Role of Australian Energy Supply and Demand Fluctuations in Macro-Economic Development

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Abstract
Energy has an essential role in the economic and social development of all countries around the world, and its consumption is rising considerably due to the fast industrial development and increasing the standards of living. However, due to the high dependency on fossil fuel resources by all the developed and developing countries around the world to cover their energy supply needs, fluctuations in supply and demand of energy as well as the energy prices would definitely lead to considerable macro- and micro-economic effects for both the energy exporter and importer countries. Therefore, the necessity of stability of economy and its understanding is becoming more and more popular among policy-makers and researchers around the world.

As many energy consuming industries in Australia such as services and products are highly dependent on energy prices, understanding the economic robustness relationships with the supply and demand fluctuations of fossil fuel resources is important for the researchers and also policy-makers. In this paper, the effect of oil price fluctuations on several macro-economic parameters as well as energy sector’s resilience and electricity market as the main Australian energy economics issues are discussed.

Keywords: Energy System Resilience, Energy Price Fluctuations, Macro-economic, Fossil Fuels, Elasticity Method.

1. Introduction
The importance of energy for any society around the world is increasing rapidly. Almost all the human activities as well as every economic sector like communication, transportation, delivery systems, security, and health require a reliable and constant energy supply.

Although by the rapid population growth and also the improvement of life quality around the world the consumption of energy has increased considerably, having various energy resources as well as the proper access to these resources is completely essential for creatures and civilizations around the world [1]. In the recent years, the over-consumption of energy resources like fossil fuels by industrialized countries around the world has reduced these resources considerably, and serious environmental problems such as the climate change, water and air pollutions, and health risks have occurred [2]. However, different renewable resources such as the hydropower, geothermal, biomass, solar, wind, and marine energies by providing 19.3% of the world final energy consumption in 2016 proved to have the capability to supply a great portion of the human being energy needs as the inexhaustible and clean sources of energy [3, 4]. According to many researchers around the world, the fluctuations of oil price through the transmission mechanisms including both the energy supply and energy demand channels have different consequences on economic factors in both the oil importing and exporting countries. In the case of energy supply, as the production sector is highly dependent on the crude oil, the increase in oil price leads to an increase in the production cost, and as a result of this situation, many firms and producers are induced to reduce their outputs. Moreover, the oil price changes can have different consequences in the investment and consumption sectors [5, 6].

Australia by having 2.97 million square miles of land mass, as the sixth largest country in the world, and also a population of around 24 million people in 2016 with an annual growth rate of 1.57% has one of the most stable and diverse economies in the world. In 2015, Australia by having an annual economic growth of 3.3% succeeded to have an
uninterrupted annual economic growth for 25 years in a raw [7].
In addition, although Australia has an abundant variety of non-renewable resources such as oil, gas, coal, Liquefied Natural Gas (LNG), and uranium in order to enhance the energy security of the country as well as to meet its energy needs, it has encouraged the development of renewable electricity generation as well.
One of the statutory authority organizations established in this way to develop renewable energies in large and small scales is the Office of Renewable Energy Regulator [8, 9]. It should be considered that during the recent years, there have not been many research works on analyzing the oil price impacts on the different economic sectors like the total and industrial energy consumption, Gross Domestic Product (GDP), unemployment rate, and inflation rate. In this research work, using the elasticity method, different challenges and opportunities of the Australian economy as well as the electricity market situation and different economic factors including the total energy consumption are discussed and thoroughly investigated.
According to the statistics, Australia by exporting iron ore ($60 billion), petroleum gas ($16.3 billion), coal briquettes ($37.2 billion), crude petroleum ($9.1 billion), and gold ($16.3 billion) as the main primary exports, and by a growth rate of 7.7% annually is considered as the 21st largest exporter in the world during 2014. Moreover, the Australian top imports include crude petroleum ($16.2 billion), computers ($7.37 billion), refined petroleum ($16.6 billion), cars ($15.7 billion), and packaged medicaments (6.5 billion) [10]. The growth of GDP per capita of Australia is highly dependent on its major export earnings from its various mineral and natural resources like crude oil, uranium, LNG, black and brown coal, processed metals, and iron ore [11, 12]. Based on the plenty of research works, due to the imports from external markets and domestic production form the primary consumption of energy in Australia, the energy consumption and GDP per capita growth have a direct relationship with each other. During the 1970s and 1980s, the global economic recession due to the major oil price shocks declined the Australian GDP growth rate considerably. However it is worth mentioning that Australia by relying on the domestic energy production for 49% of its energy need and importing 51% its energy needs from imports in 2012 was considered as the 18th major energy consumer and the 14th high per capita GDP country around the world (Ma et al., 2016).
However, about 38% of this total energy consumption, which is a considerable portion, is consumed in the transportation sector, which has an influential impact on the Australian GDP growth rate. Moreover, it is worth mentioning that based on the Australian Department of Foreign Affairs and Trade, the contribution of trade to Australia's GDP was around 27%, and this amount increased to 41% of GDP in 2013. [7]. On the other hand, the per capita trade between the years 1960 and 1984 and from 1985 to 2012 increased consistently and also the mining sector increased during the years 2000-2009, and thus it can be deduced that per capita trade has a great impact on the GDP growth in Australia. The role of trade variables such as the export and import energies in the Australian macro-economic production function should not be ignored. In 2012 to 2013, the net energy exports in Australia (energy exports minus energy imports) between the years 2012 to 2013 were accounted for 68% of the total production of energy, and also during 2013-2014, the exports of energy accounted for 31% of the total commodity exports in Australia. However, Australia by producing different energy resources such as coal, which accounts for 59% of the total energy production in Australia, was the world's 8th-largest energy producer. Moreover, Australia by covering 35% of its oil consumption from imported crude oil and petroleum products, is also considered as the net importer of oil products during 2012-2013 [11].

2. Australian Economy and Energy Investment
Based on the World Bank data, the severe global financial crisis in 2008, which affected all the countries especially the most industrial and developing ones around the world, also affected the Australian growing economy. However, due to the several financial policies established by the government, the impact of the 2008 crisis on the Australian economy was less than many other countries.
Figure 1 shows the Australian economic growth. However, after the 2008 crisis, due to the more resilient financial system in Australia, the GDP production increased rapidly and also the inflation rate and interest rate decreased [13]. Australia by having the world’s 2nd rank in coal exporting, the world’s 3rd rank for uranium exporting, and also the world’s 4th rank for gas exporting is considered as one of the only three net energy exporters among the Organization for Economic Cooperation and Development (OECD) countries. The energy sector in Australia by forming around 16% the current country’s GDP has a major effect on the Australian economy [14].
Based on the statistics, Australia is considered as the 18th largest country in per capita energy consumption, the 9th largest country in energy production, and also the 17th largest fossil energy consumer in the world. The share of renewable energy resources in total energy consumption is still small (9.49% of total energy consumption in 2014), and it has targeted that through several policy instruments the renewable sources cover 20% of the Australia’s electricity demand by 2020 [15]. As shown in Figs. 2 and 3, increasing the oil price between 2004 and 2008 and between 2009 and 2013 and due to the high dependency of the transportation sector on oil that by increasing the oil price, transportation became more expensive as well, and as a result of that goods became more expensive, which also led to an inflation increase.

As shown in figure 2, the industrial production growth rate and GDP have a strong relationship with each other. By the oil price reduction during 2008-2009, the GDP growth declined as well, and also the industry growth decreased too, although there were more fuel available for the industry, and this was because of the fact that the economy shrunk during that period, and this affected the industrial growth. However, it is worth mentioning that it takes time for the industrial investments to reach their productive stage.

3. Energy Policies
H Providing the most adequate, affordable, and reliable energy sources for the future energy
consumption and economic growth demand requires establishing the proper energy policies, which play an essential role in developing the economy. Australia is one of the energy exporter countries in the world. Therefore, in the following section, the energy policy actions and programs that have been established by the Australian government in order to boost the economic development is reviewed thoroughly [14, 16, 17].

3.1. Economical and financial actions
There are several financial initiatives in every individual state in Australia in order to promote energy production and also boost the economic growth. Feed in Tariff (FIT) Schemes for small-scale power generation and run by Australian Capital Territory (ACT) are among the numerous established plans for providing the energy supply [18]. In addition, R&D Tax Incentive plans besides feed in tariff actions belong to the activities that development of renewable energies are almost established in all the industry sectors [19]. Moreover, solar energy and heat pump hot water system development plans under the financial assistance named by the Local Government Energy Efficiency Program (LGEEP) are provided for buildings and facilities in communities that are situated in low socio-economic or otherwise disadvantaged areas. In addition, solar power system installation funds and improving the energy efficiency in more than 5,310 schools besides educating students about the importance of renewable energies and energy efficiency are also among the Australian government energy improvement actions [19]. Moreover, under the Renewable Energy Bonus Scheme, those households that are eligible for replacing their electric hot water storage systems with heat pump or solar water systems, $1000 for a solar hot water system or $600 for a heat pump hot water system would be provided [18].

3.2. Trade Actions
Australia by removing the tariffs from almost all the energy products and resources exported to China such as coking coal and aluminum oxide is trying to seek for a better and more secure market access to the world important markets and also improve its economy as well as enhancing its competitive position, and by the help of these free trade agreements, reduces the import costs [20].

3.3. Governmental Organizations and Possessions
In the case of the governmental organizations in Australia, it should be mentioned that the National Electricity Market (NEM) connected grid runs across most parts of Australia [21-25]. In this kind of system, a number of electricity generators supply its electricity demand and then sell the electricity in a wholesale market. However, the smaller grids outside NEM are usually managed locally by the relevant territory or state [26-28]. The electricity sectors in each territory and sector are divided into the generation sector, transmission sector, and distribution and retail businesses sectors. Moreover, it is worth mentioning that almost all the gas pipelines are regulated by the private sectors and only some sections of gas market are regulated by the government [29-31].

3.4. Regulations
In order to boost the economy, there are a number of laws and regulations. The Australian government among which, the Community Energy Efficiency Program, which is part of the government’s climate change strategies, can be mentioned [19]. This merit-based grant program supports the projects that work on energy efficiency improvement in different sectors such as community buildings, facilities, and sites. In addition, the Energy Efficiency Information Grants Program and the Low Income Energy Efficiency Program are the other programs that assist the industry associations to reduce their operational costs by making decisions about energy efficiency and improving the energy efficiency of low-income households and enabling them to better manage their energy use and the Energy Efficiency Opportunities Program, which has been established for evaluation and identification of energy efficiency for large energy consumption corporations [19].

3.5. Research and Development
In the way of research and development policies in Australia, there are several agencies and organizations such as the Australian Renewable Energy Agency (ARENA), which is an independent government-established agency that has the two significant objectives of increasing the renewable energy electricity supply in Australia and improving the competitiveness of renewable energy technologies for the renewable energy development activities [20]. In addition, the first commercial-scale smart grid in Australia is another program that is part of the Smart Grid, Smart City project, managed by Australian Government's National Energy Efficiency Initiative. Moreover, in the case of the solar energy development, there are seven solar city programs working in partnership
with the local government and industrial consortia groups [34-36].

4. Energy Analysis of Australia based on Economic Factors

Based on the previous studies, it was revealed that the oil price fluctuations would lead to a significant effect on the Australian economic factors as one of the energy importer countries around the world, which is highly dependent on fossil fuels like oil to supply its energy needs. In this work, the elasticity method as one of the important economic methods to understand the effects of oil prices on different economic sectors was used, and various economic factors such as the impact of oil prices on the total and industrial energy consumption, inflation rate and gross domestic product (GDP), and unemployment rate were analyzed [37-40].

Generally, the elasticity method can be used in the economic studies in order to measure how responsive an economic variable is to a change in another economic variable.

In this work, stating the share of oil in GDP in Australia was calculated based on the elasticity measurements taken on the energy consumption of the consumers against changes in a country's GDP. However as in Australia energy consumption is very important for the development and as with an increase in the production and population growth, energy consumption increases subsequently, therefore, sustainable energy consumption is very essential in optimizing the efficiency of energy for most developed countries like Australia. In addition, by having the two amounts of GDP and the consumption of energy in the previous years, using the elasticity approach, the amount of energy consumption and GDP in the upcoming years can be forecasted (Bhattacharyya, S.C., 2011). Based on the elasticity standards, an energy consumption elasticity of more than one indicates that the share of oil in GDP is low, and changes in the oil prices has a trivial change in the GDP, whereas the elasticity amount of less than one indicates that the share of oil in GDP is high. In this work, the relationship between the crude oil price and GDP and also the effect of energy consumption on GDP and GDP on the industrial energy consumption was investigated based on the elasticity concept. Moreover, the GDP elasticity of oil price is an index to determine how energy is used in the production sector [41].

Table 1 shows the elasticity analysis data between the years 2004 and 2014. The energy consumption prediction based on the GDP growth and the elasticity concept is shown in equation (1) (Bhattacharyya, S.C., 2011):

\[
E_n = \frac{(Energy_n - Energy_{n-1})}{Energy_{n-1}} \cdot \frac{GDP_n - GDP_{n-1}}{GDP_{n-1}}
\]

where \(E\) is the elasticity, \(n\) is the year, \(Energy\) is the total energy consumption, and \(GDP\) is the gross domestic product. The data obtained from equation (1) is shown in Table 1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Poi ($)</th>
<th>GDP (BUS$)</th>
<th>Total Energy Consumption (PJ)</th>
<th>Industry Energy Consumption (PJ)</th>
<th>Elasticity (Poi-GDP)</th>
<th>Elasticity (E-total GDP)</th>
<th>Elasticity (E-industry-GDP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>37.66</td>
<td>612.69</td>
<td>5598.08</td>
<td>5400</td>
<td>2.51</td>
<td>0.05</td>
<td>0.18</td>
</tr>
<tr>
<td>2005</td>
<td>50.04</td>
<td>693.07</td>
<td>5640.08</td>
<td>5530</td>
<td>2.13</td>
<td>0.34</td>
<td>0.63</td>
</tr>
<tr>
<td>2006</td>
<td>48.3</td>
<td>746.88</td>
<td>5709.32</td>
<td>5800</td>
<td>0.71</td>
<td>0.20</td>
<td>0.06</td>
</tr>
<tr>
<td>2007</td>
<td>64.2</td>
<td>853.05</td>
<td>5865.34</td>
<td>5750</td>
<td>1.8</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>2008</td>
<td>91.48</td>
<td>1054.56</td>
<td>5964.62</td>
<td>5850</td>
<td>3.42</td>
<td>0.14</td>
<td>0.07</td>
</tr>
<tr>
<td>2009</td>
<td>53.48</td>
<td>926.56</td>
<td>5862.55</td>
<td>5800</td>
<td>1.42</td>
<td>0.16</td>
<td>0.11</td>
</tr>
<tr>
<td>2010</td>
<td>71.21</td>
<td>1142.25</td>
<td>5648.69</td>
<td>5950</td>
<td>1.03</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>2011</td>
<td>87.04</td>
<td>1389.92</td>
<td>5638.49</td>
<td>5960</td>
<td>0.06</td>
<td>0.13</td>
<td>0.01</td>
</tr>
<tr>
<td>2012</td>
<td>86.46</td>
<td>1537.48</td>
<td>5558.60</td>
<td>5965</td>
<td>3.16</td>
<td>0.29</td>
<td>0.05</td>
</tr>
<tr>
<td>2013</td>
<td>91.17</td>
<td>1563.95</td>
<td>5586.33</td>
<td>5970</td>
<td>0.87</td>
<td>0.26</td>
<td>0.04</td>
</tr>
<tr>
<td>2014</td>
<td>85.6</td>
<td>1454.68</td>
<td>5484.74</td>
<td>5955</td>
<td>6.46</td>
<td>0.02</td>
<td>0.62</td>
</tr>
<tr>
<td>2015</td>
<td>48.72</td>
<td>1498.56</td>
<td>5886.65</td>
<td>6105</td>
<td>0.56</td>
<td>0.25</td>
<td>0.09</td>
</tr>
<tr>
<td>2016</td>
<td>43.58</td>
<td>1586.65</td>
<td>5678.63</td>
<td>6245</td>
<td>1.02</td>
<td>0.08</td>
<td>0.22</td>
</tr>
<tr>
<td>2017</td>
<td>50.84</td>
<td>1598.65</td>
<td>5802.36</td>
<td>6165</td>
<td>0.71</td>
<td>0.36</td>
<td>0.65</td>
</tr>
<tr>
<td>2018</td>
<td>64.90</td>
<td>1623.15</td>
<td>6023.65</td>
<td>6269</td>
<td>1.65</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Geometry mean 1.3927 0.1146 0.0580

According to this table, it can be perceived that oil imports do not have very negative effects on GDP, and this is because of the elasticity of crude oil price to GDP, which is larger than one, and this means that GDP is not dependent on the oil prices.
In Australia, the share of the wind and solar energies has continued to rise considerably and the consumption of oil has decreased gradually, and also the coal production for domestic uses and exports has also increased. Moreover, based on the elasticity measurements, it was also revealed that the energy productivity in Australia, which is the ratio of gross domestic product to energy consumption, has risen considerably, which is due to the fact that Australia is trying to use more efficient systems and the total GDP elasticity (ETotal-GDP) that is smaller than one and shows that GDP does not have an intense dependence on the total energy consumption.

In addition, the latest statistics reveal that the government regulation actions have had a good effect on the optimal energy consumption, and as a result of that, the energy consumption has declined in most states and territories in Australia. Moreover, the amount of elasticity for the industry (EIndustry-GDP) is smaller than one and shows that the Australian industrial systems are using the energy in a more optimal way and that the Australian GDP does not rely on the industry productions, and it relies more on services, businesses, agriculture, investment, etc. The energy analysis for Australia shows a considerable growth of energy consumption in the mining, transport, and service sectors. However, transportation is considered as the largest energy consumer in Australia.

In this work, elasticity can also be used for estimation of the total energy consumption for Australia in 2020. According to the data taken from World Bank, the amount of GDP for Australia in 2020 is estimated to be about 1720 BUS$ [32-36]. However, according to Eq. 2, by considering GDP, the energy consumption can be predicted in 2020. As a result of the total energy consumption estimated using the elasticity method, it is estimated to be 12277.27 PJ.

$$E_n = \frac{(Energy_{2020} - Energy_{2014})}{Energy_{2014} \times \frac{GDP_{2020} - GDP_{2014}}{GDP_{2014}}} = Elasticity$$

$$\Rightarrow Energy_{2020} = 12277.27 \text{ (PJ)}$$

5. Electricity Market

The economic growth and the electricity consumption in different economic sectors have a direct relationship with each other. Figures 4 and 5 show the amount of electricity consumed by different economic sectors as well as the customer type, respectively. As it is perceived from figure 4, the domestic sector and the commercial sector are the most electricity consumers in Australia. Therefore, NEM, which contains the state government-operated infrastructure assets and also private business arrangements supplies the electricity to retailers and end-users in most parts of Australia for social, industrial, and commercial growth.

![Electricity consumption by different sectors in Australia.](image-url)
(AEMO), which has been created by the Council of Australian Government and manages NEM and gas markets as well.

![Figure 5. The number of electricity customers by sector.](image)

6. Conclusion

Although a great portion of the Australian energy needs is supplied from the domestic energy production (around 49% of TPES) and its gross domestic product (GDP) is highly dependent on export earnings of natural and mineral sources like black coal, brown coal, crude oil, iron ore, processed metal, uranium, and liquefied natural gas, it still highly depends on energy import (51% of TPES) to supply its different economic sectors such as the transportation, communication, security, health, and delivery systems. In this work, the elasticity method as one of the important economic methods to understand the effects of oil prices on different economic sectors was used and various economic factors such as the impact of oil prices on the total and industrial energy consumption, inflation rate and gross domestic product (GDP), and unemployment rate were analyzed.

Through the elasticity calculations, it was realized that the elasticity of energy consumption in Australia was less than 1 (ETotal-GDP < 1), which indicated that energy productivity (gross domestic product/energy consumption) had increased significantly more, and highly efficient systems were being used in different industries. In addition, through the statistics, it was realized that although the energy consumption in Australia had decreased in most states and territories, the government actions such as regulations and policies had a great effect on the optimal energy consumption.

References


