

Investigating the GDP and the National Debt of a Country and Exploring the Cases when the National Debt of the Country will Exceed its GDP

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Abstract – News about national debt often goes uncommunicated and may also sound absurd and totally unrelated to the general masses of a country, yet it has great significance on our lives, in terms of how it can impact us. In simple terms, interest payments on the national debt are potentially burden to a country. Hence, we might consider that essentially, what matters is the size of the interest burden (which depends on the national debt) on the country and how it compares with the country’s economy (which can be measured by country’s GDP). This exploration is aimed to investigate the relationship between the GDP of a country and its national debt and even try to find the cases when it will be possible for a nation’s debt to exceed its GDP.

Keywords – Data Modelling using Differential Equations, GDP of USA, Mathematical Analysis of Economic Data Using Functions and Software, National Debt of USA.

I. INTRODUCTION

“Interest on federal debt will triple over coming decade,”¹ roared the *The Washington Post*² headline, while the NPR issued a small caveat that although the annual gap between the US Government’s revenues and expenditures have been decreasing, it will start rising again after 2018³. This was in the beginning of the year 2015 during which *The Washington Post* also forewarned us that the “interest on federal debt will triple over coming decade”. The more the country borrows, the more the country must pay interest on the borrowed sum, and to pay that interest the country has to either take money out of its revenues (which mainly compose of taxes) or borrow further, which might risk in an increase in the interest rates for loans or in the long run, high inflation. The Gross Domestic Product (GDP) is a measure of the value of aggregate output of an economy, it is the market value of all final goods and services produced within a country during a given time period⁴. The national debt or the public debt is the total amount owed by the government to all creditors (lenders)⁵. GDP and national debt, both are frequently connected to economic health of nations. Although some people argue the valid meaning of GDP and national debt ratios, most of the time, this comparison is taken extremely seriously. This is because it is a measure of the ability of a nation to pay off its debts. For example, when the Eurozone⁶ was created 1999, the

member countries had to uphold a debt to GDP ratio of less than 60% for them to enter the currency.⁷ This was primarily done to ensure the stability of the euro.

If a country defaults on public debt, billions or trillions of dollars might be at stake. As a result, governments may face several internal problems, for example, they might not be able to pay the foreign investors. Agencies such as the International Monetary Fund, aim to recognize such problems and hence help prevent the defaults to be occurring.

Therefore, this exploration is aimed to investigate the relationship between the GDP of a country and its national debt and try to find the cases when it will be possible for a nation’s debt to exceed its GDP. Throughout this exploration, statistics of the USA were used for various analyses.

II. FINDING THE CORRELATION BETWEEN NATIONAL DEBT AND GDP OF USA

First, data was collected through trusted online sources. After collating data for the GDP and national debt of USA, a scatter plot graph was produced in order to figure out the regression model that would best fit the predicted trend. Then, the correlation was found between these two variables by producing a best-fit line. This was done using *Vernier’s LoggerPro 3.8.6.1* and the graph is shown as below:

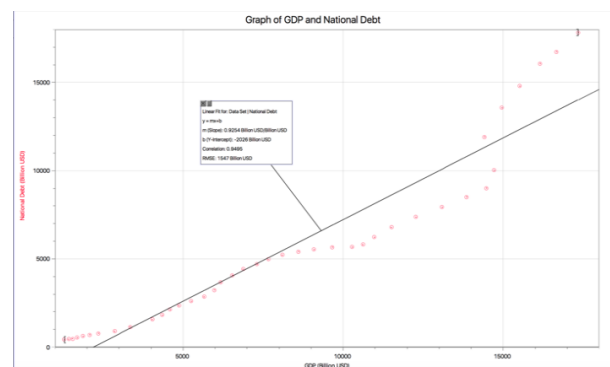


Fig. 1. Graph showing positive correlation between GDP and National Debt

¹ Mufson, Steven. "CBO: Interest on Federal Debt Will Triple over Coming Decade." *The Washington Post*. The Washington Post, 26 Jan. 2015. Web. 1 Nov. 2015.

² Spross, Jeff. "Don't Worry about the Rising National Debt. Seriously, Just Don't." *The Week*. The Week, 29 Jan. 2015. Web. 1 Nov. 2015.

³ DÁTE, S. V. "The CBO's Good News, Bad News Economic Report." *NPR*. NPR, 26 Jan. 2015. Web. 1 Nov. 2015.

⁴ Tragakes, Ellie. *Economics for the IB Diploma*. Cambridge: Cambridge UP, 2009. Print.

⁵ Tragakes, Ellie. *Economics for the IB Diploma*. Cambridge: Cambridge UP, 2009. Print.

⁶ The European Commission. "The Euro." *The European Commission*. The European Commission, n.d. Web. 1 Nov. 2015.

⁷ *Progress Towards Convergence*. Rep.: European Monetary Institute, 1995. *European Central Bank*. Web. 2 Nov. 2015.



III. FINDING THE CAGR OF THE GDP OF THE USA

After finding the correlation between the two quantities, the Compounded Annual Growth Rate (CAGR)⁸ of the GDP of USA from year 1970 to 2014 was calculated, using the data collected. CAGR is the mean annual growth rate. The calculations were done using formulas in an Excel workbook. The results are shown below:

Table I. gives the value of the CAGR as 6.57%, which can be used in the further calculations

Year	S. No. (X)	GDP USD Billion (Y)	Growth rate
1970	0	1,075.90	-
1971	1	1,167.80	8.54168603
1972	2	1282.4	9.813324199
1973	3	1428.5	11.39270119
1974	4	1548.8	8.421421071
1975	5	1688.9	9.04571281
1976	6	1877.6	11.17295281
1977	7	2086	11.09927567
1978	8	2356.6	12.97219559
1979	9	2632.1	11.69057116
1980	10	2862.5	8.753466814
1981	11	3211	12.17467249
1982	12	3345	4.17315478
1983	13	3638.1	8.762331839
1984	14	4040.7	11.06621588
1985	15	4346.7	7.572945282
1986	16	4590.2	5.601950905
1987	17	4870.2	6.099952072
1988	18	5252.6	7.8518336
1989	19	5657.7	7.712371016
1990	20	5979.6	5.689591177
1991	21	6174	3.251053582
1992	22	6539.3	5.916747651
1993	23	6878.7	5.190157968
1994	24	7308.8	6.252634946
1995	25	7664.1	4.861263135
1996	26	8100.2	5.690165838
1997	27	8608.5	6.2751537
1998	28	9089.2	5.584015798
1999	29	9660.6	6.286581877
2000	30	10284.8	6.4612964
2001	31	10621.8	3.276680149
2002	32	10977.5	3.348773278
2003	33	11510.7	4.857207925
2004	34	12274.9	6.639040197
2005	35	13093.7	6.670522774
2006	36	13855.9	5.821120081
2007	37	14477.6	4.486897278
2008	38	14718.6	1.664640548
2009	39	14418.7	-2.03755792
2010	40	14964.4	3.784668521
2011	41	15517.9	3.698778434
2012	42	16155.3	4.107514548
2013	43	16663.2	3.14385991
2014	44	17348.1	4.110254933
		Compounded	6.567040862

IV. CREATING A SYSTEM OF DIFFERENTIAL EQUATIONS

Now, since there is a positive correlation between GDP and national debt, a system of ordinary differential equations was created. The first differential equation shows that the rate of change of GDP is proportional to the GDP.

$$\frac{dGDP}{dt} = 0.0657GDP$$

The second equation shows that the National debt is increasing at a rate proportional to the GDP.

$$\frac{dN_D}{dt} = kGDP$$

Assuming that GDP in the year 1970 (S. No. 0) ($t = 0$) is M_0 and the national debt in the year 1970 (S. No. 0) ($t = 0$) is N_{D_0} . we can solve the differential equations as following:

$$\int \frac{dGDP}{GDP} = \int 0.0657 dt$$

$$\ln GDP = 0.0657t + c$$

At $t = 0$, $GDP = M_0$ and so,

$$c = \ln M_0$$

$$\ln GDP = 0.0657t + \ln M_0$$

$$\ln\left(\frac{GDP}{M_0}\right) = 0.0657t$$

$$\frac{GDP}{M_0} = e^{0.0657t}$$

$$GDP(t) = M_0 e^{0.0657t}$$

Therefore, for the national debt,

$$\frac{dN_D}{dt} = kGDP$$

$$dN_D = k(GDP)dt$$

$$\int dN_D = \int kM_0 e^{0.0657t} dt$$

$$N_D(t) = \frac{kM_0 e^{0.0657t}}{0.0657} - \frac{kM_0}{0.0657} + N_{D_0}$$

$$N_D(t) = \frac{kM_0}{0.0657} (e^{0.0657t} - 1) + N_{D_0}$$

Now, to find the case(s) when the nation's national debt would exceed its GDP,

$$N_D(t) > GDP(t)$$

$$\frac{kM_0}{0.0657} (e^{0.0657t} - 1) + N_{D_0} > M_0 e^{0.0657t}$$

$$\frac{kM_0}{0.0657} (e^{0.0657t} - 1) > 0.0657(M_0 e^{0.0657t} - N_{D_0})$$

$$kM_0 e^{0.0657t} - kM_0 > 0.0657M_0 e^{0.0657t} - 0.0657N_{D_0}$$

$$kM_0 e^{0.0657t} - 0.0657M_0 e^{0.0657t} > kM_0 - 0.0657N_{D_0}$$

Now, if the ratio k satisfies the inequality $k > 0.0657$ then, the relation above is equivalent to

$$e^{0.0657t} > \frac{kM_0 - 0.0657N_{D_0}}{(k - 0.0657)M_0}$$

So, in this case, it can be concluded the national debt will eventually exceed the GDP. Therefore, when $k > 0.0657$, the national debt will become more than the GDP at some point of time.

Now, we take the case when the ratio k satisfies the equation $k = 0.0657$. If $k = 0.0657$, we get,

$$0 > 0.0657M_0 - 0.0657N_{D_0} = 0.0657(M_0 - N_{D_0})$$

In this case, the national debt will become large than the GDP only if the national debt was larger than the GDP in the year 0 (year 1970). This case can be rejected because according to my data, the national debt of USA is not greater than the GDP of USA in the year 0 (year 1970).

Now, we take the case when the ratio k satisfies the inequality $k < 0.0657$. We now have,

$$e^{0.0657t} < \frac{kM_0 - 0.0657N_{D_0}}{(k - 0.0657)M_0}$$

⁸ Investopedia. "Compound Annual Growth Rate (CAGR)." Investopedia. Investopedia, LLC, 16 Nov. 2003. Web. 2 Nov. 2015.



If the right hand side of this inequality becomes negative, this inequality will become false. If the right hand side is positive, with increasing time, the inequality will become false. This means that the GDP will become larger than the national debt even if the GDP was initially smaller than the national debt.

Now, using the collected data of USA, the country’s current economic health (on the basis of GDP and national debt) can be assessed. To find the values of k of different years, the data for the rate of change of national debt and the GDP would be required, since k is the ratio of rate of change of national debt to the GDP. Using formulas in the Excel workbook, the rate of change of national debt for every year was calculated and the ratio k for every year in the taken time period was found as shown below:

Table II: The value of ratio k is equal to the ratio CAGR in debt to the GDP. Hence, $k = 0.044523161$

Year	S. No.	GDP (USD Billion) (B)	National Debt (USD Billion)	Rate of change of National Debt (A)	Ratio k (A/B)
1970	0	1,075.90	370.92	-	-
1971	1	1,167.80	398.13	27.21	0.023301111
1972	2	1282.4	427.2604609	29.13	0.02271578
1973	3	1428.5	458.1416053	30.88	0.021617882
1974	4	1548.8	475.0598157	16.92	0.010923431
1975	5	1688.9	533.189	58.13	0.03441837
1976	6	1877.6	620.43	87.24	0.046465701
1977	7	2086	698.84	78.41	0.037587248
1978	8	2356.6	771.544	72.70	0.030851226
1979	9	2632.1	826.519	54.98	0.020886364
1980	10	2862.5	907.701	81.18	0.028360524
1981	11	3211	997.855	90.15	0.028076612
1982	12	3345	1,142.03	144.18	0.043101644
1983	13	3638.1	1377.210	235.18	0.064643633
1984	14	4040.7	1572.266	195.06	0.048272824
1985	15	4346.7	1823.103	250.84	0.057707456
1986	16	4590.2	2025.302617	202.20	0.044050285
1987	17	4870.2	2350.276891	324.97	0.06672709
1988	18	5252.6	2,602.34	252.06	0.04798782
1989	19	5657.7	2,857.43	255.09	0.0450878
1990	20	5979.6	3233.313452	375.88	0.062860809
1991	21	6174	3555.303352	321.99	0.052152559
1992	22	6539.3	4064.620656	509.32	0.0778856
1993	23	6878.7	4411.488883	346.87	0.050426422
1994	24	7308.8	4692.74991	281.26	0.038482518
1995	25	7664.1	4973.982901	281.23	0.036694849
1996	26	8100.2	5224.810939	250.83	0.03096566
1997	27	8608.5	5413.146011	188.34	0.021877804
1998	28	9089.2	5526.193009	113.05	0.012437508
1999	29	9660.6	5656.270902	130.08	0.013464784
2000	30	10284.8	5674.17821	17.91	0.001741143
2001	31	10621.8	5807.463412	133.29	0.012548269
2002	32	10977.5	6228.235966	420.77	0.038330454
2003	33	11510.7	6783.231063	555.00	0.048215582
2004	34	12274.9	7379.052696	595.82	0.048539836
2005	35	13093.7	7932.709662	553.66	0.042284226
2006	36	13855.9	8506.973899	574.26	0.041445466
2007	37	14477.6	9007.653372	500.68	0.034583044
2008	38	14718.6	10024.7249	1,017.07	0.069101105
2009	39	14418.7	11909.829	1,885.10	0.130740227
2010	40	14964.4	13561.62303	1,651.79	0.110381574
2011	41	15517.9	14790.34033	1,228.72	0.079180643
2012	42	16155.3	16066.24141	1,275.90	0.078977245
2013	43	16663.2	16738.18353	671.94	0.040324915
2014	44	17348.1	17824.07138	1,085.89	0.062594051
			Compounded	396.6625608	0.044523161

When we look at the individual values of k for different years, we see that from the year 2008 to 2012, the value k has more than 0.0657. Hence, according to the mathematical analysis described heretofore, the national debt of USA will become greater than its national GDP. Interestingly, we do notice that the debt of the USA exceeded its GDP in the year 2013! Therefore, if we had done this analysis in the year, say, 2008, we could have

predicted that there will definitely be a time when the national debt will exceed the GDP. Therefore, I would assume this method to be appropriate for finding such a result.

It is intriguing that if such an analysis is done again in the future, we might be able to find the time when the national debt of an economy will exceed its GDP and hence, we can take appropriate measures for it. Though this investigation relies on the data for the USA, similar data sets can be obtained for other economies of the world and the mathematical relation can be set for further investigation.

V. MODELING THE FUNCTIONS OF GDP AND NATIONAL DEBT

Although the appropriate values of k had been found, it would be interesting to look at the same data from the perspective functions, graphs, and related calculus. To do this, the functions of GDP and debt were found using graphs.

A. Modeling the Functions of GDP

To find the functions of USA’s GDP, the collected data was inputted into Vernier’s *LoggerPro* 3.8.6.1 to form a scatterplot. Then, several functions were tried and eventually the most realistic one was found. In these graphs, the dependent variable (GDP of USA) on the y-axis and the independent variable (time t) on the x-axis were taken. After creating a scatterplot, the best-fit quintic graph for the GDP data was found.

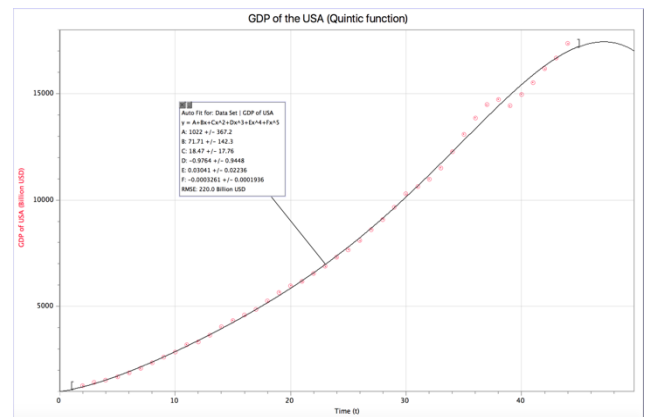


Fig. 2. Quintic model connects data points with a reasonable degree of accuracy

If we extrapolate this graph, the graph seems to be reaching a maximum point at $x = 47$ and then decreasing. Therefore, according to this model, the GDP of the USA will peak in the year 2017. Although there is a slight possibility for this to happen, it cannot be expected that the GDP of USA would suddenly start decreasing one or two months from now. Hence, this model was discarded because this model suggests that, after a particular point, the GDP of USA would continue to decrease for a few more years. Therefore, there was the need to try to fit another function in these data points and find another regression model that seems more realistic. Hence, the logistic function graph was tried.

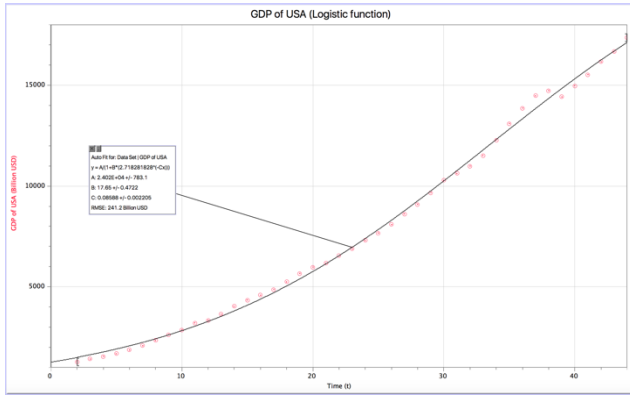


Fig. 3. The logistic curve fits well and hence we can see how it looks like for future years

Extrapolating the graph, we get the following graph:

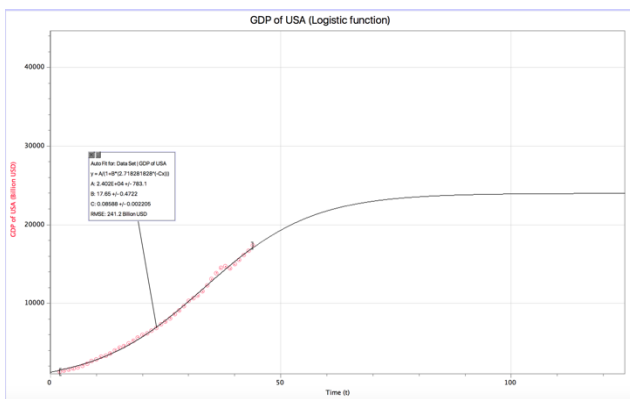


Fig. 4. The graph is continuously increasing even if there is a decrease in the rate of increase

There is no point where we notice that the graph (Figure 4) is going under drastic unexpected changes. This might seem realistic considering that there might be a decrease in the rate of increase of GDP because of use of natural resources. So, this function can be taken for the GDP of USA.

The logistic function that we got using the software and that is finalized is:

$$f(t) = \frac{2.402 \times 10^4}{1 + 17.65e^{-0.08588t}}$$

B. Modeling the Functions of National Debt

To find the functions of USA's national debt, the data was inputted into Vernier's *LoggerPro* 3.8.6.1 to form a scatterplot. Then, several functions were tried and eventually the best, most realistic one was found. In these graphs, the dependent variable (National Debt of USA) on the y-axis and the independent variable (time t) on the x-axis were taken. At first, a best-fit quartic graph for the data of national debt was found.

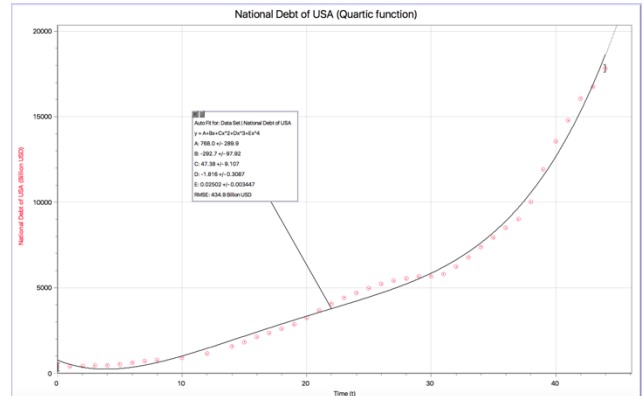


Fig. 5. This graph does seem realistic; it is an increasing function and there are no sudden drastic changes visible

According to this graph, the national debt will continue to increase in the near future. This may sound reasonable because many other research firms have actually discussed the increasing debt of the US Government. The main reasons that they gave why the debt is expected to increase include higher spending on health care because of ageing population, increasing interest rates on the borrowed sum, and insufficient revenue being earned by the government. The quartic function obtained is:

$$f(t) = 0.02502t^4 - 1.816t^3 + 47.38t^2 - 292.7t + 768$$

To better understand the accuracy of this function, the absolute mean error for this function was found. This was done using formulas in an Excel Workbook.

Table III: The mean absolute error obtained using a quartic function is around 341.92 (2 decimal places)

Year	S. No (X)	National Debt (USD BILLION) (Y)	National Debt obtained from quartic model	Absolute Error
1970	0	370.9187069	767.9668186	397.0481117
1971	1	398.1297445	520.8817121	122.7519677
1972	2	427.2604609	358.0058222	69.25463878
1973	3	458.1416053	269.3422315	188.7993738
1974	4	475.0598157	245.4944556	229.5653601
1975	5	533.189	277.666443	255.522557
1976	6	620.433	357.6625749	262.7704251
1977	7	698.84	477.8876652	220.9523348
1978	8	771.544	631.346961	140.197039
1979	9	826.519	811.6461419	14.8728581
1980	10	907.701	1012.991321	105.2903206
1981	11	997.855	1230.189042	232.334042
1982	12	1142.034	1458.646286	316.6122856
1983	13	1377.210	1694.370461	317.160461
1984	14	1572.266	1933.969413	361.7034134
1985	15	1823.103	2174.651419	351.5484186
1986	16	2125.302617	2414.225187	288.9225699
1987	17	2350.276891	2651.09986	300.8229688
1988	18	2602.337712	2884.285013	281.9473014
1989	19	2857.43096	3113.390656	255.9596954
1990	20	3233.313452	3338.627227	105.3137755
1991	21	3665.303352	3560.805602	104.4977495
1992	22	4064.620656	3781.337087	283.2835685
1993	23	4411.488883	4002.233421	409.2554619
1994	24	4692.74991	4226.106777	466.643133



1995	25	4973.982901	4456.16976	517.8131411
1996	26	5224.810939	4696.235407	528.5755323
1997	27	5413.146011	4950.71719	462.4288218
1998	28	5526.193009	5224.629011	301.5639975
1999	29	5656.270902	5523.585209	132.6856927
2000	30	5674.17821	5853.800551	179.6223414
2001	31	5807.463412	6222.090241	414.6268285
2002	32	6228.235966	6635.869912	407.6339466
2003	33	6783.231063	7103.155634	319.9245708
2004	34	7379.052696	7632.563905	253.511209
2005	35	7932.709662	8233.311661	300.6019994
2006	36	8506.973899	8915.216267	408.242368
2007	37	9007.653372	9688.695523	681.0421505
2008	38	10024.7249	10564.76766	540.0427629
2009	39	11909.829	11555.05134	354.7776603
2010	40	13561.62303	12671.76567	889.8573604
2011	41	14790.34033	13927.73017	862.6101563
2012	42	16066.24141	15336.36481	729.8765955
2013	43	16738.18353	16911.68999	173.5064588
2014	44	17824.07138	18668.32652	844.2551415
			Mean	341.9161904

1976	6	620.433	437.1063521	183.3266479
1977	7	698.84	540.2850323	158.5549677
1978	8	771.544	671.7079894	99.83601064
1979	9	826.519	827.7496637	1.2306637
1980	10	907.701	1004.880365	97.1793648
1981	11	997.855	1199.702367	201.847367
1982	12	1142.034	1408.986007	266.9520074
1983	13	1377.210	1629.705777	252.495777
1984	14	1572.266	1859.076422	286.8104219
1985	15	1823.103	2094.589036	271.4860355
1986	16	2125.302617	2334.047156	208.7445395
1987	17	2350.276891	2575.602862	225.3259713
1988	18	2602.337712	2817.792868	215.4551563
1989	19	2857.43096	3059.574621	202.1436605
1990	20	3233.313452	3300.362394	67.04894194
1991	21	3665.303352	3540.063385	125.2399665
1992	22	4064.620656	3779.113812	285.5068431
1993	23	4411.488883	4018.515008	392.9738749
1994	24	4692.74991	4259.869516	432.8803937
1995	25	4973.982901	4505.417188	468.565713
1996	26	5224.810939	4758.071276	466.7396631
1997	27	5413.146011	5021.454534	391.6914776
1998	28	5526.193009	5299.935308	226.2577006
1999	29	5656.270902	5598.663637	57.60726479
2000	30	5674.17821	5923.607343	249.4291334
2001	31	5807.463412	6281.588134	474.1247213
2002	32	6228.235966	6680.317691	452.0817259
2003	33	6783.231063	7128.433775	345.2027121
2004	34	7379.052696	7635.536311	256.4836147
2005	35	7932.709662	8212.223493	279.5138312
2006	36	8506.973899	8870.127875	363.1539757
2007	37	9007.653372	9621.952468	614.2990962
2008	38	10024.7249	10481.50684	456.7819412
2009	39	11909.829	11463.7432	446.0858061
2010	40	13561.62303	12584.7925	976.8305263
2011	41	14790.34033	13862.00056	928.33977
2012	42	16066.24141	15313.96409	752.2773126
2013	43	16738.18353	16960.56688	222.3833542
2014	44	17824.07138	18823.01581	998.944432
			Mean	315.706505

Then, the best-fit function for a quintic graph was applied and the following result was obtained:

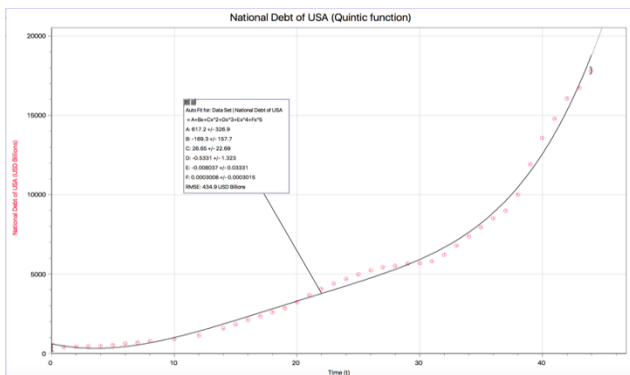


Fig. 6. This graph also seems realistic; it is an increasing function and there are no sudden drastic changes visible

According to this graph also, the national debt will continue to increase in the near future. From this graph, the quintic function obtained is:

$$f(t) = 0.0003008t^5 - 0.008037t^4 - 0.5331t^3 + 26.65t^2 - 169.3t + 617.2$$

To better understand how accurate this function is for my data set, the absolute mean error for this function was also found.

Table IV: The mean obtained using the quintic function is around 315.71 (2 decimal places).

Year	S. No. (t)	National Debt (USD BILLION)	National Debt obtained from quintic model	Absolute Error
1970	0	370.9187069	617.1788077	246.2601008
1971	1	398.1297445	473.9344689	75.80472443
1972	2	427.2604609	380.6796528	46.58080809
1973	3	458.1416053	333.971597	124.1700083
1974	4	475.0598157	330.2468329	144.8129829
1975	5	533.189	365.8572821	167.3317179

Therefore, the absolute mean error is lesser when we use the quintic model and hence, this can be considered to be more accurate compared to the quartic model.

VI. FINDING THE VALUES OF K USING A GRAPHIC DISPLAY CALCULATOR (GDC)

From the analysis above, we know that,

$$dN_D = k (GDP)dt$$

So,

$$k = \frac{dN_D}{dt \cdot GDP}$$

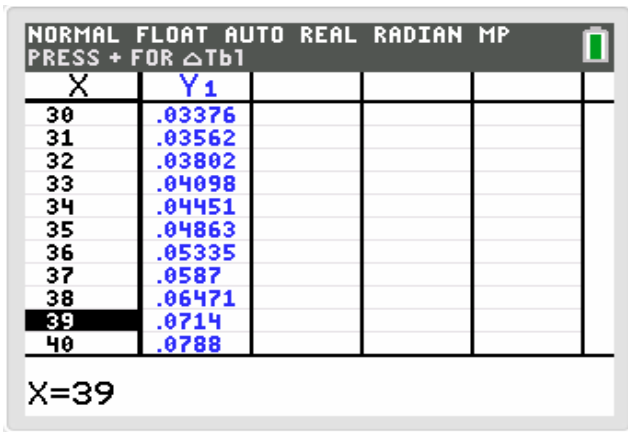
Now, from the functions that we found,

$$\frac{dN_D}{dt} = 0.001504t^4 - 0.032148t^3 - 1.5993t^2 + 53.3t - 169.3$$

Keeping the same logistic function of GDP obtained above, a function for the values of k was formed as following:

$$k = \frac{0.001504t^4 - 0.032148t^3 - 1.5993t^2 + 53.3t - 169.3}{\frac{2.402 \times 10^4}{1 + 17.65e^{-0.08588t}}}$$

Now, I entered this function of k in the TI-84 Plus C Silver Edition Graphic Display Calculator and saw the readings in a tabulated form.



X	Y1
30	.03376
31	.03562
32	.03802
33	.04098
34	.04451
35	.04863
36	.05335
37	.0587
38	.06471
39	.0714
40	.0788

X=39

Fig. 7. Using the GDC, it was found that the values of k are greater than 0.0657 from years 2009 onwards

This is slightly different from the calculations done using Microsoft Excel. Looking at the values after year 2015 ($t = 45$), it can be noticed that the values of k are continuously rising and become much greater than 0.0657. Hence, there is a slight difference between the calculations done using the GDC and the ones done using Excel.

VII. CONCLUSION

It is fairly easy to conclude that had this investigation been done in the years before 2012, we might have found the time when the debt of the USA will exceed its GDP. Therefore, if this type of research is done in the future, we will be able to calculate when a country like the USA might run into a situation of debt being higher than the GDP of the economy.

Looking at this analysis from a different perspective, the large amount of debt might result in the increase in interest rates for the people of the country because if the government must pay off the debt, it must earn higher revenues. These interest rates can affect us in a big way. If they ramp up, a larger portion of the government's budget will be spent on paying the debt, causing less money to be spent on public welfare, infrastructure, etc. Further, the burden of the debt might limit the policymakers' ability to tax and spending as fiscal policy instruments to respond to unexpected future situations, such as an economic downturn or financial crises.

However, it must be noted that there exist certain limitations in this investigation. The predictions might not hold true in case there is a natural calamity such as an earthquake, flood, etc. as such a situation can vastly affect the GDP and debt both. Similarly, in case of wars or political instability, these estimates might not hold true because of possibility of drastic changes in the policies and international relations of USA with other countries. If the

US shakes hands with a country it owes a great sum of money to and the ally relieves the USA from a large portion of the debt, then the debt burden on the US economy will significantly reduce and there would be decreased probability of the US running into a debt crises.

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