

## **Dynamics of Financial System: A System Dynamics Approach**

**Girish K. Nair**

Team Leader - International Hospitality Management Faculty  
(Finance & Economics), Stenden University, QATAR.  
Email: gknair7474@yahoo.com

**Lewlyn Lester Raj Rodrigues**

Department of Humanities & Social Sciences, Manipal Institute of Technology,  
Manipal University, India. Email: rodriguSr@gmail.com

**ABSTRACT:** There are several ratios which define the financial health of an organization but the importance of Net cash flow, Gross income, Net income, Pending bills, Receivable bills, Debt, and Book value can never be undermined as they give the exact picture of the financial condition. While there are several approaches to study the dynamics of these variables, system dynamics based modelling and simulation is one of the modern techniques. The paper explores this method to simulate the before mentioned parameters during production capacity expansion in an electronic industry. Debt and Book value have shown a non-linear pattern of variation which is discussed. The model can be used by the financial experts as a decision support tool in arriving at conclusions in connection to the expansion plans of the organization.

**Keywords:** Financial System; Taxable Income; Net Income.

**JEL Classifications:** M20; M21; M29.

### **1. Introduction**

There are a number of forces which make the issue of financial system design extremely complicated and various approaches have been floated into this research domain. Fundamental and radical changes in the financial industries, such as deregulation and concurrent advances in technology, have made a visible impact on the provision of financial services and the way the financial terms are used to enhance the system performance. Deregulation, in various parts of the world, has made flexible the provision of financial services and promoted competition among financial institutions and advances in technology has increased profitability and facilitated faster processing and monitoring of multiple activities at even lower costs (Berger, 2003; Berger and DeYoung 2006; and Artikis et al., 2008).

Concurrently, a thorough study of financial terms has been practiced since the past several decades, as it provides direct benefits such as: enhanced leverage particularly in the form of tax benefits, support in terms of restructuring or economic downturns because of long-term lender relations, ability to borrow more for long-term project purposes, and increase in investment efficiency (Saunders and Walter, 1996). Allocation decisions are also vital because they are the basis for future success or failure of the company (Rumelt, 1991, McGahan and Porter, 1997; Bowman and Helfat 2001; and Ruefli & Wiggins, 2003).

Researchers have used various approaches to study the firm's performance. Dick (2009) has examined the effect of competition for internal resources on income volatility of investment banks. Chen et al. (2001) have used financial factors to enhance the productivity of manufacturing firms. Prince (2008) designed a model and identified three financial styles, each of which comprises three financial signatures leading to characteristic financial decisions with specific valuation outcomes. Gouws and Lucouw (2000) endorse systems concept and have developed an empirically tested dynamic balance model to establish whether entities are able to adapt, survive and prosper. They have used systems thinking to provide an alternative to financial analysis to uncover new dimensions within organizations that could enhance thinking in terms of business survival and success. They considered

four ratios in their dynamic model: profit margin on turnover, return on equity, assets on liability and profit on expenses. Glautier & Underdown (2001) consider accounting as a social science which lends itself to analysis as an information system, because it has all the attributes of a system. As accounting information is required for decision making purposes, systems approach through modeling and simulation is very well justified and provides ample scope to study the influence of dynamic factors on system performance. This paper is basically a systems approach to the finance dynamics in a manufacturing firm.

## **2. Literature Review**

The financial dynamics modeled and simulated in this paper revolve around the following variables, which have influence on business performance. There have been extensive study on the influence of key financial terms on business performance since past several decades, and research in direction is an ongoing endeavor. In the context of this research, following are the variables of interest.

### ***Taxable Income***

Gruber and Saez (2002) have extensively studied the elasticity of Taxable income. They have estimated that the compensated and uncompensated elasticities of taxable income are very similar. They opine that standard behavioral responses are only one component of what drives taxable income; other responses such as the form of compensation, unmeasured effort, and compliance also ultimately determine taxable income, and these may be more elastic with respect to taxation. Further, overall elasticity of taxable income is relevant for assessing the implications of tax changes for revenue raising. There is research literature on the responsiveness of other elements of taxable income to taxation, such as charitable giving and the form of compensation (as well as tax evasion), which suggests that these elements are fairly sensitive to taxation (Slemrod, 1990). It is observed that compensated elasticity of taxable income is the crucial parameter in models of optimal progressivity.

A lot of research is in progress to study the relationship of taxable income and its bearing on the overall performance of the organization on financial terms. Robinson (1987) has undertaken an after tax analysis for both capitalization and cash flow techniques and emphasizes that in order to assess the effect of the allowance, some form of after tax analysis is required. Gellego (2004) has studied the relationship between accounting and fiscal rules and concludes that financial statements conform to accounting principles and methods regardless of tax rules. Malkawi and Haloush (2008) have distinguished between tax evasion and tax avoidance and provided empirical data on the size of income tax evasion. They also suggest several means that can be used to address income tax evasion. Lin and Zeng (2010) examine the distributional impact of income tax in Canada and China over the past decade and suggest that future studies should be conducted to compare the distributional impacts of the new tax system against those of the old tax system. Hence, the study of the influence of income tax dynamics is already a potential area of research.

Taxable income is generally the gross income or adjusted gross income minus any deductions, exemptions or other adjustments that are allowable in that tax year. Taxable income is also generated from appreciated assets that have been sold or capitalized during the year and from dividends and interest income. Income from these sources is generally taxed at a different rate and calculated separately by the tax entity.

### ***Net Income***

Dhaliwal et al. (1999) have conducted a research to compare the comprehensive income to net income as a measure of firm's performance. They have found out that there is no evidence that comprehensive income is more strongly associated with returns/market value or better predictor of future cash flows/income than net income. So, Net income is obviously a reliable measure of firm's performance. Comprehensive income measure includes net income and net-of-tax adjustments for changes in unrealized gains/losses on securities, foreign currency gain/loss adjustments, and minimum pension liability adjustments. Kreuze, and Newell (1999) analyzed the effects of comprehensive income disclosures for 100 randomly selected Fortune 500 companies and have proved empirically that a large number of firms may report a comprehensive income amount different from reported net income and although these differences may be significant for some firms, the majority of these adjustments will not cause comprehensive income to be materially different from reported net income for most firms.

Relationship between the market price of firms and their reported net income and equity values has also been studied by a group of researchers. Rees (1999) proved that the relative weight of the equity and net income coefficients vary across the short time span available with increasing emphasis on net income. Abuzayed et al. (2009) have followed the value relevance literature methodology to tests for the difference between book and market values using a variety of indicators including net income and its components. They have found that net earnings (and its components) are value relevant and explain the gap between market and book values. All these studies underscore the importance of Net earnings in financial dynamics of an organization and its bearing on several other parameters of interest.

#### **Net Cash flow**

Uzma et al. (2011) in their research article mention about Discounted Cash Flow (DCF) method, which forms the traditional cash flow method, used in business valuation and claim that even leading companies use it even today. There are several variations in Cash flow as such and Fernandez (2007) has made comprehensive study using DCF method for valuing companies by adopting different approaches such as equity cash flow, capital cash flow, adjusted present value, business risk adjusted free cash flow and equity cash flow, risk-free rate-adjusted free cash flow and equity cash flow, economic profit, and economic value added (EVA) and concluded that all these arrive at same value. However, DCF mainly refers to the intangible assets of the organization which is receiving an increasing importance in the current business scenario. Whether to have a single discount rate for a year or a series of discounted rates varying with the number of years is a question that bothers many, and consequently, the researchers have also used probability-based valuation to incorporate the uncertainty element in their study (Schumann, 2006). Computer-aided technology has been applied by the companies for using the option pricing models by Monte Carlo and other simulation approaches. Proponents of agency theory argue that firm leverage is positively associated with Cash flow (Jensen, 1986; Stulz, 1990). In the context of current research the Cash flow is with reference to the tangible assets of the organization and it is considered to be a function of Receivable cash, Loans, New investment, Variable costs, Interest payments, Repayment rate and Taxes.

#### **Debt**

Since the early days, the impact of capital structure on the value of the firm has been a puzzling issue in corporate finance (Modigliani and Miller, 1958). A review of the literature suggests that noninterest income is not only a function of size of the industry, credit risk, interest rate risk, liquidity risk, overheads, loan loss provisions, and before tax profit, but also, has an important bearing on the debt structure (Nguyen, 2012). The capital structure of a company is usually leveraged by the ratio of debt and equity (Uzma et al., 2011). There is also an argument that the role of debt is in conveying inside information to the market (Ross, 1977). The capital structure consists of companies obtaining funds or capital from equity or the combination of debt and equity. The cost of debt capital generally can be determined as the interest rate being charged for the long-term debt. Liu (2000) empirically compared the debt service capacity indicators between the most important factors that cause financial crises. According to him the critical factor that causes financial crisis is short-term debt to total debt ratio.

Causholli and Knechel (2011) examines whether high quality audits reduce a firm's cost of debt and observe that effect of auditor quality is larger for firms in the high tech industry sector. There are series of research in this direction focusing on the influence of audit quality on equity (Beatty, 1989 and Willenborg, 1999) and the influence on debt (Mansi et al., 2004; Pittman and Fortin, 2004; Fortin and Pittman 2007; and Kim et al., 2011).

There is also a stream of debt related study to find out whether investors tend to reward firms that resist the urge to borrow and operate with debt free balance sheet and penalize firms that have high levels of debt. Zaher (2010) has empirically proved that investments in portfolios of debt free firms tend to generate higher returns than investments in their peers of portfolios of leveraged firms over long and short periods.

All these studies have delineated the fact that cost of Debt has an important bearing on business performance, and its dynamics has to be studied, if at all the overall performance has to be increased in a continual basis.

### **Book Value**

Book value is the value of an asset according to its balance sheet account balance. The value is based on the original cost of the asset less any depreciation, amortization or Impairment costs made against the asset. Book value is its total assets minus intangible assets and liabilities. However, in practice, depending on the source of the calculation, book value may variably include goodwill, intangible assets, or both (Hermanson et al., 1987). Most of the time the fact that the Book value can be tangible or intangible is ignored in financial calculations. When intangible assets and goodwill are explicitly excluded, the metric is often specified to be tangible book value. In the current analysis the Book value is taken as New investment minus the Tax depreciation and refers only to the tangibles.

Study of the influence of Book value has been a constant endeavor in financial research. Barth et al. (2001) conducted an extensive study to test predictions that pricing multiples on and incremental explanatory power of equity book value increases as financial health decreases. Fama and French (1992) argue that leverage based on book values is associated with lower average returns, whereas leverage based on market is associated with higher returns and conclude that this variation in their findings is explained and absorbed by the book-to-market effect.

### **3. Research Methodology**

In this paper, the principles of cybernetics as proposed by Wiener (1948) and Ashby (1957) and the System Dynamics (SD) methodology proposed by Forrester (1961), which have been applied by various researchers (including Coyle 1977, Mohapatra et al., 1994; Morecroft, 1999; Jessen, 1990; Reichelt, 1990; and Richardson & Pugh 1981) in different problem situations was used in developing causal loop diagrams, flow diagrams, and the governing equations. The SD model thus developed has been used to analyze the factors such as change in scope due to the development of new technology. The key steps in the methodology of this paper include: problem identification, cybernetics, model formulation, simulation and validation, and policy analysis and improvement (Sterman, 2000).

### **4. The Financial Structure Model**

The system dynamics modeling scenario chosen in this analysis is that of a hypothetical electronic system manufacturer who aims at an expected annual production of about 8000 units in the next five years from a current production of about 1100 units. The company plans for an annual increase rate of production by 10% to 40% per year through augmentation of production equipment and wants to simulate the financial dynamics with the specific variables of interest.

Revenue for the manufacturer is basically through the production sales. Unit price of sales (US\$) is taken for convenience as the simulation figures may be multiplied by the selling price for realistic values. The dynamics involved considers Receivable bills and Pending bills the difference of which is actual Billings. Variable cost per unit is assumed to be about 60% of the unit selling price. Pending bills will be the actual billing minus the production revenue and Receivable bills is the Billings minus the sum of the receivable cash and losses (with a loss rate of about 6%). The rate of Receivable cash is calculated in terms of the payment delay which is considered slightly over a month. The stock and flow diagram (Figure 1) indicates the interrelationship between the variables of research interest. The complete set of equations used in modeling has been given in appendix 1, however, some key formulae are as follows:

$$\text{Taxable income} = \text{Gross income} - (\text{Variable costs} + \text{Losses} + \text{Interest payments} + \text{Tax Depreciation}).$$

$$\text{Net income} = \text{Taxable income} - \text{Taxes}.$$

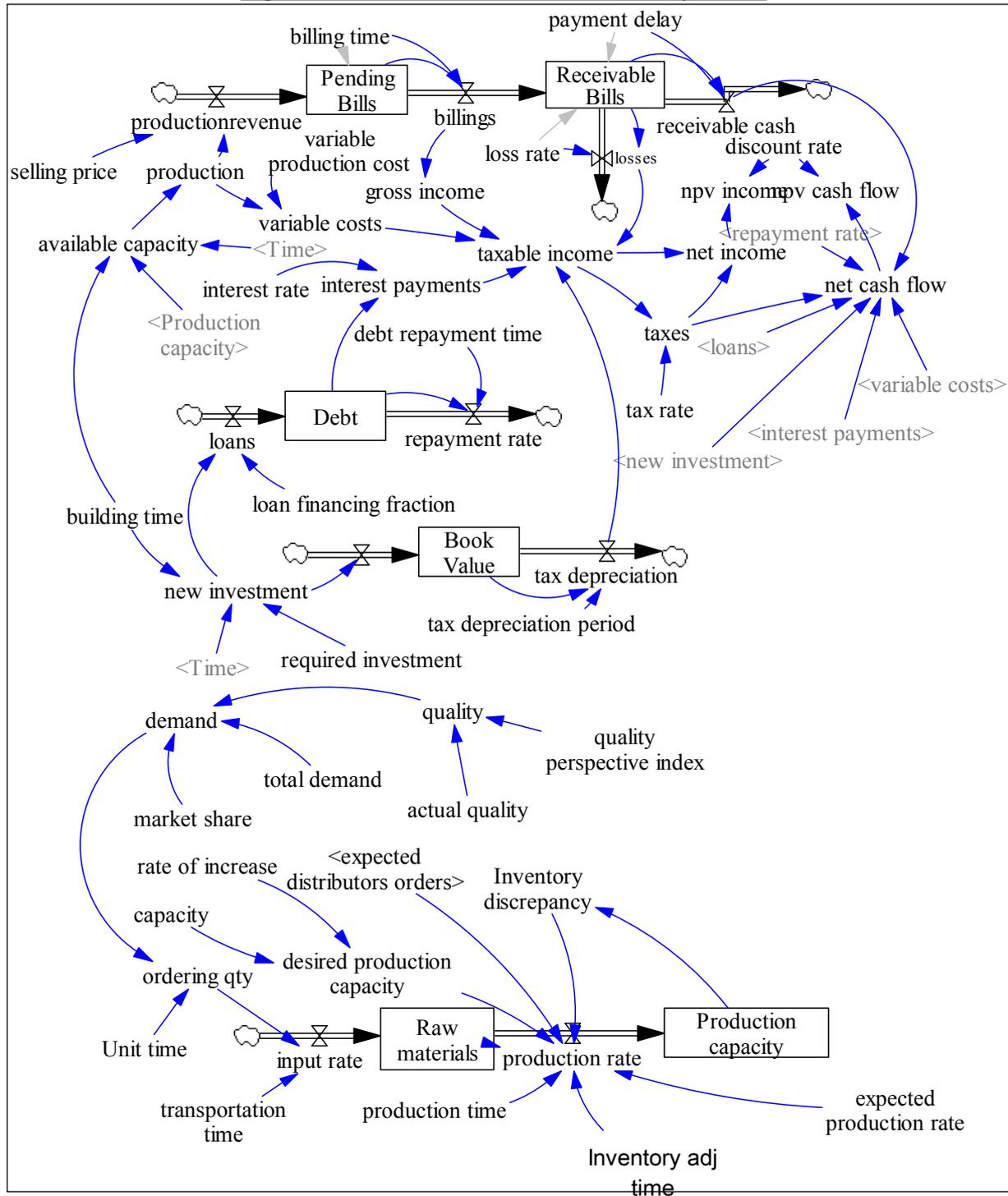
$$\text{Net cash flow} = \text{Receivable cash} + \text{Loans} - (\text{New investment} + \text{Variable costs} + \text{Interest payments} + \text{Repayment rate} + \text{Taxes}).$$

$$\text{Debt} = \text{Loans} - \text{Repayment rate}.$$

$$\text{Book value} = \text{New investment} - \text{Tax depreciation}.$$

The details of the equations as used in the software (Vensim™) is given in Appendix I. Simulation is carried out to study the influence of the planned increase of production on: Pending bills, Receivable bills, Net cash flow, Gross income, Net income, Debt and Book value.

**Figure 1. The Stock and flow of financial dynamics**

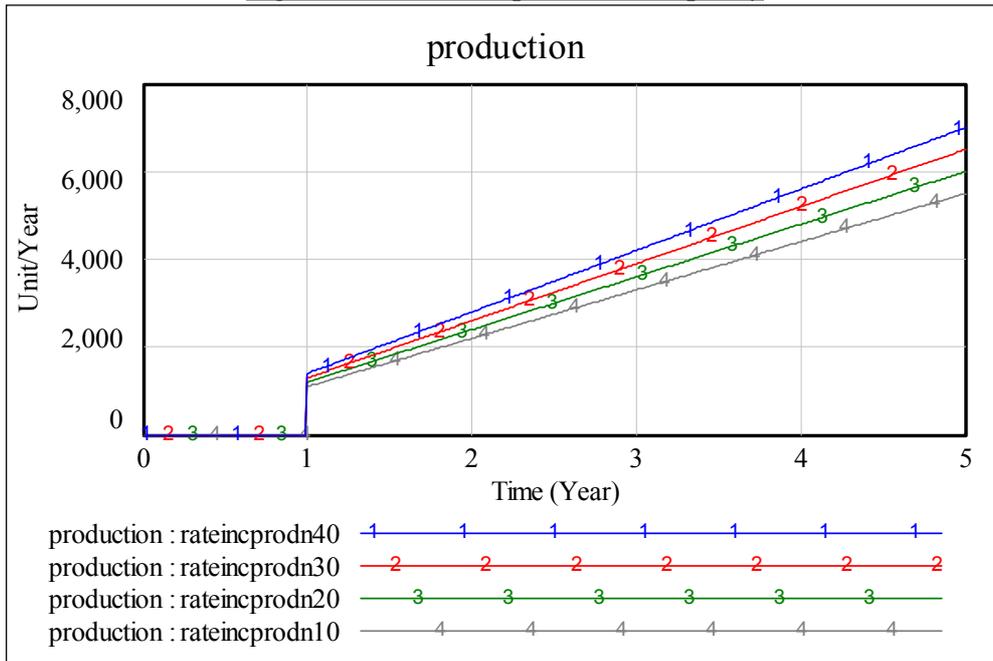


## 5. Simulations and Discussions

### *Production capacity:*

The simulations have been carried out to study the variations for a ten to forty percent increase in production rate per year, which the company has aimed for. The increased production on yearly basis is shown in the figure 2.

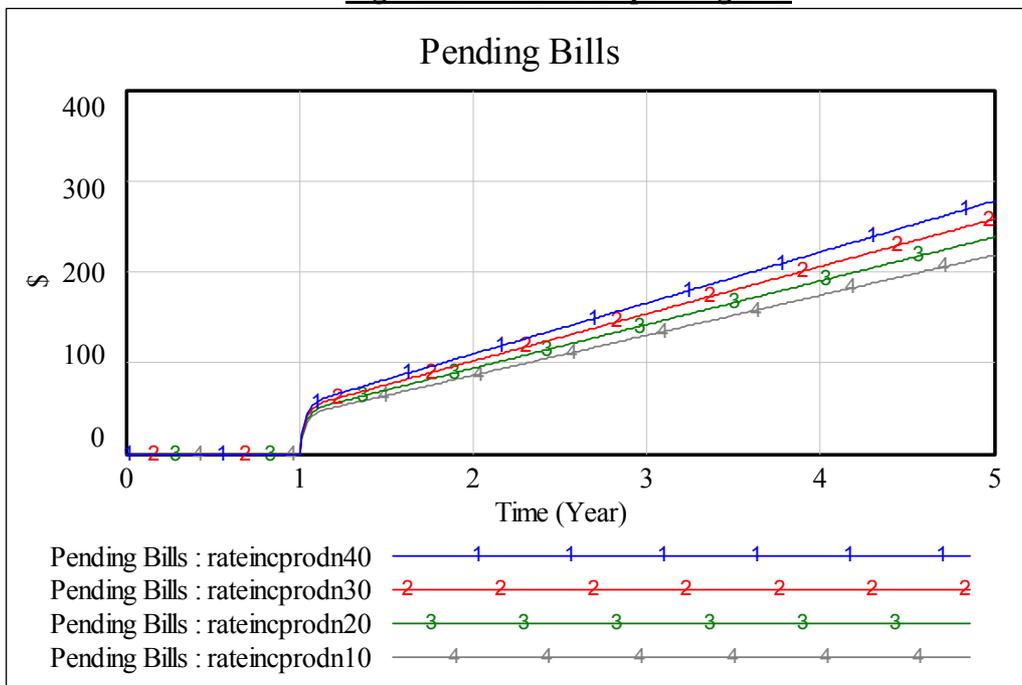
**Figure 2. Increase in production capacity**



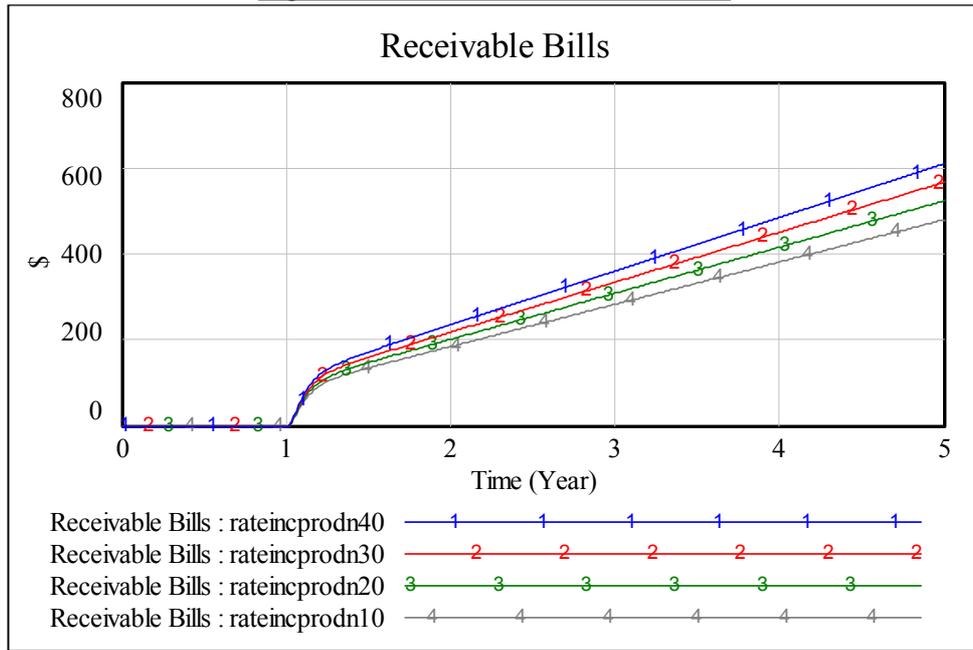
**Pending bills and Receivable bills**

The model has predicted the linear increase in the rate of Pending bills and Receivable bills starting from the first year with the existing conditions prevailing for a variation of production rate from 10 to 40 percent. The billing time is considered to be about 2 weeks. Due to the linear growth pattern that can be observed (Figure 3 & 4) a proportionate rise in the pending bills can be observed. At any intermediate period of time the amount can be easily observed through the simulation results.

**Figure 3. Influence on pending bills**



**Figure 4. Influence on receivable bills**

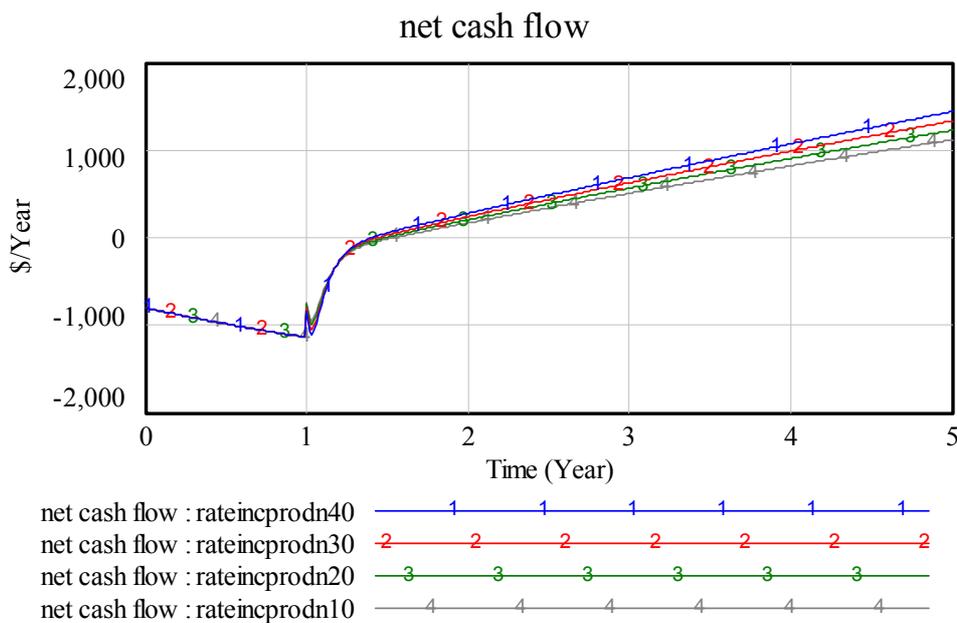


**Net cash flow**

In business, cash flow is considered to be the life-blood because if the business is not able to obtain new finance it will become insolvent. Hence, it is important to predict (forecast) what is going to happen to cash flow to make sure the business has enough to survive.

Increase in the Net cash flow is non-linear rise during the beginning of the second year and then approaches a linear growth pattern. It is interesting to note that initially the increase in the cash flow is negligibly small, however, after the fourth year, there is a uniform growth in the Net cash flow for the given increase in the production rate. From the second to the fifth year when the production rate is increased from 10 to 40% the Net cash flow increase would be about 35% (figure 5).

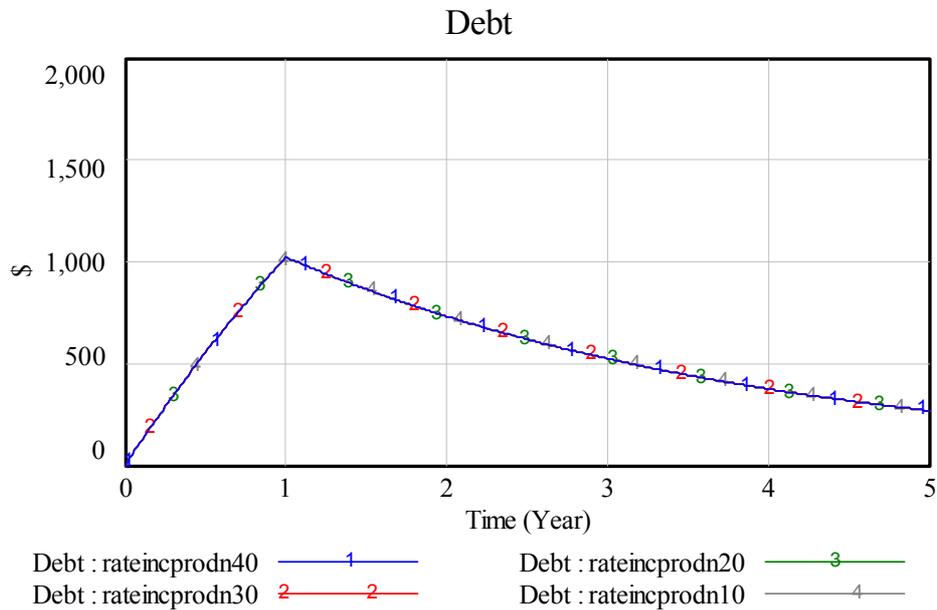
**Figure 5. Influence on net cash flow**



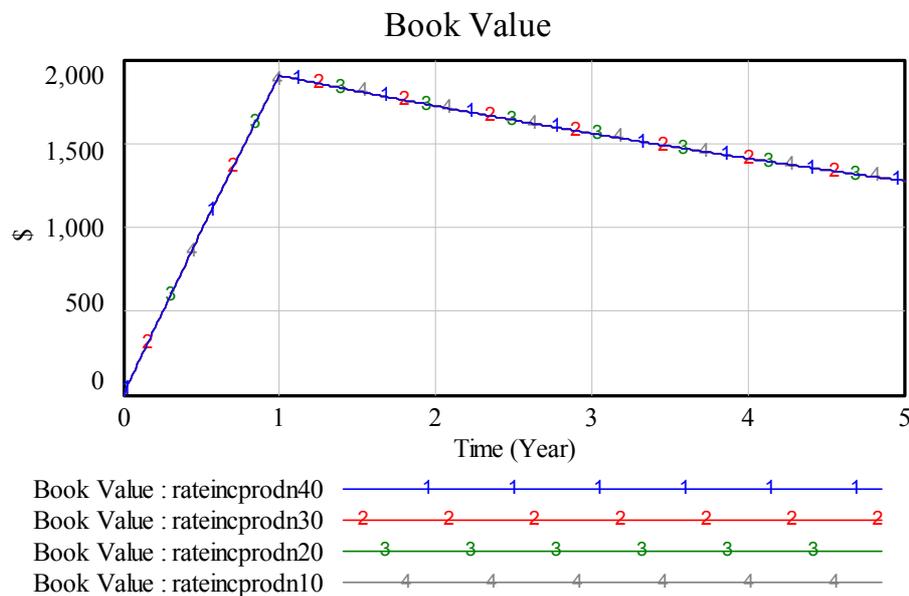


fifth year of operation. Similar trend can also be observed in the Book value of the company and it reduces to about 64% of the value by the fifth year.

**Figure 8. Variation in debt**



**Figure 9. Variation of Book value**



## 6. Conclusion

This paper has explored the possibility of using systems concept in financial system and modeled a real life scenario. When a company plans for the increase in production the corresponding dynamics in financial scenario has been simulated. For an increase in production from 10 to 40%, the variations in Net cash flow, Gross income, Net income, Pending bills, Receivable bills, Debt, and Book value have been simulated. Debt and Book value have shown a non-linear pattern of variation. The model can be used by the financial experts as a decision support tool in arriving at conclusions in connection to the expansion plans of the organization. From the second to the fifth year of operation, when the production rate is increased from 10 to 40% the Net cash flow increase would be about 35%, Gross income by 40%, and Net income by 60%. At the same time the Debt gets reduced to about 27% and

Book value gets reduced to 64% by the end of the fifth year of operation. While these figures cannot be generalized completely to a manufacturing company as there could be extraneous factors which might cause a confounded relationship, it provides ample scope for discussion and opens up a new direction for research. Future researchers can also think of simulating the various ratios for a given increase in production.

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**Appendix 1**

- (01) actual quality = 0.6  
Units: Dmnl
- (02) available capacity=IF THEN ELSE(Time >= building time,Production capacity,0)  
Units: Unit/Year
- (03) billing time = 0.04  
Units: Year
- (04) billings = Pending Bills/billing time  
Units: \$/Year
- (05) Book Value = INTEG(new investment-tax depreciation,0)  
Units: US \$
- (06) building time = 1  
Units: Year
- (07) capacity=1000  
Units: Unit
- (08) Debt = INTEG(loans-repayment rate,0)  
Units: US \$
- (09) debt repayment time=3  
Units: Year
- (10) demand=market share\*total demand\*quality  
Units: Unit
- (11) desired production capacity=capacity\*rate of increase  
Units: Unit/Year
- (12) discount rate = 0.12  
Units: 1/Year
- (13) expected distributors orders=8000  
Units: Unit
- (14) expected production rate=3000  
Units: Unit/Year
- (15) FINAL TIME = 5  
Units: Year
- (16) gross income = billings  
Units: US \$/Year
- (17) INITIAL TIME = 0  
Units: Year
- (18) input rate=ordering qty/transportation time  
Units: items/Week
- (19) interest payments = Debt \* interest rate  
Units: US \$/Year
- (20) interest rate = 0.12  
Units: 1/Year
- (21) Inventory adj time=0.04  
Units: Year
- (22) Inventory discrepancy=Production capacity  
Units: Unit
- (23) loan financing fraction = 0.6  
Units: Dmnl
- (24) loans = new investment \* loan financing fraction  
Units: US \$/Year
- (25) loss rate = 0.06  
Units: 1/Year
- (26) losses = Receivable Bills \* loss rate  
Units: US \$/Year
- (27) market share= 6000  
Units: Unit
- (28) net cash flow=receivable cash + loans - new investment -variable costs - interest  
payments - repayment rate - taxes  
Units: US \$/Year
- (29) net income = taxable income - taxes  
Units: US \$/Year
- (30) new investment=IF THEN ELSE(Time>= building time,0,required investment/building  
time)  
Units: US \$/Year
- (31) npv cash flow = NPV(net cash flow,discount rate,0,1)

- Units: US \$
- (32)  $npv\ income = NPV(\text{net income}, \text{discount rate}, 0, 1)$   
Units: US \$
- (33)  $\text{ordering qty} = \text{demand} * \text{Unit time}$   
Units: Unit
- (34)  $\text{payment delay} = 0.09$   
Units: Year
- (35)  $\text{Pending Bills} = \text{INTEG}(\text{production revenue} - \text{billings}, \text{production revenue} * \text{billing time})$   
Units: US \$
- (36)  $\text{production} = \text{available capacity}$   
Units: Unit/Year
- (37)  $\text{Production capacity} = \text{INTEG}(\text{production rate}, 0)$   
Units: Unit
- (38)  $\text{production rate} = \text{MAX}(\text{MIN}(\text{MIN}(\text{Raw materials}/\text{production time}, \text{desired production capacity}), \text{expected distributors orders} - \text{expected production rate} + \text{Inventory discrepancy}/\text{Inventory adj time}), 0)$   
Units: Unit/Year
- (39)  $\text{production time} = 0.04$   
Units: Week
- (40)  $\text{production revenue} = \text{production} * \text{selling price}$   
Units: US \$/Year
- (41)  $\text{quality} = \text{actual quality} * \text{quality perspective index}$   
Units: Dmnl
- (42)  $\text{quality perspective index} = 0.6$   
Units: Dmnl
- (43)  $\text{rate of increase} = 1.4$   
Units: Dmnl
- (44)  $\text{Raw materials} = \text{INTEG}(\text{input rate} - \text{production rate}, 100)$   
Units: Unit
- (45)  $\text{Receivable Bills} = \text{INTEG}(\text{billings} - \text{receivable cash} - \text{losses}, \text{billings} / (1/\text{payment delay} + \text{loss rate}))$   
Units: US \$
- (46)  $\text{receivable cash} = \text{Receivable Bills}/\text{payment delay}$   
Units: US \$/Year
- (47)  $\text{repayment rate} = \text{Debt}/\text{debt repayment time}$   
Units: US \$/Year
- (48)  $\text{required investment} = 2000$   
Units: US \$
- (49)  $\text{SAVEPER} = \text{TIME STEP}$   
Units: Year
- (50)  $\text{selling price} = 1$   
Units: US \$/Unit
- (51)  $\text{tax depreciation} = \text{Book Value}/\text{tax depreciation period}$   
Units: S \$/Year
- (52)  $\text{tax depreciation period} = 10$   
Units: Year
- (53)  $\text{tax rate} = 0.4$   
Units: Dmnl
- (54)  $\text{taxable income} = \text{gross income} - \text{variable costs} - \text{losses} - \text{interest payments} - \text{tax depreciation}$   
Units: US \$/Year
- (55)  $\text{taxes} = \text{taxable income} * \text{tax rate}$   
Units: US \$/Year
- (56)  $\text{TIME STEP} = 0.015625$   
Units: Year
- (57)  $\text{total demand} = \text{RANDOM UNIFORM}(800, 1000, 2)$   
Units: Unit/Week
- (58)  $\text{transportation time} = 0.08$   
Units: Year
- (59)  $\text{Unit time} = 0.08$   
Units: Year
- (60)  $\text{variable costs} = \text{production} * \text{variable production cost}$   
Units: US \$/Year
- (61)  $\text{variable production cost} = 0.6$   
Units: US \$/Unit