Set -1 : Modelling of IBM's Revenue and Human Resource

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In this lab we predict the nature of growth of IBM's revenue and human resources over time by using the integral solution of logistic equation.Also, we compare our result with the actual data to see the accuracy of our prediction.By Modelling we try to find the relation between the mandatory and human assets of global companies like IBM.

I. INTRODUCTION

This paper aims to delve into the dynamic interplay between revenue growth and human resource development within IBM from its foundational years in 1914 to the year of 2006. By Modelling , we try to find the co-relation between the human resources and monetary assets. This paper endeavors to construct models that elucidate the patterns, trends, and underlying factors contributing to IBM's growth in revenue and its parallel evolution in managing its workforce.

II. MODEL

The logistic equation is a standard example of a first-order autonomous nonlinear dynamical system.First-order autonomous dynamical systems have the general form of $\frac{dx}{dt} = f(x)$ where x = x(t), with t being time.A basic model of a nonlinear function is given by

$$\frac{dx}{dt} = ax - bx^2 \tag{1}$$

with a and b being fixed parameters. This leads to the well-known logistic equation,

$$f(x) = ax - bx^2 \tag{2}$$

Under the initial condition of x(0) = x_0, and with the definition of k = a/b, the integral solution of Eq. (1) is

$$x(t) = \frac{kx_0e^{at}}{k + x_0(e^{at} - 1)} \tag{3}$$

which is the logistic function.Eq. (2) represents the logistic equation whose integral solution Eq. (3) is widely used to predicate human resources, profit and net revenue of the companies like IBM. It is also used to predict the GDP and other parameters of various countries over a certain period of time.

The time at which the non-linear effect starts asserting itself is given by

$$t_{nl} = \frac{1}{a}\log(\frac{k}{x_0} - 1) \tag{4}$$

The linearisation of human resources and revenue given the following formula:

$$V \sim U^{\beta} \tag{5}$$

Defining $V = R^{-1} - k_R^{-1}R$, $U = H^{-1} - k_H^{-1}H$, and $\beta = \rho_1/\eta_1$, the H-R phase solutions are transformed to a compact power-law form. The power-law in Eq. (5) fits the data well in the log-log plot in Fig. 4.

III. RESULTS

Fig. 1 shows the net revenue growth of IBM company over span of 75-80 years.The graph starts saturating over the span of 75-80 years.This is the general behavior of a first order autonomous nonlinear dynamic system. The growth of a company also shows the same behavior over a considerable amount of period and hence the revenue growth curve fits the logistic model almost at every region.

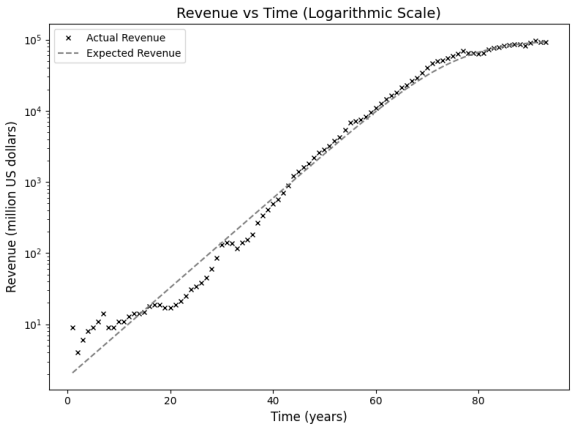

FIG. 1: Modelling the annual revenue growth of IBM, using the company data from 1914 to 2006 [1]. The parameter values to fit the revenue growth are $\rho_1 = 0.145\ year^{-1}$ and k_R= 100 billion dollars. The mean $\mu_R = 0.0254$ and standard deviation $\sigma_R = 0.4592$ is found between real and analytical data.

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Fig. 2 shows the growth of human resources of IBM company over span of 75-80 years.This graph also almost overlaps with our logistic model and shows same behavior as revenue growth.

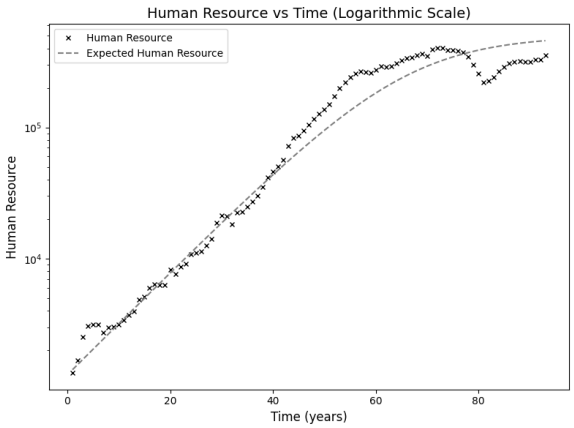

FIG. 2: Modelling the human resource growth of IBM, using the company data from 1914 to 2006 . The parameter values to fit the human resource growth are $\eta_1 = 0.09$ year^{-1} and $k_H = 500000$ The mean μ_H = -0.0011 and standard deviation $\sigma_H = 0.0018$ is found between real and analytical data.

Fig. 3 shows profit of IBM company over the span of 75-80 years.Around this time IBM suffered huge losses.Its effect is seen in loss of human resources around the same time period inf Fig. 2.

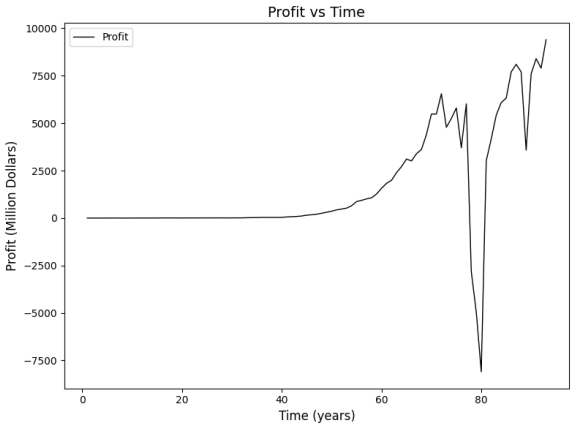

FIG. 3: The net annual earnings (the profit P) of IBM grow steadily up to 75-80 years which is also the same timescale as above two graphs.

Fig. 4 shows correlation of Human resources and Net revenue of IBM over the timescale of 75-80 years.Here Defining V = $R^{-1} - k_r^{-1}$ and U = $H^{-1} - k_h^{-1}$ and $\beta = \frac{\rho_1}{\eta_1}$, the H-R phase solutions are transformed to a compact power-law form as $V = U^{\beta}$.The log-log fits the power law very well except the bottom left.

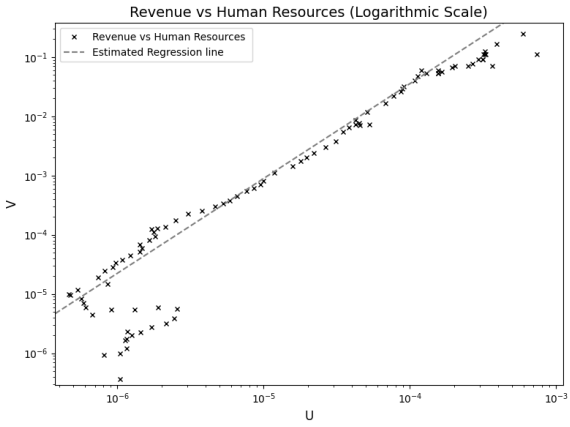

FIG. 4: Log-log plot of correlated growth of H and R, with $\beta = 1.5$ (close to $\beta = 1.6$).

IV. CONCLUSIONS

In conclusion, our exploration involved a basic mathematical model, the logistic equation, to predict the growth of IBM's revenue and human resources.

⇒ From Fig. 1 and Fig. 2, we can see that the modeled curve follows the general trend of the annual revenue and the human resource count. It saturates at a constant value when t→∞.

⇒ From Fig. 2 and Fig. 3, we can observe a drop in Profits of IBM indicating a major loss and dip in Human Resources of IBM which thus explains Layoffs that took place in the year 1990.

⇒The log-log plot of actual data and the logistic function of correlated growth of H and R closely align except for the lower left bottom which seems quite unpredictable. Hence the logistic equation fits our curve very well.

[1] Arnab K. Ray, *Logistic modelling of economic dynamics*, DA-IICT (2023).