Abstract—Working capital (WC) is closely associated with profitability has been asserted by many correlation studies. Furthermore, the financial performance data of scores of manufacturing, trading and service firms indicate that a negative relationship seems to exist between the constituents of WC—and the firm’s net operating profitability (NOP). However, such inferences are almost all correlation-based—a statistical procedure that quantifies association but does not establish causality. The present study takes a different path to probe this conjectured dependency—it sets up a first-principles model and statistical experiments. The model is crafted to represent the cost of net working capital with which the factors hypothesized to be influencing NOP can be varied systematically and the consequent effect on it examined. Thus conducted, the results establish statistically valid affirmation of causation of WC, if any, on NOP. We conclude, unlike earlier studies, that there is no exclusive prescription for managing WC to raise NOP, as “it depends!”

Keywords—Working Capital, Profitability, Causality, Economic Cost Modeling, Statistical Experiments

I. PROFITABILITY AND WORKING CAPITAL

A firm’s ultimate objective is to maximize profit or the wealth generated for its stakeholders, by conducting its operations in the most prudent manner. Wal-Mart’s ways in this regard have been unique. In order to generate additional profits for itself it has been innovative and counter-conventional. With a daily revenue of $1.2 billion (2012), Wal-Mart currently maintains accounts payable (AP) of $30-40 billion, while its accounts receivables are close to $4 billion. Accounts payable is the amount that Wal-Mart is yet to pay to its suppliers for the inventory it has purchased, while accounts receivable (AR) is the sales revenue that Wal-Mart is yet to collect from its customers. Wal-Mart’s “Every day low price!” to raise profits has an enabler—“Delay payments; Collect cash from customers immediately!”—a strategy that frees up a great deal of cash with which it finances its short term operations. To be fair, this strategy is not for everyone. Wal-Mart has been able to maintain the wide difference between payables and receivables because of its influence over the suppliers and the brand image that it has built over the years. For its business, those high payables balances now allow Wal-Mart to hold significant cash and bank deposit that it can invest in its own business or that can earn interest. Significantly, by managing its working capital this way, Wal-Mart earns over $2 million per day based on earning a modest 3% annualized return on $40 billion of cash yet to be paid to its suppliers.

Furthermore, other than AP and AR, Wal-Mart manages yet another component of WC smartly. It holds inventories that are only 8-10% of its annual sales. Thus it rotates its entire inventory almost every month. Such action further reduces net working capital (the accounting term defined as the difference between current assets and current liability, or Cash and bank deposit + Accounts Receivable + Inventory – Accounts Payable) for Wal-Mart, freeing up additional cash for investment. As a way to maximize shareholders’ wealth Wal-Mart acknowledges this mode of its conducting business as a formal strategy as follows:

“We generally operate with a working capital deficit due to our efficient use of cash and bank deposit in funding operations and in providing returns to our shareholders in the form of stock repurchases and the payment of dividends.” [8].

Clearly this is workable for a firm with the reputation and market clout comparable to Wal-Mart’s. In any other situation, large payables are a sign that the firm may be in serious financial trouble. Still, be that as it may, it raises an intrigue—how does negative working capital impact a company’s bottom line? If this effect can be proven to be advantageous, it would impel any firm’s policy makers to create conditions so one may indeed strive to sustain negative working capital.

We conduct this cause-effect inquiry by first developing an analytical model for the cost of working capital—from first principles. Next we conduct certain L9 statistical experiments with it to probe causalities if any [6]. We begin by defining below key terms used later in this paper.

Inventory must be visualized as stacks of money sitting on forklifts, shelves, pallets, storage tanks, trucks, tankers and planes while in transit. At minimum, this money is not earning any interest, nor is available to be immediately invested in some profitable venture. Firms, particularly small
businesses, frequently suffer due to lack of money, for they need operating **cash and bank deposit** to pay bills, wages, etc. and for unforeseen expenses while conducting day-to-day operations. Thus cash flows—it comes in and goes out—with money left over at the end of the month.

**Accounts payables** (AP) are created by credit purchases—for buying goods and services for which payments are not immediately made to suppliers. Generally this relies on mutual trust and the reputation of the firm. In cash management creditors form a vital part and a firm.

**Accounts receivables** (AR) are created to attract customers, for these allow customers to assess product or service quality and to enjoy its consumption before paying. Such arrangement generally increases sales, though it requires the firm to recover the receivables later, and possibly also incur bad debts that are never paid back. Expanding AR has the general effect of raising working capital requirement.

**Working capital** (WC) is the money needed to fund the normal, day to day operations of a business. WC ensures that the firm has enough cash to pay its debts and expenses as they fall due. **Net working capital** (NWC) is the difference between current assets and current liabilities. If the former is less than the latter, then NWC is negative. A firm that generates negative working capital is using supplier credit as a *source of capital*. Wal-Mart and Dell do this as regular strategy to grow. But a negative non-cash working capital may be viewed by rating agencies as a source of default risk.

It is possible to track and measure the efficiency of a firm in managing corporate liquidity—inventory, accounts receivable and accounts payable. The measure is **cash and bank deposit conversion cycle** (CCC), which indicates how long the firm’s cash is tied up in working capital. Cash gets tied up between the expenditure for the purchase of raw materials and the collection of sales of finished goods.

Figure 1 is the enhanced depiction of the different cyclic physical, informational and monetary transactions that occur as a firm operates, sketched originally by [2]. One measure of **CCC in days** is given by [7] as

\[
CCC = 365 \left( \frac{\text{Average Inventory}}{\text{Annual Cost of Goods sold}} + \frac{\text{Average Accounts Receivable}}{\text{Annual Sales}} - \frac{\text{Average Accounts Payable}}{\text{Annual Purchases}} \right)
\]

Having encountered this, some firms have not only reduced CCC to zero (0), but have also made it negative, generating what is called negative working capital for the firm. In the lingo of finance, CCC is the theoretical amount of time between the firm spending cash and bank deposit to purchase goods or services from vendors and receiving cash from customers when sales occur.

### II. Literature Survey

Recent studies suggest that negative working capital can also improve profitability. One researcher, for instance, studied correlations to suggest positive association existing between negative working capital and profits—without, however, establishing *causality*. By observing correlation, researchers [5] also detected association between these two variables and on the strength of this detection alone concluded *influence* (causality) and went on to conduct *regression*. Researcher [4] used correlations to probe any possible impact that working capital management might show on profitability. Their study revealed that the *length* of the working capital cycle is negatively associated with the firm’s profitability. This study cited the negative relationship between cash conversion cycle (Figure 1) and profitability, again only by observing correlation.

Many others also studied this association only by correlation. Some argue in favor of shortening the cash conversion cycle, by invoking correlation and regression, but not by establishing causality. They invoke Pearson’s correlation, when statistical literature clearly states that correlation *does not* imply causality. Indeed, *correlation does not* imply causation [1], [3]. As noted in [3], no causation can be detected without manipulation. Such deliberate manipulations are the subject of statistical design of experiments one tests the hypotheses that certain factors (tested at different treatment levels) are indeed causes of the effects on the response observed. Others have employed system dynamics modeling to set a conceptual platform to study association among the variables of interest.

To the best of our knowledge, in respect to finding causality between working capital and profitability, empirical manipulations of decision variables that contribute to a firm’s cost of employing working capital have not been attempted yet, so correlation-based assertions of causality such as those cited above cannot be accepted on their face value.

### III. An Economic Cost Model of Profitability

One may intuitively acknowledge that both excess (say in inventories and accounts receivable) and shortage (say to support payables and of liquid cash and bank deposit to meet...
everyday expenses) are bad for a firm. Out of the two, shortage of working capital is more dangerous than taking steps such as extending credits to boost sales. To probe this issue quantitatively (and not just looking to find historical association or correlations) one would be advised to construct economic cost models. This is attempted in this section, starting with defining certain key terms as follows.

Net Cost of delaying Accounts Payable = \( \pi \) / AP rupee/day
This net cost equals the incremental increase in the cost of borrowing, loss of business, and the cost of foregoing discounts and the benefits from alternate uses of idle cash.

Net Cost of Accounts Receivable = \( \rho \) / AR rupee/day
Costs associated with AR are collection cost, capital cost, delinquency cost, and default cost. On the other hand, there are benefits generated by operating with AR—increased sales due to extended credits, and anticipated profits due to sales retention. Such benefits increase profit. Indeed Finance literature states, “The objective of liquidity of receivables management is to promote sales and profit until that point is reached when the ROI in further funding receivables is less than the cost of funds raised to finance that additional credit.”

Net Cost of managing (holding + ordering) Inventory = \( \sigma \) / unit of inventory/day
Sustaining the cost of managing inventory (holding, then processing, or selling) and ordering materials in repeated order cycles is common in firms. The development of this cost will be illustrated below in a separate section.

Net Cost of holding Cash and bank deposit = \( \eta \) / rupee held as liquid/day
This would include opportunity loss of not putting cash and bank deposit on hand in risk-free investments, and any advantages of improved liquidity.

The term “cost” in respect to the quantities \( \pi, \rho, \sigma \) and \( \eta \) is used here as generic constructs. Each of these may be a true cost, leading to a payment to be made by the firm. These quantities may also represent benefits where the firm somehow gains. We retain this generality as we develop the economic cost model in this section. The additional terms of relevance are defined as follows.

Annual Purchases = \( P \) / year
Cost of Goods Sold = COGS / year
COGS is total cost to produce the finished goods sold during the year. It comprises all costs (including AP for raw materials and services), conversion costs, wages, utilities, administration + any carry forward adjustment due to unsold inventory of goods held over from the previous year.

\[ X_{AP} = \text{average Accounts Payable in rupees over the year} \]
\[ X_{AR} = \text{average Accounts Receivable in rupees over the year} \]
\[ X_I = \text{average Inventory valued in rupees held by the firm over the year} \]
\[ X_S = \text{average Cash and bank deposit in rupees held by the firm over the year} \]
Annual sales = \( S \) = total revenue generated by selling goods in \( \text{₹} / \text{year} \)
Hence, we shall seek a first principles expression in the form:

Total annual cost of working capital

\[ = f(\pi, X_{AP}, \rho, X_{AR}, \sigma, X_I, \eta, X_S, P, S, COGS) \]  \hspace{1cm} (1)

The Cash and bank deposit Conversion cycle (CCC) in days is calculated from three dependent MIS “dashboard” variables as follows.

Days of sales outstanding (goods supplied but payment not received) averaged over the year = Average Accounts Receivable/ (Annual Sales/365)

Days of sales in inventory = Average Inventory/ (Cost of goods sold/365)

Days of Average Accounts Payables outstanding (bills received by not immediately paid) = Accounts Payable/ (P/365)

Hence, using the earlier notation,

\[ \text{CCC} = 365(X_{COGS} + X_{AR}/S - X_{AP}/P) \]  \hspace{1cm} (2)

We restate that the quantities \( \pi, \rho, \sigma \) and \( \eta \) are used in (1) as generic constructs. Each of these may be a true cost, leading to a payment to be made by the firm. But these quantities may also represent benefits where the firm somehow gains. We retain this generality as we develop the economic cost model in this section. Developing a model for the annual total cost of working capital/day from first principles would require working out two expressions, beginning with

Annual Operating Profit

\[ = \text{Operating Revenue generated from Operations} - \text{COGS} \]
\[ = g(\text{working capital and other decision variables and constraints}) \]  \hspace{1cm} (3)

By definition, the net working capital (NWC) for a firm is given by

\[ \text{NWC} = \text{Current Assets} - \text{Current Liabilities} \]
\[ = \text{Value of average Inventory held + Value of AR held} + \text{Value of Cash and bank deposit held and Bank deposits - Value of AP} \]  \hspace{1cm} (4)

IV. DERIVATION OF THE ANNUAL COST OF MAINTAINING WC

Now to determine the cost incurred by the firm over its one operating cycle, we need to focus on the cost over its average inventory holding period only, since the operating cycles overlap (Figure 4), and we must avoid “double dipping” or ignoring the costs of managing with AR. Cash and bank deposit and bank deposit and AP, where operationally, the different inventory holding periods get juxta posed as idealized by Figure 4. Figure 4 lays out on the time line each such inventory holding period (inventory cycle in days) contributing its share to the total cost of maintaining the working capital—AR, Cash and bank deposit, AP and
In order to develop this we use the relationship COGS/XI = Inventory turnover per year. Hence XI/COGS = fraction (measured in year) covered by a single operating cycle (OC) of a full year. Thus CostNWC over each operating cycle picks up cost contributions of each NWC constituent as follows. The cost contributions of each NWC component over one operating cycle (measured in year) are

Net Cost of holding Inventory per operating cycle =

\[ 365 \sigma X_I \frac{X_I}{\text{COGS}} \]

Net Cost of AR per operating cycle =

\[ 365 \beta X_{AR} \frac{X_{AR}}{S} \]

Net Cost of AP per operating cycle =

\[ 365 \pi X_{AP} \frac{X_{AP}}{P} \]

Net Cost of holding Cash and bank deposit and bank deposit per operating cycle =

\[ 365 \eta X_s \frac{X_s}{\text{COGS}} \]

It may be shown that \( X_s/\text{COGS} = X_{AR}/S = X_{AP}/P \).

Note that when we add the four above net costs, different operating cycles and hence their respective costs overlap, but these respective costs are incurred in each OC. Each operating cycle here indicates how cash and bank deposit, goods and information flow in each round of purchases, holding and selling goods—a process that repeats itself in every successive operating cycle. However, in each successive OC the business itself operates by placing order ahead of sales keeping in perspective the lead time, and transacts activities that produce income by the purchase, stocking and selling of goods without any break in servicing customers. Therefore,

\[ \text{Cost}_{\text{NWC}}^{\text{OC}} = \text{Cost}_{\text{NWC}} \times \text{Inventory Cycle} \]

\( = (\text{Net Cost of holding inventory/unit/day} \times \text{Average Inventory held over Operating Cycle} \times \text{Average Inventory holding period in days}) \)

\( + (\text{Net Cost of AR/rupee/day} \times \text{Average AR held over Operating Cycle} \times \text{Average days age of AR}) \)

\( + (\text{Net Cost of AP/rupee/day} \times \text{Average AP held over Operating Cycle} \times \text{Average days age of AP}) \)

\( + (\text{Net Cost of holding Cash and bank deposit and bank deposit/rupee/day} \times \text{Average Cash and bank deposit held over Operating Cycle} \times \text{Average Inventory holding period}) \) (5)

Therefore,

\[ \text{Annual Cost of holding net working capital} \]

\[ = 365 \left[ \frac{\text{COGS}}{X_i} \left( \sigma X_i \frac{X_i}{\text{COGS}} + \beta X_{AR} \frac{X_{AR}}{S} + \pi X_{AP} \frac{X_{AP}}{P} + \eta X_s \frac{X_s}{\text{COGS}} \right) \right] \]

\[ = 365 [\sigma X_i + \eta X_s] + 365 \frac{\text{COGS}}{X_i} \left[ \beta X_{AR} \frac{X_{AR}}{S} + \pi X_{AP} \frac{X_{AP}}{P} \right] \]

\[ = 365 [\sigma X_i + \eta X_s] + 365 \frac{\text{COGS}}{X_i} \left[ \beta \frac{X_{AR}^2}{S} + \pi \frac{X_{AP}^2}{P} \right] \] (6)

Model (6) is the mainstay of this study.

A. Interpretation and Significance of Model (6)

Equation (3) provides the general form of the expression for the firm’s annual operating profit, a relationship for which the cost of working capital is derived and displayed in (6).

Equation (6) is a close form expression for the annual cost of holding net working capital—with the assumptions stated earlier. It is eminently clear that this annual cost is a linear function of average inventory \( X_i \) held by the firm, a linear function of cash and bank deposit and bank deposits \( X_s \) held by the firm, a quadratic function of the average accounts receivable level \( X_{AR} \) of the firm and a quadratic function of the average accounts receivable level \( X_{AP} \) of the firm. Model (6), forgiven values of \( X_i, X_s, X_{AR} \) and \( X_{AP} \), is a linear function of each generic cost parameters \( \pi, \rho, \sigma \) and \( \eta \). Furthermore, (6) tells us that how changes in the four NWC components—\( X_i, X_s, X_{AR} \) and \( X_{AP} \)—affect the firm’s annual profit will depend on the relative values and signs (positive or negative) of the generic costs \( \pi, \rho, \sigma \) and \( \eta \) defined earlier.

Assuming that they are all positive (i.e., cause the firm a “cost”), it would behoove the firm to minimize average inventory held, cash and bank deposit held, accounts receivables and accounts payables. Indeed it is easy to see that the most desirable values of AP and AR should then be both zero—“Have no payables and also have no receivables when \( \rho > 0 \) and \( \sigma > 0 \)”! However, this is not always true. For instance, if the money under payable (AP) can be invested by the firm to generate a higher return than the cost \( (\eta) \) of capital held as liquid, it would be smart to delay payments—for such benefits would rise quadratically proportional to the unpaid AP. Thus, not surprisingly, operating with a WC deficit is a strategy that sits close to the core of Wal-Mart’s business [8]. In fact, when \( X_{AP} \) is made really high, CCC given by (2) can become negative! In that case NWC (4) will also become negative.

This last condition is what impels many firms to delay payments, and indeed use those funds to finance their own short term operational expenditures that generate higher profitability. Wal-Mart concedes this publicly.

Thus we have established the quantitative evidence that in some situations it pays to work with negative working capital, while in others it may not. In the section below we study the viability and the limits of this strategy—experimentally.

V. EXPERIMENTAL SETUP FOR PARAMETRIC STUDY OF PROFITABILITY

Expression (6) makes the study of the sensitivity of a firm’s profitability to a variety of scenarios possible. For a firm these scenarios would possibly change based on the values and signs of the generic cost parameters, and \( X_{AP}, X_{AR}, X_i \) and \( X_s \). To study this we utilized (6) and invoked2-level orthogonal array (OA) computational experimentation [6] to manipulate the factors involved—to check the causality hypotheses [3]. In the rest of this section we focus on describing experiments that established the impact of the different factors on the cost of net working capital (NWC). We chose here not to directly
evaluate profits, assuming that annual sales revenue $S$ remained constant for a firm. In the illustrative calculations the costs assumed were $\pi = -0.25 \$/year/\$/ AP = -0.000685 \$/day/\$/ AP, $\rho = 0.365 \$/year/\$/ AR = 0.001000$/day/\$/ AR, $\sigma = 0.3 \$/year/\$/ Inventory = 0.000822 \$/day/\$/ Inventory and $\eta = 0.05 \$/year/\$/ Cash = 0.000137 \$/day/\$/ Cash (each held here in AP generates a benefit).

To proceed we first tested the sensitivity of NWC to cost parameter settings, by holding $X_{AP}$, $X_{AR}$, $X_I$ and $X_S$ at fixed levels. To manipulate the “Experimental Factors” $\pi$, $\rho$, $\sigma$ and $\eta$, we selected two reasonable working levels (settings or treatments), all values set symmetrically about the daily costs given above. For each factor the “high” setting was a higher daily cost value, the “low” setting being a similarly set other value. In the present case we used combinations of these settings to conduct the computational experiments with (6) as guided by the $L_8$ orthogonal array (Table 1). Each experiment (a row in Table 1) simulated a firm’s operation when its cost parameters $\pi$, $\rho$ etc. would exist as specified in that row, with the “response” NWC cost in each row computed by using (6). The results in the form of “factor effects” on NWC cost are shown in Figure 2. In all these experiments it was assumed that for the illustrative firm annual sales were $\$500$, COGS was $\$400$ and annual purchases were $\$300$. In a row, a positive quantity under the NWC column head would indicate a resulting cost (reduction in profit) whereas a negative quantity would indicate a benefit (increase in profit).

Figure 2, for the specific values of $X_{AP}$, $X_{AR}$, $X_I$ and $X_S$, values shown in Table 1, indicates that when $\pi$ changes from $\$-0.000342\to-0.001027$per day (now a benefit, for the sign is negative), it contributes a reduction in annual NWC cost (the cost line slopes down and becomes more negative). The other daily cost parameters—$\rho$ raised from $\$0.000500$ to $0.001500$, $\sigma$ raised from $\$0.000616$ to $0.001027$ and $\eta$ raised from $\$0.000103$ to $0.000171$—each raise the annual NWC cost (each effect lines rises and becomes less negative). In this example, a higher numerical value of $\pi$ (in this case its becoming more negative or beneficial to the firm) has the largest impact on reducing the annual cost of NWC. One infers from this that with such benefits (accruing when any of the costs $\pi$, $\rho$, $\sigma$ or $\eta$ is negative and becomes more negative), the firm gains by an increase in its net profitability.

Next the same study was repeated, with different inputs. This time the daily cost parameters $\pi$, $\rho$, $\sigma$ and $\eta$ were held constant at their mid-points of the first set of experiments, while $X_{AP}$, $X_{AR}$, $X_I$ and $X_S$ were manipulated to probe their causality on cost of NWC, each set at two different levels as guided by the $L_8$ array. Table 2 was thus created to guide these next set of eight computational experiments. The results are displayed in Figure 3. For the causalities identified, increase in accounts payable ($X_{AP}$) improved profitability (annual cost of NWC reduced) while an increase in investment inventory ($X_I$) raised annual cost of NWC, hurting profitability. The other two components of NWC—$X_{AR}$ and $X_S$—did not significantly impact profitability for the particular cost values for $\pi$, $\rho$, $\sigma$ and $\eta$ selected.

### Table 1: $L_8$ Experiments Conducted by Manipulating Genetic WC Costs $\pi$, $\rho$, $\sigma$ and $\eta$

<table>
<thead>
<tr>
<th>Experiment</th>
<th>$\pi$</th>
<th>$\rho$</th>
<th>$\sigma$</th>
<th>$\eta$</th>
<th>NWC Cost $$/</th>
</tr>
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<tr>
<td>1</td>
<td>-0.000342</td>
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<td>0.000616</td>
<td>0.000103</td>
<td>1.0</td>
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<tr>
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<td>0.000500</td>
<td>0.001027</td>
<td>0.000171</td>
<td>5.2</td>
</tr>
<tr>
<td>3</td>
<td>-0.000342</td>
<td>0.001500</td>
<td>0.000616</td>
<td>0.000171</td>
<td>2.6</td>
</tr>
<tr>
<td>4</td>
<td>-0.000342</td>
<td>0.001500</td>
<td>0.000616</td>
<td>0.000616</td>
<td>5.9</td>
</tr>
<tr>
<td>5</td>
<td>-0.0001027</td>
<td>0.000500</td>
<td>0.000616</td>
<td>0.000171</td>
<td>-10.5</td>
</tr>
<tr>
<td>6</td>
<td>-0.0001027</td>
<td>0.000500</td>
<td>0.001027</td>
<td>0.000103</td>
<td>-7.3</td>
</tr>
<tr>
<td>7</td>
<td>-0.0001027</td>
<td>0.001500</td>
<td>0.000616</td>
<td>0.000103</td>
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</tr>
<tr>
<td>8</td>
<td>-0.0001027</td>
<td>0.001500</td>
<td>0.000616</td>
<td>0.000171</td>
<td>-5.6</td>
</tr>
</tbody>
</table>

For any other situation, the impact of the decision maker’s adjusting the working capital components $X_{AP}$, $X_{AR}$, $X_I$ and $X_S$ may be assessed with the help of (6). To do this one would need to estimate the corresponding actual costs or benefits ($\pi$, $\rho$, $\sigma$ and $\eta$) and then substitute those into (6).

One therefore cannot state in general that a reduction in investment in working capital always raises profitability as asserted by the studies by [2], [4], [5] and others.

### VI. Establishing Causality

A causal effect is defined as finding that change in one variable leads to change in another variable, ceteris paribus (other things being equal). More specifically, a causal effect is said to occur if variation in the independent variable is followed by variation in the dependent variable, when all other things are equal. Correlation—observing that two variables merely vary together—does not imply causation [1], [3].

In the present study we hypothesized that factors AP, AR, Inventory and Cash caused an effect on a firm’s profitability and applied the $L_8$ experimental design to probe this. Table 2 retains data relevant to the targeted causality test. As shown in Table 2, the hypothesized “cause” factors were varied here in accordance with the $L_8$ design, sufficient to study “main factor” effects [6], whereas the consequent NWC cost calculated using the economic cost model (6) was the response.
In all these experiments (each row in Table 2 representing the factor settings or “treatments” in one experiment) the generic costs or benefits (π, ρ, σ and η) were held constant at means. It is redundant to state that if these costs/benefits were all zero (0), model (6) would immediately suggest that none of the working capital components would have any effect on the cost of net working capital (NWC), hence on the firm’s profitability.

To test causation between the four working capital components and the cost of NWC the data in Table 2 were subjected to ANOVA. SAS-produced results are shown in Table 3. For the cost/benefit values of π = -0.000685 ₹/day/₹, ρ = 0.001000 ₹/day/₹ AR, σ =-0.000822 ₹/day/₹, Inventory and η = 0.000137 ₹/day/₹ Cash, factors accounts payable (X_AP) and inventory (X_I) are indicated to be significant causes that affect NWC Cost (hence profitability), whereas the effects of X_AR and X_S were not significant. Clearly, such inferences are totally dependent on the values of the generic costs π, ρ, σ and η. As noted earlier, if these values are all zero, none of the working capital components would affect profitability in any manner—a consequence of model (6).

Thus the present approach of analytically modeling the impact of working capital components on profitability has established (a) a valid approach to look for causality and its direction, given estimates of NWC component costs, and (b) a way to determine the impact of the various cost (benefit) parameters and WC conditions—individually. Correlation studies do not yield such information.

**TABLE 2: EXPERIMENTS CONDUCTED BY MANIPULATING WORKING CAPITAL COMPONENTS X_AP, X_AR, X_I AND X_S**

<table>
<thead>
<tr>
<th>Experiment #</th>
<th>X_AP</th>
<th>X_AR</th>
<th>X_I</th>
<th>X_S</th>
<th>NWC Cost ₹</th>
</tr>
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<tr>
<td>1</td>
<td>22.5</td>
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<td>15.0</td>
<td>-1.7</td>
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<td>18.8</td>
<td>25.0</td>
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<td>31.3</td>
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<td>5</td>
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<td>7.5</td>
<td>18.8</td>
<td>25.0</td>
<td>-17.2</td>
</tr>
<tr>
<td>6</td>
<td>37.5</td>
<td>7.5</td>
<td>31.3</td>
<td>15.0</td>
<td>-4.3</td>
</tr>
<tr>
<td>7</td>
<td>37.5</td>
<td>12.5</td>
<td>18.8</td>
<td>15.0</td>
<td>-16.2</td>
</tr>
<tr>
<td>8</td>
<td>37.5</td>
<td>12.5</td>
<td>31.3</td>
<td>25.0</td>
<td>-2.9</td>
</tr>
</tbody>
</table>

**FIG. 3 Sensitivity of Annual Cost of Net Working Capital to X_AP, X_AR, X_I and X_S**

**TABLE 3: THE ANOVA PROCEDURE EXECUTED BY SAS**

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum Sq</th>
<th>Mean Sq</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 4</td>
<td>4</td>
<td>527.080</td>
<td>131.770</td>
<td>19.13</td>
<td>0.0179</td>
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<tr>
<td>Error 3</td>
<td>20.660</td>
<td>6.886667</td>
<td>47.58</td>
<td>0.0062</td>
<td></td>
</tr>
<tr>
<td>Source</td>
<td>ANOVA SS</td>
<td>Mean Sq</td>
<td>F Value</td>
<td>Pr &gt; F</td>
<td></td>
</tr>
<tr>
<td>X_AP</td>
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<td>327.680</td>
<td>47.58</td>
<td>0.0062</td>
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<tr>
<td>X_AR</td>
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<td>0.5639</td>
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<td>0.500</td>
<td>0.07</td>
<td>0.8051</td>
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</tr>
</tbody>
</table>

**VII. CONCLUSIONS**

This study concludes that the impact of current assets and liabilities in a firm’s working capital—accounts payable, accounts receivable, inventory and cash and bank deposits—on its profitability cannot be categorically stated as done in many earlier studies, most of which conclude that profitability is favorably affected by a negative working capital. The present study has pursued the path of analytical modeling using first principles of economic costing, and then statistical experiments with the orthogonal array framework, to discover the magnitude and direction (visible in Figure 3) of causality.

The strength and uniqueness of this study come from the analytical mythology it has employed. By choice it stayed away from historical and anecdotal citations of earlier studies in which sound theoretical anchors were not sunk or the specific economic circumstances impinging on the firms or industries cited in these studies were not probed nor modeled.

**REFERENCES**