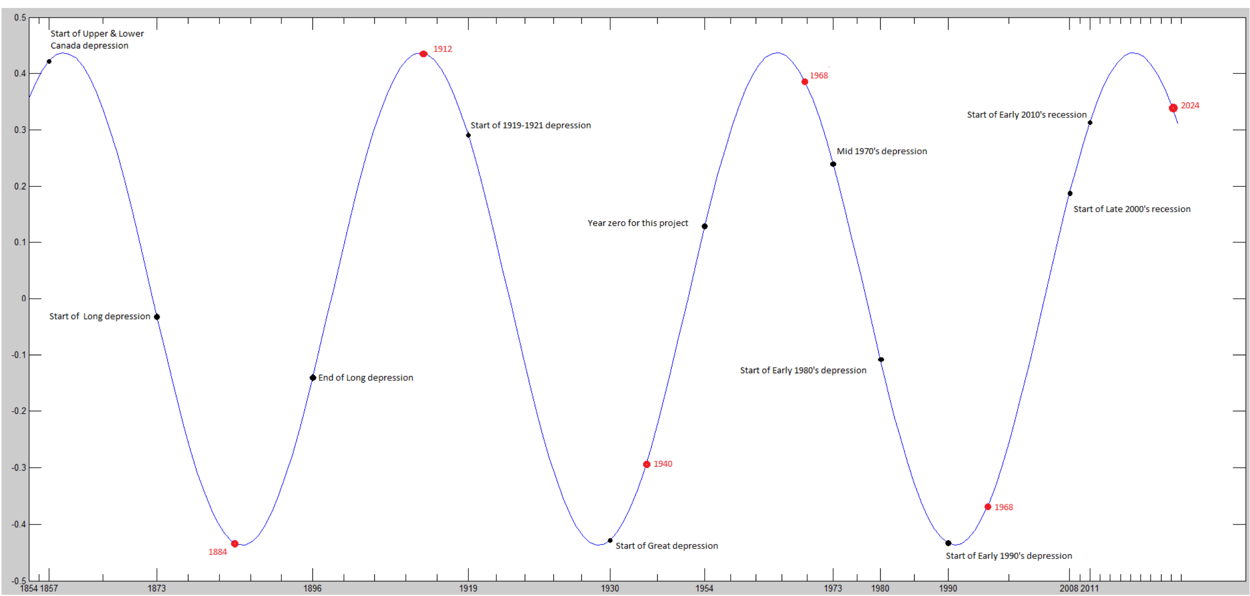
Technical University of Crete
Production Engineering and Management School

Forcast of economic cycles using the industrial energy consumption



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Abstract

The aim of this project is to investigate the behavour of a major European and global economy, that of the U.K. The norm used to do that was the I.E.C. The data collected was used to fit a sigmoid curve with variables the cumulative I.E.C. vs. time in years. Subsequently, the percentage difference between the various data points and the ideal sigmoid was calculated for each year, which was used to create a Kondratiev Wave (K-wave or Long wave) curve, the parameters of which, including each period, were evaluated. Matlab was used as a tool to form both curves. The results were then compared to a number of brake points of the U.K.'s economy and it was verified that those two did not contradict. Finally an attempt of a short term prediction was held and a number of propositions of future work on this project were given.

1.Theory

1.1 Sigmoid function

A sigmoid function is a function having an “S” shape (sigmoid curve). A definition of this function may be

$$S(t) = \frac{1}{1+e^{-t}} \quad (1.1)$$

which is a special case of the logistic function. This is depicted in figure 1.1

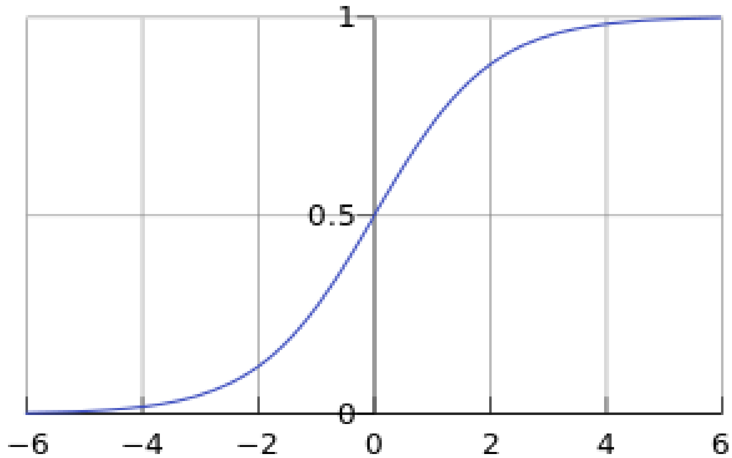

figure 1.1

The logistic function is not the only example of the sigmoid curve. Another one is the so called compentz curve, which is used in modeling systems that saturate at large values of t and yet another is the ogee curve, wed is the spillway of some dams. All the same, a wide variety of sigmoid functions are used to describe the behavior of evolution of populations as well as the activation function of artificial neurons, such as the hyperbolic tangent functions.

Strictly speaking, a sigmoid function is a bounded differentiable real function that is defined for all real input values and which has a positive derivative anywhere.

There is a pair of horizontal asymptotes, for $t \rightarrow \pm\infty$. The differential equation

$$\frac{d}{dt}\left(s(t)\right) = c_1 * S(t) * \left(c_2 - S(t)\right) \quad (1.1)$$

Together with a boundary condition, this providing a third degree of freedom, c_3, provides a class of functions of this type.

1.2 Sigmoid function in probability therory

In general, the integral of any smooth, positive, “bump-shaped” function will be sigmoidal. In this sense, the cumulative distribution function (C.D.F.) for many common probability distributions are sigmoidal indeed, the cumulative growth of a population is at first relatively slow, thus giving a derivative close to zero. In due time, this growth significantly increases and, after a crucial point (most of the time when the vertical axis is reached), the pace of growth starts decaying again, to reach an asymptotic horizontal saturation at the end of the phenomenon. All the above are shown in figure 1.2,

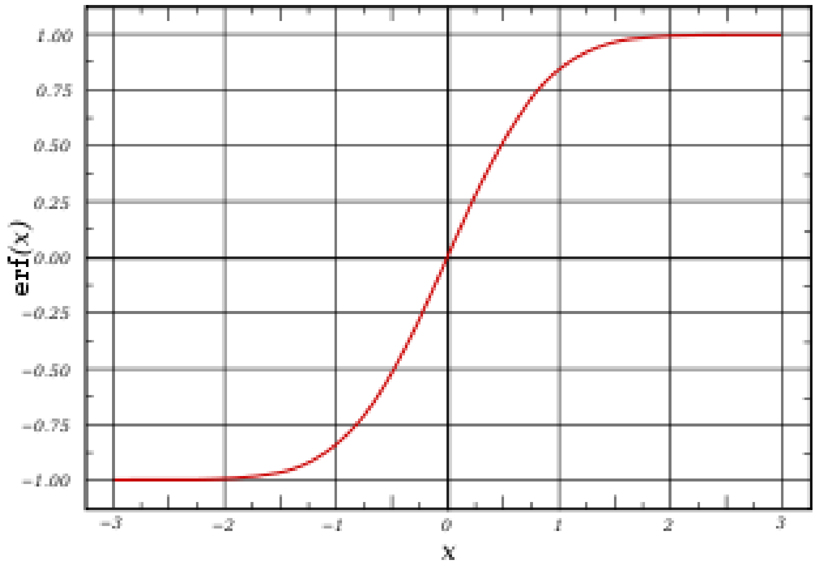

figure1.2

The climax of the horizontal axis does not always need to be symmetrical about t=0. When a phenomenon is described with respect to time, the horizontal axis may refer to seconds, minutes, hours and so on, which starts at t=0.

This can “glide” horizontally sing a DC component for time, starting the whole procedure e.g. at a specific time, year and so on.

1.3 K-Waves

K-Waves stand for Kondratiev waves, sometimes called supercycles, great surges, long waves or long economic cycle. They are sinusoidal-like cycles used in the modern capitalistic world economy. The cycles which were mentioned above, consist of alternating periods between high sectorial growth and periods of relatively slow growth. These cycles range from approximately fifty to sixty years.

A Kondratiev cycle has three phases:

- expansion
- stagnation and
- recession

Nowadays a fourth phase, namely collapse or turning point between the first and second phase is in use.

Kondratiev applied the theory to the 19th century:

- 1790-1849, with a turning point in 1815 and
- 1850-1896, with a turning point in 1873

An economic stagnation is created by the saturation of major markets such as agriculture during the transportation revolution or in infrastructures. This does not mean, however, that markets are mature. During 1790s the temporary oversupply, also brought a “creative destruction” in industries:

Iron was replaced by steel and labour by machinery and so on, which led to lowered credit standards and, finally, to high debt levels, followed by a crash. The same phenomenon exists nowadays including bubbles in the stock markets.

All the above are analysed in a better way if international, rather than national, production data is considered. Of course the pre-1870 cycles can only be seen in Western economies.

A long cycle affects all sectors of economy. Although Kondratiev focused mainly on prices, inflation and interest rates, such a cycles concerns mainly output rather than the elements mentioned above. Another aspect which has to be examined, though , is the so called structural deflation. This is a result of accelerating productivity growth. However, nowadays, non-asset deflation is not expected, as a result of that currency systems, low productivity growth and depleting natural resources, which cause prices to use. Economic stagnation is expected as a result.

During the last decades, there has been considerable progress in historical economics and the history of technology. As a result, a great number of investigations of the relationship between technological innovation and economic cycles have taken and are taking place. The most recent idea was held in 2002 by Perez, thought, who placed the phases of a cycle on a logistic ("S") curve, with the following labels:

- Beginning of the technological era was <u>irruption</u>
- The ascent was the <u>frenzy</u> period
- The rapid build out was named <u>synergy</u> and
- The completions was named <u>maturity</u>

Figure 1.3 shows the discrete phases of some K-Waves with respect to a number of technological innovations

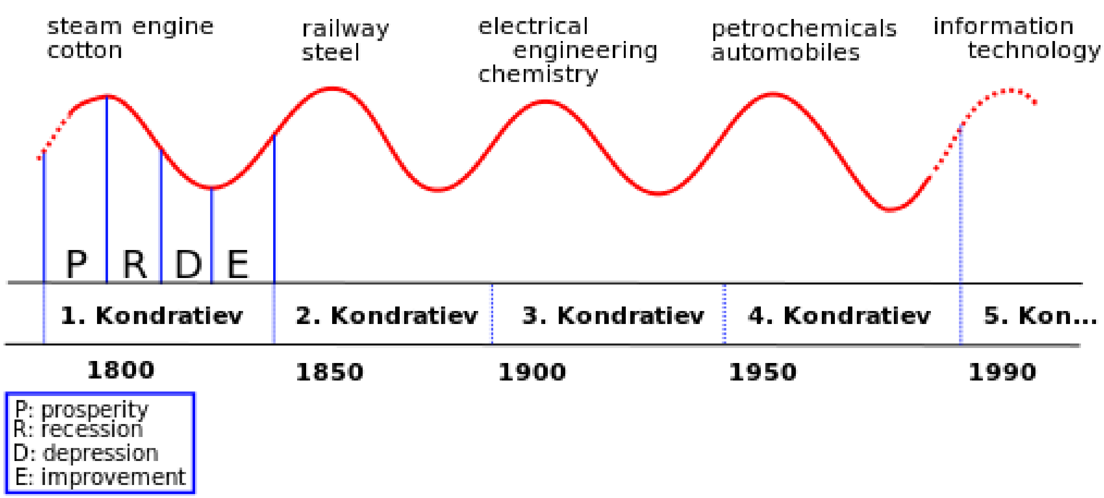

figure1.3

In figure, 1.4 the theoretical K-wave curve of the U.K. economy is shown. The minima are at 1884, 1940, 1996, 2052 (not shown in the curve) while the maxima at 1856, 1912, 1968, 2024. The curve can also be found in a bigger format in appendix A.1.

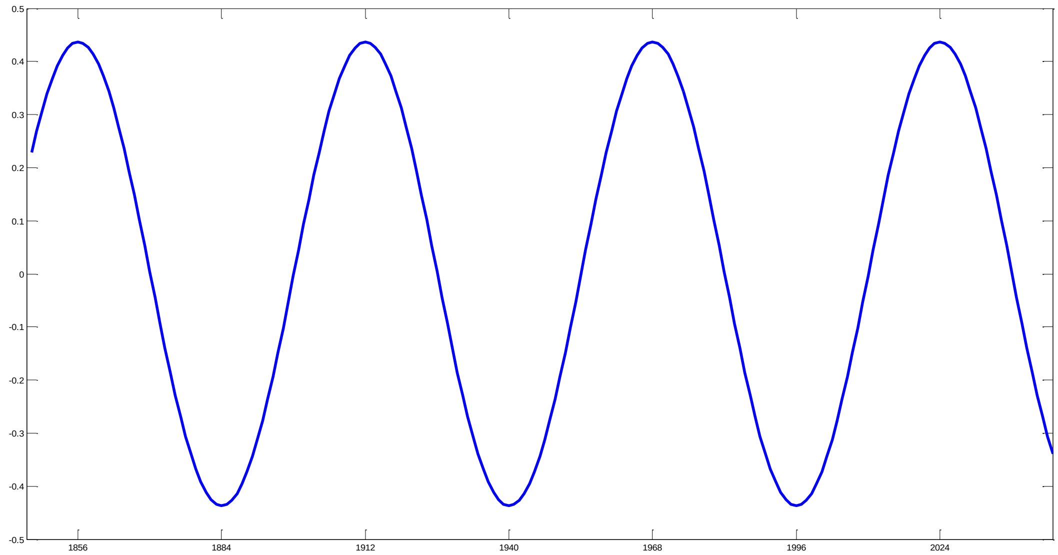

figure1.4

1.3.1 Explanations of the Cycle

There has been skepticism as to why capitalistic economies experience long waves. Several thoughts center upon innovations, capital investment, war, capitalistic crisis and land speculation, although some believe that war and capitalistic crisis do not affect the cycle. After thorough investigation, the range of possible cycles was found to be longer or shorter. In a special theory by Mandel, there are no long cycles, only eras of growth, faster or slower, spanning 20-25 years.

The most important theories on long waves are:

- The credit cycle theory, which focuses on excessive debt, internal and external, which leads to financial crises.
- The demographic theory, which states that typical spending patterns through people's life cycle, demographic anomalies exert a predictable influence on the economy
- The technological innovation theory which, as prementioned, long waves arise from basic technology innovations.

1.3.2 Modern modifications of K-Waves' theory

As present, timing versions of the cycle are based either on technology or the credit cycle. These technological cycles are

- The industrial revolution - 1771
- The age of steam railways - 1829
- The age of steel and engineering – 1875
- The age of oil, electricity and the automobile – 1908
- The age of Telecoms and information – 1971

On the other hand, according to the credit cycle theory, the economic cycle which started in about 1938 is just ending, the structure of economy having changed in the 80s, after a peak oil and steel use to what is called "FIRE" (finance, insurance and real estate) economy. A number of recessions, mainly in the 70s and 80s took place, but those cannot be accounted for as depressions (like the 1870s and the 1990s).

1.4 Royston's Spiral of life

Michael Royston, in a 1982 paper suggested that human life evolves in a spiral-like way, going through four levels: discharge, relaxation, charge and intensity, after which there is a return to the starting point but enriched with new knowledge, experience and power. The period of discharge, is a period of economic prosperity. Relaxation is characterized by economic recession. Charge is a period of new technology, while intensity is a period of evolution which leads, once more, to discharge and prosperity. The cycle completes in a 56 year time interval and, then, repeats itself. Figure 1.5 shows such a spiral starting at 1884 and conclude in 2052. The four levels of the spiral are also indicated.

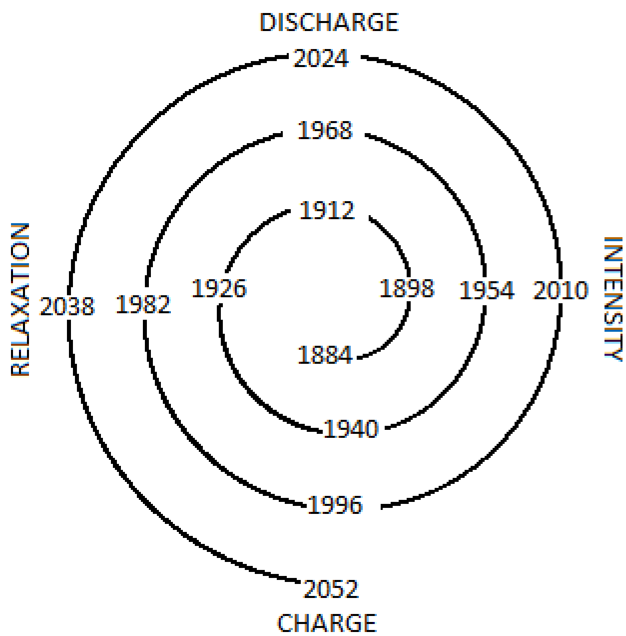

Figure 1.5 Royston's Spiral of life

It should be mentioned that, although, a pretty large number of human activities follows the same spiral, in some cases this fact does not apply, for example the evolution of personal computers

2. Historical data

2.1 Economy of the UK

The economy of the United Kingdom is the seventh largest in the world when measured by GDP and the eight largest when measured by PPP. When measured per capita both GDP and PPP place the UK in the 22th position in the world

In the 18th century the UK was the first country in the world to industrialize and during the 19th century, the country played a dominant role in the global economy. Although during the late 19th century, the Second Industrial Revolution took place, both the First and Second World Wars weakened the UK's economy. However, still, the UK maintains a significant role in the global economy.

The UK has one of the most globalized economies. In 2010-11, the country had the third largest stock of both inward and outward foreign direct investment. The aerospace as well as the pharmaceutical industries, together with the North Sea oil and gas reserve play an important role in the country's economy although this has weakened after the late 2000s recession.

This project will focus on the post-2nd World War up to the present period since this is the epoch of interest of it.

1945-1979: Just after the war, the UK enjoyed a long period without a major recession. This ended in 1973, after the oil crises and a stock crash occurred in 1973-74. Even after the recession, in 1975 the economy suffered a double-digit inflation and unemployment. Finally in 1979 this made the government to fall.

1979-1997: Neo-liberal economics began in 1979, with most state owned enterprises being privatised, taxes cut and markets deregulated. At first, GDP fell but, having its peak in 1988 it considerably rose. However, mass unemployment took place due to the closure of not economically viable enterprises (such as cool pits and factories). British economy slid into another recession after 1995.

1997-2008: The governing party changed again on 1997 and an economic growth started. This ended in 2008 due to the global financial crisis. Banks collapsed and soon unemployment reached a peak.

2008-present: The crisis ended in the fourth quarter of 2009, after since consecutive quarters of negative growth. A positive growth followed but again, in the early 1012 the UK entered a new recession, which seems to give their place in July 2012, when industrial production growth increased significantly again. Table 2.1 shows the trend of GDP of the UK in millions of pound sterling

Table 2.1

Year	Gross domestic product	US dollar exchange	Inflation index (2000=100)	Per Capita Income (as % of USA)
1925	4,466	£0.21	3	61.79
1930	4,572	£0.21	3	66.08
1935	4,676	£0.20	2	85.67
1940	7,117	£0.26	3	74.28
1945	9,816	£0.25	4	50.93
1950	13,162	£0.36	5	38.26
1955	19,264	£0.36	6	42.54
1960	25,678	£0.36	7	47.86
1965	35,781	£0.36	9	49.96
1970	51,515	£0.42	11	44.04
1975	105,773	£0.45	20	55.54
1980	230,695	£0.42	43	78.57
1985	354,952	£0.77	60	46.84
1990	557,300	£0.56	76	76.62
1995	718,383	£0.63	92	71.84
2000	953,576	£0.65	100	72.29
2005	1,209,334	£0.54	107	90.17

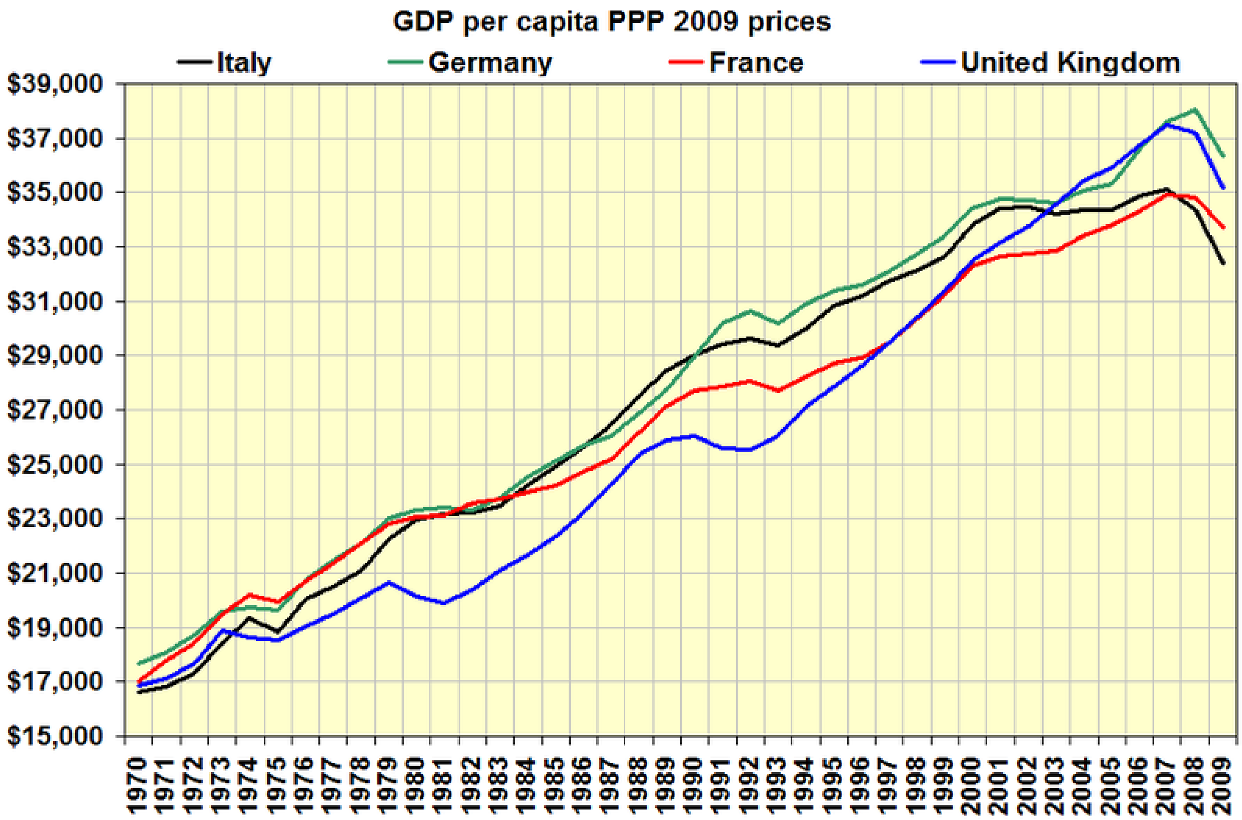
GDP per capita PPP 2009 prices
Italy
Germany
France
United Kingdom
$39,000
$37,000
$35,000
$33,000
$31,000
$29,000
$27,000
$25,000
$23,000
$21,000
$19,000
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Figure 2.2

2.2 Recessions in the UK

The following table (table 2.2) shows the most important financial depressions and recessions starting at mid-19th century.

Name	Date	GDP reduction	Causes
Upper & lower Canada depression	1857-1862		Post war problems, ongoing industrial revolution
Long depression	1873-1896		World-wide
1919-1921 depression	1919-1921	10.9% 1919 6.0% 1920 8.1% 1921	End of World War 1
Great depression	1930-1931	0.7% 1930 5.1% 1931	UK came off gold standard Sept 1931
Mid 1970's depression	1973-1975	~3.5%	Oil crisis
Early 1980's depression	1980-1982	~5.9%	Company earnings decline unemployment
Early 1990's depression	1990-1992	2.5%	Loan crisis
Late 2000's recession	2008-2009	6.0-7.1%	Financial crisis
Early 2010's recession	2011-2012	1.1%	European sovereign debt crisis

Table 2.2

2.3 Energy use in the UK

The energy use in the UK was 3894,6 Kg of oil equivalent (TOE) per capita in 2005. The world average was 1778.0. During 2008, the total energy consumed in the UK was 234.439 million T.O.E. This can be mainly be divided into coal, fossil fuels, natural gas and electricity consumption. The generating capacity comes from coal, oil and lately, nuclear plants. Table 2.3 gives percentages of sources of the total electricity production in 2009

- Gas - 39.39% (0.05% in 1990)
- Coal - 33.08 (67.22% in 1990)
- Nuclear - 19.26% (0% in 1990)
- RES - 3.55% (0% in 1990)
- Hydroelectric - 1.10% (2.55% in 1990)
- Imports - 1.96% (3.85% in 1990)
- Oil - 1.12% (6.82% in 1990)

It should be mentioned that an “energy gap” is most likely to arise soon in the UK, the reason being the closure of a number of coal-fired power stations since they are unable to meet the clean air directive 2001/80 of the EU. If no action takes place, there will be a 20% shortfall in electricity generation capacity by 2015

3.Method

3.1 Data collection procedure

Since it was decided the industry energy consumption to be used as a measure of prosperity in the UK, the appropriate data had to be collected. The most trustworthy source was the UK National Statics organisation, which directed the writer to the Department of Energy & Climate Change. Eventually the following table was acquired (table 3.1)

year	Industrial Electricity consumption
1960	44.51
1961	-
1962	-
1963	-
1964	-
1965	58.54
1966	60.11
1967	60.91
1968	66.15
1969	70.34
1970	72.99
1971	73.43
1972	73.16
1973	80.07
1974	75.81
1975	75.36
1976	80.84
1977	82.06
1978	84.00
1979	87.55
1980	79.73
1981	77.03
1982	73.91
1983	74.17
1984	78.64
1985	79.53

1986	88.80
1987	93.14
1988	97.14
1989	99.42
1990	100.64
1991	99.57
1992	95.28
1993	96.84
1994	96.12
1995	101.78
1996	107.63
1997	108.10
1998	108.44
1999	112.25
2000	115.29
2001	112.50
2002	110.82
2003	109.93
2004	112.09
2005	116.70
2006	115.53
2007	113.41
2008	114.72
2009	100.34
2010	104.94

Table 3.1

Table 3.1 is abridged the initial table contained information about fuel inputs, energy supply generation and consumption, GDP and other aspects of economy which were omitted since they were not to be used in the project. The whole table of data can be found in appendix A.1

3.2 Data Processing

3.2.1 Creating the Sigmoid

Using the following simple code,

```
datasum(1)=TWh(1)
for i=1:46
     datasum(i+1)=TWh(i+1)+datasum(i)
end
```

the cumulative Industrial Energy Consuption was obtained.

The data of table 3.1 was then fitted to create a sigmoid curve by means of Matlab. First of all the data was inserted to the Curve Fitting tool of Matlab. Using Equation 3.1

$$y = M * \exp(a * x + b)/(1 + \exp(a * x + b)) \quad (3.1)$$

which is the definition of the Sigmoid used. In that, the horizontal (x) axis is the non-biased (starting at x=0) year of consideration, while the vertical (y) axis is the Cumulative Energy consumption in TWh. M, a and b are parameters to be evaluated by the Curve Fitting tool. These parameters determine the steepness of the curve. It should be mentioned that a polarisation (DC component adding) of 1954 years took place i.e. the start (year zero) was 1954 A.D., year 1 was 1955 A.D. and so on. The curve that occurred will be presented in the next chapter.

3.2.2 The Long waves curve (K-waves)

Using the code

```
M =       130.2;
a =     0.04453;
```

```
b =     -0.1656;

data=datasum';
for x=1:46
      results(x)=M*exp(a*x+b)/(1+exp(a*x+b))
end

 percentage_diff=(results-data)./data;

subplot(2,1,1)
plot([1:46],results,[1:46],data)
subplot(2,1,2)
plot([1:48],percentage_diff)
```

the percentage difference of the numerical data and the ideal Sigmoid was found. These differences were subsequently fitted, using the Curve Fitting tool, into a K-wave curve defined as

$$y = a1 * \sin(b1 * x + c1) \quad (3.2)$$

Were axis x is the time (in years) and axis y is the percentage difference and a1,b1,c1 parameters. It should be noted that the coefficient of the time x, namely b1, is the circular frequency ω of the periodic phenomenon. Since

$$\omega = 2\pi/t \quad (3.3)$$

Evaluation of b1 will also evaluate the period T of the event. A graphical presentation of the prementioned curve will take place in the next chapter.

4. Presentation of results

Following the procedure that was described is the previous chapter, the part of the sigmoid curve fitted between the data points is shown in figure 4.1

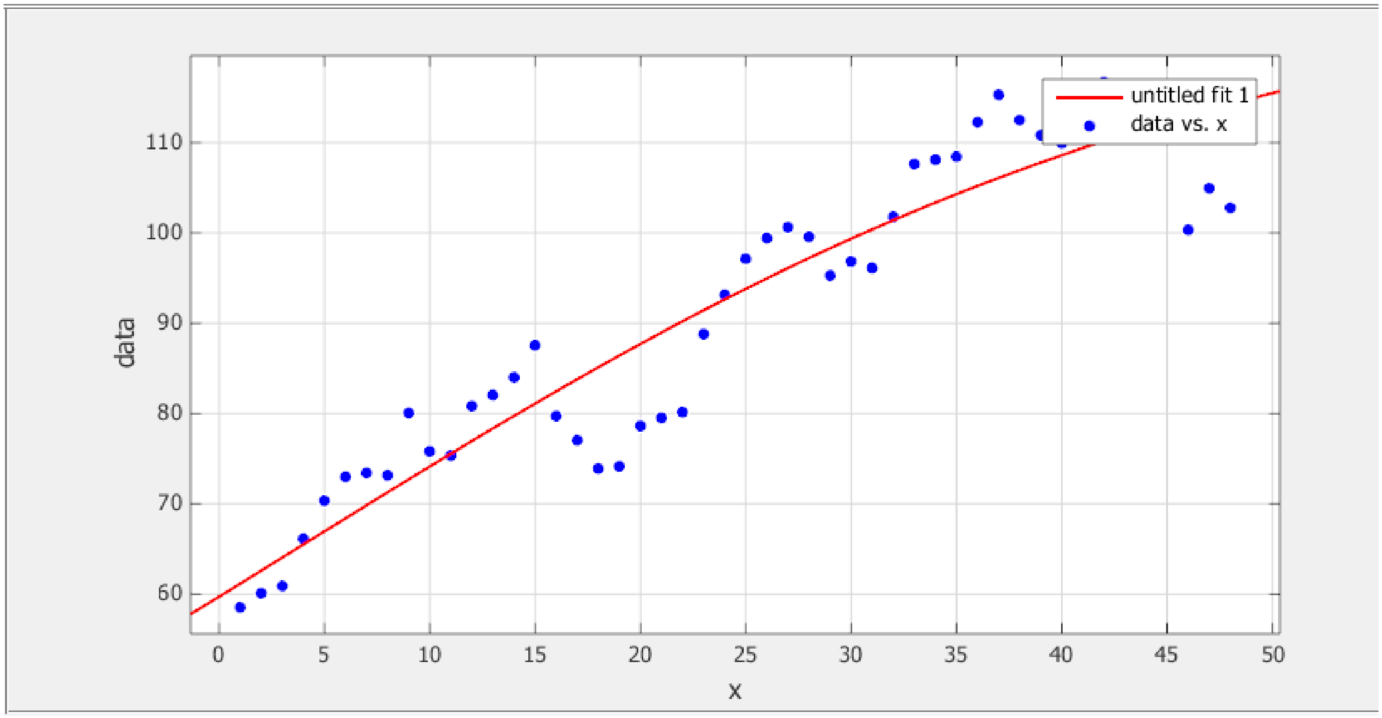


Figure 4.1

Parameters M, a and b were evaluated by Matlab as show in table 4.1

Results

```
General model:
   f(x) = M*exp(a*x+b)/(1+exp(a*x+b))
Coefficients (with 95% confidence bounds):
     M =       130.2  (108, 152.4)
     a =     0.04451  (0.02495, 0.06407)
     b =     -0.1658  (-0.4078, 0.07622)

Goodness of fit:
  SSE: 1610
  R-square: 0.8837
  Adjusted R-square: 0.8785
  RMSE: 5.981
```

Table 4.1

The curve present above is not the entire sigmoid curve though, which is presented in figure 4.2

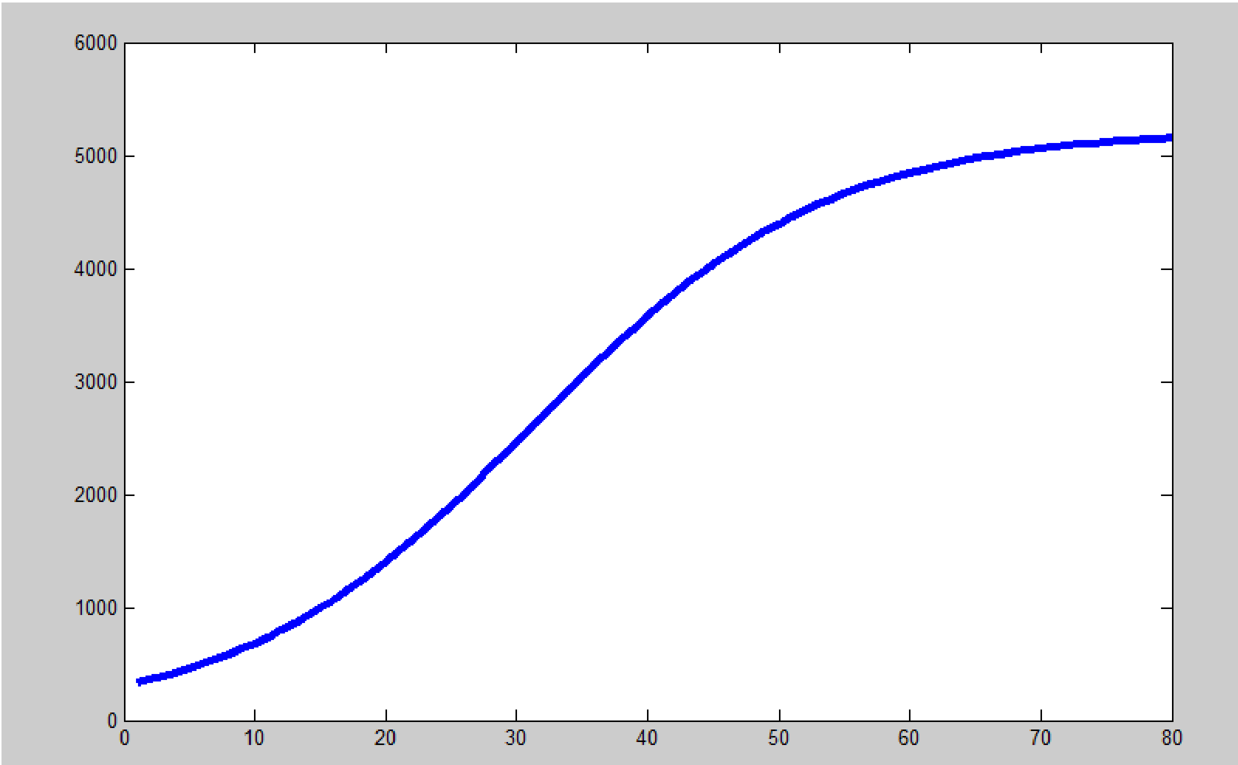


Figure 4.2

The following should be mentioned: even though the start of the curve is the year 1954, virtually no data exists up to 1965 (with the exception of 1960). The decision of using year 1954 as the start will be given eventually

As far as the long wave curve, this is presented together with the data points in figure 4.3

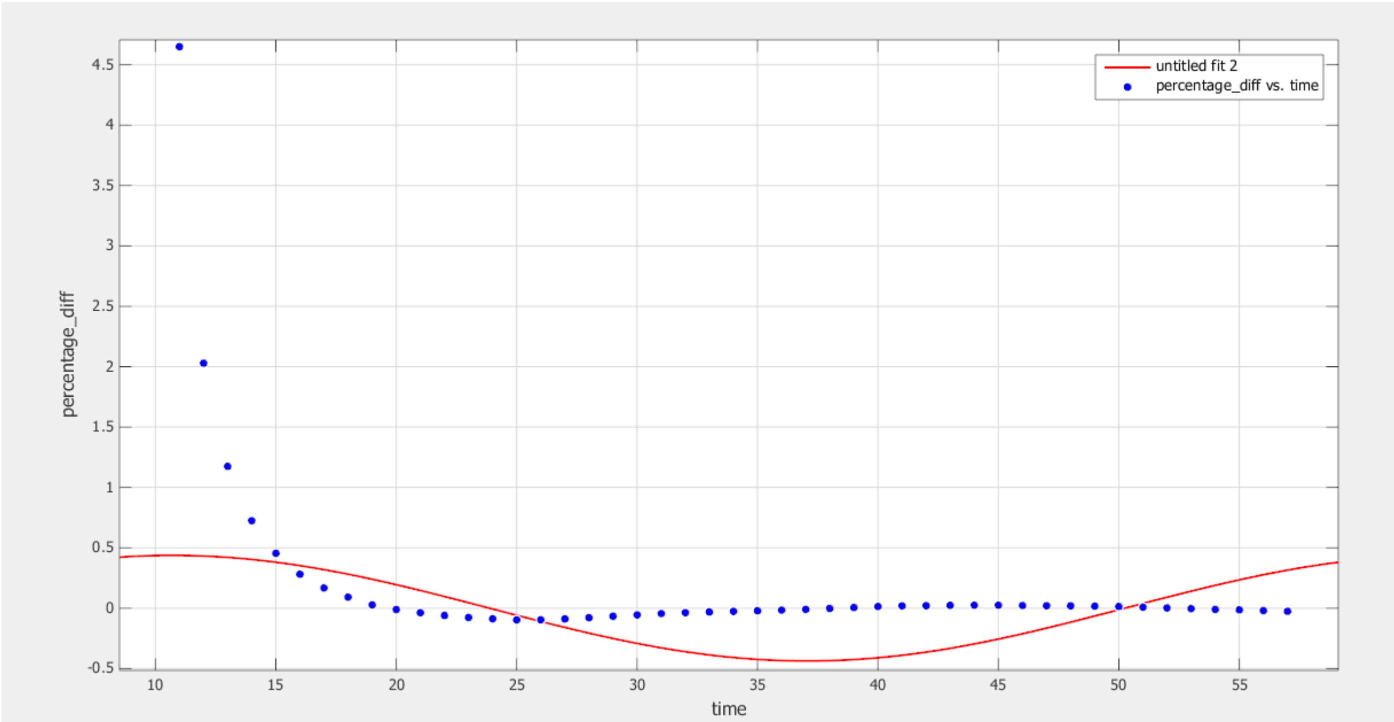


Figure 4.3

The parameters a1,b1,c1 are shown in table 4.2

Results

General model Sin1:
f(x) = a1*sin(b1*x+c1)
Coefficients (with 95% confidence bounds):
a1 = 0.4371 (0.1079, 0.7663)
b1 = 0.1191 (0.06852, 0.1697)
c1 = 0.2976 (-1.67, 2.265)

Goodness of fit:
SSE: 23.92
R-square: 0.09312
Adjusted R-square: 0.0519
RMSE: 0.7373

Table 4.2

The period of the K-Wave is $T = \frac{2\pi}{b1} = \frac{2\pi}{0.1191} = 52.7555\ years$ which is satisfactory.

The curve showing somewhat longer than two cycles is presented in figure 4.4.

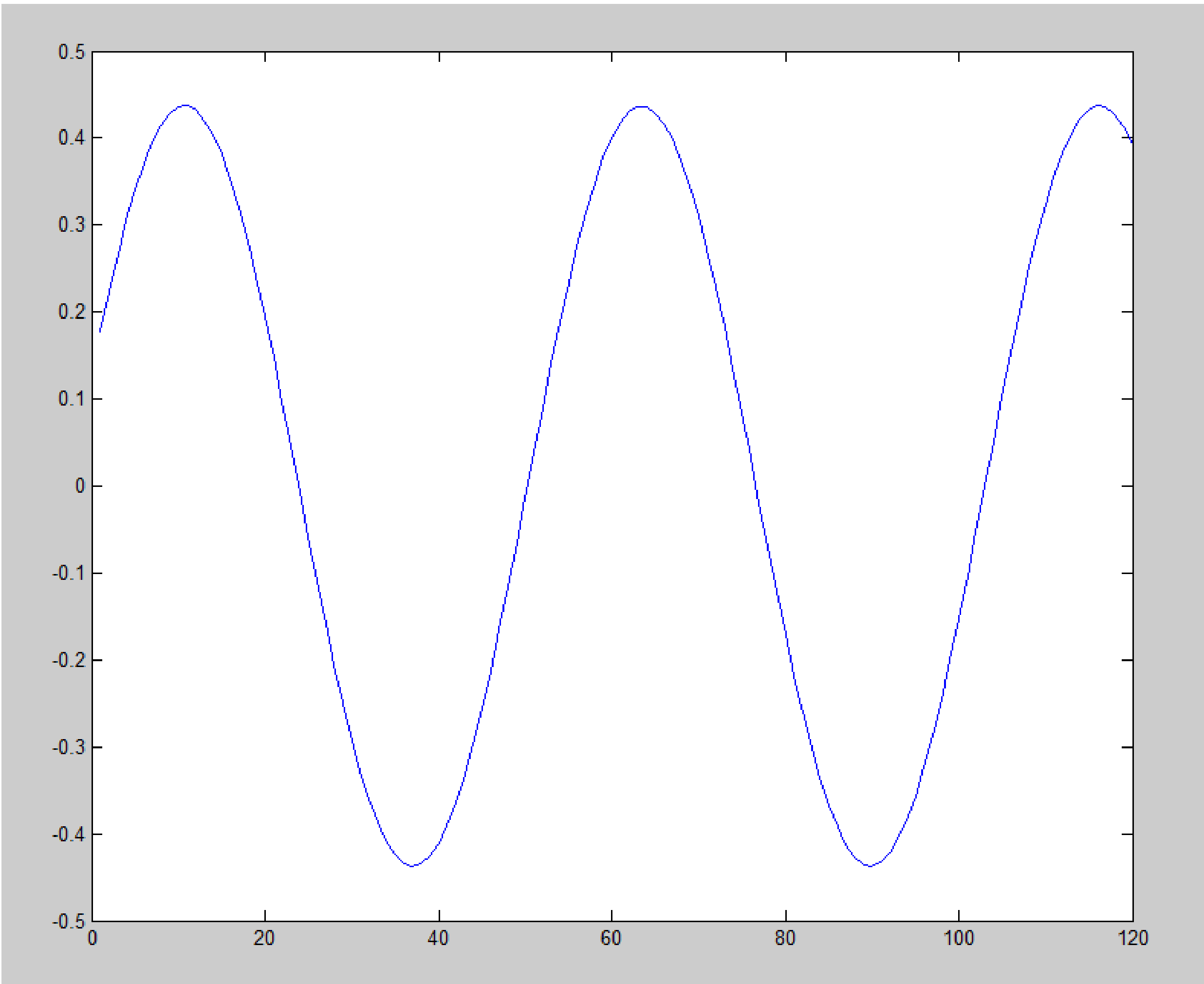


Figure 4.4

The matlab code to active this curve can be found in appendix A.2

Figure 4.5 is repetition of the previous figure containing the time points of the start of all depressions and recessions (for the Long depression of 1873-1896 the end point is also included). The theoretical maxima and minima are also included in the curve. These are indicated in red colour.

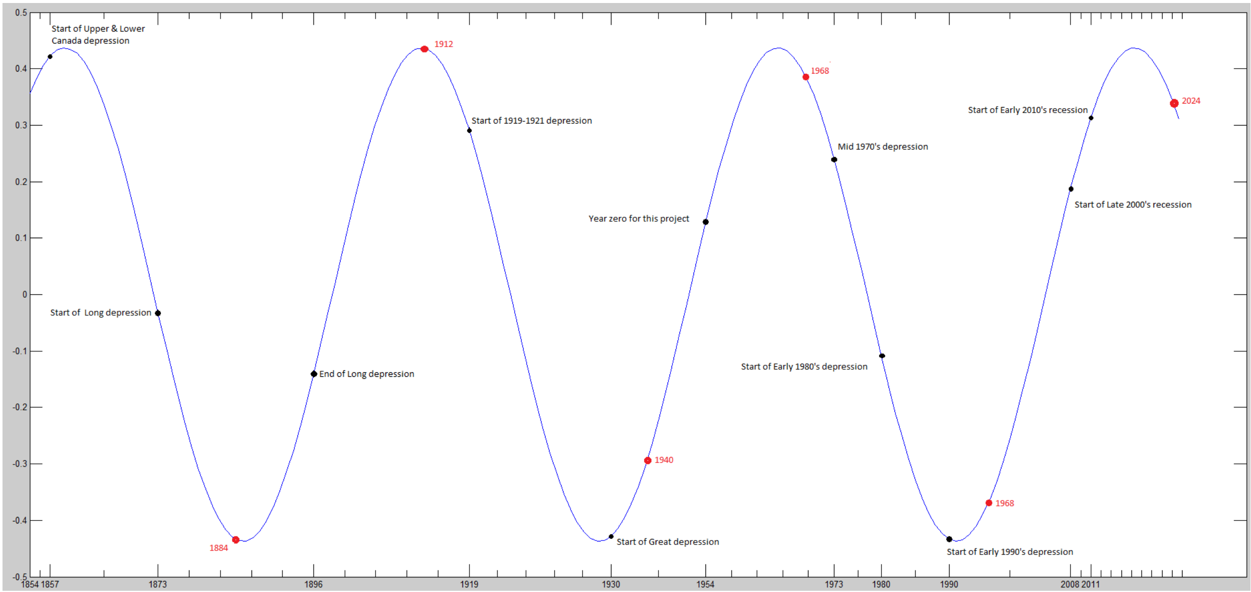


Figure 4.5

Due to the fact that the graph of figure 4.5 is too small it is presented again in appendix A.3. The aim of this figure was to compare the theoretical results with the actual UK depressions and recessions of the 19th, the 20th and the early 21st century.

5. Commentation of the results

As shown in figure 4.1 and 4.2 the choice of industrial energy consumption as a measure of economic prosperity (and recession) was successful. Indeed the cumulative I.E.C. follows the shape of a sigmoid curve, starting at 1954 and, after a short period of relatively small rise it then grows rapidly, breaking in about 2000 and then, ideally, asymptotically tending to a constant value. The dispersion of the actual data points from the fitted curve seems to be higher in about the middle of the curve, which is years 1980-1990. This phenomenon happens because during this period, the Early 80's depression occurred (the dispersion between 80-85 is bigger). As it will be explained later on, this time interval corresponds to the local minimum of the K-wave curve of figure 4.5. The same phenomenon appears to repeat itself later on, due to following economic rescissions.

The choice of the starting year is of great importance since it affects the steepness of the sigmoid curve. The decision of 1954 was made because this is the midpoint of the 1940 -1968 anodic time period. When the starting year changes, the sigmoid curve also changes, leading to mischiefing results. This decision makes sense even though no data exits for 1954-1964 period, with the exception of 1960. This is the reason why the starting part of the sigmoid may not be very accurate. The same comment applies to the end of the curve, which refer to the future.

On the other hand, observation of the K-Wave curve, figure 4.3, showed that the first data points start very far away from the sinusoid and after, a while they converge to a slightly fluctuating round zero curve. The reason for this is, again, the fact that no data existed for the first 11 years. Under these circumstances, the period of the long wave curve was found equal to 52,7555 years which is very close to the theoretical period of 56 years. One should know that this is a mean period of a long wave though. Matlab gives a range of values for the parameters of the curve thus giving a lower and upper limit for the fitting to have sense. The upper limit for this period is 91.698 years, corresponding to a value of the parameter b1=0.06852, while the lower limit was found 37.919 years for b1=0.1697.The theoretical value of T=56 years occurs when b1=0.1122. We did not choose b1 to be equal to the theoretical value for obvious reasons.

Matlab provides us with the possibility of excluding certain data points and then fit the appropriate curve. When this was done, for the first 4 to 5 first data points, the parameters of the K-wave were significantly altered. In particular the period of the long wave found to be very far off the theoretical value since it was circa 28 years

The general conclusions concerning the long wave curve are

- There is always a depression round the minima of the curve. Especially for the Long depression this period covers 23 years, from 1873 to 1896.
- Depressions also exist after the maxima of the curve. These depressions do not last for long though
- The prementioned maxima and minima almost coincide with those mentioned in § 1.4, figure 1.5. In particular the period round the minima of the curve is the start of the charge period, the ascending part of the curve is the intensity leading to the maxima which is the start of discharge, while the descending part of the curve is the relaxation. It should be mentioned that all the above are intervals rather than points on the curve.

Farther examination of figure 4.5 reveals the fact that, during the present long wave, depressions and recessions, though shorter, become more frequent. For this reason starting the sigmoid curve at 1954 was the right thing to do instead of considering an earlier date as the starting point. Bearing that in mind the period of consideration i.e. 1854 up to the present (and, perhaps, even farther in time) can be accommodated by a number of sigmoid curves rather than a unique one.

5.1 Attempting a prediction

If someone tries to make a prediction of what will happen in the U.K. economy in the near future years, they should know that the present is virtually the intensity point, which means that development is taking place. This place is moving to discharge (within the next few years) which translates to prosperity and well-being. Then, the cycle will pass through the other two phases and so on. Should this happen yet needs to prove. If this is the case a new depression about 2035, give or take a few years, is likely to happen.

6. Conclusion

The choice of I.E.C.as a norm of economic behavour was proved to be correct, both the sigmoid and the Long wave curves were found to follow the general history and trends of the U.K. economy. Diversions of the theoretical values occurred but in affordable levels. In particular the period of the K-waves was found to be equal almost to 52.8 years and not 56 years as the theory dictates. This shrunk the K-wave curve thus shifting the points were major economic events (depressions, recessions etc.) happen. Apart from the above, another reason for this diversity is the fact that Long waves describe the microscopic behavour and trend of human activities, such as the economy.

7. Proposal for future work

7.1 Choosing more precise parameter values

In chapter 5 it was stated that when the value of parameter b1 is chosen equal to 0.1122 the period of the Long wave becomes exactly 56 years. One could investigate under which circumstances this can be achieved.

7.2 Excluding data points

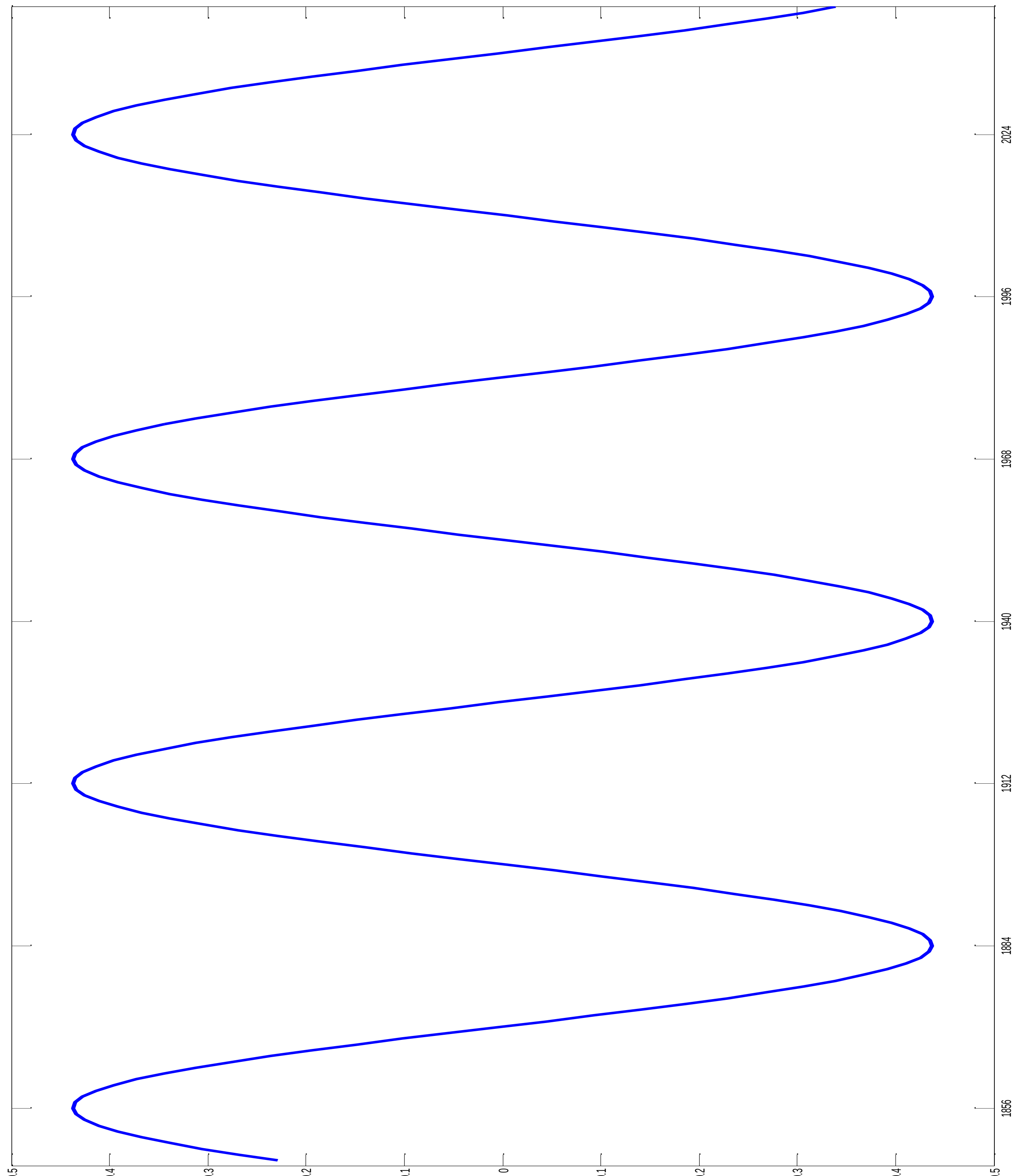
When awkward data points are excluded before fitting the sinusoidal curve the parameters of the Long wave, the period included, also change. This requires further investigation.

7.3 Choosing other norms

I.E.C. proved to be a fair measure of economic trends, one could work on the possibility of other aspects of economy e.g. household or public energy consumption being chosen as a norm, compare results and note any similarities and/or differences.

Appendix

A.1



A.2

Historical electricity data: 1920 to 2011

Fuel input for electricity generation (1)   (Million tonnes of oil equivalent)

	Total all fuels	Coal (7)	Oil (2)(7)	Natural gas (3)	Electricity Nuclear	Electricity Natural flow hydro	Electricity Wind	Coke and breeze (7)	Other fuels (4)
1920	3.68	3.67	0.02	-	-	0.00		-	
1921	3.19	3.10	0.09	-	-	0.00		-	
1922	3.21	3.17	0.04	-	-	0.00		-	
1923	3.62	3.57	0.05	-	-	0.00		-	
1924	3.90	3.85	0.05	-	-	0.00		-	
1925	4.08	4.04	0.04	-	-	0.00		-	
1926	4.14	4.05	0.10	-	-	0.00		-	
1927	4.63	4.60	0.03	-	-	0.00		-	
1928	4.79	4.75	0.03	-	-	0.01		-	
1929	5.17	5.13	0.03	-	-	0.01		-	
1930	5.78	5.59	0.03	-	-	0.03		0.14	
1931	5.76	5.55	0.03	-	-	0.04		0.14	
1932	5.90	5.67	0.04	-	-	0.03		0.17	
1933	6.18	5.96	0.03	-	-	0.03		0.15	
1934	6.65	6.45	0.02	-	-	0.04		0.13	
1935	7.26	7.07	0.02	-	-	0.05		0.11	
1936	8.05	7.86	0.02	-	-	0.06		0.11	
1937	8.76	8.53	0.02	-	-	0.06		0.14	
1938	8.85	8.62	0.02	-	-	0.08		0.12	
1939	9.46	9.20	0.02	-	-	0.08		0.15	
1940	10.72	10.46	0.03	-	-	0.07		0.17	
1941	12.07	11.80	0.02	-	-	0.07		0.18	
1942	13.19	12.87	0.02	-	-	0.09		0.21	
1943	13.39	13.05	0.01	-	-	0.11		0.21	
1944	14.24	13.90	0.02	-	-	0.10		0.22	
1945	13.90	13.57	0.02	-	-	0.10		0.22	
1946	15.51	15.13	0.03	-	-	0.10		0.25	
1947	15.93	15.62	0.07	-	-	0.10		0.15	0.72

1948	17.01	16.58	0.07	-	-	0.08		0.28	0.77
1949	17.92	17.26	0.09	-	-	0.06		0.50	0.88
1950 (6)	19.06	18.32	0.07	-	-	0.09		0.58	0.84
1951	20.47	19.74	0.08	-	-	0.15		0.50	0.94
1952	20.68	19.90	0.07	-	-	0.16		0.55	1.09
1953	21.41	20.56	0.10	-	-	0.16		0.59	1.02
1954	23.41	22.30	0.18	-	-	0.20		0.72	1.06
1955	25.23	24.20	0.22	-	-	0.15		0.67	1.79
1956	27.06	25.87	0.38	-	0.02	0.20		0.59	2.14
1957	27.86	26.34	0.60	-	0.13	0.24		0.56	2.29
1958	29.77	26.18	2.60	-	0.10	0.23		0.66	2.52
1959	31.82	26.21	4.25	-	0.38	0.23		0.75	2.79
1960	37.31	30.07	5.78	-	0.65	0.27		0.54	2.93
1961	40.23	32.97	5.60	-	0.75	0.33		0.58	2.91
1962	44.22	36.35	5.85	-	1.09	0.34		0.61	3.13
1963	47.87	40.12	5.13	-	1.86	0.31		0.44	3.93
1964	49.75	40.83	5.75	-	2.39	0.34		0.45	4.15
1965	51.72	40.03	6.74	-	4.34	0.40		0.21	5.23
1966	54.41	40.09	7.81	-	5.80	0.39		0.32	5.02
1967	55.05	39.61	7.92	-	6.68	0.42		0.42	4.67
1968	58.22	43.33	6.85	-	7.51	0.32		0.21	4.64
1969	62.04	44.74	8.89	0.11	7.91	0.28		0.11	4.94
1970	63.84	43.07	13.27	0.11	7.00	0.39		-	5.16
1971	66.46	42.42	15.63	0.64	7.37	0.29		0.11	5.67
1972	68.37	38.47	20.13	1.61	7.87	0.29		-	
1973	70.93	44.30	18.09	0.64	7.46	0.33		0.11	
1974	69.01	38.71	18.41	2.46	8.97	0.35		0.11	
1975	66.25	41.85	13.70	2.14	8.12	0.33		0.11	
1976	66.97	44.49	10.92	1.61	9.56	0.39		-	
1977	69.32	45.71	11.35	1.28	10.64	0.34		-	
1978	69.64	46.05	12.31	0.86	9.96	0.35		0.11	
1979	72.80	50.10	11.45	0.54	10.23	0.37		0.11	
1980	69.46	51.01	7.67	0.42	9.91	0.34		0.11	
1981	65.98	49.64	5.46	0.21	10.18	0.38		0.11	
1982	65.98	46.75	6.64	0.21	11.88	0.39		0.11	

1983	66.37	47.16	5.14	0.21	13.47	0.39		-	
1984	69.18	31.07	22.80	0.42	14.50	0.39		-	
1985	71.54	42.81	11.35	0.54	16.50	0.34		-	
1986	70.46	47.91	6.51	0.18	15.44	0.41		-	
1987 (5)	70.50	50.37	5.14	0.19	14.44	0.36		-	
1987 (5)	74.31	51.58	6.30	0.91	14.44	0.36	-	-	
1988	75.57	49.83	7.01	0.97	16.57	0.42	-	-	
1989	75.27	48.59	7.11	0.54	17.74	0.41	-	-	
1990	76.34	49.84	8.40	0.56	16.26	0.44	-	-	
1991	76.87	49.98	7.56	0.57	17.43	0.39	-	-	
1992	76.57	46.94	8.07	1.54	18.45	0.46	-	-	
1993	75.40	39.61	5.78	7.04	21.58	0.37	-	-	
1994	74.01	37.10	4.11	10.10	21.20	0.44	-	-	
1995	77.15	36.29	4.15	13.27	21.25	0.40	-	-	
1996	79.56	33.62	3.95	17.37	22.18	0.29	0.04	-	
1997	76.76	28.30	2.01	21.74	21.98	0.38	0.06	-	
1998	81.14	29.90	1.53	23.02	23.44	0.44	0.08	-	0.72
1999	79.72	25.51	1.54	27.13	22.22	0.46	0.07	-	0.77
2000	81.21	28.67	1.55	27.91	19.64	0.44	0.08	-	0.88
2001	84.01	31.61	1.42	26.87	20.77	0.35	0.08	-	0.84
2002	83.00	29.63	1.29	28.33	20.10	0.41	0.11	-	0.94
2003	85.95	32.54	1.19	27.85	20.04	0.28	0.11	-	1.09
2004	84.57	31.31	1.10	29.25	18.16	0.42	0.17	-	1.02
2005	86.68	32.58	1.31	28.52	18.37	0.42	0.25	-	1.06
2006	87.06	35.94	1.43	26.78	17.13	0.39	0.36	-	1.79
2007	84.28	32.92	1.16	30.60	14.04	0.44	0.46	-	2.14
2008	81.54	29.96	1.58	32.40	11.91	0.44	0.61	-	2.29
2009	78.49	24.66	1.51	30.89	15.23	0.45	0.80	-	2.52
2010	79.14	25.56	1.18	32.12	13.93	0.31	0.88	-	2.79
2011	76.50	26.03	0.90	26.42	15.63	0.49	1.35	-	2.93

NOTES

(1) Fuel inputs have been calculated on an energy supplied basis - see explanatory notes at Digest of UK Energy Statistics 2002, Chapter 5, paragraph 5.26.

(2) Includes oil used in gas turbine and diesel plant or for lighting up coal fired boilers, Orimulsion, and (from 1987) refinery gas.

(3) Includes colliery methane from 1987 onwards.

(4) Main fuels included are coke oven gas, blast furnace gas, waste products from chemical processes, refuse derived fuels and other renewable sources including wind.

(5) Data for all generating companies are only available from 1987 onwards, and the figures for 1987 to 1989 include a high degree of estimation. Before 1987 the data are for major power producers, transport undertakings and industrial hydro and nuclear stations only (see also note 6).

(6) Industrial hydro data are not available before 1951

(7) 1920-1959 converted into mtoe using estimated average gross calorific values for 1960 from DUKES 1993 table A18 ie coal 23.8 GJ/t, Oil 41.8 GJ/t and coke and breeze 27.0GJ/t (Therms values converted to GJ)

Electricity supply, availability and consumption (TWh)

	Electricity supplied (net)	Purchases from other producers	Net Imports (1)	Electricity available	Losses in transmission etc (2)	Total	Fuel industries	Final users			
								Industrial	Domestic	Other (3)	Total
1920	3.98	0.089	-	4.065							
1921	3.61	0.059	-	3.664							
1922	4.23	0.15	-	4.376							
1923	4.93	0.249	-	5.177							
1924	5.63	0.272	-	5.899							
1925	6.18	0.308	-	6.492							
1926	6.53	0.262	-	6.788							
1927	7.93	0.176	-	8.102							
1928	8.75	0.229	-	8.979							
1929	9.76	0.222	-	9.979							
1930	10.26	0.213	-	10.475							
1931	10.76	0.15	-	10.913							

		8									
1932	11.54	0.166	-	11.701							
1933	12.78	0.183	-	12.964							
1934	14.58	0.187	-	14.769							
1935	16.60	0.221	-	16.817							
1936	19.17	0.237	-	19.404							
1937	21.67	0.169	-	21.841							
1938	23.09	0.249	-	23.338							
1939	25.02	0.171	-	25.189							
1940	27.21	0.116	-	27.327							
1941	30.59	0.416	-	31.010							
1942	33.69	0.147	-	33.841							
1943	34.92	0.181	-	35.096							
1944	36.20	0.39	-	36.585							
1945	35.15	0.558	-	35.706							
1946	38.93	0.246	-	39.178							
1947	40.17	0.197	-	40.369							
1948	43.40	0.411	-	43.815							
1949	45.82	0.423	-	46.241							
1950	51.47	0.41	-	51.877							
1951	56.19	0.467	-0.002	56.658							
1952	58.40	0.418	-0.002	58.816							
1953	61.64	0.322	-0.002	61.955							
1954	68.57	0.353	-0.002	68.921							
1955	75.33	0.321	-0.002	75.648							
1956	81.92	0.277	-0.001	82.191							
1957	85.50	0.501	-0.002	85.999							

1958	92.69	0.753	-0.001	93.441							
1959	98.94	1.629	-0.001	100.572							
1960	116.96	0.15	-0.001	117.11	12.07	105.04	6.25	44.51	33.68	20.60	78.19
1961	120.07	2.757	0.001	122.82	-	-	-	-	-	-	-
1962	132.77	3.158	0.087	136.02	-	-	-	-	-	-	-
1963	162.65	3.35	-0.015	147.10	-	-	-	-	-	-	-
1964	170.95	3.18	-0.211	154.53	-	-	-	-	-	-	-
1965	169.57	0.21	0.10	169.88	15.17	154.71	7.55	58.54	57.23	31.39	147.16
1966	175.38	0.22	0.35	175.95	15.30	160.65	7.66	60.11	59.81	33.07	152.99
1967	181.14	0.21	0.16	181.51	15.76	165.75	7.75	60.91	62.35	34.74	158.00
1968	193.56	0.20	0.73	194.49	16.29	178.20	7.68	66.15	66.66	37.71	170.52
1969	206.37	0.20	0.58	207.15	17.29	189.86	6.88	70.34	72.19	40.45	182.98
1970	215.76	0.19	0.55	216.50	17.50	199.00	6.59	72.99	77.04	42.38	192.41
1971	222.92	0.53	0.12	223.57	19.01	204.56	6.60	73.43	80.67	43.86	197.96
1972	229.45	0.53	0.48	230.46	18.91	211.55	6.37	73.16	86.89	45.13	205.18
1973	245.42	0.59	0.06	246.07	19.59	226.48	6.67	80.07	91.30	48.44	219.81
1974	237.21	0.60	0.05	237.86	18.22	219.64	6.12	75.81	92.63	45.08	213.52
1975	237.76	0.70	0.08	238.54	19.47	219.07	6.29	75.36	89.21	48.21	212.78
1976	240.22	0.61	-0.10	240.73	18.73	222.00	6.39	80.84	85.12	49.65	215.61
1977	246.82	0.74	-	247.56	20.76	226.80	6.41	82.06	85.90	52.43	220.39
1978	252.65	0.66	-0.08	253.23	21.81	231.42	6.52	84.00	85.80	55.10	224.90
1979	264.34	0.63	-	264.97	22.97	242.00	6.78	87.55	89.67	58.00	235.22
1980	252.02	0.61	-	252.63	21.53	231.11	6.86	79.73	86.11	58.41	224.25
1981	246.60	0.74	-	247.34	20.13	227.21	6.86	77.03	84.44	58.88	220.35
1982	242.48	0.82	-	243.30	20.48	222.82	6.81	73.91	82.79	59.31	216.01
1983	246.1	1.15	-	247.30	21.21	226.	6.69	74.17	82.95	62.2	219.

	5					09				8	40
1984	251.47	0.55	-	252.02	21.06	230.96	6.64	78.64	83.90	61.78	224.32
1985	263.56	0.92	-	264.48	22.63	241.85	7.76	79.53	88.23	66.33	234.09
1986(*4)*	266.81	1.10	4.26	272.17	22.83	249.34	7.68	80.15	91.83	69.68	241.66
1986(*4)*	278.48	-	4.26	282.73	22.91	259.82	9.51	88.80	91.83	69.68	250.31
1987	279.71	-	11.64	291.34	22.96	268.38	9.49	93.14	93.25	72.50	258.89
1988	285.71	-	12.14	297.85	23.35	274.50	9.16	97.14	92.36	75.84	265.34
1989	291.75	-	12.63	304.38	24.98	279.40	9.00	99.42	92.27	78.71	270.40
1990	297.50	-	11.91	309.41	24.99	284.42	9.99	100.64	93.79	80.00	274.43
1991	300.65	-	16.41	317.06	26.22	290.84	9.79	99.57	98.10	83.38	281.05
1992	298.55	-	16.69	315.24	23.79	291.45	9.98	95.28	99.48	86.71	281.47
1993	301.87	-	16.72	318.59	22.84	295.75	9.62	96.84	100.46	88.83	286.13
1994	306.94	-	16.89	323.83	31.00	292.83	7.52	96.12	101.41	87.78	285.31
1995	317.63	-	16.61	334.24	30.32	303.92	8.07	101.78	102.21	91.86	295.85
1996	332.36	-	16.76	349.11	29.34	319.78	9.21	107.63	107.51	95.42	310.57
1997	331.63	-	16.57	348.20	27.14	321.07	8.62	108.10	104.46	99.88	312.44
1998	342.70	-	12.47	355.17	29.82	325.35	8.41	108.44	109.41	99.09	316.94
1999	347.67	-	14.24	361.92	29.86	332.05	8.04	112.25	110.31	101.46	324.02
2000	357.27	-	14.17	371.44	31.14	340.30	9.70	115.29	111.84	103.47	330.59
2001	364.17	-	10.40	374.57	32.07	342.50	8.63	112.50	115.34	106.05	333.88
2002	366.66	-	8.41	375.07	30.96	344.11	10.06	110.82	120.01	103.22	334.05
2003	376.53	-	2.16	378.69	32.07	346.62	9.75	109.93	123.00	103.94	336.87
2004	373.40	-	7.49	380.89	33.18	347.71	8.14	112.09	124.20	103.28	339.57
2005	376.78	-	8.32	385.10	27.90	357.20	7.85	116.70	125.71	106.94	349.35
2006	373.86	-	7.52	381.38	27.52	353.86	8.00	115.53	124.70	105.63	345.87
2007	374.06	-	5.22	379.28	27.83	351.45	9.19	113.41	123.08	105.78	342.26

2008	367.27	-	11.02	378.29	28.20	350.10	7.71	114.72	119.80	107.87	342.39
2009	355.36	-	2.86	358.22	28.20	330.02	7.67	100.34	118.54	103.47	322.35
2010	361.45	-	2.66	364.12	26.66	337.46	8.25	104.94	118.82	105.44	329.20
2011	347.51	-	6.22	353.73	27.86	325.86	7.49	102.77	111.59	104.03	318.38

The figures in the boxes below all exclude Northern Ireland

(These data has been converted from million KWh to TWh by dividing by 1000)

Domestic and farm premises	Shops offices,and other commercial premises	Factories and other industrial premises	Public lighting	Traction	Total
0.30	0.40	2.55	0.048	0.419	3.71
0.32	0.40	2.08	0.051	0.391	3.24
0.37	0.46	2.46	0.058	0.415	3.76
0.45	0.54	2.99	0.067	0.443	4.50
0.54	0.63	3.44	0.078	0.486	5.17
0.64	0.70	3.71	0.090	0.519	5.65
0.75	0.81	3.59	0.096	0.563	5.82
0.92	0.92	4.38	0.113	0.649	6.98
1.10	1.04	4.76	0.126	0.716	7.74
1.31	1.19	5.32	0.144	0.782	8.75
1.53	1.31	5.36	0.162	0.806	9.17
1.78	1.44	5.28	0.181	0.822	9.50
2.03	1.58	5.52	0.199	0.855	10.18
2.30	1.74	6.07	0.216	0.947	11.27
2.65	1.96	7.06	0.240	0.982	12.89
3.23	2.26	7.85	0.268	1.036	14.64
3.96	2.62	8.91	0.298	1.096	16.89
4.69	2.94	10.02	0.339	1.180	19.17
5.36	3.11	10.32	0.367	1.249	20.40
5.94	3.12	11.67	0.248	1.261	22.23
6.23	3.00	13.87	0.017	1.147	24.26
6.64	3.27	16.24	0.018	1.143	27.31
6.72	3.26	19.14	0.020	1.148	30.29
6.71	3.06	20.52	0.020	1.142	31.45
7.84	3.51	19.98	0.029	1.169	32.52
8.81	3.48	17.68	0.161	1.236	31.36
11.66	3.89	17.63	0.242	1.369	34.80
12.73	3.97	17.61	0.190	1.361	35.86
13.58	4.47	19.12	0.257	1.398	38.82
13.66	5.04	20.45	0.335	1.447	40.92

14.91	5.77	22.92	0.415	1.463	45.47
16.94	6.35	25.35	0.441	1.429	50.51
16.87	7.12	26.07	0.479	1.419	51.95
17.69	7.95	28.00	0.528	1.401	55.57
19.08	8.75	31.55	0.576	1.451	61.40
21.15	9.55	34.64	0.627	1.470	67.42
23.76	10.34	37.22	0.692	1.512	73.52
24.85	10.73	39.35	0.742	1.545	77.22
28.23	12.06	41.24	0.793	1.551	83.87
30.49	12.84	44.70	0.855	1.630	90.50
35.27	14.53	49.99	0.922	1.654	102.36
39.97	15.81	51.74	0.994	1.721	110.23
47.63	18.28	53.53	1.060	1.856	122.36
54.48	20.26	56.11	1.127	1.879	133.85
54.41	21.32	61.60	1.191	1.847	140.37
59.42	23.43	65.04	1.260	1.923	151.07

Number of Consumers (5)	
850	1920
1,000	1921
1,200	1922
1,400	1923
1,600	1924
1,900	1925
2,200	1926
2,600	1927
3,007	1928
3,472	1929
4,012	1930
4,646	1931
5,337	1932
6,109	1933
6,903	1934
7,704	1935
8,557	1936
9,358	1937
10,113	1938
10,559	1939
10,499	1940
10,574	1941
10,688	1942
10,786	1943
10,829	1944
11,006	1945

11,481	1946
11,917	1947
12,286	1948
12,742	1949
13,216	1950
13,655	1951
14,054	1952
14,565	1953
15,115	1954
15,628	1955
16,074	1956
16,472	1957
16,824	1958
17,150	1959
17,490	1960
17,816	1961
18,115	1962
18,398	1963
18,732	1964
19,060	1965
19,363	1966
19,668	1967
19,964	1968
20,200	1969
20,425	1970
20,627	1971
20,885	1972
21,100	1973
21,286	1974
21,520	1975
21,777	1976
22,029	1977
22,297	1978
22,531	1979
22,603	1980
22,789	1981
22,951	1982
23,180	1983
23,431	1984
23,665	1985
23,915	1986
24,481	1987
24,743	1988
24,990	1989
25,268	1990
25,503	1991
25,648	1992
25,847	1993
26,048	1994
26,220	1995

26,569	1996
26,960	1997
26,611	1998
27,125	1999
27,125	2000
29,068	2001
29,068	2002
28,247	2003
28,379	2004
28,498	2005
28,875	2006
29,105	2007
29,212	2008
29,365	2009
29,591	2010

NOTES

(1) Net transfers between the Irish Republic and Northern Ireland (ceased in 1975 and recommenced in 1996) and between France and England (1961 to 1982 and from 1986).

(2) Losses on the public distribution system (grid system and local networks) and other differences between data collected on sales and data collected on availability.

(3) Public administration, transport, agricultural and commercial sectors.

(4) Data for all generating companies are only available from 1986 onwards. Before 1986 the data are for major power producers, transport undertakings and industrial hydro and nuclear stations only.

(5) Great Britain only until 1986 and from 2003. Prior to 1948 the figures are for financial years, and prior to 1927 the numbers are estimated. From 2003 the figures are the number of Meter Point Administration numbers (MPANs); every meter point has this unique reference number

Generating capacity

	England and Wales MW (Net)	Millions of customers	GWh Sales
1895	79		38
1900	295		120
1905	775		450
1910	960		1,000
1915	1,300		1,700
1920	2,400	0.9	3,240
1925	3,900	1.7	5,040
1930	6,200	3.5	8,160
1935	7,300	7.0	13,200
1940	8,700	9.6	21,900
1945	11,100	10.0	28,000
1950	11,500	12.0	38,000
1955	17,300	14.1	58,000
1960	25,500	15.5	86,000
1965	34,400	17.0	130,000
1970	46,900	18.3	168,000
1975	58,500	19.3	196,000
1980	57,000	20.3	205,000

	Installed Capacity	Output Capacity	Public Electricity Supply			
	GB MW	GB MW	No of Stations	NI MW	UK DNC MW	UK TEC MW
1892	44					
1893	54					
1894	67					
1895	79					
1896	102					
1897	122					
1898	155					
1899	216					
1900	295					
1901	402					
1902	495					
1903	575					
1904	669					
1905	775					
1906	858					
1907	960					
1908	999					
1909	1,054					

1910	1,124			
1911	1,221			
1912	1,406			
1913	1,523			
1914	1,135			
1915	..			
1916	..			
1917	..			
1918	2,175			
1919	2,310			
1920	2,447			
1921	2,641			
1922	3,036		473	
1923	3,483		..	
1924	3,724		494	
1925	4,422		491	
1926	4,682		482	
1927	5,258		490	
1928	5,802		485	
1929	6,600		500	
1930	6,946		483	
1931	7,195		464	
1932	7,366		451	
1933	7,837		437	
1934	7,785		421	
1935	8,100		398	
1936	8,398		395	
1937	8,913		387	
1938	9,365		374	
1939	9,712		365	
1940	10,159		365	
1941	10,842		360	
1942	11,679		365	
1943	11,972		364	
1944	12,177		362	
1945	12,320		356	
1946	12,546		351	
1947	12,951		348	
1948	13,101	11,709	338	
1949	13,819	12,430	331	
1950	15,000	13,518	337	
1951	16,249	14,645	341	
1952	17,740	16,079	338	
1953	19,173	17,388	338	
1954	20,562	18,806	345	361
1955	22,489	20,629	347	391
1956	24,615	22,597	336	391
1957	26,635	24,521	340	451
1958	28,023	25,846	331	511
1959	30,015	27,799	329	600

1960	31,865	29,582	319	600		
1961	33,922	31,526	321	655		
1962	37,207	34,543	334	644		
1963	39,298	36,534	333	700		
1964	39,974	37,137	332	700		
1965	43,491	40,725	335	757		
1966	46,233	42,989	332	814		
1967	50,031	46,622	331	871		
1968	53,559	50,084	314	969		
1969	55,110	51,674	294	1,083		
1970	60,538	56,057	289	1,204		
1971	65,567	60,792	286	1,204		
1972	68,794	63,812	273	1,510		
1973	71,125	65,999	266	1,705		
1974	72,136	67,238	259	1,905		
1975	71,816	66,765	229	1,905		
1976	69,852	65,581	230	2,025		
1977	69,747	65,368	223	2,025		
1978	69,911	65,449	216	2,025		
1979	71,426	66,944	217	1,845		
1980	70,086	66,541	213	2,115		
1981	68,382	62,731	196	2,053	64,784	
1982	68,106	62,784	186	2,290	65,074	
1983	67,022	60,089	177	2,290	62,379	
1984	68,632	60,579	167	2,290	62,869	
1985	69,763	61,504	168	2,290	63,794	
1986	70,087	61,159	168	1,726	62,885	
1987	69,704	62,143	164	1,726	63,869	
1988(1)	70,348	63,630	163	2,290	66,536	
1989	74,669	68,512	163	2,290	70,327	
1990					69,320	
1991					66,336	
1992					63,377	
1993					66,901	
1994					64,923	
1995(1)					66,100	
1996					69,090	
1997					68,288	
1998					68,312	
1999					70,245	
2000					72,193	
2001					73,382	
2002					70,369	
2003					71,465	
2004					73,293	
2005					71,968	73,941
2006					73,023	74,996
2007					74,006	75,979

2008		75,020	76,993
2009		75,803	77,776
2010		81,334	83,307
2011		79,777	81,750

Simultaneous maximum load met	
	MW
1924	2,298
1925	2,558
1926	2,701
1927	3,235
1928	3,369
1929	3,601
1930	3,801
1931	3,951
1932	4,156
1933	4,802
1934	5,297
1935	6,044
1936	6,609
1937	7,284
1938	8,003
1939	8,186
1940	8,599
1941	9,215
1942	9,544
1943	9,968
1944	10,383
1945	10,837
1946	11,188
1947	11,599
	11,995
1948	
	11,548
1949	12,425
1950	13,840
1951	14,000
1952	15,347
1953	16,677
1954	17,720
1955	19,835

1956	19,357	
1957	21,187	
1958	23,012	
1959	25,354	
1960	26,918	
1961	30,311	
1962	35,267	
1963	33,296	
1964	34,533	
1965	37,078	
1966	37,909	
1967	39,966	
1968	42,059	
1969	43,027	
1970	43,270	
1971	44,914	
1972	45,868	
1973	44,883	
1974	46,526	
1975	46,677	
1976	47,902	
1977	48,605	
1978	50,144	
1979	49,582	
1980	48,284	
1981	48,561	
1982	47,333	
1983	47,396	
1984	51,710	
1985	50,943	
1986	53,980	
1987	52,490	
1988	51,335	
1989	53,555	
1990	53,414	
1991	54,068	
1992	54,472	
1993	51,663	Data covering the 12 months ending March of the following year eg 2006 data are for the year ending March 2007
1994	54,848	
1995	52,363	
1996	56,815	
1997	56,965	
1998	56,312	
1999	57,849	
2000	58,452	
2001	58,589	
2002	61,717	
2003	60,501	
2004	61,013	
2005	61,697	

2006	59,071
2007	61,527
2008	60,289
2009	60,231
2010	60,893
2011	57,086

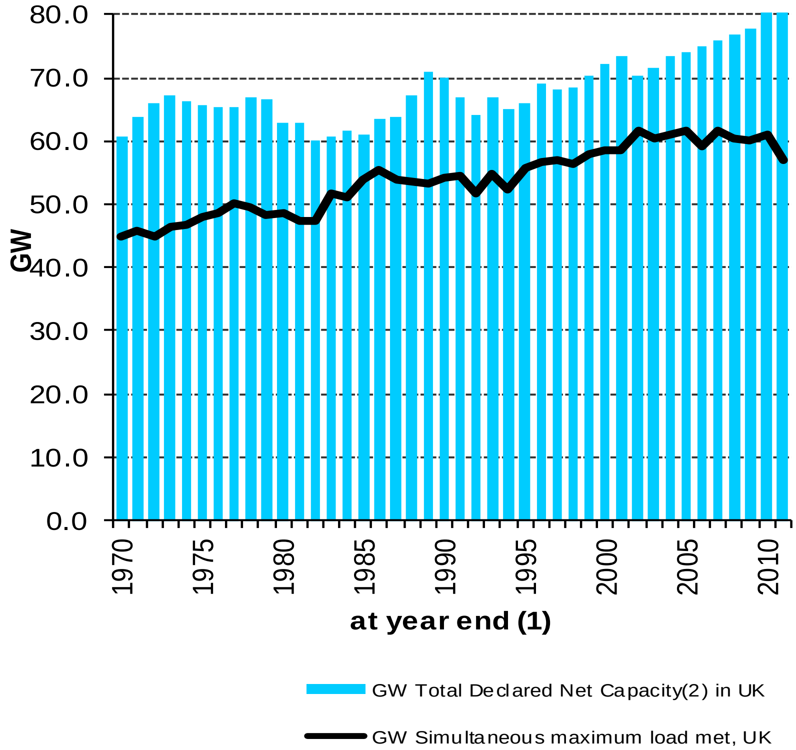
NOTES

(1) UK DNC figures for the years 1988-1995 are for the year ending March of the following calendar year

Electricity generating capacity and simultaneous maximum load met for major power producers			
	GW Total Declared Net Capacity(2) in UK	**GW Simultaneous maximum load met, UK**	
1970	60.8	44.9	
	63.8	45.9	
	66.0	44.9	
	67.2	46.5	
	66.3	46.7	
1975	65.6	47.9	
	65.4	48.6	
	65.4	50.1	
	66.9	49.6	
	66.5	48.3	
1980	62.7	48.6	
	62.8	47.3	
	60.1	47.4	
	60.6	51.7	

	61.5	50.9	
1985	61.2	54.0	
	63.6	55.3	
	63.8	53.8	
	67.2	53.6	
	71.0	53.4	
1990	69.9	54.1	
	67.0	54.5	
	64.0	51.7	
	66.9	54.8	
	64.9	52.4	
1995	66.1	55.6	
	69.1	56.8	
	68.3	57.0	
	68.4	56.3	
	70.2	57.8	
2000	72.2	58.5	
	73.4	58.6	
	70.4	61.7	
	71.5	60.5	
	73.3	61.0	
2005	73.9	61.7	
	75.0	59.1	
	76.0	61.5	
	77.0	60.3	
	77.8	60.2	
2010	83.3	60.9	
	81.7	57.1	

Electricity generating capacity and simultaneous maximum load met for major power producers



(1) before 1997 capacities are as at the end of March of the following year
Figures prior to 1985 are for GB
(2) 2005 onwards are on a Transmission Entry Capacity basis

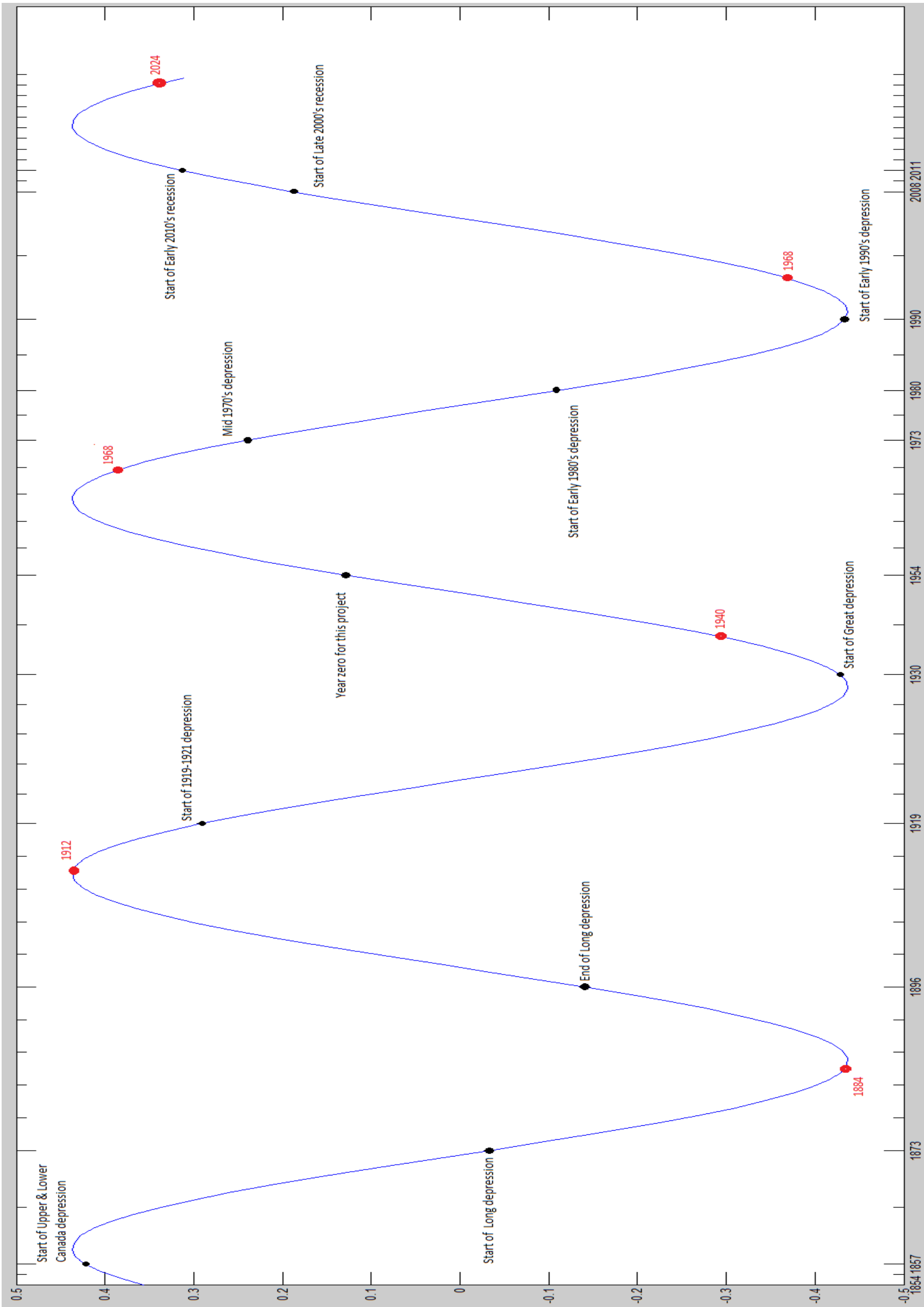
Source: DECC

A.3

Matlab code to get figure 4.4

```
a1= 0.4371;

b1= 0.1191;

c1= 0.2976;

x=1:120

for i=1:120


   y(i)=a1*sin(b1*x(i)+c1)

end


plot(x,y)
```

A.4



Start of Upper & Lower Canada depression
Start of Long depression
1884
End of Long depression
1912
Start of 1919-1921 depression
Start of Great depression
1940
Year zero for this project
1968
Mid 1970's depression
Start of Early 1980's depression
Start of Early 1990's depression
1968
Start of Early 2010's recession
Start of Late 2000's recession
2024
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
1854 1867
1873
1896
1919
1930
1954
1973
1980
1990
2008 2011

Initials glossary

A.D.: Anno Domini, after the birth of Christ

G.D.P. : Gross Domestic Product: this is the market value of all officially recognized final goals and services produced within a country in a given period of time GDP per capita is an indicator of a country's standard of living

I.E.C.: Industrial Energy Consumption

P.P.P.: Purchasing Power Parity: it is a technique used to determine the relative value of currencies estimating the amount of adjustment needed on the exchange rate between countries in order for the exchange to be equivalent to each currency's purchasing power.

R.E.S.: Renewable Energy Sources (wind, solar energy, etc.)

T.O.E.: Tonne of Oil Equivalent. This is a unit of energy, more specifically, the amount of energy released by burning one tonne of crude oil, approximately 42GJoules. T.O.E. is used for large amounts of energy

U.K.: United Kingdom i.e. great Britain (England, Wales, Scotland) and Northern Ireland.

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