

The background of the entire page is a white surface with a pattern of flowing, wavy teal-colored bands that create a sense of movement and depth.

Petri S. Nieminen

**TOTAL COST OF  
OWNERSHIP IN  
MANUFACTURING  
INDUSTRY**

-

**BASICS AND  
MORE**

# **TOTAL COST OF OWNERSHIP IN MANUFACTURING INDUSTRY – BASICS AND MORE**



**PETRI S. NIEMINEN**

## 0 FOREWORD

“Can’t see the forest but only the trees” is a fluent translation of a Finnish saying “Ei näe metsää puilta”, which basically means that one can see only the single units, the trees, but not the whole entity that is the whole forest including trees together, undergrowth, flowers and other small plants growing and many kinds of animals living in the forest.

The same can be applied in business in any working position: We can see the elements but not the big picture. Because of this, we make our decisions based on partial information about the whole truth, which then leads to not comprehensively understanding the business-related consequences of the decisions made. For example, making an investment decision based on the lowest procurement price, leading to a saving of 20 000 € upon the initial purchase increasing the operating or maintenance expenses worth of 0,2 € per product in the lifetime volume of 7 years of production with total volume of 400 000 pieces. This means that the 20 000 € saving on the initial price ends up costing 80 000 € in operational expenses. As a result, we easily end up wondering why total expenses keep on increasing despite putting so much effort into saving on the initial purchase price.

And this is where the concept called Total Cost of Ownership, TCO, steps in. As the name very well describes, it is a concept focusing on defining all the aspects of all costs related to a purchase. Moreover, it can be applied to working processes and anything in business and many things, also in private life. Furthermore, by optimizing total costs of ownership, much more sustainable financial gains can be made than, for example, the temporary savings achieved by laying people off in an economic downturn. And this is exactly what makes TCO such a versatile tool in trying to make more money in business.

It is also one reason this book exists: To try to convince decision makers in business life that there are many more ways to make money in business than just trying to buy low, sell high and lay off a lot of the personnel during the first financial hiccup. But more about this in the later chapters of this book.

In this book, to make it efficient just like the concept itself, Total Cost of Ownership is referred to as TCO. Based on research done on the topic during the writing process of this book, TCO is the common abbreviation, which means it can be used in any aspect of the whole concept if wanting to search for further knowledge beyond what’s written in this book. As an author, I also do not claim to know everything about TCO. Just like you, the reader of this book, I am also a student of this topic, even if I already know quite a bit. And I’ve also brought my experience into

the creation of this book, often referred to as “(author’s experience)” to distinguish it from the information or ways of expressing things coming from other sources. I also want to make a notion that this is not a 100% schoolbook. Aside from bringing in my knowledge of Total Cost of Ownership that I already have plus what I learn in the process of making this book, I also intend to bring in my motivations for the whole topic, which can be seen in a few parts of this book, remarked as “(author’s view)”. I find it highly fascinating to learn new aspects of the topics I am interested in. And you, the reader, also have complete freedom to apply anything you find useful within this book in your own private life or in business. However, I strongly recommend reflecting it in the conditions under which these things are being applied, such as data systems available, corporate culture, strategy and so on to achieve actual financial gains. A single universal model of TCO that works everywhere equally well does not exist.

However, at this point I want to apologise for not having any pictures in this book. My intention was to have quite a few pictures, but life and general terms and conditions got in the way. And I don’t intend this as blame; it is what it is. I hope this will not hinder your motivation to get to know this fascinating subject.

Without further ado, let us embark on a fascinating journey on the comprehensive ship that is called TCO and sail the seas of complex interdependencies and waves of decision making.

Sail on!

## Abbreviations & Glossary

TCO = Total Cost of Ownership

KPI = Key Performance Indicator

OPEX = Operation Expense

CAPEX = Capital Expenditure

OEM = Original Equipment Manufacturer

Cost from the supplier's point of view = The price it pays to its own suppliers for goods or services and what it pays to internal/external personnel for the related work to implement the goods/services.

Price from the supplier's point of view = Cost + profit margin (+ contingency).

Initial cost = The price tag including the full cost breakdown + the internal work gone into getting the quotations + work done until before installation and commissioning.

Cost of operation = All costs during installation and commissioning phase, including related tests and test material, internal work of potential issue resolution and quality development. This also includes the energy and process utility consumption of a piece of physical machinery.

Cost of maintenance = All costs related to preventive, documenting and reactive maintenance of the purchase item.

Cost of downtime = All costs related to the stoppage of work because of malfunction or failure of the purchased item.

Cost of production = Capacity, availability, quality output and environmental impact of the purchase item, as well as potential rework and scrapping costs related to quality defects.

Remaining value / Costs of disposal = What is the total cost effect of the end of the planned use life of the purchase item? Can it be, e.g. sold onwards or reused?

CBD = Cost Breakdown = Splitting the total quotation over several items, showing the total € for each item separately.

MTTR = Mean Time To Repair

MCTR = Mean Cost To Repair

NPD = New Product Development

NDA = Non-disclosure agreement

CoP = Community of Practice

SoP = Start of Production

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## **PART A – BASICS, APPLICATIONS AND IMPLEMENTATION OF TCO**

Even though many aspects of Total Cost of Ownership are considered at work, and thought of, for example, during the purchasing process, they're mostly not considered as one connected concept. Just like one of our managers said when I was holding a TCO basic training at work, "This concept gives a clear structure to all these topics".

Just like with any big topic, we must start from the basics, starting with its importance and a practical real-life example to help you, dear reader, understand the topic. After this, we'll elaborate on the elements of TCO. And, even though these elements contain quite a bit to internalise, knowing the theory alone won't be very useful if not applying it, nor knowing how to apply it, which is why after going through the elements of TCO we shall look into how to apply and implement it. And to help the implementation, we must understand in which situations it can be applied, as well as certain basic terminology and concepts within cost engineering and management accounting. Let's not forget one of the key requirements for success at any transformation change in a working organisation, either: management commitment. After all, management is in a crucial position to ensure the workload, non-human resources and facilitation of collaboration to succeed at implementing the Total Cost of Ownership. Let's set our sails and embark our fascinating journey together.

# 1 BASICS OF TCO

"No gain is so certain as that which proceeds from the economical use of what you already have", says a Latin proverb (Forbes, 2015). The Latin language has a lot of proverbs that are simple yet contain a lot of truth within. In TCO, this exact proverb applies especially well, as it can be extended both to what we already have, and to what we are planning to achieve or obtain. And this is basically what TCO is all about: understanding the comprehensive view of the total costs related to any purchase item, asset, organisational function and so on. And when we understand the whole big picture, we can make better-informed decisions, which leads to improved operational efficiency and profitability.

Traditionally, TCO contains the following categories:

- initial cost
- cost of operation
- cost of maintenance
- cost of downtime
- cost of production and
- remaining value.

But there is much more to the whole concept, both in terms of cost elements included as well as time scope of each purchase topic. In fact, even though TCO is often considered to start from receiving the quotation for the requested goods or services and activities related to the selection of the supplier and the goods or services to be procured and making the purchase decision, a lot of effort is put into the topic in question already even long before the purchase decision is made. These cost components can be described as pre-transaction components, and they include, for example:

- identifying the purchase needs
- investigating and contacting potential suppliers for the needed goods or services
- checking the background and financial status of the suppliers
- mutual education for the supplier to get to know their customer and vice versa
- creating the technical specifications for the purposes of *Request for Quotation* and
- adding the selected supplier into the corporate data systems if required.

Next, in the chronological order of a purchase, are the transaction components. These are the cost elements related to the whole initial purchase itself, from the supplier selection all the way

until the goods or services have been received, evaluated, verified OK and paid. These cost components include things like:

- purchase price
- preparation and placement of the purchase order
- follow-up and potential correction needs
- costs related to interim approvals if required
- delivery transportation
- tariffs and duties
- billing and payment
- inspection of the received goods or services
- (reclamation and related correction process)
- installation and commissioning in the case of physical goods
- required qualification or training.

Each of these cost components can and should also be evaluated separately, but this evaluation work is also part of the total cost of ownership of each purchase. Thus, I strongly recommend putting the most effort in the comparison of the major cost drivers, but light evaluation of even minor cost drivers is recommended, because it is not very uncommon to realize something particularly important for the whole purchase when analysing each cost component.

Lastly, there is the third category of cost components called post-transaction components. These include:

- line fallout = percentage of anticipated defects by Supplier for all parts and/or assemblies (Law Insider Inc., 2013-2024).
- defective finished goods rejected before sales
- preventive and reactive maintenance and related downtime
- customer goodwill
- potential reputation effects from good or bad punctuality and/or quality of delivery of products
- energy and water costs
- disposal costs at the end of the use life (Ellram, 1993).

This third category of cost components is in a way quite paradoxical. As it is often the most distant one from the purchase in time, it is least frequently considered in relation to a specific purchase. Yet, this category can form the biggest share of the overall TCO due to its long

duration. This underlines the importance of Total Cost of Ownership further when comparing all expenses related to any purchase.

## **1.1 Why is TCO important**

Total Cost of Ownership is highly beneficial when aiming for improved profitability in any area of business, any function or any activity. This boils back down to the Latin proverb presented at the beginning of this chapter. And thus, it doesn't apply only to purchasing and collaboration with suppliers but also many other aspects, such as internal working processes, quality, supporting business strategy work, evaluation of stakeholder value and making quotations for potential customers. This is because, as cynical or materialistic as it sounds, almost anything can be measured in money. And this is true even if not all costs can be allocated per purchase or asset and many things cannot be defined in money until being fully completed, seeing the total actualized costs. Furthermore, TCO helps in showing how all these are interconnected in business.

Moreover, where TCO also brings a huge added value is in planning work. This is because a proper TCO evaluation requires vast amounts of clarification, investigation and data if one wants to form a comprehensive picture of costs related to any purchase or process ownership. While conducting these clarifications and data collection, it often happens that some crucial points are realized and would have been missed without this work (Spencer, 2024). TCO plays a big role also in financial feasibility studies and financial decision making because by understanding the TCO of a single purchase and even an entire project, more accurate financial projections can be made about the expenses and returns in each case. Being applicable for entire projects means TCO is also a highly useful concept in program management, which, among other tasks in it, concerns prioritization of different projects and the resources between them (Fernandes. 2023).

A TCO model also benefits decision making and potentially gives a full indication of total costs and returns on investment of a purchase. Through this, maybe the option with the lowest purchase price will turn out expensive, for example, by significantly increasing handling and warehousing costs (Logistiikan maailma, 2024). Furthermore, Total Cost of Ownership is not only applicable in internal decision-making and internal processes but also in business-to-business trade and with suppliers and other external stakeholders. For example, many

companies nowadays require a complete analysis of total cost of ownership from their suppliers to make more informed decisions in supplier selection and so on (Fishman Corporation, 2024). Besides this, TCO has plenty of other benefits and uses that are handled in this book. But enough theory for now; let us look at a real-life practical example.

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## **1.2 Practical example**

Imagine you have decided to buy a car. For some of us this is exciting; for some of us this is stressful and just a necessary “evil” to make do in life without proper public transport or not to be tied to fixed schedules. Whichever is the case, I hope this example can be of some use. However, I recommend proceeding with caution in pairing this practical, non-corporate example to everyday life in business: Many aspects of a car might be more of a question of

emotion to many of us, rather than sense, whereas I hope most of the decisions are made in business with logic and reason, rather than emotion. Therefore, we shall apply here what some call “cold business” and stick to the evaluation of total cost of ownership. And to avoid taking half the book with this example, we shall simplify.

When buying a car for everyday use, many of us start by pondering what kind of car it should be. And just like described in the opening chapter of this book, this is where the TCO starts, even though this phase applies to any of the options out of which one will ultimately be selected. However, even though the amount of work done, and time spent, at this phase might be quite similar regardless of which option we finally end up with, the decisions made at this point may have an enormous impact on the total cost of ownership of the car we ultimately end up choosing. Unless the choice is already obvious, many of us start with the body type of the car. Should it be a sedan, station wagon, hatchback or perhaps an SUV? All of them have their benefits and reasons why people tend to choose any of them, but with pure reason, this choice is often made based on the required amount and type of load capacity. Basically, this means how many people the car must transport around regularly and how much cargo besides people. Aside from the number of people, also their physical size matters; how big a car you need. From the point of view of total cost of ownership, I recommend keeping in mind that unnecessary weight and height increases the fuel costs, albeit there are many other factors that affect those, too.

Once the body type has been decided, it is time to evaluate what can be called the driving profile: How many kilometres or miles you drive annually on average and where do you drive? Is most driving done in a city or highway? Do you drive regularly on roads that are not in good condition? This information tends to be used to determine the best choice of fuel. In addition to the actual need, it's also important to keep the potential restrictions in mind. In this case, they might be fuel and size restrictions, for example, in some major cities. Also, not choosing a bigger engine than is really needed is often beneficial to the total cost of ownership of the car.

After this consideration has been done, the next one is to think about the budget of both the initial purchase, as well as operation costs. And this is where careful consideration is needed in the estimation between potential funding costs of a more expensive, newer car in comparison to an older and cheaper car potentially requiring more maintenance. Here, it's good to consider how much of the maintenance we can do ourselves; do we have a helpful family friend to assist us, or do we need to outsource all maintenance and repairs to a professional? And how often and how extensive maintenance might be required. Another very important aspect here is to do

some research to find out what kind of common faults the vehicles we are considering have, how expensive those faults might be to repair and if they might put us in a risk of being left stranded on the side of the road, increasing the total cost of ownership by having to resort to a tow truck. The third aspect to consider here is the depreciation in value. Cars tend to lose 30-50% of their initial purchase value within the first 2-3 years of ownership and first 50 000 km or so of driving, which is something we should also consider in the total cost of ownership of a car. This, plus the fact that optional extras, meaning additional equipment on top of so-called baseline equipment, lose value, too. This means it is possible to purchase a 2-3-year-old car with more features cheaper than a brand new, less well-equipped car.

Next, we come to the insurance and taxation expenses. Depending on the national or regional legislation, these might depend even strongly on the engine size or the fuel type and fuel consumption of the car. The difference might be hundreds or even thousands of euros per year, which means this is a very considerable expense. And the fuel consumption can make an enormous difference in itself, depending on the fuel price and how much the average annual mileage is.

What we also should consider is how long we are planning to keep the car. This has a tremendous impact on the required longevity. We might plan to keep it only for a year or, for example, ten years. This also commonly influences whether we decide to go for a newer car with less mileage or an older car with often a cheaper purchase price.

Lastly, unless we are going to drive the same car for as long as it is economically viable to keep it going, we should consider the potential resale value. The longer we are planning to keep the car, the harder it will be to predict any trends affecting the resale value at the time, but what we can do is going for reputable brands with some features that have a positive impact on the resale value. In many cases, reputable brands also tend to build more reliable cars, but this cannot be taken for granted. It is better to resort to your own research on the exact type of vehicle you're looking for. Of course, another aspect affecting the resale value is how well we're going to take care of the car. If not even replacing the engine oil, or having it done by a professional garage, I would not worry about the resale value too much because a badly maintained car is hard to sell for anything near the average market value. Additionally, skipping the maintenance saves money only during the time of skipping the maintenance, but it increases the total cost of ownership later, sometimes even exponentially.

As a car enthusiast I could carry on about this topic for a whole week or maybe for a whole book, which I someday might, but since it's best spared for some other occasion, let's return to the topic at hand, the total cost of ownership and its elements.

### 1.3 Elements of TCO

As discussed in the opening chapter of this book, there are multiple ways to categorize TCO. In this book we shall follow the more traditional categorisation, which includes:

- initial purchase
- operation cost
- maintenance cost
- downtime cost, which is sometimes included within maintenance costs
- production cost and
- remaining value (Graco Inc., 2024).

This categorisation is selected because much of the literature on the topic seems to follow this, or a very similar categorisation, and because it helps to keep the categorisation clear. Furthermore, the topics discussed in the opening chapter of this book shall be included within this categorisation, since they are essential elements of total cost of ownership. However, there are other ways to categorize TCO, too, including examples related to each category:

- Initial purchase
  - Purchase price including cost and supplier margin
- Cost incurred
  - Transport and packaging
  - Payment terms
  - Customs duties
- Cost of acquisition
  - Procurement department operations
- Cost of ownership
  - Stock management
  - Depreciation costs
- Cost of maintenance
  - Spare parts
  - Servicing

Have You ever wondered the same as I have: When there's an economic downturn, many employers are quick to lay off some of their personnel, reduce or stop their investments and to look for other short-term cost reductions. What if it didn't have to be this way?

The concept of Total Cost of Ownership (TCO) has a huge potential to help companies make money and retain a increase their profitability more sustainably and in more long-lasting way.

In manufacturing industry TCO has traditionally been applied on purchasing, supply chain and ICT topics, but there is so much more to it. TCO can be applied e.g. in topics of quality, office work, strategy and stakeholder management.

And let's not forget about the most important aspect: Us humans who run the companies and work in them. Let's hoist the sails and embark on this fascinating journey through the ocean that is TCO.