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MOMENTUM ACCOUNTING AND MANAGERIAL GOALS ON IMPULSES*

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Conventional accounting measures wealth W (assets and liabilities) and accounts for its net change, $W(t+1) - W(t)$, by means of income $\Delta W(t)$, classified into various revenue and expense items. Proposed "momentum accounting" measures income momentum $\dot{W} = dW/dt$ (time rate at which income is being earned at a given point in time) and accounts for its net change, $\dot{W}(t+1) - \dot{W}(t)$, by means of impulses $\Delta\dot{W}(t)$. Here the impulses, a term borrowed from the momentum-impulse principle in mechanics, are classified into various factors, internal or external to the enterprise, that contributed to the momentum change. If conventional accounting is viewed as focusing on an odometer of a car, momentum accounting is analogous to focusing on its speedometer and attributing the change in its reading to impulses that are judged to be responsible for the change. This paper proposes impulse-based managerial goals as a substitute for currently popular income-based managerial goals, discussing problems associated with the latter that highlights short-term income achievements and that tends to reward management for the momentum created by their predecessors as it is realized as income by the mere passage of time.

(MOMENTUM ACCOUNTING; TRIPLE-ENTRY BOOKKEEPING; PERFORMANCE MEASUREMENT BASED ON IMPULSES)

1. Momentum Accounting

Conventional accounting measures "wealth," positive (assets) or negative (liabilities). It measures wealth not in isolation as in single-entry bookkeeping but in relation to "income" so that every change in net wealth is explained or accounted for by revenue or expense items that are considered to be responsible for the change. In this way, wealth W and income ΔW are linked together under a double-entry framework.

Momentum accounting measures various income momenta, or "momenta" for short. Momenta are measured as a time rate of change in wealth, namely dW/dt or $\dot{W}$. If wealth measurements are analogous to odometer readings, momentum measurements are analogous to speedometer readings. Momentum differs from income in that income is a change in wealth between two points in time while momentum is a time rate of change in wealth at a given point in time. Two time points must be specified to define income while one time point is enough to specify momentum. Hence, just like wealth, momenta can be "inventoried" at any given point in time and listed in a "balance sheet."

Momentum accounting measures momenta $\dot{W}$ not in isolation as in single-entry bookkeeping but in relation to "impulses" $\Delta\dot{W}$ which account for changes in net momenta. (The term was borrowed from Newtonian mechanics which relates impulse with momentum under the principle of impulse and momentum.) Impulses describe reasons for momentum changes just as income describes reasons for wealth changes. Hence, the same double-entry framework can be applied to both wealth accounting and momentum accounting, as shown in Table 1 which contrasts basic financial statements from the two systems using a simple example.

In this table, wealth statement and momentum statement are shown as the balance

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TABLE 1

The Conventional and Proposed Measurement Systems

Conventional Measurements [Wealth W and Income ΔW]		Proposed Measurements [Momentum $\dot{W}$ and Impulse $\Delta\dot{W}$]		
(Balance Sheet) Wealth Statement as of 1/1/87		(Balance Sheet) Momentum Statement as of 1/1/87		
Cash	$150	Sales		$125/mo
Receivables	300	Cost of Sales		−85/mo
Inventories	450	Operating Expenses		−10/mo
Fixed Assets	900	Depreciation		−5/mo
TOTAL ASSETS	$1,800	Interest Expenses		−5/mo
Payables	−400	Income Taxes		−8/mo
Loans	−500	NET MOMENTA		$12/mo
OWNERS' EQUITY	900			
Less: Owners' Net Contribution	600			
NET WEALTH	$300			
(Change Sheet) Income Statement for 1987		(Change Sheet) Impulse Statement for 1987		
Sales	$1,800	New Product Introduction	(4/1/87)	$5/mo
Cost of Sales	−1,200	Its Tax Effect	(4/1/87)	−2/mo
Operating Expenses	−180	New Product Introduction	(7/1/87)	10/mo
Depreciation	−60	Operating Staff Addition	(7/1/87)	−10/mo
Interest Expenses	−60	Mfg Cost Cutting	(10/1/87)	5/mo
Income Taxes	−120	Its Tax Effect	(10/1/87)	−2/mo
NET INCOME	$180	NET IMPULSES		$6/mo
(Balance Sheet) Wealth Statement as of 12/31/87		(Balance Sheet) Momentum Statement as of 12/31/87		
Cash	$200	Sales		$175/mo
Receivables	360	Cost of Sales		−115/mo
Inventories	600	Operating Expenses		−20/mo
Fixed Assets	840	Depreciation		−5/mo
TOTAL ASSETS	$2,000	Interest Expenses		−5/mo
Payables	−420	Income Taxes		−12/mo
Loans	−500	NET MOMENTA		$18/mo
OWNERS' EQUITY	$1,080			
Less: Owners' Net Contribution	600			
NET WEALTH	$480			

sheet in the respective accounting system, and income statement and impulse statement are shown as the "change sheet" in the respective accounting system. The conventional balance sheet is slightly reorganized as wealth statement so that its relationship with other statements are made clearer. Note that in either system the net balance amount at the end less the net balance amount at the beginning agrees with the total in the change sheet (i.e., $480 − $300 = $180; $18/mo − $12/mo = $6/mo).

While in conventional accounting wealth and income are measured in a monetary unit such as dollars, momenta and impulses are measured in a time-rate of change in the monetary measurement, such as dollars per month. Month is chosen here just as an example; for some managerial uses a different time period such as quarter, week, or even day may be preferable to month. The choice of the time period is merely a matter of expression, just as stating an amount in cents, dollars, thousands of dollars, or millions of dollars does not change the amount. The choice has nothing to do with the frequency of measurements or journal entries.

The two systems, wealth and momentum accounting, are not independent but are

TABLE 2

Differential and Difference Relationships among Six Basic Measurements

Six Basic Measurements and Their Classifications			
Classification of Accounts by:	Conventional Wealth Measurements	Proposed Momentum Measurements	Possible Force Measurement
Types of Wealth (Assets, Liabilities)	Wealth W		
Reasons for Wealth Change (Revenues, Expenses)	Income ΔW	Momentum $\dot{W}$	
Reasons for Income or Momentum Change (Actions Resulting from Impulses Created by Forces)	Action $\Delta^2 W$	Impulse $\Delta\dot{W}$	Force $\ddot{W}$

Relationships among the Six Basic Measurements

Wealth:	Income:	Momentum:	$W(t+1) - W(t) = \Delta W(t) = \int_t^{t+1} \dot{W}(\tau)d\tau$
Momentum:	Impulse:	Force:	$\dot{W}(t+1) - \dot{W}(t) = \Delta\dot{W}(t) = \int_t^{t+1} \ddot{W}(\tau)$
Income:	Action:	Impulse:	$\Delta W(t+1) - \Delta W(t) = \Delta^2 W(t) = \int_t^{t+1} \Delta\dot{W}(\tau)d\tau$

mathematically related to each other by the derivative-integral relationship. In particular, momenta integrated over time should equal income during the period (although some reconciliations may be needed when there are differences in accounting standards in the two systems). In the example, net momenta is \$12/mo in the first quarter, is \$15/mo (\$12 + 5 − 2) in the second and third quarters, and is \$18/mo (\$15 + 5 − 2) in the fourth quarter, totaling \$180 for the year which agrees with the net income.

It may be noted here that while momenta integrated over time should equal income, impulses integrated over time generate a new dimension in conventional accounting, which will be called "actions." Actions account for changes in income from one period to the next, attributing the changes to various impulses. Wealth, income, and actions then provide the basic three axes of measurements, where income accounts for wealth changes and actions account for income changes. In this way the double-entry framework is logically extended to a triple-entry framework. Table 2 shows the relationship among the measurements in the two accounting systems, along with a third possible system centered on the measurement of "force."

Research has been conducted on momentum accounting and the framework of triple-entry bookkeeping has been developed as shown in the references at the end of the paper. Any further discussions on the details of the subject will be omitted and referred to these references so that the issue of managerial goals may now be discussed.

2. Income versus Impulses as Managerial Goals

Managerial goals have been overwhelmingly centered on income as evidenced by numerous income-based incentive compensation plans. In addition to monetary incentives in the form of bonuses, promotions and salary raises have also been frequently tied to income.

Lately such emphasis on income has been criticized as promoting decisions oriented toward short-run benefits of the company at the expense of its long-run benefits. Since

income is a change in wealth over a relatively short period of time, normally one year, a better income figure does not necessarily mean that the company is better off at the end of the period as compared with its beginning if the betteroffness is evaluated on the basis of long-run profitability of the company.

Although it is easy to say that emphasis should be on a long-run prospect of the company, there is a fundamental problem in doing so. That is the lack of measurements on long-run benefits to the company that are as reliable as income figures. This does not mean that income measurement is easy. It is indeed a significant contribution of accountants over the centuries that this basically ambiguous concept of income has been brought to such a level of objectivity and specificity that taxes, contracts and other legal relationships are built upon accountants' income figures. It seems obvious, however, that accountants must go beyond income in designing their system if they were to meet the managerial need for reliable measurements focused on long-run benefits.

Impulse measurements, while they are still current-period performance measurements, are at the minimum a step in the right direction. Of course, they are by no means measurements of long-run benefits in the true sense of the term. The extent to which impulse measurements incorporate the long-run aspect depends upon the rate at which momenta, created by the impulses, dissipate in a particular environment.

If maximization of long-run income is not operationally verifiable and by nature management's focus has to be limited to current-period performance, it is then interesting to compare managerial behavior oriented toward maximizing current-period income and that oriented toward maximizing current-period impulses.

As a simple illustration, take a project that boosts the momentum from zero to k dollars/yr instantly at the beginning of the project and leaves it at that level from that point on. The impulses $\Delta\dot{W}$ and the income ΔW are k dollar/yr and k dollars, respectively, for the first year. Then compare this with a second project whose momentum starts at zero, increases uniformly to \$1/yr at the end of the first year, and stays at that level from that point on. (This is the case if a constant force $\ddot{W} = \$1/\text{yr}^2$ is applied with a duration of one year.) The impulse $\Delta\dot{W}$ and the income ΔW are \$1/yr and \$0.5, respectively, for the first year.

If $k \geqq 1$, both a current-income maximizer and a current-impulse maximizer will choose the first project, and if $k \leqq 0.5$, both will choose the second project; while if $0.5 < k < 1$, the current-income maximizer will choose the first project while the current-impulse maximizer will choose the second project. Who is right in the choice depends upon how long the project is expected to earn income at the rate that has been achieved at the end of the first year.

Suppose that both projects terminate at the end of year n. Then, the lifetime incomes of the first and the second projects are kn dollars and $0.5 + (n - 1)$ (or $n - 0.5$) dollars, respectively. (Since the issue is on income and not on cash flows, discounting will not enter into consideration, although it will be briefly discussed later.) Hence, the current-income maximizer who chooses the first project achieves a better life-time income if $1 > k > 1 - 0.5/n$, while the current-impulse maximizer who chooses the second project achieves a better lifetime income if $0.5 < k < 1 - 0.5/n$. The ratio of the widths of the second range over the first range is $n - 1$ $(=[0.5 - 0.5/n]/[0.5/n])$, favoring the current-impulse maximizer for any $n > 2$.

This issue of income versus impulses as managerial goals is related to the choice of what is considered to be "status quo." The income-based performance evaluation views status quo to be no change in net wealth, giving credit to management for any increase in net wealth generated by the operation. The impulse-based performance evaluation takes a totally different notion of status quo. It views status quo to mean constant momenta, namely the state of a firm earning income at a constant rate. Credit is given to the management only for any increase in net momenta attributable to the operation during the period, and not to a mere realization of momenta created in the past.

This contrast between the two viewpoints is analogous to the ways in which moving bodies were viewed in physics. Once it was commonly understood that bodies could move only as long as a force acted on them and would come to rest without it. Now it is common knowledge that in the absence of force, bodies continue to move linearly with a constant velocity. Bodies come to rest not because the force supporting the move disappeared but on the contrary because there was another force acting against the movement of the bodies. This law of inertia suggests an important consideration in momentum accounting which will be considered next.

3. Depreciation and Momentum Dissipation

Income measurement in conventional accounting has been made possible by two important conventions—the historical cost principle and the depreciation convention.

First, the historical cost principle allows the accountant to presume that if A is exchanged for B the cost of A is transferred and embodied in B. A counterpart in momentum accounting will be the "historical momentum principle." Namely, if A is exchanged for B, the momentum in A that was given up is assumed to be transferred and embodied in B—the principle of momentum conservation. Thus, if an inventory was acquired in exchange for cash which has been earning interest, that interest momentum is assumed to be transferred to the inventory, which will hopefully be realized in the form of gross margin when sold. Both the historical cost principle and the historical momentum principle may be overruled by evidence to the contrary. But they allow the accountant to maintain status quo (unchanged net wealth or net momenta) in the meantime, eliminating the need to continually update the bookvalue.

Second, the depreciation convention helps the accountant in a different way. For depreciable assets, this convention allows the accountant to reduce the bookvalue based on a formula. In reality, income for any given period cannot be determined without the ability to forecast the future. The depreciation convention allows the accountant to work under a common scenario as to what the future may look like and compute current-period income accordingly.

The depreciation convention lightens the load of the accountant in still another way. When an asset's bookvalue is reduced, the loss must be accounted for by finding a proper income account that explains the reason for the loss. Each such decline is analyzed, reasoned, and accounted for individually. For the decline in the value of depreciable assets no such explanations are needed. By the operation of the formula a lump sum is deducted and they are all accounted for in total by an account called depreciation. Accountability stops there even if there are many factors contributing to the decline in the asset values that may in fact need further explanation.

The above comments on depreciation are not intended to criticize the depreciation convention but to highlight the indispensable role it plays in income determination. Without it, it is virtually impossible to determine income. It will then be understandable why a similar convention might be needed in momentum accounting, dealing with a pattern of momentum dissipation.

Managerial goals may then be established on the basis of impulses before or after covering the charges for momentum dissipation. Impulses before dissipation charges may be meaningful in some cases, just as cash income (net income adding back depreciation and other noncash charges) is useful for some purposes. However, it is likely that net impulses after dissipation charges offer a better basis for evaluating managerial performance. Net impulses indicates what the management has done over and above replacing the lost momenta on old projects or product lines.

A further analysis of the earlier illustration may be in order here. As before, assume that the first project boosts the momentum to k dollars/yr immediately at the beginning of the project, stays at the level for one year, and its momentum starts dissipating from

the beginning of the second year at an annual rate of d, compounded continuously. For the elegance of the formulas, we shall assume that the project will last indefinitely. The assumption will do little harm since income in a distant future will be reduced heavily anyway by the dissipation factor. (While discounting does not make sense in dealing with income figures which include noncash items, if discounting is desired for some purposes, it is a simple matter to incorporate it in the analysis; for example, the present value of a \$1/yr momentum dissipating at d and discounted at r, both on the continuous compounding basis, is $1/(d + r)$, instead of $1/d$ without discounting.)

The momentum at any time $t \geqq 1$ ($t = 0$ meaning the time of the inception of the project) is given by $k \times \exp(-d(t - 1))$. Integrating this from $t = 1$ to infinity, the lifetime income starting at the beginning of the second year is simply k/d, or, for example, $5k$ if $d = 0.2$. Adding the first-year income of k dollars, the lifetime income comes to $6k$ dollars.

Now consider the second project with the assumption that during the first year the momentum increases linearly as before and its dissipation starts from the beginning of the second year. The \$1 momentum at the beginning of the second year, dissipating at the annual rate of d compounded continuously, yields a lifetime income of $1/d$ plus \$0.5 for the first-year income, or at $d = 0.2$, the total of \$5.5

Hence, the current-income maximizer makes the right choice if $6k > 5.5$, or if $1 > k > 0.92$, while the current-impulse maximizer makes the right choice if $0.92 > k > 0.5$, which is a much wider range. The midpoint $k = 0.75$ is achieved only when the dissipation rate is as high as 1, meaning that the \$1 momentum will be reduced to $\exp(-1) = 0.37$ dollars in one year, in which case the lifetime income from either project is \$1.5.

These illustrations are intended to demonstrate that for a wider range of situations, the maximization of current-period impulses improves the overall managerial goals oriented toward lifetime income as compared with the maximization of current-period income.

4. Lifetime Performance versus Period Performance

In establishing managerial goals, long-term measurements are not necessarily preferred to short-term measurements. Measurements that incorporate cash flow forecasts in a distant future, for example, are not necessarily better than those that incorporate only cash flows in the near future. This is because the precision of an aggregate figure is determined by the least precise figure included in the aggregation process.

Management goals based on impulses makes performance measurement slightly more forward looking than the conventional income-based goals, but not as forward looking as a project evaluation based on the lifetime cash flows. Under the assumption of systematic momentum dissipation, the impulse-based performance evaluation takes into account the future of the project operation. Yet it differs fundamentally from what we normally see in project evaluation, where the profitability of a project, whether it is measured in net present value or internal rate of return, is critically influenced by an evaluator's subjective estimate of cash flows in the future periods. Rather than letting such an unreliable estimate influence the performance evaluation directly, the impulse-based measurement requires that evidence of performance be shown in the current year, from which a projection into the future is made under a systematic method of momentum dissipation.

In conclusion, managerial goals based on impulses will mitigate greatly the criticisms raised on the income-based performance measurement as being too short-term oriented. At the same time, managerial goals based on impulses avoid the danger of making performance measurements completely at the mercy of someone's subjective forecasts for the future events. When standards are established for momentum account-

ing and the practice of momentum accounting is developed fully, some of the dilemma we face in performance measurements in accounting (the conflict between objectivity and relevance of data) could be reconciled more favorably than we currently see in conventional accounting.

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