An Investigation of Energy Usage Intensity Changes in Iran

Feisal Mirkazehi Rigi

Ph.D. in Economics from University of Pune
mirkazehirigifeisal@yahoo.com

Abstract: Iran as a most famous energy exporting country had a increasing in energy intensity from the 1979 revolution until 2009, but since then the rate of increasing slowed and energy intensity actually decreased in 2007. Most of this energy intensity decline can be accounted for by falling coal and gas consumption in the industrial sector. In other word and to the best of our knowledge, no decomposition study has investigated the role of inter-fuel substitution in the decline in energy intensity or causes of the rise in energy intensity since 2007. In this paper, logarithmic mean Divisia index (LMDI) techniques are established for decompose changes in energy intensity in the period 1980-2009. The results showed that technological change is confirmed as the dominant contributor to improve in energy intensity and structural change at the industry level actually increased energy intensity over this period. Also this changes for industry sector is more and for agriculture is so smoothed.

[Feisal Mirkazehi Rigi. **An Investigation of Energy Usage Intensity Changes in Iran.** *Academ Arena* 2019;11(8):82-88]. ISSN 1553-992X (print); ISSN 2158-771X (online). http://www.sciencepub.net/academia. 12. doi:10.7537/marsaaj110819.12.

Keywords: Energy Intensity, Logarithmic Mean Divisia index (LDMI), Technological Change, Structural Change.

1. Introduction

Iran is one of the most important members of Organization of Petroleum Exporting Countries (OPEC) and Gas Exporting Countries Forum (GECF). Iran received approximately $47 billion in oil export revenues, which accounts for about 50% of state revenues. Natural gas and oil consumption both account for about half of Iran's domestic energy consumption. With its heavy dependence on oil and gas revenues Iran continues to explore for new sources of natural gas and oil. Recently Iran has focused its energy sector on the exploration of the South Pars offshore natural gas fields in the Persian Gulf (CBI, 2009). Cheap energy prices stipulated by government as part its policy agenda to protect and serve the poor constitutes an indirect subsidy for energy carriers efforts over the past decade to improve pricing policy via Price Reform Policies have only slightly improved prices in real terms and have not succeeded in limiting demand. These subsidized low prices result in the irrational, over-consumption of energy which is reflected in the high energy intensity indicator compared to other countries and a sub-optimal energy mix. Iran possesses abundant fuels from which to generate energy. Iran held 10.3% of the world total proven oil reserves and that figures out to be about 137.6 billion barrels (2.188×1010 m^3) of oil reserves at the end of 2009. Oil also is found in northern Iran and in the offshore waters of the Persian Gulf. Nevertheless, in 2005 Iran spent US$4 billion dollars on gasoline imports, mainly because of contraband and inefficient domestic use that result from subsidies. Iran is one of the largest gasoline consumers in the world ranking second behind United States in consumption per car. The contemporary political economic history of Iran shows that the economy has performed better during strong autocracies. More specifically, the average real GDP per capita growth rate amounted to 8% per year from 1966-1976. The same figure for the post-revolution period (1980-2009) was about 1% (World Bank, 2010).

Recent work in the productivity literature suggests that productivity differences between countries can in part be explained by firm specific factors such as technology or managerial approach (Bloom and van Reenen, 2007; Bloom et al., 2007, 2008). Studies by Sinton and Levine (1994), Lin and Polenske (1995), and Garbaccio et al (1990) have attempted to measure the relative contributions of sectoral shift and subsector productivity change. A shortcoming of these studies is their reliance on aggregations of data, usually at the two-digit industry level. Energy intensity measures energy supply per unit of economic output in a given economy. For the purposes of this analysis, we will use annual total primary energy supply (TPES) in an economy (which includes net exports and stock changes), as measured in millions of tons of oil equivalent, and GDP, as measured in millions of 2000 U.S. dollars. As acknowledged in these studies and confirmed by our analysis, the use of aggregations may cause the contribution of subsector energy productivity improvements to be overstated while assigning insufficient weight to the role of sectoral shift. An advantage of these studies may be their relatively comprehensive coverage. The reason to use the LMDI additive method is that this method not only yields perfect decomposition with no residual term but also can accommodate the value zero in the data set. Additionally, for three of the decomposed sectors, availability of the annual time series data within the study period enabled the decomposition of each successive year. By this way, this paper has the advantage of evaluating all information in the data set for explaining the pattern of changes in the production, structural and intensity effects. The rest of the paper proceeds in the following steps: Section 2 will introduce our Review of literature. Section 3 gives methodology and model. Section 4 presents results. Finally, section 5 is this paper's conclusion.

Early studies show that structural shift plays more important role to energy consumption. Smil (1990) and Kambara (1992) have argued that structural shifts away from more energy-intensive industrial sub- sectors have been the major causal factor; real intensity change and structural shift play different roles over different periods of time. Zha et al. (2009) analyzed the structural and intensity effects that affect energy consumption of 36 industrial sub-sectors from 1993 to 2003. The results showed that the real intensity change had played a more important role before 1998 while structural shift dominated after 1999. Sinton and Levine (1994) examined the same issue for the period of 1980–1990 and they found that real intensity change accounted for 85 percent of the country's overall industrial energy intensity change. Zhang (2003) found that 88 percent of China's cumulative energy savings in the industrial sector were attributed to real intensity change for the period of 1990–1997. Similar results were also found by Lin and Polenske (1995) for the period of 1981–1987, Garbaccio et al. (1999) for the period of 1987–1992. Cornillie and Fankhauser (2002) in their paper decomposed energy data and used panel data methodology to identify the main factors driving improvements in energy intensity. Results showed that energy prices and progress in enterprise restructuring are the two most important drivers for more efficient energy use. Fisher-Vanden et al. (2003) examined the absolute decline in energy consumption as well as intensity decline during 1997–1999. They applied the multiplicative arithmetic mean Divisia methods to a unique set of enterprise-level data. Worrell et al., (2007) in an investigation discussed that the values of energy intensity are represented by main processes of energy-consuming for industrial sectors to contain and allow comparisons for each process level. Values of energy are provided just for final energy and also defined as the energy used at the product facility as well as for primary energy, defined as the energy used at the production facility as well as the energy used to produce the electricity consumed at the facility. In this research the "best practice" figures as these may depend strongly on the material inputs provided in this report for energy consumption should be considered as indicative. Martin (2009) investigated the energy intensity for US economy and he mentioned that potential explanations for the higher energy intensity are lower US energy price levels. However, common price elasticity estimates are not high enough to explain the observed differences between countries. This paper suggested firstly, that barriers to knowledge diffusion are an important concern and secondly, that the long term response to a sustained price increase might be stronger than common price elasticity estimates suggest. This study also provided, for the first time, estimations of energy price elasticity for the US on the basis of representative plant level panel data for the manufacturing sector. Matheny (2010) argued that countries which have higher energy intensity – those that require more energy per unit of economic output – tend to suffer from deeper recessions and are more susceptible to price shocks. So he analyzed three policy alternatives that approach the issue of decreasing economy-wide energy intensity and finds that reducing price subsidies - while often politically difficult - is the most attractive option.

2. Material and Methods

There are two groups of decomposition approaches (Hoekstra and Van der Bergh, 2003):

- Input - Output Techniques or Structural Decomposition Analysis (SDA)
- Disaggregation Techniques or Index Decomposition Analysis (IDA)

The SDA approach is based on input–output coefficients and final demands from input–output tables while the IDA framework uses aggregate input and output data that are typically at a higher level of aggregation than input–output tables. This basic difference also determines the advantages and disadvantages of the two methods. One advantage of SDA is that the input–output model includes indirect demand effects – demand for inputs from supplying sectors that can be attributed to the downstream sector's demand – so that SDA can differentiate between direct and indirect energy demands. The IDA model is incapable of capturing indirect demand effects. Thanks to the greater structural detail in the input–output table, SDA has another advantage of being able to distinguish between a range of technological effects and structural effects that are not possible in the IDA model. The advantage of the IDA framework is that it can readily be applied to any available data at any level of aggregation. While input–output tables may only be available sporadically, IDA can be applied to data available in time series form. In this paper, the IDA model is established and, therefore, energy consumption refers to direct energy consumption without considering indirect spillovers. There are a variety of different indexing methods that can be used in IDA. Ang (2004) provides a useful summary of the various methods and their advantages and disadvantages. Several of these have been applied in analyses of China's energy intensity. Huang (1993) uses multiplicative arithmetic mean Divisia indices to decompose energy intensity changes in Chinese secondary industry and the six sectors into which he divided it in the period 1980–1988 into the effects of structural change and improvements in energy intensities. The six sectors are: paper, chemicals, building, metal, mechanical–electric–electronic (MEE), and other secondary industry. He found that the main contribution to declining intensity in each industry is from the improvements in subsector intensity during the period. Most studies assume that such changes are the result of technological change. Structural change due to shifts of production among sub-sectors contributed little to the total change in Huang's study. The following terms are defined:

E_t: total industrial energy consumption in year t

$E_{i,t}$: energy consumption in industrial sector i in year t

Y_t: total industrial production in year t (2000 constant prices)

$Y_{i,t}$: production of industrial sector i in year t (2000 constant prices)

$S_{i,t}$: production share of industrial sector i in year t ($=Y_{i,t}/Y_t$)

$I_{i,t}$: energy intensity of industrial sector i in year t ($=E_{i,t}/Y_{i,t}$)

The total industrial energy consumption can be specified as follows:

$$E_t = \sum Y_t . \frac{Y_{i,t}}{Y_t} . \frac{E_{i,t}}{Y_{i,t}} = \sum Y_t . S_{i,t} I_{i,t} \quad [1]$$

And the change in total industrial energy consumption between base year 0 and year t can be decomposed in the following format:

$$\Delta E_{tot} = E_t - E_0 = \Delta E_{tot} + \Delta E_{str} + \Delta E_{int} \quad [2]$$

According to LMDI approach (Ang, 2004), these relationships are presented:

$$\Delta E_{out} = \sum w_{i,t} \ Ln(Y_t / Y_0) \quad [3]$$

$$\Delta E_{str} = \sum w_{i,t} \ Ln(S_{i,t} / S_{i,0}) \quad [4]$$

$$\Delta E_{int} = \sum w_{i,t} \ Ln(I_{i,t} / I_{i,0}) \quad [5]$$

$$\Delta E_{tot} = \sum w_{i,t} \ Ln\left(\frac{Y_t S_{i,t} I_{i,t}}{Y_0 S_{i,0} I_{i,0}}\right) \quad [6]$$

This research data are selected 1980 – 2009 as study period and the subsector data on industrial final energy consumption and industrial production from1980 to 2009 are collected accordingly.

3. Results

Table.1 and figure.1 show the primary energy consumption of the Iran economy.

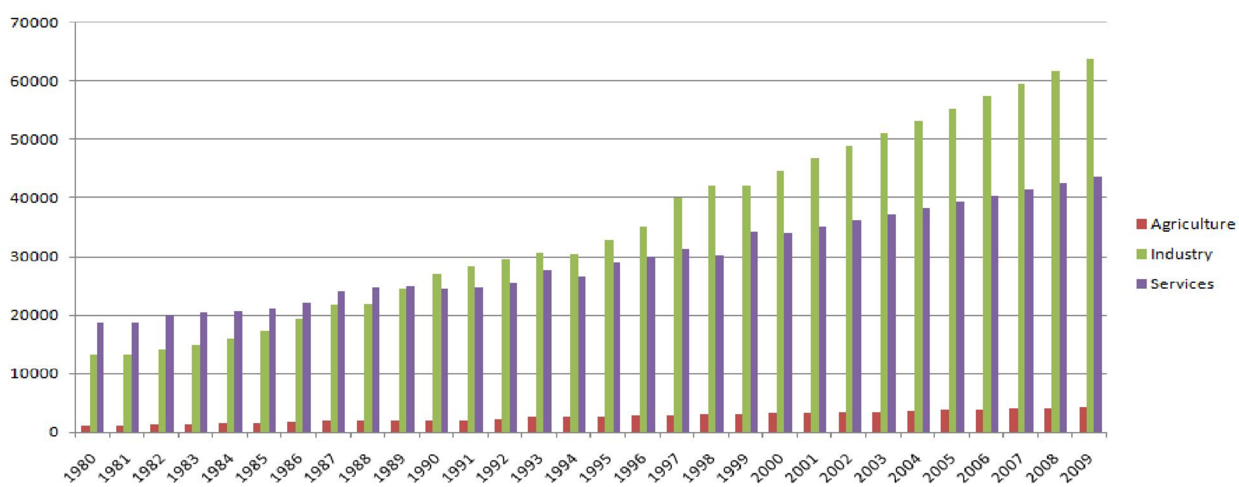


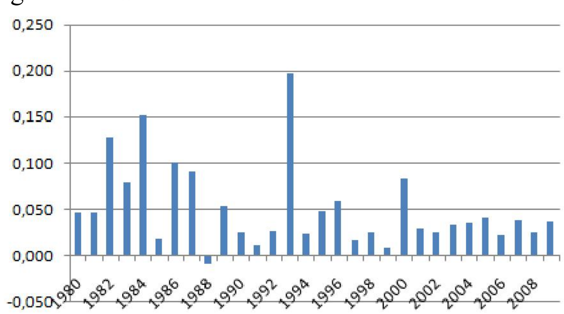
Figure 1: Primary energy consumption of the Iran economy

Table 1: Primary energy consumption of the Iran economy

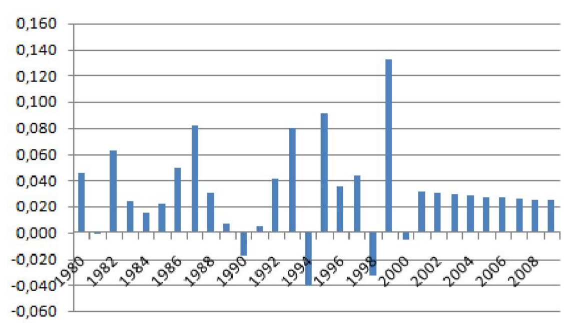
	TPEC (1000×toe)			
Year	Agriculture	Industry	Services	Total
1980	1030	13107	18767	32905
1981	1079	13160	18756	32994
1982	1217	13993	19929	35139
1983	1313	14908	20401	36622
1984	1512	15866	20713	38091
1985	1539	17332	21165	40036
1986	1694	19265	22208	43167
1987	1849	21741	24033	47622
1988	1833	22019	24758	48610
1989	1931	24531	24921	51383
1990	1980	27027	24490	53496
1991	2001	28288	24620	54909
1992	2055	29541	25637	57233
1993	2461	30708	27697	60866
1994	2519	30445	26561	59525
1995	2642	32722	28980	64344
1996	2799	35090	30003	67892
1997	2847	39930	31318	74096
1998	2921	42081	30308	75310
1999	2945	42096	34314	79355
2000	3190	44776	34125	82091
2001	3284	46754	35185	85223
2002	3368	48882	36246	88496
2003	3482	51128	37307	91917
2004	3605	53114	38367	95086
2005	3752	55325	39428	98504
2006	3837	57348	40488	101673
2007	3983	59587	41549	105119
2008	4081	61605	42609	108296
2009	4234	63743	43670	111647

In Figure.2, rate of changes in energy consumption for each sector and total economy is presented.

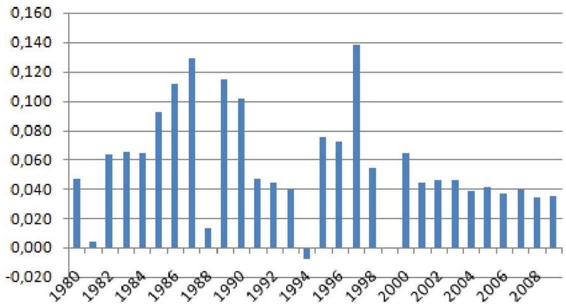
Agriculture Sector



Services Sector



Industry Sector



Total Economy

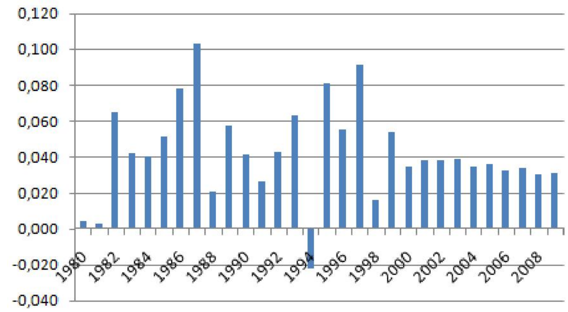


Figure 2: changes in primary energy consumption

In this step, the complete decompositions over the period from 1980 to 2009 are conducted. Tables.2 shows the decomposition results.

Table 2: Complete decomposition of energy intensity change

Year	Agriculture	Industry	Services	Total
1980-1981	0,048	0,004	-0,001	0,003
1981-1982	0,128	0,063	0,063	0,065
1982-1983	0,079	0,065	0,024	0,042
1983-1984	0,152	0,064	0,015	0,040
1984-1985	0,018	0,092	0,022	0,051
1985-1986	0,101	0,112	0,049	0,078
1986-1987	0,091	0,129	0,082	0,103
1987-1988	-0,009	0,013	0,030	0,021
1988-1989	0,053	0,114	0,007	0,057
1989-1990	0,025	0,102	-0,017	0,041
1990-1991	0,011	0,047	0,005	0,026
1991-1992	0,027	0,044	0,041	0,042
1992-1993	0,198	0,040	0,080	0,063
1993-1994	0,024	-0,009	-0,041	-0,022
1994-1995	0,049	0,075	0,091	0,081
1995-1996	0,059	0,072	0,035	0,055
1996-1997	0,017	0,138	0,044	0,091
1997-1998	0,026	0,054	-0,032	0,016
1998-1999	0,008	0,000	0,132	0,054
1999-2000	0,083	0,064	-0,006	0,034
2000-2001	0,029	0,044	0,031	0,038
2001-2002	0,026	0,046	0,030	0,038
2002-2003	0,034	0,046	0,029	0,039
2003-2004	0,035	0,039	0,028	0,034
2004-2005	0,041	0,042	0,028	0,036
2005-2006	0,023	0,037	0,027	0,032
2006-2007	0,038	0,039	0,026	0,034
2007-2008	0,025	0,034	0,026	0,030
2008-2009	0,037	0,035	0,025	0,031

It clears that primary energy consumption for service sector is so less that other sectors. Also primary sector for industry sector for years before 1990 is less that service sector, but after this year this section's energy consumption has improved.

5. Conclusion

This paper surveyed the application of LMDI for energy intensive calculation. Since the onset of economic reform and revolution in the late 1970s, Iran has experienced an increase in the energy intensity of economic output. While most studies consider the increase of real energy intensity within sectors as the dominant contributor, there is disagreement on the role of structural effects as well as the effect of sectoral disaggregation on the measured contribution of structural change. Based on a consistent set of data (1980-2009), this research examined the structural effects at three levels of sectoral disaggregation within one model using the LMDI method so that the contributions of structural change at different levels of aggregation are measured. The results showed that energy intensity changes for 1980-1996 are increasing and for rest of research period is constant or weakly decreasing. The energy intensities of Iran economy, which have historically been very high compared with other industrialized economies, has started to come down since the beginning of transition. Also there are meaningful differences between several sectors energy intensity changes, so intensity changes for industry sector is more fluctuate than other sectors. Finally it seems that in agriculture sector, energy intensity changes are so consistent. These analyses furthermore points at the importance of capital endowment and know-how as key drivers in the war year process. While there is a clear correlation between enterprise restructuring and energy use, there is little evidence that privatization, on its own, will decreasing the intensity of energy. These results due to the Iran's energy situations and policies are logical and predictable, because industry sector is so sensitive against the energy policies, but this discussion it not true for agriculture sector in Iran; the reason is that Iran's agriculture system is more traditional and is not together with the world level. The data for decomposition of energy intensity have shown different patterns in the evolution of energy intensity over the two last decades. An explanation for some of these patterns can be found in the various econometric techniques for analyzing of industrial energy intensity in Iran. Also for first years of this economy, the energy intensity of industry came down sharply, but that of the rest of the economy decreased less or remained so stable.

Corresponding Author:
Feisal Mirkazehi Rigi
Ph.D. in Economics from University of Pune
mirkazehirigifeisal@yahoo.com

References

1. Ang BW (2004). Decomposition Analysis for Policymaking in Energy: Which is the Preferred Method. Energy Policy. 32(2): 1131–1139.
2. Bloom N, Genakos C, Martin R, Sadun R (2008). Modern Management: Good for the Environment or just Hot Air. Working Pap. 14394. Nation. Bur. Economic Res.
3. Bloom N, Sadun R, Van Reenen J (2007). Americans Do I.T. Better: US Multinationals and the Productivity Miracle. Tech. Rep. 13085. Nation. Bur. Economic Res.
4. Bloom N, Van Reenen J (2007). Measuring and Explaining Management Practices Across Firms and Countries. Quarterly J. Economics. 122(4): 31-37.
5. Cornillie J, Fankhauser S (2002). The energy intensity of transition countries. European Bank. Working paper. 72: 1-26.
6. Fisher-Vanden, K, Jefferson G, Liu H, Tao Q (2003). What is Driving China's Decline in Energy Intensity. Resource and Energy Economics. 26(1): 77–97.
7. Garbaccio RF (1995). Price Reform and Structural Change in the Chinese Economy: Policy Simulations using a CGE Model. China Economic Rev. 6(1): 1–34.
8. Garbaccio RF, Ho MS, Jorgenson DW (1999). Why Has the Energy-Output Ratio Fallen in China. Energy J. 20(3): 63–91.
9. Hoekstra R, Van der Bergh JC (2003). Comparing Structural and Index Decomposition Analysis. Energy Economics. 25(1): 39-64.
10. Huang JP (1993). Industrial Energy Use and Structural Change: A Case Study of the People's Republic of China. Energy Economics. 15(1): 131–136.
11. Kambara T (1992). The Energy Situation in China. China Quarterly. 131(3): 608–636.
12. Lin X, Polenske KR (1995). Input-Output Anatomy of China's Energy Use Changes in the 1980s. Economic Sys. Res. 7(1): 67-84.
13. Martin R (2009). Why Is the USA So Energy Intensive? Evidence from US Multinationals in the UK. Centre for Climate Change Economics and Policy. Working Paper. 17(15):1-37.
14. Matheny AP (2010). Reducing the Impact of Price Shocks in Energy-Intensive Economies. Harvard Environmental Economics Program. 14(1): 1-34.

15. Sinton JE, Levine MD (1994). Changing Energy Intensity in Chinese Industry. Energy Policy. 17(3): 239-255.
16. Smil V (1990). China's Energy. Report Prepared for the U.S. Congress. Off. Tech. Assess. Washington. DC.
17. World Bank (2008). World Development Indicators 2008. World Bank. Washington. DC.
18. World Bank (2010). World Development Indicators. Online Database.
19. Worrell E, Neelis M, Price L, Galitsky C, Nan Z (2007). World Best Practice Energy Intensity Values for Selected Industrial Sectors. Ernest Ornaldo Lawrence Berkeley National Laboratory. Rev (1): 1-52.
20. Zha DL, Zhou DQ, Ding N (2009). The Contribution Degree of Subsectors to Structure Effect and Intensity Effects on Industry Energy Intensity in China from 1993 to 2003. Renewable and Sustainable Energy Rev. 13(4): 895-902.
21. Zhang ZX (2003). Why Did the Energy Intensity Fall in China's Industrial Sector in the 1990s? The Relative Importance of Structural Change and Intensity Change. Energy Economics. 25(1): 625-638.

8/21/2019