of countries, such as the U.S and Israel, could also be identified to further understand their perception and potential role that could influence the proposal for multinational enrichment. Moreover, the role that international nations could play to mediate regional relations and assist in the establishment of multinational enrichment venture could be further analyzed. This would allow for the examination of alternative long term approaches which could promote and enhance regional cooperation and security within the Middle East.

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