The Impact of International Sanctions on Iran's Transition to Sustainability: The Case of Socio-technical Systems of Car Fuel in Iran (1980-2015)

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Abstract

This paper aims to study the impact of the economic sanctions imposed on the Islamic Republic of Iran during the years 1980-2015, by reviewing the sustainability transition of the car-fuel socio-technical system of the country. This paper raises the following questions; what are the impacts of the international sanctions imposed on Iran? which aspects of the regime is more strongly affected by these sanctions? and finally, whether the sanctions have made the Iranian car fuel system more or less carbon-based? This paper concludes that while the impacts of the economic sanctions have had mixed results on the technology selection mechanism, their indirect impacts on the cultural-cognitive institutions of the society has created a new balance leaning towards a pro-change discourse.

Keywords: *economic sanctions, car fuel, socio-technical system, incumbent regime, Iran, air pollution*

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Introduction

Iran faces difficult times. Firstly, there is a constant threat of international sanctions (Miremadi, 2011) (Miremadi, 2015) (Seymour, 2017). Secondly, there are socio-economic problems related to a weak presence within the increasingly competitive industrial world (Gloabl Innovation Index, 2017) (Global Competitveness report, 2017-2018). And thirdly, there are a number of environmental problems (Eslamian, 2010) (Sengupta, 2018).

Concerning the third challenge; air pollution, aridity, deforestation and climate change are looming large and Iran needs to design and implement long term, coordinated policies and strategies. Yet, together with the two other challenges, its move toward such goals seem slow. This slow pace has long-term environmental, political and economic effects that will ultimately prove costly.

This paper aims to study the impact of international sanctions on Iran's drive for transition management. Here, the weakness of the technological capability is also an important issue but, due to the limits of the research, it will be invoked only occasionally to complement the main analysis, as a thorough study on this matter must be conducted in a separate paper.

Economic sanctions are, by definition, an attempt by states to coerce a change in the policy of another state by restricting their economic relationship with the latter (Oxford Research Encyclopedia)[1]. They often involve trade embargos, prohibition of

1. http://politics.oxfordre.com/view/10.1093/acrefore/9780190228637. 001. 0001/ acrefore-9780190228637-e-477

sensitive technology transfer and bans on investments in high tech sectors. Depending on how extensively the sanctions are designed, the environmental, social, economic and technological impact on the targeted country differs.

The issues of economic sanctions and sustainable transition management have, thus far, been two separate bodies of study. The effects and efficacy of international sanctions have traditionally been examined from the point of view of the sanction-imposing country in the discipline of international political economy and international relations (Gary Clyde Hufbauer, 2008), (Hussein Akhtary, 2003). Attention has recently been drawn to the impact of sanctions on various internal aspects of targeted countries such as inequality (Afesorgbor, 2016), economic growth (Neuenkirch, 2015), and health conditions (Kheirandish, 2015) and even tourism (Ovcharov, 2015). Yet, the impacts on environmental degradation and carbon lock-in policies of these countries have rarely been the subject of research.

By focusing on a case study, this paper is designed to address this gap. The case is the Iranian car fuel system adopted during the years 1980-2015. Drawing on the approach of multilevel perspective (MLP) proposed by Geels (2002; Geels and Schot 2004), the paper builds a theoretical construct of socio-technical systems in three levels, namely landscape, regime and niches. It raises three questions:

1)- How international sanctions impact the stability of the carbon based socio-technical regime?

2)- Which aspects of the socio-technical systems experience the shocks and jolts of sanctions at the levels of regime and niches, and how are these changes felt?

3)- Do they encourage the diffusion of green innovations via the de-stabilization of the incumbent regime, or discourage them by banning technology transfer and FDI?

In order to answer these questions, the paper considers the impacts of international sanctions at the landscape level, exerting pressure on the socio-technical regime of car fuel. Following these

pressures, the regime either reacts by breaking open the window of opportunity for technological niches, or closes them. Expounding the international events which transpired during these 35 years (1980-2015), this paper distinguishes between different patterns of landscape impacts, and analyzes the incurred costs on the incumbent regime in concrete, empirical domains (mobility and energy). Monitoring the reactions of the regime, it delineates the interactions of the distressed regime and the striving niches. It, finally, puts forward three historic episodes each with a distinctive pattern of sanction impacts. Each pattern starts with a jolt from the landscape and continues through a chain of cumulative causation of systemic interaction between the regime and niches. The paper wraps up by answering the three fundamental questions raised in the introduction.

In studying this empirical case, the paper builds on the existing literature of international sanctions by illuminating their environmental repercussions from the point of view of the targeted countries. In relation to existing transition research, this paper aims to make two contributions. The first is to broaden the analytical focus to include international factors such as sanctions. While economic sanctions as extensive as the ones imposed on Iran are rare, it does not mean Iran's case is not appropriate for a lesson in policymaking. Due to the emerging tendency to wage trade wars and the increasing possibility of invoking economic sanctions as an instrument of policy, the Iranian case certainly deserves careful consideration, as it enriches the greater discussion on the impact of the discourse of trade protectionism on sustainability transition.

The second contribution of the paper is related to the specific context of Iranian economy as an oil exporting country. The paper contributes, by framing the Iranian car fuel socio-technical systems within the MLP theoretical framework, first to the literature of the geography of transitions and multi-sacarity and then, it illuminates how the regime and the market-ready niches are both carbon locked-in. Thus, the paper stretches the

conceptualization of a double lock-in which was first introduced by Lovia and Kimivaa (2012).

The paper begins with the conceptual framework and then proceeds to describe how as an oil exporting country, Iran suffers from a special condition of double lock-in. Then, it proceeds to introduce the three levels of socio-technical system of car fuel and the impact of the international sanctions in three episodes: 1980-2005, 2006-2010 and 2011-2015. In the third part of the paper, the interactions between the regime and the niches are discussed. The paper ends with the conclusions drawn from these analyses

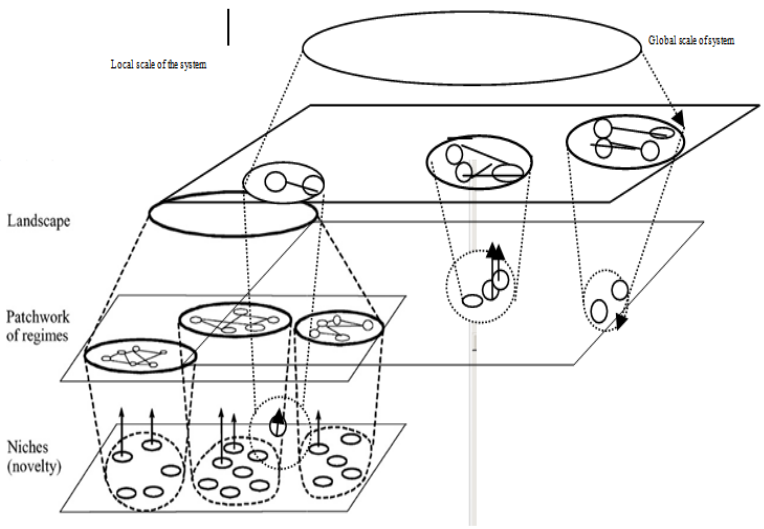
I. Conceptual Framework:

The bridging of the two separate literatures of economic sanctions and multilevel perspective is made possible by approaching the concepts of MLP as a multi-scalar socio-technical system.Originally, socio-technical systems consist of an interdependent and co-evolving mix of technologies, supply chain, infrastructure, market, regulation, user practice and cultural meaning (Geels Frank, 2014). The regime, as one of the subsystems, can be defined as "relatively stable configurations, techniques and artefacts, as well as rules, practices and networks that determine normal development and use of technologies" (Smith et al., 2005). Such a regime includes a series of complex, nested real world phenomena such as economic, cultural and cognitive attributes (Geels, 2002a and Geels, 2002b). It includes different global and local scales or subsystems of production and consumption. The global scale of the system might have the upper hand on the local scale; it provides the technology, the capital and the implicit knowledge embodied in the experts on the production side, as wells as the pattern of consumption and after sale services on the demand side of the system.

This framework presumes economic sanctions are used by international policymakers to block normal interactions between the global and local scales of a system. They wield their muscles and leverage their power by controlling or obstructing capital

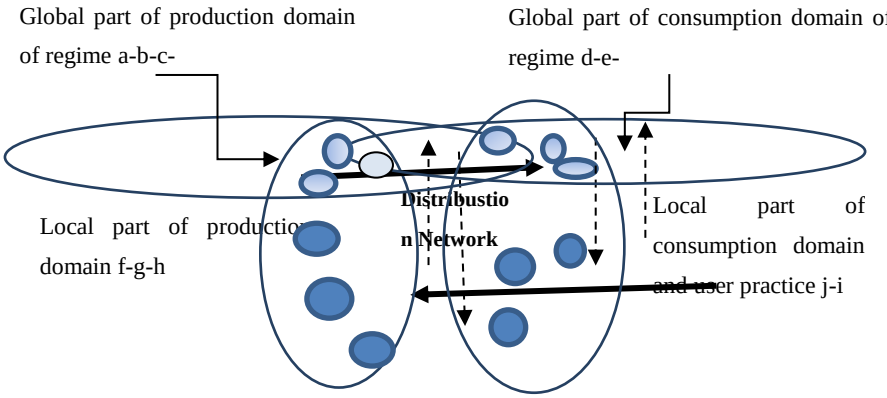
investment, importation of goods and technology transfer to put pressure on the local scale. These pressures are exerted at landscape level with differing intensities, amplitudes and speeds. The mechanical perturbation of the interactions between various scales have different mental and cognitive repercussions e.g. adding to uncertainty, questioning the way the system works and the legitimacy of its institutions. It sometimes turns into full-blown societal crises. Crises, by definition are confusing and contested phenomena (Geels F. , 2013) and each actor has a different interpretation which adds to the chaotic conditions. On the other hand, local policymakers apply countermeasures, and respond to and defy the pressures through discursive standoffs; galvanizing public opinion to push back, and also by mobilizing resources. To lessen its dependency on interactions at the global scale, it may adapt itself to new conditions by indigenous technological development or it could circumvent the sanctions using loopholes in international sanctions.

Figure1. representation of multi-scalar system



This multi-scalar system has different levels and basic elements within that are illustrated in the second figure.

Figure 2. Basic scales, levels and elements

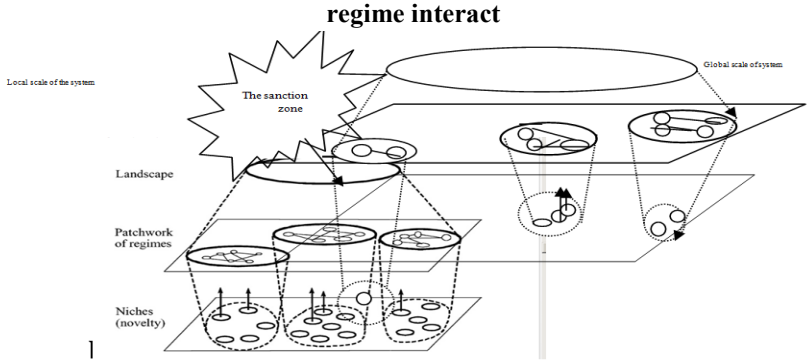


Source: Author inspired by Geels (Geels F. , 2004)

The dark and light blue dots represent different ingredients of systems at the global scale and light blue at the local scale; a-technology and know-how, b-global supply chain, c-FDI, d-international after sale services, e-global pattern of consumption practice, f-infrastructure, g-domestic knowledge and know-how, h-human capital, j- cultural meaning of artefact, i- local repair and maintenance.

The relations between local and global parts of regimes make the sanction zone where the landscape can effectively disturb the interactions between these two parts.

Figure 3. the sanction zone, the place the global and local parts of the regime interact



Author inspired by Geels (2002)

These measures and countermeasures generate a chain of cumulative causation which begins with pressures of differing

intensity, amplitude, speed and impacts from the landscape. Then, the countermeasure policies are implemented by the incumbent regime to defy, circumvent, or adapt to the impacts of the sanctions. Both the direct impacts of sanctions and countermeasures, which are considered an indirect impact of sanctions, are conditioned by the deeply embedded structures of the society. They are firstly the techno-economic structures which carry the objective and tangible parts and process of the production and consumption of the regime, and secondly, the cultural-cognitive structures which convey the cultural legitimacy of the artefacts and the balance between discursive rivals of pro-change and pro-stability coalitions (Lovio, 2012),

According to this conceptual model:

1. An ex-post evaluation of the impact of economic sanctions on a socio-technical regime should consist of both the direct and indirect impacts, that is, the sanctions and countermeasures taken by local policymakers.

2. Both the direct and indirect impacts are profoundly conditioned by deep societal structures and dynamics. Geels (2016), investigates these deep structures in four questions; how organized civil society is, how coordinated market economy is, how strong environmentalist tradition is, and how resilient the manufacturing structure is ((Geels F. W., 2011) p. 910).

3. It encompasses the long-term impacts of sanctions on cultural and cognitive aspects of socio-technical regime instead of merely the palpable and tangible aspects which are mostly immediate and short-term. This further explains the aforementioned aspects. (Kimivaa and Lovio, 2012).

4. In sum, sanctions, as external factors, initiate the chain of events that leads to the formation of a series of cumulative causal interactions between the global and local domains of landscape, and the global and local domains of regime. This affects the short-term economic–technical aspect as well as long-term cultural and cognitive aspects of the regime. It also has impacts on the relations between incumbent regimes and striving niches.

II. Iran; a Double Carbon Locked-in Economy:

Iran, a developing society with an estimated population of 80 million people, underwent rapid industrialization during 1960-1978 (Karshenas, 1990), followed by a fast urbanization after 1978 (Sharbatgholie, 1991; Hosseini Chavoshi and Shavazi, 2012). The changes have brought about modern institutions and modern lifestyle for millions of urban dwellers (currently more than 75% of the population). These urban areas, like Tehran (the capital with a population of more than 10 million) and other major cities, are crowded and because of that experience air pollution and traffic congestion (Naddafi, 2012) (Amirreza Talaiekhozani, 2017), (Kakoui A, 2012).

Underlying this fast track modernization with grave environmental repercussions, is the macrosocietal dynamic stemming from Iran's geographical position (linking central Asia to Middle East) and its natural resources (second in natural gas and the fourth in oil reserves) (Tribune, 2017). Economically, the most important source of foreign currency is oil export, the proceeds of which are gained by the state and injected into the Iranian economy. This impacts the economic, societal-political and international dimensions of society. That makes this context double carbon lock in the deepest and broadest way with three features:

First: The state is the main player in the economy. Market prices are distorted by state intervention in the form of various subsidies and custom barriers. This phenomenon, called Dutch disease (Karamelikli, 2017), affects technological advancements (advocating rentseeking behavior at the expense of technological novelty) and technological selection (non-economical).

Second: The state is far less financially dependent on tax revenues from the society. Conversely, different social classes seek a share of oil revenue through various formal and informal channels (Wegenast, 2016). This encourages industrial partimonialism, a hierarchical ordering of the industrial firms.

Third: Fanned by tense international relations, the discourse

of hyper-independency has progressively become the dominant discourse of policymaking in the industrial and agricultural sectors during the last 40 years (Miremadi, Vicious Circles of underdevelopment and national innovation system in Iran, in persian, 2012). There are two other competing discourses that have affected the public policymaking process from time to time, but never quite succeeded to dethrone the dominant discourse: one is the discourse of economic growth and second, the discourse of environmentalism (Fadaee, 2012).

The dominance of the hyper-dependency discourse would not have been possible were it not the first and second features of Iran's social dynamism. That is, the viability of the discourse of hyper-independency is determined by the ability (feature 1) and the will (feature 2) of the state to cover the gap between the global and national level of productivity by various policy instruments such as custom barriers and subsidies on energy.

Fourth: As a result of these three features, the industrial infrastructure is large, hierarchical and non-productive, and the economy is deeply oil-based and carbon lock-in in terms of its main sources of revenue, the nature of the state-society relationship and the dominant discourse .Using Levio and Kimivaa's (2012) expression of double lock-in and broadening it to a national level, one can conclude that this country, is not just vulnerable to the carbon lock-in, but it is rather double or triple locked-in when techno-economic and cultural-cognitive institutions are considered.

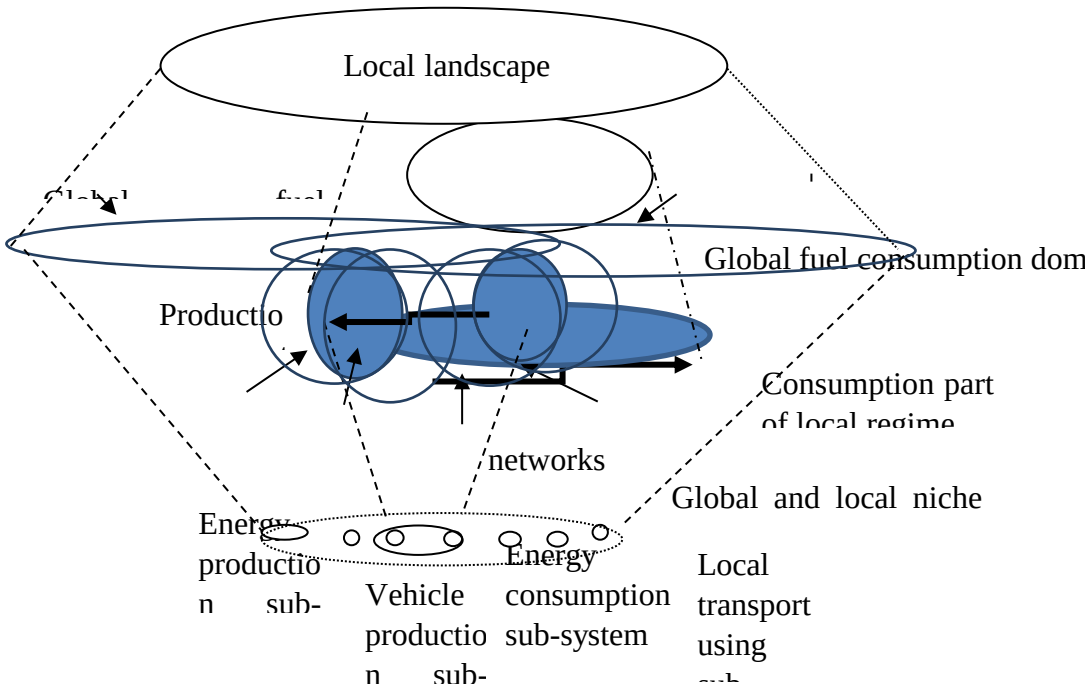
This deep institutional carbonization impacts the institutional logic of the socio-technical systems of car fuels on a regular basis and, as explained below, it shapes expectations and behaviors at the regime and niche levels.

III. The car fuel socio-technical regime of Iran:

The socio-technical system of car fuel has three levels of structural subsystems; landscape, regime and niche. To define the socio-technical regime in point, one should consider its main

societal function, i.e. supplying fuel to the Iranian transport system, and place it within the overlapping sectors of national energy and transportation regimes. It is also involved with some sectors of the energy and transport regimes at the global scale, due to the critical role that the import of goods, services and technology transfer plays in both sectors.

Figure4. The multi-scalar analysis of socio-technical system of car fuel in Iran;



Car industries and refineries are the symbols of national pride. Iran produced 1.5 million cars in 2017, fifteen percent more than the previous year (association, 2018), which makes this country the 18th car manufacturer in global rankings (Pedal News, 2018).

This growing output needs justification because the target market has been limited to domestic consumers due to low quality, and complications from international sanctions. In order to keep demands high, car manufacturers, with the help of the

Iranian public banks have formulated several payment plans such as installment sales with no down payments required. As a result of the different policies and programs, the demand for cars and consequently car fuel in Iran is accelerating (Barazandeh, 2016). National refineries produce around 85 percent of the fuel required for national consumption, around 65-70 million liters, leaving 10-15 million which must be imported.

The feature shared by both car and energy regimes is the presence of the state as the major player. Nine of Iran's oil refineries are owned by the state, in accordance to the constitution (I.R.I constitutions, 1995[1]). There are 28 automakers of which Saipa and Iran Khodro are the major producers with 54 percent and 46 percent of the output respectively (Parliament, 2014-2015). Although, the automakers are listed in the stock market, in reality, the privatization process was a complex shift of ownership from the state to a variety of parastatal organizations including banks, cooperatives, pension funds, foundations, and military-linked contractors (Harris, 2013). Having said that, however, privatization remained minor, and the government still owns around 40 percent of the major companies (Parliament, 2014-2015). The state also plays an operative role in the management of demand, by determining the price of fuel.

At the landscape level, there are different local and global factors including economic sanctions, affecting this regime. As the chronology of events illustrates (Appendix.1), the course of economic sanctions underwent three distinct episodes: First in 1979-1980[2], a series of US government executive orders halted American investment in Iranian oil industry, blocked Iranian government property in US and banned Iranian oil importation[3]. In 1996, ILSA[4] was approved by Congress meaning the US

[1] Chapter4, Principle 43, para.8

[2] Executive orders, 12170,12205,12211

[3] Executive order12613

[4] Iran Libya Sanction Act , in August ۱۹۹۶

unilaterally extended the territorial jurisdiction of the American sanctions to non-US companies.

Second: This second episode began in 2006 when the UN[1] and European sanctions[2] joined the ones already imposed by the US. The sanctions targeted Iranian companies as well as individuals involved in nuclear projects, the production of missiles, arms and other sensitive material in Iran. They were smart sanctions, meaning they were targeted, and limited to certain sectors. Yet, the geographical extension of the sanctions, as explained below, may possibly have had deeper impacts on the incumbent regime.

Third: In 2011, by sanctioning the Iranian Central Bank and limiting oil exports, the international sanctions mutated into more comprehensive sanctions[3]. The nature of the impacts of these comprehensive sanctions is very different from smart sanctions. They affected ordinary people in all walks of life by cutting off the Iranian economy from the global market. One of the paragraphs of the Act includes the ban on the export of gasoline or support for the domestic gasoline industry.[4] The pressures of the comprehensive sanctions were eased in 2013 but officially lasted until 2015 when the nuclear talks culminated in the Joint Comprehensive Plan of Action (JCPOA). In the following sections, the impacts of each three episode will be analyzed.

American sanctions 1980-2006: The first episode of international economic sanctions against Iran lasted 25 years. The pattern of pressure was chronic and steady on the energy and motor industries. The direct impact was limited to specific

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[1] SC resolutions 16696 (2006), 1737 (2006), 1747 (2007), 1803 (2008), 1835 (2008), 1929 (2010)

[2] Council common position 2007/140/CFSP, 2010/413/CFSP, 2011/235/CFSP, 2012/35/CFSP, 2012/152/cfsp, 2012/635/CFSP

[3]

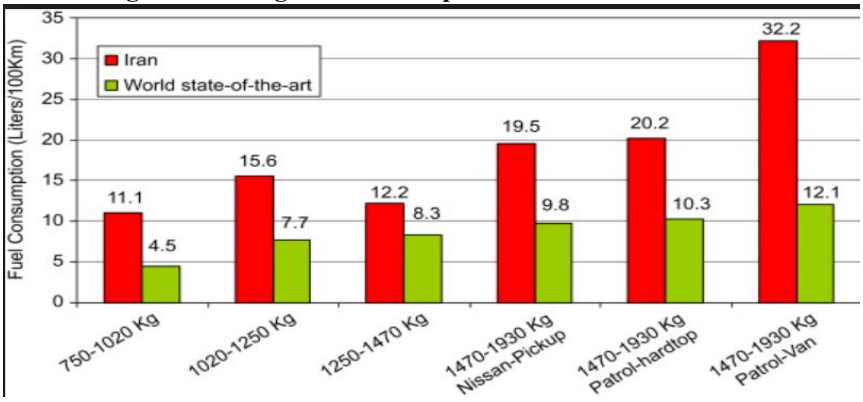
[4] Comprehensive Iran Sanctions Accountability and Divestment act in July 2010.

individuals, illicit materials and defense related activities. The indirect impact was uncertainty, which increased the risk of investing in Iran, discouraging international transactions and technology transfer to Iran (Cohen, 2014): 407).

The steady and regular pressure of the sanctions for 25 years had formed the socio-technical regime of car fuel in Iran. The consequence was Iran's deprivation from acquiring state of the art technology for the car and oil industry. The gasoline and diesel produced by the local refineries have been several times more pollutant than the standard (Amirreza Talaiekhozani, 2017). Cars manufactured with outdated and inefficient technology, allowed fuel consumption and the emission of GHG to become multiple times more than the global lead standard (Barazandeh, 2016).

A survey shows that the urban transport system consumes an estimated 178 and 4224 million liters of diesel and petrol per year, respectively, and releases around 10 million tons of CO2 (Kakoui A, 2012). It also shows that the overall average for the contribution to CO2 emissions in cars, motorcycles, buses, and taxis were 26372, 1648, 1433 and 374 tons per day, respectively.

Figure5. Average fuel consumption in Iran and the world



Source: Jafary and Baratimalayeri, 2008

Nowadays in the transportation fleet, there are more than 19 million cars. The statistics show Iran's daily consumption of gasoline is more than 80 million liters and it has even reached 105 million liters on peak days (official site of NIORDC, 2017).

Table1. Comparison between Iran Turkey car fuel patterns of consumption

	Turkey	Iran
Population	79 million	80 million
Number of cars	21 million	19 million
Price of car fuel	1.5 $	0.27 $
Daily Consumption of car fuel	8 million litres	80 million liters
Annual Consumption of car fuel	3 Billion litres	30 Billion liters
GDP	857 Billion $	309 Billion $

Source: http://www.eghtesadonline.com

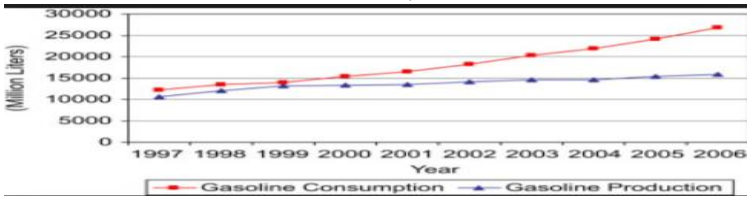
Table 1 compares Iran to Turkey. They both have approximately the same population and number of cars, yet, Iran has ten times the consumption of car fuel both daily and annually. In Turkey, the price of oil is more than 5.5 times of that in Iran.

Obviously, the Iranian system was sustained by the energy subsidies (now up to 32.19 percent of GDP, (Coady, Parry, Sears, & Shang, 2016) paid by the state. This would not have been possible were it not supported by the three features of the oil rentier economy of Iran. The concordance of the double lock-in institutional logic between the macro level industrial and economic system (landscape) and the car fuel regime, guarantees the regime structural coherency and institutional stability while exacerbating air pollution, energy waste and consumerism. The high structuration of the regime makes no room for any technological and organizational innovations that would lead to the attaining of more fuel-efficient cars or less pollutant fuels.

International targeted sanctions 2006-2011: In 2006 when the UN, and later in 2007 Europe, joined the US in sanctioning the Iranian economy, the chronic and steady effects of international sanctions changed and felt like shock waves with strong de-stabilizing impacts. The geographical extension of the sanctions put the minds of the main actors of the incumbent regime at unease. After several years of threats, in 2010, the US finally

banned gasoline exportation to Iran. At that time, 37 to 40 percent of the demand of gasoline, valued at $5 million (Majidpour, 2012), was met by importation (Katzman, 2018). Gasoline importation was the Achilles' heel of the regime whose mantra was energy based industrialization. The fear of not being able to import gasoline made the major actors of the regime scramble for the exploring of different alternatives while managing to hinder the increase of demand.

Figure 6. The deficit of gasoline consumption and production on the verge of new sanctions, 2006



Source : (Baratimalayeri, 2008)

In this conjuncture, the incumbent regime had no choice but to find space for the emergence of the multiple niche-innovations that at that time were competing for public attention and resources. At the same time, another program was launched to use fuel rationing to manage demand.

Looking at the chronology of events during 2009-2012 (see appendix 1), it is observable that many renewable energy based fuels came out of research labs and were examined seriously, for the first time, during this time. The advanced pilot plant of micro-algae was financed by the High Council of Science and Technology Research in 2011 (Moazzami, 2011), the project of planting jatropha was approved by the Ministry of Trade and Industry in 2011 (Khalili, 2010), and the research project on fuel cells as well as hydrogen and electric cars succeeded to attract different V.C.'s attentions (Miremadi and Rahimi Rad, 2015). While Iran has great potential for photovoltaic, microalgae (Miremadi and Rahimirad, 201) and renewable energies, overall, none of them proved to be market-ready as a result of many years of double carbon lock-in public policies.

Consequently, the first (side) effect of the geographical extension of international sanctions (2006) was materialized in the change of direction taken by researchers (guidance of research and development) toward renewable energies, followed by mobilization of resources for these technological niches in the form of government funding, V.C. investment and private equity. However, this process failed to lead to market formation, because, the incumbent regime would use subsidies to keep the price of carbon-based energy very low. None of the niches could show any sign of market readiness in this condition. At that time, the sanctions were not designated to blocking the oil revenue and the state could still afford to pay massive government subsidies amounting to $34 billion per year ((Coady, Parry, Sears, & Shang, 2016)). These subsidies dwarfed any serious support for renewables and signaled the continued willingness of the regime to prop up fossil fuel industries, despite the symbolic expressions that the environmental laws e.g. “the law of clean air” conveyed. The output of such contradictory mix of policy clearly raised red flags for the growth of renewable energy in Iran despite their potentials.

Compared to renewable energy, natural gas had a better chance to join the incumbent regime. Firstly, natural gas is always an easy choice for Iran since it is the second country in the world in terms of gas resources (Sergie, 2017). Second, natural gas positions itself as a clean fuel worldwide (Suurs, 2009). It is known to be the cleanest fossil fuel and it has high energy conversion efficiencies for power generation (Wei, 2016). Thirdly, it had been incorporated in heating system in the form of CNG and LPG in the world (Wei, 2016) and in Iran. In the first decade of 2000, it was the middle ground between gasoline and renewable energy in motor fuels.

The first project of retrofitting a small segment of the transport fleet (unban buses) was set up to promote CNG in 1969 and it continued gradually in different forms of research, development and demonstration (Miremadi, Shojaee, Ashnani,

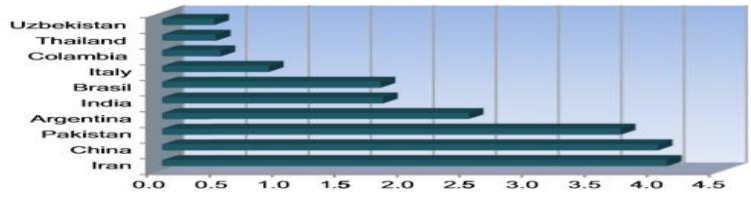
2016). When the threat of sanctions grew amid intense international tensions, a major industrial project was launched in 2004 to materialize CNG-based fuel transport in Iran, named EF7. The producer was the major car company Iran Khodro, but it was its affiliate, IPCO, that set out to design and manufacture EF7s.

The EF7 project was conducted as a collaborative research and development (R&D) project between Iran Khodro (IKCO) and a leading German company in engine design technology, named F.E.V GmbH. Iran Khodro has a vast supplier network comprising of many local and foreign suppliers. The priority of the project was to supply engine parts locally to the extent possible. This procurement policy meant that during the EF7 project, local suppliers had to start retrofitting their production lines to survive in the competition, otherwise the required parts and components would be provided by foreign suppliers.

One of the aims of this project was learning by interaction and competition in terms of design knowledge, as well as production capability from the German side to the Iranian side. The IPCO supplier handling department has had trade relationships with engaged suppliers and is well aware of their organizations and manufacturing capabilities (Majidpour, 2012). By conducting the EF7, IPCO provided an opportunity for their most reliable suppliers to implement technical changes and to adapt their products to meet required quality standards. From the outset, IPCO set a deadline for the suppliers to upgrade their production lines and build the capabilities to produce the engine parts (Majidpour, 2012). In these circumstances, the domestic suppliers were not only obligated to deliver the parts according to the project time-plan but also to upgrade their manufacturing capabilities as well as their production equipment. Many suppliers succeeded to acquire technological knowledge from foreign (mostly European) suppliers through collaboration agreements, including Bosch, Benteler, INA, Valeo and Mahle (Złoty, 2015). As a result, both the main car manufacturing company and the related suppliers were involved in the learning process.

Some have considered the EF7 project a success story (Mohannak, 2015) and some others, a failed one (Mehdizadeh, 2017). The proponents pinpoint the establishment of a successful networked model of learning with IPCO in the center, with the local suppliers around it. They appreciate the process of learning/innovating conducted with several top foreign partners with a strong technological base in the heat of international threats. The number of CNG-fueled cars soon surpassed four million. It has placed Iran on the rank of the first three countries with CNG-run cars along with China and Pakistan. The proponents also highlight the fact that replacing CNG with gasoline has generated $37 million of foreign currency during a period of 12 years (Shana, 2017).

Figure7: Iran has the first rank among the countries with CNG-fueled cars:



Source : (Khan, 2015)

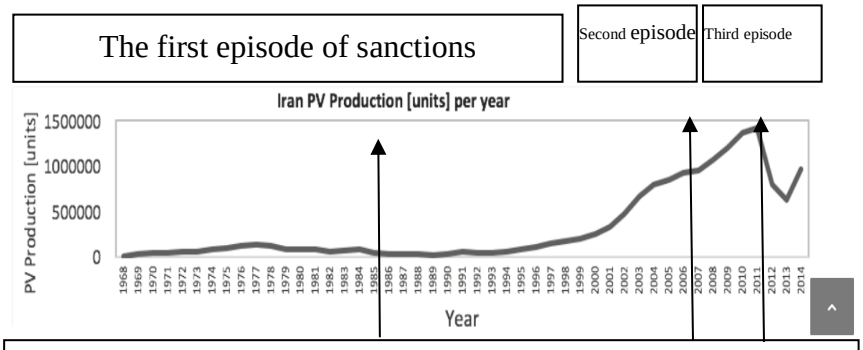
The opponents, on the other hand, have questioned the value of having a great number of CNG-fueled cars in the transportation system when the mitigation of air pollution was lower than expected. They have raised serious questions about the appropriateness of the selection of passenger cars for this project (Mehdizadeh, 2017). According to them, trucks and buses are more valuable candidates for CNG retrofitting. The other negative points are deprecation of the engine and life of the vehicle, and power loss due to incomplete combustion of fuel in the cylinder and finally, the problems of maintenance and the periodic inspection of dual-fuel vehicles (Mehdizadeh, 2017).

As the sanctions deepened, broadened and intensified, the EF7 project and the car industry in general, experienced trouble. The foreign partners left the project and industrial retrofitting or

OEM, was substituted by unauthorized sweatshops with non-standard processes and worn-out parts (Mashyekhi, 2018). More than 20 percent (over one million) of CNG retrofitted cars were made by unauthorized shops. The explosion of CNG fueled cars with makeshift retrofitting occurs frequently, and has put the legitimacy, safety and security of national cars under question. They resembled "moving bombs" (Ahmadi, 2012). That is why in the post-JCPOA era, the production and retrofitting of CNG cars were slowed and as of 2018, the diffusion of CNG-based cars suffered a setback after the early hype, and there is now a 50 percent underutilization of CNG fuel (Chief, 2018).

In the figure below, one can see that during the first and second episode of the sanctions, the production of cars had increased tremendously while it slumped in the third episode.

Figure 8. The fluctuation of Iranian auto making products under international sanctions



The Trend of Car Production. www.ilia-corporation.com/ insights/ white-papers/sanction-effects-on-iran-automotive/

The global comprehensive sanctions; 2011-2015:

The shock of the ban on gasoline importation in 2010 was added to by another US Congress Act that targeted insurance and financial institutions. In 2011, US sanctions targeted the Iranian Central Bank leading to a de facto embargo on Iranian oil exports. The international companies were required to decrease their oil

imports from Iran.[1] This shook the foundations of the Iranian industrial sector as it had grown accustomed to a routine injection of energy subsidies attained through oil revenues.

The measures of a pro-carbon based regime of car fuel facing the impacts of the international sanctions proves once again that the economy's carbon lock-in is far more entrenched than many conventional cases, since the regime and the technologically viable niches are both carbon-based. In this time of urgency, the regime resorted to a petrochemical product called dried petrochemical or DPG. This product contains the dangerous ingredient benzene, which is proved to be one of the causes of cancer. DPG was produced by 6 petrochemical sites. The decision was made by an ad hoc task force in the high council of national security to counterbalance the gasoline exportation sanction in 2010 and the restriction of oil exports in 2011. At first, the product was supposed to go through some treatment to lose its harmful ingredient. It was never done, making the air pollution worse than ever in the major cities of Iran.

In fact, during the time when DGP was used, large cities like Tehran experienced the worst days of pollution to the point of being likened to a gas chamber by the Iranian Organization of Environment (Naderi, 2017). Between 2011 and 2013 the benzene content of gasoline samples was between 46 /. up to 2.56% vol. In the years of 2013 and 2014, this amount reached the standard, and remains constant. Suffices to say that benzene is added to fuel to increase the octane number, but a content of more than 1% by volume, according to the Euro standard, can be directly and indirectly hazardous. The octane number of gasoline should be high. If lower, it will increase gasoline consumption and decrease the life of the engine and increase the amount of oil. In short, octane was low and sulfur and benzene was very high. The sulfur content of diesel was also very high. This is why the air quality from 2011 until 2013 was extremely poor (Naderi, 2017).

[1] Section 1245, National Defense Authorization Act FY 2012, December 2011

According to multiple reports, the quality of air in Iran, especially in the Tehran metropolis was very unhealthy and most of the pollution indices, specifically CO and PM indices were above the standard and at sometimes at dangerous levels (Shahrabi NS1, 2013). Nonstandard gasoline and CNG motor engines have been the most important cause of poor air quality. Based on reports, the annual average of air toxicants including PM 10, SO_2, NO_2 and O_3 in Tehran, the capital city of Iran with more than 8.3 million inhabitants, at that time were 90.58, 89.16, 85, and 68.82 $\mu g/m^3$, respectively. These values are far more than the standards defined by EPA and WHO.

The reports published during these years would warn citizens of the adverse effects of DPG. They argued that air pollution was the cause of death for 2194 people annually, out of total number of 47284 deaths. According to the report published by the physician organization (WHO) in 2013, SO_2, NO_2, and O_3, respectively, have caused an additional 1458, 1050, and 819 deaths in 2011 (Phys. Org. ,2013).

These facts and figures had vast reflections on public opinion. Ayandehban, the non-governmental report of foresight in Iran, announced that in 2015, air pollution was the sixth most important issue out of one hundred that concerned the Iranian public, right after national insecurity, political polarization, economic instability, ethnographic tensions and aridity (Ayandehban, 2015). There are no statistics, in this regard, for the preceding years. In 2016, the issue of air pollution ranked 3rd on this list, after the fate of the nuclear deal and the increasing number of hospitalized cancer patients (Ayandehban, 2016).

V; Discussion:

Through the study of chronological events, the paper found that between the years 1980 and 2015 the cluster of economic sanctions have greatly impacted the Iranian economy. The nature of these clusters has changed substantially and the patterns of their impacts on Iranian economy differed accordingly. The sanctions

broadened their geographical reach, deepened social effects and intensified their effectiveness as time went by. In order to analyze the impacts, the paper classifies these clusters in three episodes of 1980-2005, 2006-2010 and 2011-2015.

Relying on Suarez and Oliva (2005) and then Geels (2007), these can be classified based on frequency, amplitude, speed and scope.

From 1980 to 2005, the chain began with landscape impact as the external independent variable. It induced a series of changes in the regime through bans on investment, technology export control and import embargo. Since the pressures were steady and chronic, the regime had the opportunity to adapt itself to the changed environment and counter-force it through more centralized governance by the state. It counter-punched the pressures via the distortion of market prices and dominance of the discourse of hyper-independency. Therefore, the economic sanctions during 1980-2005, were stabilizing and supporting the formation of the double carbon lock-in regime of car fuel in Iran.

In retrospect, the impact of chronic pressures during this episode, has strengthened the deep structures of the local scale of the landscape and stabilized the incumbent regime. Because, its pattern did not perturb but justified the state intervention in the market and the protection of the car industry with more distortion of market and their continuance invigorated the discourse of hyper-independency and secured the dominance of the discourse advocating economic self-sufficiency, cultural isolation and cognitive insensitivity toward the environmental degradation as the attributes of the socio-technical regime

During 2006-2010, the sanction clusters developed into a high intensity and disruptive form, yet, their impacts were gradual and limited to specific sectors. By threatening to ban gasoline, the socio-technical regime found itself vulnerable to future sanctions since it imported large volumes of gasoline. As a result, it left itself open to new options for car fuels. At that time, CNG-fueled cars seemed the most favorable candidate for gasoline

substitution. It was soon added to the national car, "Samand", and it was to be the "national fuel". The project was a relative success in terms of knowledge networking and technology transfer, and continued to be so until the foreign partners left the country. Yet, it was also a relative failure due to its skewed product selection mechanism. The selection of passenger cars instead of trucks or buses to be retrofitted did not have the expected economic and technological outcomes. It was based on the collective meaning-making and cultural symbols that passenger cars carry. In the discourse of hyper-independency, passenger cars, not buses or trucks, are the symbol of a self-sufficient industrialized country. Hence, the "national fuel" should be utilized for the "national car".

One can say the economic sanctions during the episodes of 2006-2011, had disruptive (low intensity, gradual and pointed) impacts which paved the way for partial technological development and CNG substitution. Although, the selection of passenger cars had diminished the benefits of CNG-fueled cars, nevertheless, CNG was a cleaner fuel and it temporarily mitigated the air pollution problem of the major cities.

On the other hand, the cultural legitimacy of the CNG-fueled car stemmed from the rhetoric of the groups supporting the hyper-independency discourse. The CNG-fueled car was the artefact of a system with technological and energy independency. It further consolidated the pro-stability mentality. Conclusively, the sanctions and the domestic policy for counteracting them, generated a partial techno-economic change without any alternations in the discursive institutions; another sign of its limited impact.

The third episode of the sanctions occasioned avalanche-like impacts. It occurred after 2011, eased up in 2013 but lasted until 2015. During this period, the change was of high intensity, high speed and simultaneously affected multiple dimensions of the socio- technical regime.

In this conjecture The foreign partners left the country and the

quality of retrofitting parts and procedures deteriorated due to the use of non-standard parts. The phenomenon of "moving bombs" hurt the legitimacy of this artefact. The high intensity of the pressures made the incumbent regime search for an immediate solution. This time, it did not have the luxury of time for technological change, nor willing foreign partners to do a transfer.

In the techno-economic aspect, the incumbent regime resisted the pressures by invoking a non-conventional strategy of using “DPG” which due to its benzene ingredient is considered hazardous to human health. This made the car fuel regime technically more carbonized. Awareness of the health concerns generated a strong public backlash. As a result, it induced an unprecedented social sensitivity about the cost of the hyper-independency discourse, a change in the cognitive-cultural regime with lasting effects.

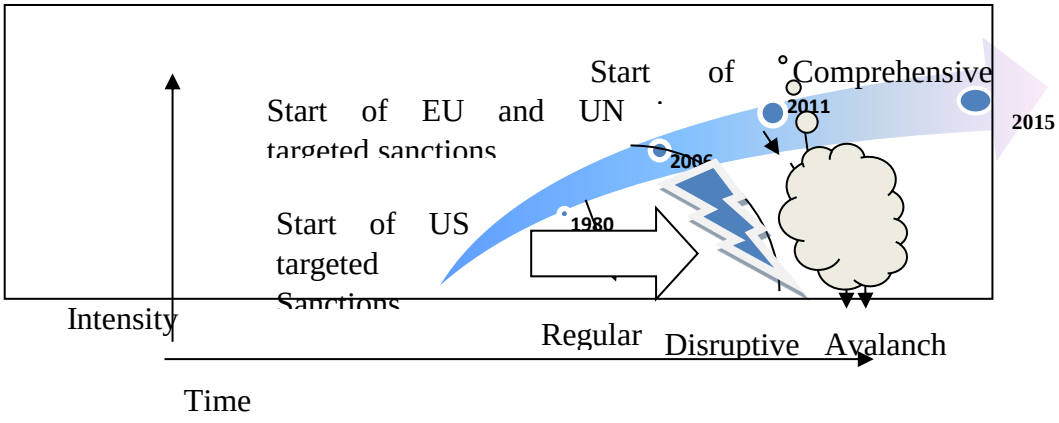
The nuclear talks with the international powers in 2015, culminated when the state government was reshuffled and a new political front with the motto of environmentalism was put in charge after a landslide victory in 2013. As a result, the use of DPG was condemned and stopped. The increase in the production of CNG-converted cars slowed. Complementary measures like gasoline rationing were abandoned and fuel consumption grew higher than ever.

The hazardous impacts of the counter-measures policy adopted during 2011-2013 raised the red flag on the environmental costs of the hyper-dependency discourse and paved the way for the growth of alternative discourse. It also launched public debates on the quality of air in the urban areas, which have been regular in the post-JCPOA era. It was definitively a step forward for pro-change, pro-environmental advocacy groups who can influence public opinion and place legitimacy pressures on policymakers. It also helps strategic managers of technological niches to network socially and further the social and cultural acceptance of renewable energy.

It is safe to say that overall, the international sanctions

directly intensified the carbon lock-in of car fuel regimes in terms of the economic-technical aspect of the regime. Yet, their indirect long-term impact on cultural–cognitive aspects is far more elusive.. There is evidence that the cultural legitimacy of green technologies is growing which illustrates that the sanctions' impact on the cultural and cognitive aspects of the incumbent regimes have been environmentally positive.

Figure 9: Evolving nature of the impacts of three clusters of International sanctions



Conclusion

This paper aimed to draw attention to the impact of economic sanctions on the carbon lock-in industries in Iran and see how they influenced the carbon-lock-in car fuel system. It also asked if the sanctions encouraged the diffusion of cleaner fuel or discouraged them.

To answer these questions, the paper built a multi-scalar framework of Multi-Levels Perspective in which pressures in the form of economic sanctions were exerted from the global scale of the landscape on the local socio-technical incumbent regime. In the case in point, these pressures have lasted for more than 35 years. The paper showed during this time, the impact of sanctions clustered in three episodes. Each cluster generated a different

chain of cumulative causal interactions between the landscape and the incumbent regime, which have substantially had different characteristics.

The first cluster had a stabilizing impact on both aspects of the regime when the impacts were regular and chronic during 1980-2005, meaning, the economic-technical institutions as well as the cultural-cognitive aspects of the incumbent regime were consolidated by these steady and regular impacts. In fact, the countermeasures were mostly defeating the sanctions since the sectoral and geographical domain of sanctions was quite narrow. Advantage was also taken of them through the energizing of the dominant discourse of hyper-independency.

The pattern of the next cluster of sanctions appeared to be disruptive in the second episode between 2006-2011. During this episode, the economic-technical institutions were disrupted and opened to a partial transition of technological substitution based on CNG, but the cognitive-cultural institutions were intact and even invigorated by the dominant discourse.

From 2011 to 2015, the impact of the sanctions appeared to be avalanche-like with overarching changes in both aspects of the incumbent regime, albeit, in different directions. It took one step backwards in terms of economic–technical institutions by selecting DPG, a definitive move towards deeper carbonization, and a step forward in terms of cognitive-cultural institutions, once health concerns heightened as the result of using it.

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