TOCICO is pleased to recognize this paper as part of the TOC Body of Knowledge.

Using Throughput Economics to make better and safer business decisions

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Using the steps of Standing on the Shoulders of Giants.

1. **Identify a giant, not a choopchik**

Eli Goldratt is the giant that brought the concepts of T, I and OE (Throughput Accounting) to focus management's attention on the right areas to be able to diagnose the current achievement towards the Goal and to make better decisions. Eli exposed the flawed assumptions behind current management accounting practices, including Activity-Based-Costing (ABC) and showed an effective way to make decisions that significantly and reliably improve the bottom line.

While the term 'Throughput' has an approximate equivalent in 'contribution margin,' the emphasis of focusing on the total T generated within a period of time is the major contribution of Throughput Accounting. This means that no decision should be made based only on the local impact of a specific sale on T; always the full impact on the total T is considered.

2. **Identify the enormity of the area not addressed by the giant.**

The current Throughput Accounting practice assumes the financial performance is limited by one constraint, which could be a resource, the incoming demand or, very rarely, a scarce material. The resulting understanding is that a decision should be viewed by its ΔT generation relative to its impact on the constraint.

Practically, this means that, when the one constraint is known, every decision should be assessed according to the capacity limitation of the constraint, or when there is no internal active constraint, then any additional demand, generating positive T, is welcome.

In most cases, **this practice is valid only for minor decisions**, which won't make a non-constraint into a constraint itself! When you also consider the possibility that a non-constraint will penetrate its protective capacity and by that become an interactive constraint, that threatens the delivery performance, then the basic Throughput Accounting approach is flawed.

Another area not clearly addressed by Throughput Accounting is how to consider the uncertainty of the impact of a decision on demand from the market. While time and stock buffers, together with protective capacity, keep Operations ready to handle internal uncertainties, these concepts don't apply for evaluating the potential uncertain impact of a more significant change, like launching a new product, a price increase or penetrating into a new market segment on the incoming demand.

Thus, the value of using Throughput Accounting for evaluating the global consequences of decisions, which aim at increasing sales, improving the total T of the product mix or considering investing in additional capacity (elevation), is limited and the enormity of the area not addressed is huge.

3. Get on the giant's shoulders.

Goldratt has demonstrated many times how clear logical analysis should be used – always starting from a significant problem which limits achieving more towards the goal.

While Goldratt emphasized the need to change the current performance measurement system, he stopped doing so from about the year 2000, when *Necessary but Not Sufficient* (Goldratt, Schragenheim and Ptak) was written. In the book, Goldratt refers to the "three engines of TOC: DBR, CCPM and replenishment." Eli Schragenheim asked him what about Throughput Accounting and Goldratt answered: "*I have a problem with Throughput Accounting, people expect me to give them a number and I cannot give them a number*."

My interpretation of Goldratt words is that he recognized that the uncertainty in demand from the market and understood that a non-constraint could penetrate into its protective capacity. The current level of guidance from Throughput Accounting was simply not enough. The 'number' – how much additional profit would be generated has no clear answer.

Eli told Eli Schragenheim later that Throughput Accounting was a topic he would go back to but he passed away before he could.

4. Identify the conceptual difference between the reality that was improved so dramatically by the giant and the area untouched.

The focus of the early days of TOC was on the short-term. The expectation that the constraint won't move from one day to the other, was a necessary assumption that made it valid to focus on exploitation of and subordination to a single constraint. Said another way, the assumption was that the impact of a single business' initiative on the free capacity of non-constraints was small. The elevation step seemed like a faraway possibility and not too much was said about how one should evaluate the operational and financial impact of elevating the constraint. The implicit assumption was that elevating the capacity of the constraint would require a substantial investment. An obvious question is, how much more throughput would be generated by the elevation and whether the resulting ROI is well justified. However, in those early days, say until the mid-1990s, this question was not raised, at least not in public.

Under the circumstance of a single active CCR, focusing on exploitation and subordination, an important topic is choosing the best product-mix, given the capacity limitation of the one and only one CCR. In this case, prioritizing products based on Throughput per Constraint unit (T/Cu) was very beneficial.

When Goldratt moved his focus to Viable Visions, using the Strategy and Tactics approach to deploy a decisive competitive edge (DCE), the perspective changed. The Viable vision templates don't mention T, I and OE. Even the term 'constraint' is not mentioned. Goldratt came with an observation of two different schemes of improvements: 'minus-minus' and 'plus-plus', where the later looks to the longer term and is a more substantial improvement, being based on introducing a DCE, like VMI with a commitment to pay penalty if a shortage occurs.

Once you extend your managerial efforts from the immediate flow of products and services to solving significant problems for clients, dealing with the possibility of the emergence of new constraints is unavoidable. When entering new markets, backed by a DCE or just through constraint elevation, we get into an area that Throughput Accounting, as it was conceived in the mid-1980s, cannot address because every such move could easily cause the emergence of a new constraint, making T/Cu problematic. Which constraint's units should guide you?

Going into new markets raises the question: how much additional demand is expected? This means considering not only the fluctuations in the current market demand but also assessing: how much increase in demand might be, whether there is enough capacity or it is possible to purchase additional capacity within the required timeframe? Information about the size of the new market is required for ensuring enough capacity, including protective capacity, to meet commitments to the market.

Acting on any decision that causes the constraint to move is an untouched area, so far.

5. Identify the wrong assumption.

The invalid assumption when larger decisions, for mid- to long-term periods are considered, is that ***it is enough to check the current weakest-link to determine whether to act on a new decision.***

Two additional assumptions must be checked again:

- Can we respond fast enough? Then, there is no need to forecast demand, as it is possible to react to any realistic level of demand.
- An imbedded assumption is that the capacity of the CCR is known and it is properly exploited. So, if there is a need to increase it, then only a step change in elevation is required. In other words, the possibility of 'temporary micro-elevation' of the constraint was not considered.

6. Conduct the full analysis to determine the core problem, solution, etc.

When evaluating the potential impact of a decision which could have significant ramifications on the demand and capacity requirements, the core problem is facing **uncertainty that cannot be protected by either time or stock buffers**.

6.1 The top objective of the decision process:

Starting with some business proposition, the management team evaluates the available relevant information on the reasonable financial ramifications, for both the short and long terms, of the proposed actions and reaches a mutual decision, taking into account the potential impact of uncertainty on demand, operations and supply, then translating into financial terms the range of possible outcomes, while supporting an analysis of various alternatives in order to reach the best set of actions

The solution proposed here, is to create two different scenarios for the outcomes of such a decision: a scenario based on conservative estimations and an optimistic scenario. Each are used to come with accurate enough predictions of the net impact on the bottom-line. Both estimations must be 'reasonable,' meaning *"paranoid but not hysterical,"* quoting Goldratt.

It is always necessary, when using human intuition or even a computerized forecast, to assess potential uncertain outcomes, however, considering protecting against extremely rare possibilities does not make sense. It is possible that the interpretation of what is 'reasonable' might significantly vary for different decisions. For instance, should a commercial organization consider the probability of an earthquake destroying the central warehouse when outlining its supply-chain practices? However, the government in coming up with standards for the construction of buildings, should consider the possibility of an earthquake up to a certain level, demanding engineers to design in the appropriate protective measures.

The scenarios within an operating business are created by a group of the relevant managers of the functions that are impacted by the decision at hand. At a minimum, the team should include managers from Sales, Operations and Finance.

When this interim objective is reached, management can assume that the actual outcome will, with good-enough confidence, lie somewhere between the two answers.

6.2 Creating a scenario means the team checks and discusses various alternatives until consensus on the best scenario is reached.

While checking the financial and operational ramifications of a decision, either through the optimistic assessment or the conservative one, alternatives to the original proposals should be raised to improve the impact on the bottom-line. This happens mainly when the assessments of the demand, considering the planned actions, is expected to overload the system by penetrating into the protective capacity of one or more resources. When this happens, two different possible changes to the proposed actions must be checked:

I. Finding a way to temporarily increase the capacity of the relevant critical resource(s). Such an approach results in ΔOE.
II. Reducing sales of certain SKUs to free capacity. That approach reduces total T and the ΔT from accepting the decision at hand. Alternatives of changing the product-mix of the current sales might be considered, depending on the predicted loss of T relative to capacity freed at the relevant resource.

More proposed changes to the original decision can be raised by the team members, looking for improving NP which is the difference, ΔT – ΔOE.

During the intuitive assessment process of determining the impact of the decision on market demand, it is necessary to expand the terms used by Throughput Accounting in order to face the possibilities not currently addressed.

6.2.a Critical Resources

Throughput Accounting is based on the assumption that one, and only one, capacity constraint resource (CCR), can be active in a relatively stable production shop floor. The DBR approach, as demonstrated in The Goal and especially in the analogy of the scouts, is focused mainly on the short-term, and thus significant changes in the product mix are not initiated, which could cause other resources, currently non-constraints, to become constraints.

But, when not-too-small new moves that should generate significantly more T are considered, then it doesn't make sense to only check the implications on the one weakest-link. There is a valid need to check the ramifications of every not-too-small move on the capacity of several critical resources.

A critical resource is one for which a not-too-small change in the product-mix could push the load on the resource to penetrate its protective capacity.

It doesn't make sense that many resources can be critical. If that were the case, then even mild changes in the product mix might have unexpected negative impacts on delivery performance to clients. When the group of critical resources is from three to seven, then the system can be under good control. It is advisable to implement the Planned Load Control (see Chapter 9 in the TOC Handbook) on each of the critical resources, to remain under control.

6.2.b Capacity Buffers

Capacity Buffers include all the various options to add relatively small amounts of capacity, generating ΔOE, but helping to generate a greater amount of ΔT. The authors believe that maintaining readily available capacity buffers is a strategic asset, ensuring that a certain amount of extra capacity can be used within the required timeframe whenever needed. Capacity buffers can be overtime, temporary workers acting as freelancers and outsourcing, where the temporary capacity is purchased outside the system. Consider the use of a capacity buffer as a ready 'micro-elevation.'

Capacity buffers are part of the protective capacity. Actually, the level of protective capacity that seems to be necessary in order to protect the delivery performance from the normal statistical noise (Murphy), should be defined as the 'red-zone' of the overall available capacity buffer.

An important point to realize is, even with a certain available capacity buffer, there is a limit to the amount of additional temporary capacity that can be practically utilized. This suggests that having a true capacity constraint means the incoming demand could periodically load the CCR very close to its limit!

When the organization cannot afford to disappoint the market due to the limited capacity of the CCR and realizing there is no practical way to subordinate the market demand to the exploitation scheme of the CCR, then even the CCR must maintain a certain level of protective capacity to ensure meeting all the commitments to the market. Practically, expect that the required level of protective capacity of the CCR should be significantly lower than what is required from the other critical resources, because non-constraint resources must have flexibility to ensure smooth flow of inputs into the CCR, on top of the urgent red orders that customers need soon.

The conclusion is that managing a true capacity buffer, along its green, yellow and red zones, is highly beneficial for any critical resource.

6.2.c T-generators

The term 't-generator' was conceived to answer a need: distinguishing between ***a product, produced by the organization***, and ***what is eventually sold to a customer***. While many times what is produced is exactly what is sold, in many occasions what is sold is a package, consisting of various products, sometimes even including products and services that were produced by another organization. Even when the same basic product is sold into two different markets for different prices, it is practical to separate the two related, but definitely not identical products.

A 'product' is an item produced by the organization to be sold.

A 't-generator' is whatever is actually sold to a customer at a certain price. It must include, at the very least, one unit of some product. It can also be built from a set of products and services, like a warranty or transportation to the desired location, all for some price.

The price for the t-generator can now be analyzed to ascertain its throughput (T). The list of products within that t-generator can be analyzed to calculate the capacity requirements from every product included in the t-generator.

6.3 The analytical process for creating a reasonable scenario

As a starting point for a meeting of the management team, have the expected baseline Sales Profile for the relevant period of time, the Capacity Profile of the critical resources for the same period and one or more of ideas for how to improve the attainment of the organization's Goal, mainly the predicted bottom-line.

6.3.a The Sales and Capacity Profiles of the Critical Resources

Every suggested idea should be evaluated relative to the current state, which we assume we can maintain as it is now. Two main areas that define the current state:

I. What we currently sell to our customers. We suggest using current sales – all the t-generators sold in the last period – as the reference Sales Profile. The assumption is: we predict that if we don't change anything, then next period will show sales very similar to the Sales Profile we have outlined. If we expect the next period to have different sales, due to seasonality, certain known trends or new customers, then construct a good enough forecast for the next period and use this as the Sales Profile reference for new ideas and proposed actions.
II. To support the Sales Profile, there is a need for capacity from the critical resources. Of course, there are more capacity requirements, but we can assume that all the non-critical resources will have enough capacity. However, the critical resources must be checked to ensure they have sufficient capacity to produce the Sales Profile.

Comments and assumptions:

While the Sales Profile is a forecast, precision is not required, because it only serves as a reference. It should be more typical, than accurate.

The Capacity Profile calculations should include good-enough estimation of setups, downtime and maintenance, still leaving enough protective capacity. When additional capacity is required, we assume that capacity buffers are ready to be used.

It is usually unnecessary to consider current inventory levels, as long as the levels are about right and there is no special need to increase or reduce inventory levels. When this assumption is invalid, certain considerations are required but they are beyond the scope of this paper.

From the above, plus general financial information, it is possible to calculate the total T the Sales Profile would generate. The current level of OE should be known, generally speaking, as it reflects the money the organization spends to maintain the existing available resources. The difference T – OE gives the expected NP for that period. The question whether the NP is actually the EBITDA, depends on whether the depreciation, amortization and interest costs are included in OE or not. There might be some revenues that were not generated from regular sales and, in that case, they are not included in the reference T and OE. Again, there is no need to be precise with the Sales Profile and the exact amounts of total T and OE. The focus of the decision-making process is to discover $\Delta NP = \Delta T - \Delta OE$.

ΔI is relevant whenever the suggested decision involves investment, including a significant increase in inventory or receivables. The way to check the ROI, regardless of how you determine the desirability of an investment, is through checking the annual predicted $\Delta T - \Delta OE$ generated by the considered decision. ROI can be checked through the two scenarios, outlining the conservative and the optimistic returns.

6.3.b Calculating the direct and indirect ΔT generated by the decision at hand

When a new idea is put on the table, the first question is: will it generate positive ΔT?

The direct ΔT is straight-forward, requiring estimation of the additional sales, less required truly variable costs (TVC).

The indirect aspect includes impact on sales outside the decision itself. In other words, if sales of other t-generators is somehow impacted by the decision. For instance, if the direct impact takes so much capacity that there is a need to limit the sales of other SKUs or that market demand for other SKUs is impacted due to decision.

As an example, suppose a promotion is announced for several SKUs with price reduction of 10%. The promotions is announced with the expectation of selling many more units. During the promotion, normal T-generators, at the usual price, will not be sold. Instead, a new group of t-generators with 90% of the regular price are sold. The direct ΔT comes from the new t-generators with the reduced T per unit relative to the normal T per unit. Please note that the reduced T per unit of the new t-generator is significantly less than 90% of the original t-generator. The expectation is that the promotion will result in enough additional units sold so the overall ΔT is positive.

Another possible indirect negative impact on ΔT is that the promotion could continue to impact the sales of that group of SKUs for some period of time **after the promotion!** Regular customers of the relevant items might buy more during the promotion and reduce their regular purchasing for some time afterwards. This could impact the validity of the promotion. That potential loss of ΔT should be reflected in the assessments of the decision at hand.

A last indirect impact on ΔT, this time positive, is whether the promotion would attract more customers permanently, being impressed with what they bought during the promotion.

If both the directly and indirectly generated ΔT is negative, then there is no point checking the idea further and it should be rejected, except in the rare case when ΔOE is even more negative.

6.3.c Verifying that there is enough capacity to deliver the new Sales Profile and including valid alternatives

At this stage, there are already two scenarios within the new Sales Profile based on the conservative and optimistic assessments of the impact of the decision-at-hand on the sales, translated to T. At this point, each scenario should be checked to insure that it is possible to deliver the new Sales Profile, meaning that no critical resource lacks capacity or, if it does happen, there is a way either to free capacity, by giving up some sales or to add capacity for some ΔOE. Of course, as an end result, the ΔT – ΔOE should remain positive. The only reason to accept a pessimistic scenario that is negative is that the other scenario, the optimistic one, is so good that the management is game to take the chance.

So, for each scenario a capacity check is carried out. The result of the load on each critical resource should leave adequate protective capacity. When one or more of the critical resources seems overloaded, then a decision must be made.

Comment 1: It is possible to come with a computerized algorithm that would yield the best alternative of utilizing the critical resources and/or reducing certain sales, optimizing ΔT – ΔOE. The problem is that **it is not clear that the optimized solution is realistic**.

When using capacity buffers, several conditions may realistically apply. Capacity is usually purchased in certain minimum chunks, like overtime in one hour increments. Workers who are willing to do overtime may want to restrict it to no more than four hours of overtime in a day and a maximum ten hours per week. This can be negotiated, verbalized and regulated.

However, reducing sales of current t-generators makes it necessary to check whether there are no other negative effects, such as clients being so annoyed by not getting all the items they want that they look elsewhere not just for the items their supplier decided to limit but for everything they usually buy. **There is a need to get an educated opinion from someone knowledgeable that such a move won't have such undesirable effects**.

Thus, an optimized AI tool could suggest a solution but the human managers should make the final call.

Comment 2: It seems obvious that the conservative scenario will always show less ΔNP than the optimistic one. While in most cases this is true, there are cases where the additional capacity required for the optimistic scenario costs so much, either in additional capacity or lost current sales that the conservative scenario yields more profit.

Comment 3: We have so far ignored the role of the supply. A higher level of sales certainly requires more raw materials. While in most cases there is no problem in getting all the required supply, the question should be asked and answered. It could also be the case that while the additional supply can be acquired, it might take too long and impact the optimistic scenario. Additional inventory and receivables also mean a temporary reduction of cash. Cash is another resource and it could well be one of the critical resources. In such a case, a detailed analysis of the available cash must be included in the overall critical resource capacity check.

Comment 4: When there are several new ideas to be considered, each idea should be checked first as a stand-alone idea. Then, the attractive ideas are checked again in combination. Don't forget to check the capacity of the critical resources, including cash. It could be the case that some of the ideas must be rejected as the overload on one or more of the critical resources cannot be resolved profitably.

6.4 Making the final decision

Eventually a decision must be made or not. The actual financial outcome of the decision, the added net profit, is given as a reasonable range between the conservative and the optimistic scenarios.

Sometimes there might be complexity when the steps for using additional capacity and/or reducing sales of certain t-generators, requires different actions between the high and low scenarios. In such a case, the main issue is the timing of when the decision about a potential action, like using the capacity buffer, or limiting the sales of a t-generator, must be finalized. Most of those actions should be decided prior to taking the action itself, as the involved parties may benefit from being informed.

It could be that to use the capacity buffer as an answer to the optimistic demand, the decision must be made before the actual demand is known. Practically, this means that the ΔOE could be higher, while the demand is considerably lower. When this might happen, the team should consider the very conservative case of:

$\Delta T_{conservative} - \Delta OE_{optimistic}$ to validate whether such a worst case result doesn't invalidate the decision to move ahead.

Conclusions

While the above process requires effort, due to the number of calculations, the logic and flow is simple, straightforward and common-sense. Any new idea is checked theoretically by adding it to the current business. The financial calculations, require Sales, TVC and all the OE, which behaves non-linearly, including the OE required to provide protective capacity to ensure meeting all the commitments to clients. There is no real difficulty in calculating the ΔNP for the pessimistic and optimistic scenarios well enough, whether you use a dedicated IT tool or a spreadsheet.

What is not straightforward is assessing the future demand resulting from the decision. Estimating the level of uncertainty is usually based on human intuition, which is far from being precise and is exposed to various biases. However, human intuition can be effectively used to assess the boundaries of what we don't know. When human intuition assesses a situation as 'too crazy to be realistic,' then it is possible to come up with two scenarios that contain the vast majority of the realistic possibilities, while the 'too crazy' situations are left out. Realizing the range of conservative to optimistic provides, by far, the best information for making decisions under uncertainty!

While the intuition of managers is satisfactory to broadly define the reasonable range of demand, it is typically not good enough to predict the impact on net profit. It is often counterintuitive to many people that the impact of a mild increase in Sales can substantially increase the net profit. The recognition that ΔT could be very different from ΔSales is a new insight and intuition is slow to adapt to new concepts. Consequently, the recognition that 10% additional sales would probably generate ΔOE

that is a fraction of 10% of the OE, is another revelation. From our experience, many times ideas that at first glance seem frightening are often surprisingly profitable. Using the above decision-making process readily indicates when a new idea is a loser and when it is great, even in the worst case. Following these steps will hone the intuition of managers to better understand how to exploit the current potential of the organization, before spending to elevating the constraint. For example, it is typically quite expensive to acquire another company that potentially elevates both the market demand and the OE spent for capacity of the critical resources but is it necessary yet or at all?

Our book, *Throughput Economics*, contains very detailed examples, including the discussion between the key managers, evaluating the possible consequences of certain moves. These examples demonstrate not just the process itself, but how decisions that seem like 'bad ideas', can be highly profitable, even according to the pessimistic scenario, while other ideas would result mediocre impact on the bottom line.

A PDF file of Chapter 8 of our book, describing a detailed example, is available on the TOCICO website.

A recording of the webinar, *From Throughput Accounting to Throughput Economics*, is also available on the TOCICO website.