

Improved Product Design Practices Would Make U.S. Manufacturing More Cost Effective

A Case to Consider Before Outsourcing to China

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Table of Contents

- 2 Abstract
- 3 Introduction
- 5 Current State of Offshore Manufacturing
- 6 Impact of Foreign Currency
- 7 Costs Associated with Outsourcing
- 11 Conclusions About Overseas Manufacturing Costs
- 12 Two Sample Case Studies
- 20 Conclusion and Further Reading
- 21 Appendix: Design for Manufacture and Assembly
- 22 About the Authors

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Abstract

In the global marketplace today, more and more companies are looking to China for both assembly and manufacturing.

Drawn in by the lure of extremely low labor rates, U.S. companies are eager to rapidly move manufacturing and assembly offshore. These companies seem very interested in reducing manufacturing costs, but many of them rarely take the time to understand the significant potential for cost savings during the design phase of their products.

Why is this so? Product development methodologies such as Design for Manufacture and Assembly (see Appendix) have shown repeatedly over the years that most of the cost of a product is fixed during design. The best time to find cost reductions, then, is during the design stage, not during manufacturing.

The question has now become: Is sending a product design overseas for manufacture really the cost-effective solution, or would U.S. companies benefit from taking the time to redesign products and keep manufacturing here?

In this paper, we examine some of the hidden costs of outsourcing that U.S. manufacturers may not be taking into account. To illustrate our claim that product redesign could be a cost-effective alternative to outsourcing, we offer two case studies that quantify costs associated with manufacturing and assembling products in China.

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Introduction

The headline reads “Forrester Updates Offshore Job Numbers.”¹ In its research report, Forrester finds that 3.3 million jobs will leave the U.S. by 2015 for foreign service companies. These jobs are in software development and business process outsourcing (BPO). But job losses have been occurring for decades in the manufacturing sector. In the 1960s and 70s the reason was cheap labor and automation in Japan. During the 1980s, manufacturing shifted to cheap labor in Mexico, and now in 2004 it is shifting to cheap labor in Asia, specifically China.

Job migration is a complex issue with many facets, but U.S. manufacturing seems to be experiencing a lemming mentality when it comes to outsourcing. Company A looks at the competition and sees that products are now being outsourced, and so it feels that it too must outsource manufacturing. The most dangerous part of this trend is that outsourcing overseas is often being done with little or no understanding of what the true costs really are. In this paper, we will uncover some of the tangible and intangible costs of offshore manufacturing in order to provide a “checklist” that will help companies recognize the additional costs associated with outsourcing that need to be taken into consideration.

If you take a careful look and calculate the total cost of offshore outsourcing, the answer may surprise you. Oftentimes the cost benefits are calculated solely on the basis of the incredibly low labor cost. The other costs, both tangible and intangible, are rarely taken into consideration because they are not allocated to the actual product but are paid for by the corporation from various other budgets.

The other danger is that manufacturing firms run the risk of becoming myopic in the design process when they look only to outsourcing for cost reduction. Suppliers may be able to shave costs off individual parts, but these savings are nowhere near as significant as the cost reductions that ensue when companies are willing to reconsider the entire design of a product, using tools like Design for Manufacture and Assembly.

¹ “Forrester Updates Offshore Job Numbers,” Jim Ericson, *Line 56 E-Business News*, May 17, 2004.

Some products, whether or not they are redesigned, are just not a good fit for offshore manufacturing:

- Products manufactured in the U.S. using a highly automated process may not show significant cost savings when produced overseas.
- Product weight and size can affect offshore manufacturing. Shipping by either air or sea is costly, particularly for bulky products regardless of weight.
- Products that require scheduling flexibility are poor candidates. Waiting four to six weeks for sea shipments is not viable.
- With newly developed products, which undergo many engineering change orders and revisions, quality issues may arise. Also, inventory on the water may need to be reworked when it arrives.
- Firms with products protected by patents risk losing proprietary information by outsourcing overseas.
- Firms that utilize expensive production equipment will find depreciation is the same worldwide.

We have found that a cost-benefit analysis examining the question of moving manufacturing offshore sometimes shows a compelling case for keeping manufacturing jobs in the U.S. This conclusion rests on two fundamental assumptions that U.S. companies may have overlooked:

1. It is possible to redesign products to reduce part count and cost; and
2. It is necessary to account for all the additional costs associated with offshore manufacturing and to apply those additional costs to the product.

This paper is a call for a closer look at the relationship between U.S. product design practices and outsourcing trends. U.S. manufacturing capability is a serious concern for our nation. We contend that more needs to be done by government and university research centers, and by public and private manufacturing companies themselves, to understand the cost dynamics of product design and manufacture.

Current State of Offshore Manufacturing

The U.S. Bureau of Labor Statistics publishes an International Comparison of Hourly Compensation Cost for Production Workers in Manufacturing. The data is adjusted and mathematically modeled to be an apples-to-apples comparison between all the countries listed in the report. The latest report, USDL 03-507 dated September 2003, showed the following data:

Country	Hourly wage in (\$U.S.) 2002
United States	\$21.33
Hong Kong	\$5.83
Singapore	\$7.27
Taiwan	\$5.41

Labor rates for mainland China are not so easy to pin down and vary widely from region to region and for urban and rural workers. Rates may range from as little as 33 cents an hour to \$3 or \$4 an hour.

China has many laws governing the treatment of workers, such as minimum-wage laws and laws governing overtime and overtime pay. As a matter of practice, however, these laws are ignored. U.S. manufacturers should understand that their outsourcing contracts may not accurately represent actual working conditions in China. In a series of articles called "The World's Sweat Shop," *The New York Times* focused on workers in different industries and areas of China who make products for the United States.

One of these stories described the Kin Ki factory in Da Kang, an enclave outside of Shenzhen, near Hong Kong. Kin Ki is the factory where the Ohio Art Etch A Sketch product is made. Production starts at 7:30 a.m., breaking only for lunch and dinner, and continues until 10:00 p.m. seven days a week. Workers' meals consist of rice, beans, and boiled vegetables. Meat is served twice a month. The work is tedious and draining. Unlike the Ohio Art factory in the U.S., the Kin Ki factory uses very few machines. Kin Ki requires four times as many workers to injection mold the plastic parts, paint the parts, and attach the strings and rods of the product's internal mechanism. Workers are paid \$85.00 per month.² When inspectors came to the plant, many workers were ordered to stay home because they did not have legal contracts on file. The remaining workers were told to memorize false numbers for wages and working hours that would reflect compliance with Shenzhen regulation.

In high-tech manufacturing, China has been held back by weak infrastructure and caution about its political leadership. The country has a poor reputation for protecting

²"The World's Sweat Shop. Ruse in Toyland: Chinese Workers' Hidden Woe," *New York Times*, December 7, 2003.

intellectual property. Power and water supplies are not dependable. Much of its contribution to the high-tech industry consists of low-tech final assembly of products such as flat screen monitors and laptops. Many industries in southern China that consume large amounts of electricity are required to take one day off a week due to electrical power generation shortages. Jack Hsu, finance controller for the Taiwanese computer peripheral maker Benq Corporation, stated that he "admired anyone who is brave enough to make cutting-edge products in China."³

Impact of Foreign Currency

China has pegged the yuan at 8.28250 to \$1 U.S. since 1994. On October 30, 2003, the Bush administration claimed that China "is not violating the 1988 U.S. law against currency manipulation to gain unfair trade advantages."⁴ This ruling came despite complaints that China's low wages played a major role in the loss of millions of U.S. manufacturing jobs. The European commission has also warned the Chinese that "the undervalued yuan is giving Chinese manufacturers an unfair trade advantage."⁵

According to the *Washington Post*, "Federal Reserve Chairman Alan Greenspan warned Congress that the global economy could suffer if China were to move now to allow its currency's value to be determined by financial markets,"⁶ as some lawmakers and manufacturing associations have suggested it do. According to Greenspan, such a move could cause China's banking system to collapse.

Partly as a result of the pegged yuan, inflation in China, previously dormant, has begun to run rampant. Between November and December 2003, it rose 6%. After 20 years of growth rates exceeding 9% annually, the government is trying to slow down the economy to try to keep inflation in check. The People's Bank of China is not an independent bank. Its authoritative policy board is controlled by the communist leadership,⁷ so its policies are not tied to free market economics. Companies investing in equipment and production in China can not be assured of a stable cost structure. Production costs are unlikely to decrease in the future.

³ "China's Tech Ambitions Stuck on the Assembly Line," Doug Young, *Reuters*, May 23, 2004.

⁴ "U.S.: China Not Violating Currency Law," Martin Crutsinger, *AP News*, October 30, 2003.

⁵ "EU to Complain to China about Currency Trade Balance," John Rega, *Bloomberg*, May 5, 2004.

⁶ "Greenspan Backs Currency Peg," Nell Henderson, *Washington Post*, March 2, 2004.

⁷ "China Rethinks The Peg Tying Yuan and Dollar," Charles Hutzler, *Wall Street Journal*, February 13, 2004.

Costs Associated with Outsourcing

The news is filled with stories of U.S. manufacturing jobs outsourced to low-wage countries. Many companies are lured by tales of low labor cost and decide to transition their products to China, only to find the initially estimated savings were never realized. Before deciding to source overseas, a firm should analyze the total cost of offshore manufacturing. Many tangible and intangible factors should be taken into consideration.

Shipping Cost

Obviously, beyond the cost of production, one of the biggest costs is shipping to and from Asia. A firm can ship either by air or by sea. Most products shipped by sea are packed into cargo containers. These containers are loaded onto container ships and spend approximately three weeks on the high sea before arriving at port. Regardless of how full the container is, the cost remains the same. The trick is to pack the container as full as possible in order to lower the cost per unit for shipping.

Container cost averages approximately \$2600 for shipping and duty. This figure excludes the cost of transport to and from the port in China and to customers or distributors within the U.S. The additional cost of these two land transports often equals the cost of shipping the product by sea. Often neglected, a proper NPV analysis should include an estimate for the cost of inventory carry while in transit.

The entire process, from land shipping in China, through unload and land ship in the U.S., can take 4 to 6 weeks. Unexpected delays, such as the West Coast dock strike of 2002, can increase this time considerably. Issues around "Homeland Security" affect shipping schedules, and these costs continue to unfold. Another important issue that many manufacturers encounter is discovering too late that the product, once it is on the ocean, has to be reworked. Products can't just be shipped back. In addition, a number of fees must be paid upon leaving and entering ports, depending on the port of origin and arrival.

Another cost not routinely recognized is that many Asian companies demand payment when the door on the container closes. The U.S. firm carries four weeks inventory that it cannot actually sell. The firm must also insure the cargo against loss.

Every year approximately 10,000 containers fall overboard. Some famous spills include:

- 80,000 Nike tennis shoes into the north Pacific Ocean
- 414 drums of arsenic near New York City (recovered)
- 29,000 bath toys (ducks, frogs, turtles, beavers)
- 34,000 hockey gloves

- 500,000 cans of beer into the Pacific Ocean
- 5 million Lego plastic pieces

About 90% of world trade is moved by ship. With that much traffic, there is a serious risk of collision, such as the recent collision south of Singapore between oil tanker Mt Kaminesan and car carrier MV Hyundai No. 105. The car carrier with 4000 new cars was sunk when the oil tanker created a hole 165 feet by 66 feet in the car carrier hull.⁸ There is also the increasing risk of piracy. In 2003, there were 445 attacks on commercial ships.⁹ Many attacks go unreported because shipping companies don't want their insurance rates to rise.

Firms may also ship a product by air. Products with small footprints that are lightweight can be shipped by air cost effectively. For these packages, costs range from \$2.00 to \$2.50 per pound. Products packaged in large corrugated boxes, however, are expensive to ship by air, and the number that an airplane can carry is limited. Shipping by sea remains the most viable method for transit. We estimate that shipping and logistics add 17% to the product cost.

Travel / Time Zones

Travel to Asia is difficult. The 20+ hours of travel is tiring, so representatives of U.S. companies tend to maximize their stay and accomplish as much as possible while there. The average stay is a week to ten days. Typically, starting up a relationship with a vendor and launching a product consumes at least three trips to Asia. Most companies allow business-class travel for such long trips. Maintaining the relationship requires frequent in-person contact. We estimate that as much as 1% is added to product cost as a result of travel communication and lost time.

The time zone difference is 13 hours ahead of the East Coast of North America (EST). This means that you need to communicate early in the morning or late at night. E-mail messages often left for the next day response don't get answered until after U.S. workers have gone home for the evening, thus losing a day's worth of time.

Vendor Selection

There are many ways to get started manufacturing in China, such as working with a U.S. third party who runs a factory for you, entering a joint relationship with a supplier, or selecting a vendor simply to manufacture your product. Vendor selection is the most critical step in your outsourcing plans and takes a lot of time and effort. A high degree of due diligence is required to make sure the company that you select can do the

⁸ "Oil Spill Detected Around Sunken Ship Carrying 4,000 Cars Off Singapore," *Automobile*, May 25, 2004.

⁹ "Sea Piracy Hits Record High," CNN.com, January 28, 2004.

manufacturing job. Multiple RFQ's must be sent to several vendors and their responses evaluated. These costs can run from 0.2 to 2% of product cost¹⁰

Quality Issues

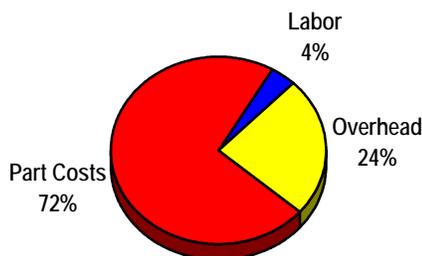
The manufacturing quality of your product is an issue that requires constant vigilance. China's low labor rate exists because there is a plentiful supply of unskilled workers from rural areas who are trying to make a better life for themselves. Since payment is often based on the number of units completed, any unit finished is a "good unit." Many companies are surprised when the container is unloaded and a product sample is pulled to find a variety of quality issues. Inspecting all products before shipment is crucial. Our experience is that these quality defects can run between 1 and 8% of product cost. In our later analysis, we assumed an average impact of poor quality cost of 4%.

Material Costs

In general, when compared to other costs associated with outsourcing, material costs overseas are not significantly different than here in the U.S. However, certain types of materials are not available in the overseas markets and must be exported from the U.S. to the overseas supplier in order to produce the parts. It is imperative to recognize the source of all materials, and any extra export costs, before beginning offshore manufacture.

Labor Costs

We have already discussed some of the costs of overseas labor, but there is another aspect to labor cost that does warrant mentioning. It is important to recognize that the significant part of a product's cost isn't the labor. The chart below has been created from data gathered by Boothroyd Dewhurst, Inc., over the last few years and is based on costs from U.S. manufacturers.¹¹ The chart clearly shows that labor is generally the least significant contributor to cost.



¹⁰ "The Hidden Costs of Offshore Outsourcing," Stephanie Overby, *CIO Magazine*, September 1, 2003.

¹¹ A typical product cost breakdown, Boothroyd Dewhurst, Inc., DFMA Training Guide, 2003.

Other Issues and Costs to Recognize

A full NPV analysis measures opportunity costs and side effects from a proposed project. In addition to the costs that we have identified in the previous sections, a number of others exist. Naturally, costs depend upon the product and industry structure. The list below details a few but is not all-inclusive:

- Legal Issues
- Theft/Piracy
- Shipping losses
- Cost of additional paperwork
- Cost of employee morale
- Cultural/Communication difficulties
- Loss of manufacturing control and flexibility
- Training costs
- Underestimation of startup costs
- Increasing labor costs once a vendor relationship is established
- Cost of transition
- Cost of layoffs and severance
- Cost of inventory carry due to shipping
- Cost of managing offshore
- Cost of bringing a project back to the U.S.

Even though China has joined the WTO and agrees to abide by all the legal world organizational rules, in reality many laws are violated. Copyright laws, in particular, are not enforced, and piracy of trademarked and copyrighted goods is ubiquitous. Many companies will not produce their product in Asia because they cannot protect the proprietary, patent, or intellectual properties of a product or its manufacturing process.

Manufacturing in China prohibits the use of just-in-time inventory methods and runs counter to lean manufacturing. Because of the long shipping times, schedules are rigid and companies are less able to respond to changes in market demand.

Upper and lower bounds should be placed upon any cost estimates for producing in Asia. These should include some allowance for catastrophic events such as shipping accidents. In addition, the health environment of China, in particular, has economic costs. The first outbreak of SARS occurred in China, and its impact on southern China's economy was significant. The more recent outbreak of the bird flu has also had some impact, although not to the extent of SARS. Currently companies are beginning to quantify the cost of employees quarantined after trips to Asia.

If outsourcing to China should fail, and this has happened, the cost associated with bringing a project back to the U.S. is high. Typically products that are outsourced do not have best-in-class design. Cheaper manufacturing rates make it possible to take a

poor design and make it economically manufacturable. However, how can such a product now be brought back to the U.S. and produced competitively? The design must be reworked from scratch, reducing parts and materials in order to compensate for higher labor rates.

We have conservatively estimated that this final category of miscellaneous costs of outsourcing to Asia adds only 1% to the product cost. We believe the actual figure would be much higher, given that every product has a unique set of external costs. We underestimate the costs involved for the purpose of presenting our argument. The likelihood that the real costs will be higher makes the argument more compelling.

Conclusions About Overseas Manufacturing Costs

Together the aforementioned costs, both tangible and intangible, sum to 24% of total product cost as shown in the table below. We arrived at this number based on our experiences with various suppliers and product development companies. Again, this is a conservative estimate because we did not want to argue over particular intangible costs relevant to a particular product or firm. Keep in mind, however, that your analysis should quantify all of the relevant intangible costs for your product.

Baseline adder for shipping and logistics	17%
Finding a vendor	1%
Quality issues	4%
Travel and communications	1%
All others	1%
Total adder	<u>24%</u>

Our results compare favorably with numbers that have been quoted by Gary Larson, vice president of sales and business development for Electronics Systems Inc., who estimates 15 to 20 percent for added costs of freight, customs, homeland security, logistics, inventory carrying costs and reduction in cash flow.¹² Not fully taken into account are quality, culture, travel, and other costs that have been raised in this paper.

Additionally, a West Coast producer of industrial products that does manufacturing in China disclosed to us that a cost adder of 16 percent covers only the costs of shipping and logistics.

¹² “Calculating the Total Costs of Offshore Outsourcing,” *Circuits Assembly*, Susan Mucha, June 2003, pp. 28-30.

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Two Sample Case Studies

To support our general conclusions, we present below two case studies that quantify costs associated with manufacturing products in China.

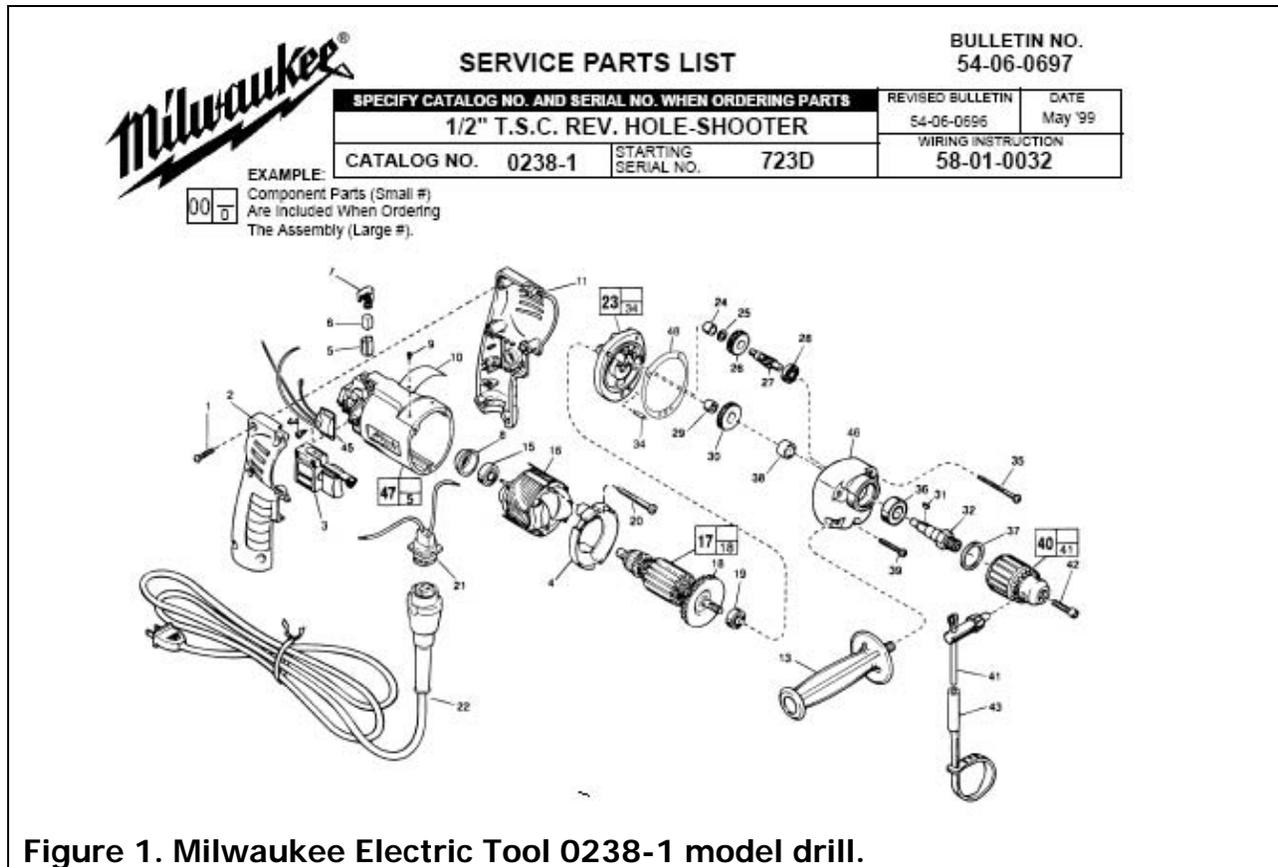
In the first case study, we detail the costs, cost savings, and potential cost of overseas manufacture for a Milwaukee Electric Tool power drill. We performed this analysis using the principles of Design for Manufacture and Assembly in order to compare the potential savings associated with redesigning the product rather than producing it in China.

In the second case study, we discuss the results of a DFMA study performed on a consumer goods product to determine whether manufacturing in China would be economical.

NOTE: All of the cost numbers provided here have been altered to protect the confidentiality of the information supplied by Milwaukee Electric Tool.

Milwaukee Electric Tool Case Study

Founded in 1924, Milwaukee Electric Tool Corporation is an industry-leading manufacturer and marketer of heavy-duty, portable electric power tools and accessories for professional users worldwide. The company is based in Brookfield, Wisc., and is part of Atlas Copco Group.



The exploded view drawing in Figure 1 shows the Milwaukee Electric Tool 0238-1 half-inch drill. This product was manufactured in 2000 and had a cost breakdown as follows:

Model	Material	Labor	Total Cost
0238-1	52.26	41.38	93.64

The 0238-1 model drill then underwent some redesign using DFMA in an attempt to both improve the design and reduce the cost. The redesign project resulted in the 0299-20 model drill produced today. The 0299-20 drill is shown in the exploded view drawing in Figure 2.

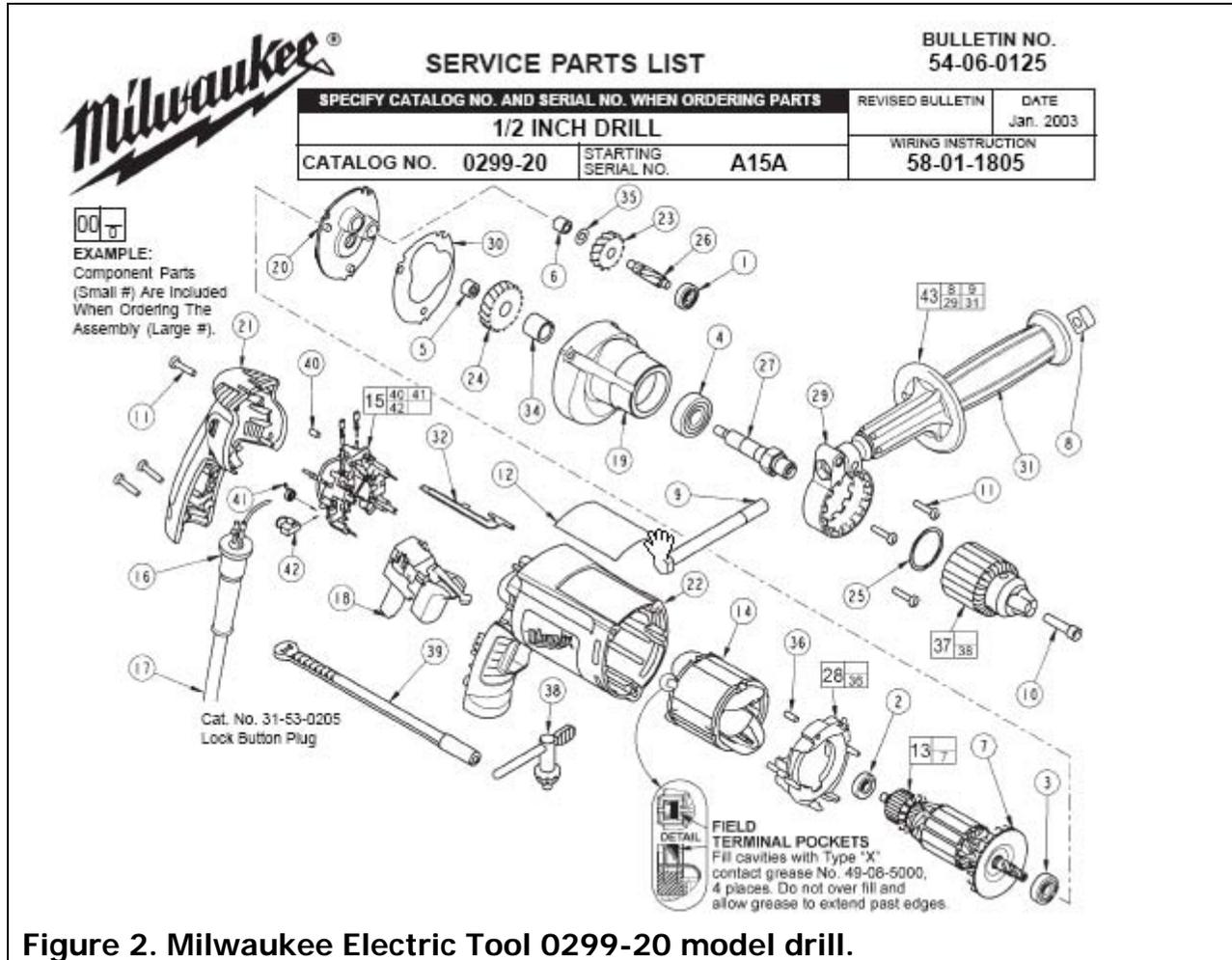


Figure 2. Milwaukee Electric Tool 0299-20 model drill.

The cost breakdown for the redesigned half-inch drill in Figure 2 is as follows:

Model	Material	Labor	Total Cost
0299-20	61.25	31.34	92.59

It is important to note that several enhancements were made to the drill as a result of the redesign, which makes a straight comparison of the two designs a little difficult. Nonetheless, the data shows that the old drill had a total cost of \$93.64 while the new drill has a cost of \$92.59. This is a savings of \$1.05, even with some significant improvements to the features, including a new motor.

Since the labor cost for the original 0238-1 model is from 2000, we must make one more adjustment to accurately compare costs for the original and redesigned drill. Applying a rate increase in labor cost obtained from the Bureau of Labor Statistics, we can scale up the labor costs of the original model to 2004 labor numbers. Adding an average annual increase of 3.65% from 2000 to 2004 gives the following cost comparison:

Model	Material	Labor	Total Cost	Savings
0299-20	61.25	31.34	92.59	7.43
0238-1	52.26	47.77	100.03	

Now we see that the redesign effort results in a savings of \$7.43 per unit while still supplying a better product than the 0238-1 model. This in itself would be a good story to tell: a product redesign in which you deliver more value to the customer, in terms of quality and performance, at a lower cost than it took to manufacture the original unit.

However, the push now is to lower costs more. The lure of very inexpensive labor overseas is difficult to ignore, especially with \$31.34 of labor still left in the current design. As we pointed out earlier in this paper, the challenge for U.S. manufacturers is first to eliminate the hidden costs that remain in their products and then to see whether it still makes sense to send manufacturing offshore. The significant costs, such as shipping, that are rarely included in the product bottom line must be traded off against the potential for cost reduction from redesign.

In this spirit, we applied another round of DFMA to the 0299-20 model drill. We came up with the following suggestions for redesign and their associated cost savings:

1. Change the gears in the drill from being machined from forged blanks to being made from powder metal (a savings of \$10.07 per unit).
2. Replace the roller ball bearings with powder metal bushings (a savings of \$0.99 per unit).
3. Change the side handle back to the 0238-1 design, where it is simply threaded into the gear case (a savings of \$1.82 in material and \$1.18 in labor).
4. Remove two screws from the gear casing and replace them with two long screws extending from the back of the handle through the body to hold the gear case to the handle body (a savings of \$0.14 per unit).
5. Mold in the service nameplate and use a laser etching process to mark the serial number (a savings of \$0.25 per unit).

6. Mold a feature into the drill body to hold the chuck key and eliminate the separate part currently used to hold the chuck key (a savings of \$0.28).

All of these new design ideas together represent potential savings of \$13.55 in material costs and \$1.18 in labor. Let's call this new version of the drill 0299-20a. The cost comparison for all three models is now as follows:

Model	Material	Labor	Total Cost	Savings
0299-20a	47.70	30.16	77.86	14.73
0299-20	61.25	31.34	92.59	7.43
0238-1	52.26	47.77	100.03	

Now we should investigate whether sending the current design of the 0299-20 model drill to China for manufacture would result in at least savings of \$14.73. The answer might surprise you.

First of all, based on our research, expecting a labor rate of 33 cents an hour is unrealistic. Because establishing relations with Chinese vendors is difficult without experience, setting up a first manufacturing project usually requires the services of a third party acting as a broker in the deal. These third parties charge overhead on the labor as fees for their services. This overhead can be significant. The true labor rate is about \$5.10 when you have engaged a third party.

Second, let's assume that there will be no change in the materials cost of the tool. (Actually, this is unrealistic since the motor winding would have to be shipped to China in order to assemble this product, given the unskilled labor force and quality issues mentioned previously.) Let's also assume no other costs involved in the outsourcing, including shipping.

Given a labor cost of \$5.10, the cost of making the 0299-20 model drill in China, compared with the cost of making the redesigned 0299-20a drill here in the U.S., would be as follows:

Model	Location	Material	Labor	Total Cost
0299-20	China	61.25	2.37	63.62
0299-20a	U.S.	47.70	30.16	77.86

The lure of cheap labor alone gives the illusion of savings of \$14.24 per unit. Now, however, we must make allowances for *all* the costs involved in the outsourcing of this design. When we add to the product cost our conservative cost-adder estimate of 24%, which takes into account both tangible and intangible costs, the comparison becomes:

Model	Location	Material	Labor	Total Cost	With 24% Adder
0299-20	China	61.25	2.37	63.62	78.89
0299-20a	U.S.	47.70	30.16	77.86	

The bottom line is that there is an actual increase in the amount of \$1.03 per unit to produce this tool in China, compared to redesigning the product with DFMA and manufacturing it in the U.S.

Industry spokespeople say that companies looking to outsource manufacturing to China will typically seek at least a 30% reduction in cost before they will consider it worth the "Leap to China." Let's say, for the sake of argument, that our 24% adder is an overestimate. Even if we halve it, the cost savings of outsourcing to China is only \$6.61, or 8.5%, still well below the 30% usually required to pursue an outsourcing venture.

You could also make the argument that our \$5.10 labor cost is very high. But even if you use the labor rate of 33 cents an hour, the numbers for making this tool in China become:

Model	Location	Material	Labor	Total Cost	With 24% Adder
0299-20	China	61.25	0.16	61.41	76.14
0299-20a	U.S.	47.70	30.16	77.86	

Here we see that the resulting saving for Chinese manufacture is \$1.72, a savings of only 2.2% over manufacture here in the U.S. This study shows that when you consider the potential for design improvement along with a realistic estimate of the full costs of outsourcing, it often makes more sense to manufacture products in the U.S.

Consumer Goods Product Case Study

NOTE: All of the cost numbers provided here have been altered to protect the confidentiality of the information supplied by this consumer goods manufacturer.

We worked with a consumer goods manufacturer to analyze the design of a major subassembly for one of the company's products. The subassembly consists of 26 electro-mechanical parts, and the costs associated with producing it in the U.S. are \$53.28. Design analysis indicated that the minimum number of parts required for the product to function was 9. Preliminary design suggestions indicate that reducing the number of parts in the subassembly from 26 to 12 parts is a realistic goal that would result in a cost saving of 27%. Currently the costs associated with the production of this product are \$53.28. The application of DFMA analysis indicated that we should be able to reduce the cost to \$38.89.

The manufacturer was able to supply us with cost information for the production of this product in China. The manufacturing cost of the unit in China, including only the costs of parts and labor, is \$35.41. If you now apply our conservative cost adder associated with overseas manufacture of 24%, the actual cost of production in China for this product is \$43.91, as follows:

<u>Design Variant</u>	<u>Cost</u>	<u>With 24% Adder</u>
Original design in U.S.	53.28	
Original design in China	35.41	43.91
DFMA redesign in U.S.	38.89	

When compared to the cost implied by DFMA redesign of \$38.89, outsourcing to China is no longer an attractive alternative. Even compared to the cost of producing the original design in the U.S., outsourcing to China does not yield as much savings as first appears. Unfortunately, many organizations focus only on the labor savings without adding back the external costs. Superficially, the quoted cost in China of \$35.41 appears to be \$17.87 below the U.S. cost of \$53.28. However, we know that the actual cost of Chinese manufacture needs to be increased to account for additional tangible and intangible costs (our 24% adder). When we figure the cost adder in, the cost to manufacture in China comes to \$43.91. Now the total savings from the original U.S. cost of \$53.28 is only \$9.37.

Moreover, for this particular product the smallest corrugated packaging is rather large. Shipping and logistic costs are significant. It turns out that the actual cost for shipping and logistics of this product is \$10.15. In reality, shipping adds 22.2% to the product cost, as compared to our estimate of a 17% adder for shipping and logistics. Considering actual shipping costs only worsens the picture for Chinese manufacture of this product, since it increases the adder by 5 percentage points to 29%, rather than the 24% that we assumed.

These data clearly show that it is imperative to anticipate all the additional costs associated with Chinese manufacture. For this subassembly, applying DFMA to redesign the product and manufacturing within the U.S. is a more cost-effective solution.

Conclusion and Further Reading

We believe that our analysis and the previous discussion show that you need to look at all the costs associated with offshore manufacture. Even though many of these costs are not accounted for directly in the product bottom line, you need to understand their magnitude and include them in the analysis when deciding whether there are benefits to outsourcing. Our results show, albeit in a limited sample, that just blindly outsourcing a product to China for low labor rates is not always a good decision.

The obvious question is, why not send the DFMA redesign to China and have it manufactured there? This is of course a good option, but you should certainly proceed with caution. In the end, manufacturing a redesigned product in China may not save as much cost as promised unless you can be sure your foreign supplier has the manufacturing capability (labor skill, material availability, quality standards, etc.) that innovative designs sometimes require. The one option that DFMA does give you is the opportunity to bring the redesign back from China and retain the ability to manufacture it in the U.S. if the need should arise.

As we acknowledged at the start of this paper, much study is still needed to determine the comparative benefits of outsourcing the manufacture of products to China versus redesigning products and manufacturing them here. Good thinking on this topic will cross over and integrate disciplines such as product design, industrial and manufacturing engineering, procurement, operations management, product costing, and corporate finance and accounting.

For those who wish to investigate it further, the offshoring debate is ongoing in the current trade and business press. Studies by business analysts, such as Boston Consulting Group, are beginning to specify the risks of outsourcing.¹³ Other analysts, particularly Aberdeen Group, have discovered that the majority of U.S. manufacturers have very limited visibility into what it costs them to make their own products.¹⁴

¹³ See "Capturing Global Advantage," April 2004, Boston Consulting Group.

¹⁴ See "Product Development in Consumer Industries Benchmark," June 2004, and "The Spending Analysis Benchmark Report," January 2003, Aberdeen Group.

Appendix: Design for Manufacture and Assembly

Design for Assembly – Simplicity Pays Off

Design for Assembly (DFA) is a methodology for evaluating part designs and the overall design of an assembly. It is a quantifiable way to identify unnecessary parts in an assembly and to determine assembly times and costs. Using DFA software, product engineers assess the cost contribution of each part and then simplify the product concept through part reduction strategies. These strategies involve incorporating as many features into one part as is economically feasible. The outcome of a DFA-based design is a more elegant product with fewer parts that is both functionally efficient and easy to assemble. The larger benefits of a DFA-based design are reduced part costs, improved quality and reliability, and shorter development cycles.

Design for Manufacture – Vital to Competitiveness

Design for Manufacture (DFM) is a systematic approach that allows engineers to anticipate manufacturing costs early in the design process, even when only rough geometries are available on the product being developed. Given the large number of process technologies and materials available, few design engineers have detailed knowledge of all the major shape-forming processes. Consequently, engineers tend to design for manufacturing processes with which they are familiar. DFM methodology encourages individual engineers and concurrent development teams to investigate additional processes and materials and to develop designs that may be more economical to produce. With more information about viable processes and materials, users can quantify manufacturing costs for competing design alternatives and decide which design is best.

The Link to Design for Assembly

DFM complements DFA. Engineers use DFA software to reduce the assembly cost of a product by consolidating parts into elegant and multifunctional designs. DFM software then allows the design engineer quickly to judge the cost of producing the new design and to compare it with the cost of producing the original assembly. Used together, DFM and DFA software give engineers an early cost profile of product designs, providing a basis for planning and decision making. Such analyses, when performed at the earliest stages of concept design, have the potential to greatly influence manufacturing and other life cycle costs before they are locked in.

Complete information about DFMA methodology is available at www.dfma.com.

About the Authors

Nicholas P. Dewhurst is executive vice president for Boothroyd Dewhurst, Inc. He directs the implementation of Design for Manufacture and Assembly at hundreds of companies around the world. His focus is to help these companies understand and manage their costs throughout the product development process. Documented savings as a result of this work runs well into the millions of dollars.

Nick is an experienced project engineer who has been responsible for the design and production of capital equipment. His work in industry focused on the design and manufacture of systems to perform online high-speed noncontact dimensional gauging of small components. He holds a B.S. in Mechanical Engineering and Applied Mechanics from the University of Rhode Island.

David G. Meeker is an authority on the application of Design for Manufacture and Assembly and its role in new product development. His areas of expertise also include benchmarking, cost estimating, and design for disassembly and recycleability.

David has more than 22 years of industry experience working as an engineer for companies in both the commercial and defense industries, including Digital Equipment Corp., Compaq Computer Corp, and Hewlett-Packard Company. He is credited with saving hundreds of millions of dollars through improved product design strategies. He is currently a private consultant applying new product development techniques to improve quality and time to market and to reduce cost. David also teaches product design in the Department of Mechanical Engineering at Massachusetts Institute of Technology.

David has published papers in the journals of professional organizations such as the American Society of Mechanical Engineering and the International Conference on Engineering Education. He holds a B.S. in Mechanical Engineering and an M.S. in Engineering and Public Policy from Carnegie Mellon University.