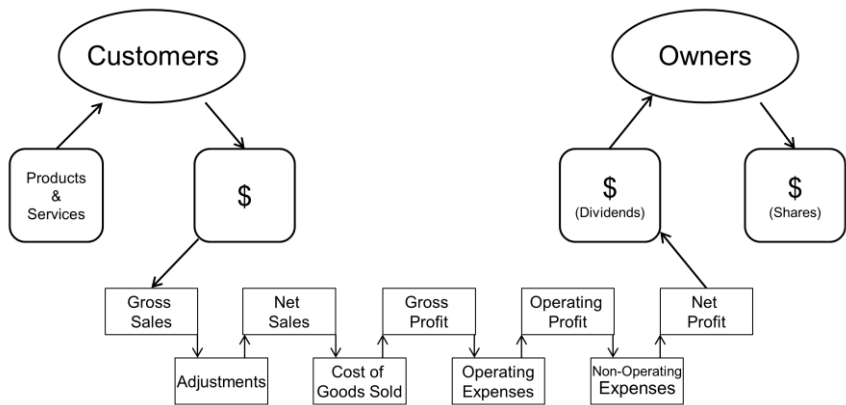


Business Management for Engineers

*How I Overcame My Moment of Inertia
and Embraced the Dark Side*



Alan C. Tribble, PhD
with Alan F. Breitbart, MBA

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ISBN 978-1-7321545-0-6

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ACKNOWLEDGMENTS

We gratefully acknowledge the helpful feedback provided by the following reviewers

- Ed Ashford, PhD
- Clayton Brown, LTC, US Army (ret.)
- David Edwards, PhD
- Ron Lukins, MBA
- James Powell

PREFACE

This is a book I never thought I'd write. After completing a PhD in Space Physics and getting a good job in the aerospace industry, I thought I'd be happy being a nerdy rocket scientist my entire career. But as my technical skills grew, the more I came to appreciate how business skills not only complemented my technical skills but also increased the value I brought to my employer. I realized that the most respected technical professionals were the ones that could spend a week in a room full of PhDs studying very complex technical issues, and then walk into the CEO's office and explain what that technical analysis meant to the business.

After about a decade, I had pretty much mastered the technical skills in my chosen area of expertise – I had written the first textbook on the subject and (some years later) won the only professional award in the field. The rest of my career – and I still had more years ahead of me than I had behind me (I hoped) – would likely be a repeat of things I'd already done.

I was ready for a new challenge, and I realized that I wanted to be more than a technical contributor – I wanted to be a leader. And to lead effectively I had to master the business skills. In the years since, I've managed groups of engineers, been a business development manager for the Asia-Pacific region, and a program manager for several different product lines and development efforts. I've enjoyed the transition immensely, and I have no regrets about my change in career paths.

Although I could have taken the time to get a traditional business education, I had realized years ago that I learn best by trying to explain things to others. I also realized that I couldn't find any books or courses targeted at people like me – technical professionals who wanted to broaden their skills. Of course, there was a lot of material available on management and leadership, but a lot of it was focused on

how to manage people. As a result, I decided I'd create my own course of study. One intended to help engineers – or anybody with a technical background – understand, and appreciate, the business side of the engineering profession.

To make sure I wasn't missing anything subtle, I worked with friends and colleagues who had a traditional business education. With the help of one of my friends, who has an MBA in International Marketing, I think we came up with a pretty good product.

If you're still reading this preface you're probably convinced that this kind of material will be of value to you in your career. But just in case you're still a little skeptical, let's agree that business and engineering go hand in hand. Whether you're the employee of a for profit business, or a government employee that works with employees of those businesses, this book is intended to make you more successful as an engineer – because you will have a deeper and broader understanding of how companies do business.

Let's define science to be the study of the laws of nature, and engineering to be the application of science. Similarly, let's define economics to be the study of the transfer of wealth, and business to be the application of economics.

How would you complete the following sentence?

Engineering is the application of science to develop new products or services that are ...

Similarly, how would you complete the following?

Business is the application of economics to develop new products or services that are ...

My answer – engineering is the application of science to develop new products or services that are “useful”; business is the application of economics to develop new products or services that are “profitable”.

What happens to products that are useful, but not profitable?

The product may be of interest to a great many people, but if the business providing it is not profitable, the business will lose money and, barring financial subsidies, will go out of business – so the product will disappear from the market.

What happens to products that are profitable, but not useful?

The product may generate world class profits, but if the product is not useful – if it does not add value to the buyer – no one will buy it, so again the product will disappear from the market.

Engineering and business go hand in hand. To be truly successful, engineers must develop products that are both useful AND profitable.

This book will help anyone with a technical background appreciate the business aspect to the project you are supporting. Even if you work for a “not for profit” business, any project you will be assigned to will have a budget and schedule. Exceed the budget and the business must cut other projects to pay for the overrun. Fall past due on the schedule, and the business will have to find a way to make up the lost time – maybe by cutting other projects. No matter how you look at it, there is always a business aspect to any engineering project.

This book is organized as follows. The *Introduction* will define some of the basic principles and set the stage for what follows. In this chapter we will review some of the earliest foundations of economics, the three factors of production, and we’ll see how those three are easier to appreciate if we introduce a fourth factor – the entrepreneur. Finally, we will define the concept of a market – a place where goods are exchanged – and we will see how that has evolved into the modern-day stock market.

In the second chapter, *The Business of Business*, we will explain the importance of the stock market, (the ultimate judge of most publicly traded, for profit companies), as well as some accounting basics. We'll explore the difference between financial accounting, which is externally focused and helps create the balance sheet that measures how profitable (or not) the company is, and cost accounting, which is internally focused and helps company management understand what each product or service truly costs. We'll then explore pricing – how a company determines what it should charge for each product or service. As we will see, price is intimately related to value, so we will finish up with a discussion of value propositions and the specific business model for the products and services brought to market.

The third chapter, *Navigating the Corporation*, will clarify what the various types of non-engineers do in a large company. We will explain both what they do, and why it's important, so that you will know when you need to seek them out for their input. We will also discuss the organizational hierarchy and what changes as you move up the food chain. First and foremost, you need to learn how to tailor your message. When you're an engineer your boss is probably another engineer and will have a need to understand the technical details of what you're doing and why it's the right approach. But as you move up the organization, leadership is more interested in whether you are executing the business plan successfully, and less about the technical details of how you're doing it. We'll show you how to tailor your message based on the priorities of the different levels of the organization.

Next, we will look at *The Rules of the Road* – the laws, regulations, and guidelines that governments insist that businesses follow. Because most of our work experience is in the US, and the US economy is the largest in the world, we will be intentionally biased towards US ways of doing business. We will explore the US Federal Acquisition Regulation (FAR) that guides how the US Government

conducts business and will see how that influences companies that do a lot of business with the US Government.

In the chapter on *Globalization*, we will then explore how things change when you choose to work internationally, and help you understand how you must navigate the export laws in your country of origin, as well as the import laws in the country of destination. We'll also make it clear how current exchange rates, and cultural differences, complicate the business model when you choose to cross international borders.

In the next chapter, *Planning for Success*, we will understand how to take an idea from concept to a finished product that is ready to generate sales. In short, we'll develop an appreciation for what those people in business development and program management really do (and why they should get paid if they do it well). We'll make sure to examine this from two perspectives – first for those people who work for large engineering firms, then for those entrepreneurs who are ready to strike out on their own and try to bring a new product to the market.

In the final chapter, *Evaluating Success*, we will review some of the metrics that are used to measure the business success of products or services, and we'll finish up with a detailed section on how to develop and present a business case for a new idea that will gather support from investors.

Any individual with a technical background who takes these ideas to heart is sure to become a more valuable employee – simply by being able to better relate to the non-technical people in your business. At the same time, there's also a good chance that this introduction may inspire you to start taking ownership of your project, to treat it like a business – even better, to treat it like your business (which it is) – and look past the inherently cool technical details into the necessary, and equally cool, business details.

Before we move on, some people – usually non-technical – ask about the subtitle

*How I Overcame My Moment of Inertia
and Embraced the Dark Side*

I've noticed over the years that many engineers, without any prompting from me, jokingly refer to business as “the dark side”. I'll go with the flow on that one, but there's nothing dark or sinister about wanting to be part of a viable business. Once you make the leap, you'll find it's actually quite lovely on the other side of the fence.

Alan Tribble

CHAPTER 1

INTRODUCTION

This chapter will introduce some of the basic concepts and terms encountered in the field of economics. We do this to make sure we have a self-consistent base to build upon in later sections.

THE FOUR FACTORS OF PRODUCTION

The publication of Adam Smith's, *The Wealth of Nations*, in 1776 is often cited as the birth of economics as a separate discipline. Smith identified land, labor, and capital as the three factors of production, and contributors to a nation's wealth. Modern economics would add a fourth factor – the entrepreneur.

Land in this context refers to any resources that are used to create a product or service. This could be the natural resources such as water, oil, minerals, wood, etc., or it could be the components or subassemblies that are made from those natural resources. Lower tier manufacturers may harvest natural resources directly from the Earth and process them into raw materials that are easier for higher tier manufacturers to work with directly. Manufacturers of Field Programmable Gate Arrays, for example, would typically purchase refined Silicon from the mining company. The FPGA manufacturer would sell their components, FPGAs, to higher tier manufacturers that would include their FPGAs into electronic systems, and so on.

Labor refers to the activities required to process the resources (land) from the raw material you start with, into the finished product. For the mining company in the previous paragraph, this would include the physical effort of the miners who pull Silicon from the ground. For the FPGA

manufacturer, this would include the physical effort of the workers who process the refined Silicon into the FPGAs.

Capital refers to wealth, specifically money or other assets (e.g., equipment that can assist with design, manufacturing, or test). Money is equivalent to equipment, because if you don't have the right equipment you can purchase it with cash. If you purchase the right equipment you may be able to reduce your labor costs.

By the way, capitalism refers to the creation of goods and services for profit, in an economic system based on private ownership of the means of production.

The fourth and final factor in production is the entrepreneur – the individual who figures out a way to combine land, labor, and capital in a new manner to fill a need. Without the entrepreneur, the driving force behind a vision, new products would rarely come to market.

How does the entrepreneur do it? In some cases, they develop a new concept, a new product or service that has value in the eyes of the buyer and create a new market. In other cases, they may simply streamline the other three factors of production. If the entrepreneur can find a way to create raw materials more cheaply, then our costs would go down and we could either: i) increase our profits; or ii) reduce the price of our product and make it more affordable, and maybe make it appeal to more buyers. If more people could buy it the market would grow. Similarly, if the entrepreneur can find a way to obtain the labor required more cheaply, but making the work force more productive, then we can produce more products in less time, which would reduce their cost. Of course, another way to reduce the labor cost might be to move the location of the factory to a part of the world where people are willing to work for less.

That last thought leads to a couple of questions about the cost of the laborers in your work force.

How can high paid domestic workers compete against low paid foreign workers who earn half as much or less?

and while we're at it

How can high paid senior workers compete against low paid junior workers who earn half as much or less?

The answer – by being more productive. Consider the following:

Why Brooks Brothers is Investing in Veteran Tailors¹

At a pioneering plant in New York, half the workers are older than 55

Yeje and her peers can cost more to employ than their younger colleagues. Older sewers in the alterations department—where half the factory's employees work, altering about 225,000 items of clothing a year from stores with too much work to handle—can earn up to 15 percent more in pay than newbies. But Brooks Brothers considers the veterans a worthwhile investment, because they excel at speed and precision and make few mistakes. The operation is largely automated, but some work is still done by hand, and older, more experienced tailors are more skilled. They can make sample neckties in only 30 minutes—a task a newbie can't handle. Twenty minutes later those ties are in the hands of Brooks Brothers executives at headquarters in Manhattan.

¹ <http://www.bloomberg.com/news/articles/2016-03-09/where-retirement-isn-t-job-one>

Just remember, as long as cost is a significant criterion, if you can get more work done per unit cost than the next person you will be in demand. If their ratio of work per unit cost is equal to or greater than yours, you may have trouble finding a position that will pay you what you want to get paid.

The third and final way the entrepreneur could streamline the means of production is to increase the amount of capital on hand. As we saw, in this context capital (or cash) can be used to purchase more equipment. If the entrepreneur can increase the amount of available equipment, then we could process more product in less time, with greater accuracy, and so on. Cash on hand means you can buy equipment quickly. More cash on hand creates options, and less cash on hand restricts options. (As we'll see in the section on cost accounting, equipment is often "capitalized" for tax purposes, but more on that later.)

Although there are certainly a number of wealthy entrepreneurs that can bring new ideas to market without assistance, there are also a lot of entrepreneurs in the making – people who have great ideas but not quite enough cash available to make them a reality. What happens when you have a great idea, but not enough cash to bring it to market? You look for people willing to lend you money. Small entrepreneurs may borrow from Mom and Dad. Lucky entrepreneurs may go on television shows such as *The Shark Tank*[™] or *The Profit*[™] or find a venture capitalist willing to invest. Large businesses borrow money by selling shares in the stock market.

We have used the term "market" a few times, but we haven't really defined it yet. We'll explore the different types of markets in the next section.

FREE AND CONTROLLED MARKETS

As the name implies, when we use the term “market” feel free to imagine what we today might call a “farmers market”, only transport yourself back several hundred years and imagine the business of the marketplace without the advantages of modern transportation, or communications. Buyers would go to the market because they had a need – a need to acquire some good or service – and sellers would go to the market because they also had a need – in this case a need to sell some good or service or trade it for something else. In short, a market is a place – either physical or virtual – where buyers and sellers meet to conduct business. Today the term market is almost interchangeable in some contexts with “customer”. When you ask – what is the market for your product? You’re really asking –what type of people or organizations would buy it?

This last point may seem obvious, but it’s very important to understand the difference between the “global” market and your “addressed” market. We used to work with a great engineer who was always bubbling over with good ideas, but his business case always boiled down to

The population of the world is Y , and if $X\%$ of the world buys my product, I’ll be fabulously wealthy.

No disagreement with that overly simplistic math, but he would have done a lot better job presenting his business case if he would have focused on what portion of the world he was really trying to reach and shown data to support his guess as to what percentage of the addressed market would really buy his product, and why.

In any market, both buyers and sellers have a choice. In times of plenty, a buyer who wants to purchase goods may find an abundance of suppliers, all of whom are eager to earn his or her business. Given many choices, the buyer would naturally look for the best bargain, as judged by some

combination of price, quality, and quantity. Realizing that the buyer has many options, sellers who would rather make some sale (and reap some profit) rather than nothing at all, would be inclined to drop prices. This is what we would call a “buyer’s market”. In times of shortage, there may be few if any sellers, offering the goods desired. As a result, buyers would be willing to pay more to acquire the goods they need rather than go home empty handed. Of course, this would be a seller’s market.

Two other terms used to describe a market are “free” and “controlled”. The buyers and sellers markets we just described are consequences of a free market. In a free market, product availability and prices are driven by the law of supply and demand. That is, prices reflect consumer habits, and competition. Over the short term, prices may go up or down depending on whether it’s a sellers’ market or buyers’ market. But over the long term, prices will tend to decrease, and quality will tend to increase, as sellers compete for market share. This is because customers will always try to obtain goods or services in the place where they are cheapest (i.e., the best value).

The alternative to a free market is a controlled market. In a controlled market prices are set arbitrarily – often by the Government – and are not affected by the law of supply and demand. In a controlled market there is little motivation manufacturers to reduce cost, or add value, since the price is set independently. Conversely, in a free market competition should flourish because other entrepreneurs are always trying to find a way to improve upon existing products or services, so they can increase their share of the market.

The stock market is a specific example of a free market. The two biggest stock exchanges in the United States are the New York Stock Exchange, founded in 1792, and the NASDAQ, founded in 1971. It is a place where people meet to buy and sell “shares” of stock. What is stock? Partial ownership in a company. They are called shares because

each piece of stock is entitled to a proportional share of the company's profit or loss. Selling shares of stock is how publicly traded companies borrow money. Buying shares of stock is (hopefully) how buyers increase their wealth. People who buy shares of stock today, typically do so because they believe the share of stock will be more valuable in the future, so they could sell it at a profit. Publicly traded companies increase the wealth of the shareholders by increasing the value of their shares.

We'll examine stock markets in more detail in the next chapter, *The Business of Business*. Just remember that shareholders buy stock because they expect them to go up in value, at a greater rate than other investment opportunities. Shareholders sell stock because they either need some short-term cash or believe there are other investments that will offer a greater long term financial return. As we'll see in the chapter on *Evaluating Success* much of the challenge of running a successful business is keeping the shareholders happy.

Finally, never forget that, in general, free markets are amoral. They reward scarcity, not intrinsic value. They provide products we want to buy, not just those that we need.

For additional information see *Naked Economics: Undressing the Dismal Science*, by Charles Wheelan.