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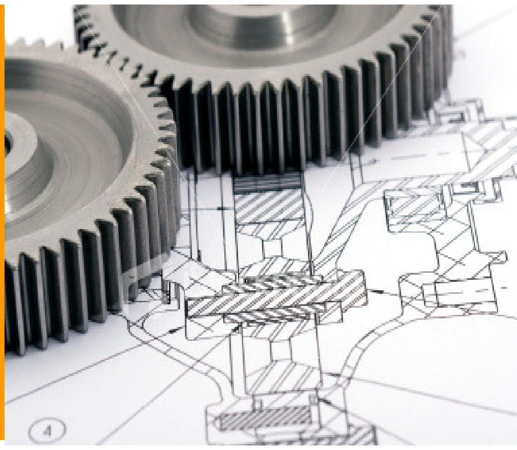

Incorporating risk and flexibility in manufacturing footprint decisions

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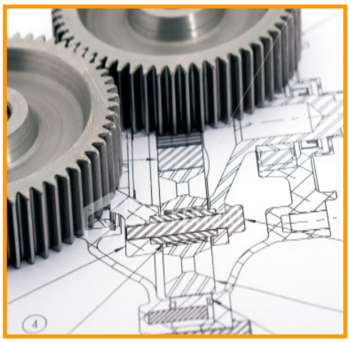

Incorporating risk and flexibility in manufacturing footprint decisions

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Executive summary

An increasing number of manufacturers are significantly reshaping their global manufacturing footprint, taking measures such as radically increasing offshore production in low-cost countries and fundamentally rethinking their sourcing strategy. Too often, manufacturers base such footprint choices primarily on their expected capacity and cost implications, without taking adequate account of the equally important aspects of risk, flexibility, and competitive positioning. As a result, companies leave value on the table, having failed to make the right cost-risk-flexibility trade-offs. This paper illustrates (with real-life case examples) some of the pitfalls companies have encountered, and outlines a more holistic approach that includes systematic identification of the key uncertainties and flexibility factors and quantifying their impact. This approach includes real options-related techniques incorporated into probabilistic risk modeling and footprint optimization.

Introduction

Offshore sourcing, globalization, multinational mergers – an increasing number of industrial companies, facing both the necessity and the opportunity to reshape their global manufacturing footprint, are redefining where and how much of each product, component and part they or their suppliers will manufacture. Sometimes this simply involves adjusting the output mix at existing production facilities. Increasingly, however, companies are also considering more radical options, such as de-localizing to low-cost countries or fundamentally redefining their relationships with suppliers.

Any such major move involves significant uncertainty. Some of this uncertainty comes from external drivers, such as commodity costs, labor rates, and foreign exchange, as well as the evolution of price and demand. Some of the uncertainty comes from internal drivers, such as the level of investment and time to execute major changes, as well as the potential productivity and quality issues that may arise in a new environment. There is additional uncertainty from unexpected events – geopolitical risks for instance – that may affect a changed footprint in challenging new ways. Companies generally recognize these uncertainties, and rightly mobilize considerable expertise and resources to prepare for them once a footprint decision is made, or to mitigate them as they occur. In our experience, however, decision makers rarely take sufficient account of them when exploring the footprint options and deciding which is the best route to follow.

Experience shows that the best possible production footprint decisions result from comparing the alternatives simultaneously on all of the following dimensions:

1. **Capacity.** What product and how much of it can the footprint produce, and is that likely to be sufficient to meet growth expectations?

2. **Expected cost.** What is the total landed cost of production, given best estimates of all factor costs? What return on the expected investment is needed to implement the changes to the footprint?

3. **Risk.** What are the key downside risk factors? How much impact do they have on the economics? To what extent and how can they be mitigated?

4. **Flexibility.** How does the footprint respond to changes in costs, prices, and demand from the currently predicted most likely levels? This includes both flexibility to adjust production "within the four walls" of a single plant or product, but also, more importantly, the flexibility to reoptimize production across the whole footprint in response to change.

5. **Competitive positioning.** How does the footprint compare to competitor footprints, and what benefits or limitations does that imply about the manufacturer's positioning in the marketplace?

The first two dimensions are commonly considered, but the last three are usually not given the attention they deserve. This uneven approach is unfortunate, since the middle three dimensions are interlinked in reality, and often involve obvious trade-offs: lower cost but higher risk, or higher flexibility but also higher cost. Allowing a decision to be driven by expected cost and capacity alone can leave significant value on the table, which can be hard to recover once a major footprint redefinition project is well under way. Techniques are available to help in early identification of the important types of risk and flexibility, as well as to quantify the important trade-offs to make the decision in a more informed way. Used conjointly, these techniques constitute a powerful approach to quantifying the risks within each potential manufacturing footprint choice, and thereby helping to identify the optimal decision.

Understanding and quantifying footprint risk

By its nature, risk involves dealing with the unknown. Not infrequently decision makers are unsure of how to account for the unknown. They make their best guesses, and then use these guesses to drive the decision, hopefully doing a bit of stress-testing along the way to guard against overly horrific consequences if they are somewhat wrong. The problem with this approach is that making a footprint change – especially one involving outsourcing or offshoring production – brings on new and unfamiliar risks and reshapes existing risks in ways that can be quite counter-intuitive.

Beware of hidden exposures

A Western European company was exploring the pros and cons of building a major plant in Eastern Europe. The plant would bring back in-house the production of a crucial part, which was currently being sole-sourced from a Western European supplier. The company was understandably concerned about foreign exchange and labor cost risk, and also about issues of construction speed and quality, since it lacked experience in Eastern Europe. Close examination revealed, however, that the key sub-suppliers of the current Western European supplier of the part were based in the U.S., which meant that value changes in the U.S. dollar would eventually percolate through the value chain and into the cost of the part.[1] In effect, the company was facing significant but hidden U.S. dollar Forex exposure of which it had not been

[1] Pricing clauses in the contract would limit the impact in the immediate term, but the likelihood of forced contract renegotiation was high.

aware. Moving to in-house Eastern European production would not, therefore, be adding Forex exposure where there was none, but actually only replacing one form of exposure with another.

The example illustrates a second point: companies often fail to go deep enough in understanding the risks of their suppliers in general, and underestimate sole-source risks in particular. In particular, they tend to underestimate the risks of a single source located in a low-risk country relative to the risk diversification of adding a second source, albeit in a higher-risk country. There are cost-risk trade-offs with either solution, and calibrating them requires a comprehensive analysis of risk drivers at the supplier and sub-supplier level.

Probabilistic estimation of key risks

In the example discussed above, the company was overestimating the overall increase in risk in the event of the footprint change. In many instances, however, companies underestimate the risk of a footprint shift. Consider the example of a diversified heavy equipment manufacturer whose footprint is heavily based in developed, high-cost countries. Its total landed unit cost of production (indexed) was 100. The company developed a new footprint option involving a significant shift to low-cost countries, with an expected (most likely) total landed unit cost of 79. This 21 percent savings was based on an in-depth, bottom-up cost build, including final assembly, components, parts and logistics. But how risky was this 79? Could it inflate drastically in the case of bad luck? And to what extent and how should this risk be mitigated?

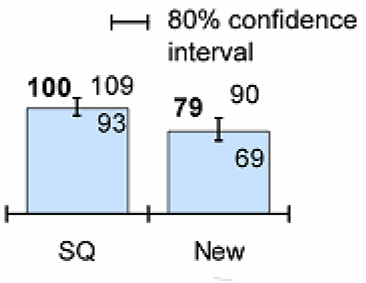
As a consequence of doing the bottom-up cost build, the footprint team found it easy to test the firm's sensitivity to basic financial or economic risks (such as upside and downside Forex, labor rate, commodity price, and inflation scenarios) and compare their impact on the status quo (SQ) and new footprint. This was helpful. But it left unanswered how likely these scenarios were and therefore how realistic and meaningful the differences were. By combining data on historical volatility with expert estimates and market currency futures, however, it was possible to construct a probabilistic model that calculated an 80 percent confidence band for the total landed cost based on these basic risks.

The results are shown in Exhibit 1, which merits some explanation. Forex, labor rates, inflation, and commodity prices are uncertain. If they behave according to history, and as the futures markets and experts believe, however, then the total landed cost of the new footprint is 80 percent likely to be between 69 and 90, while cost of the status quo footprint is 80 percent likely to be between 93 and 109. This assumes no other risks or uncertainties; for example, there will be no unexpected supply chain meltdowns, mega-earthquakes in Southeast Asia, or extreme, but unexpected, currency devaluations.

EXHIBIT 1

Footprint risk comparison

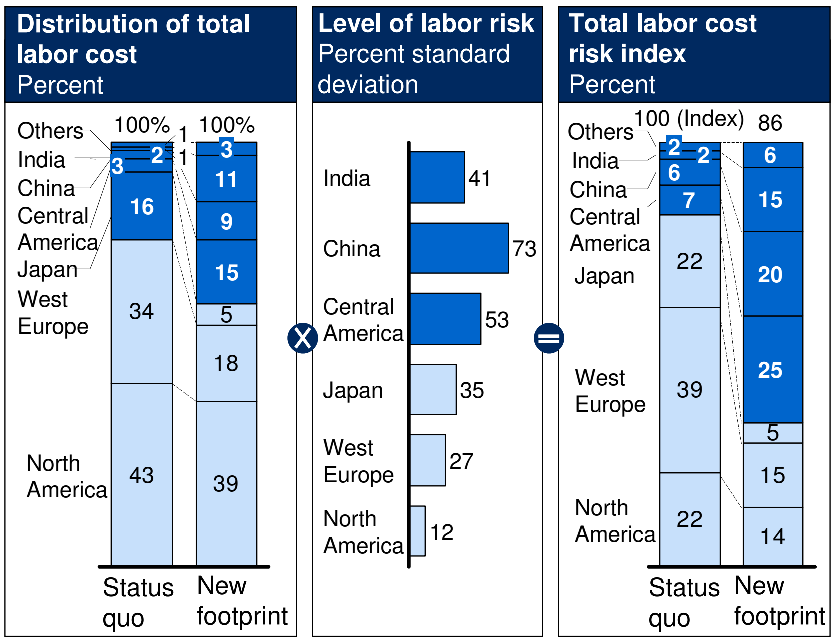
Indexed unit cost



What is the benefit of this information? It is not a foolproof quantitative ranking to demonstrate which option is better. However, it does provide significant additional information and reduces the uncertainty in making the decision. In this case, it is clear that while the risks (at least those listed above) of the new footprint are proportionately larger, the cost savings are such that it appears to be worth it. What is more, the quantitative analysis leading to this result highlights exactly how the risks have shifted. Exhibit 2 shows a deeper analysis on labor cost, indicating how more than half the risk would shift to developing countries in the new footprint.

EXHIBIT 2

Geographic shift of labor risk



Correcting bias in the expected value

The two exhibits above don't tell the whole story, however. Many additional risks – political and macroeconomic risks, supply chain/transportation risks, risk of quality flaws, etc. – have not yet been included in the analysis. What is more, these risks are higher in the unfamiliar new footprint than in the current footprint. The company used best available data specifically to estimate the most significant of those risks which would be radically different in the new footprint versus the status quo. Incorporating these risks into the model actually raised the expected total landed cost of the new footprint from 79 to 84.

That's right. The original estimate of the expected total landed cost had to be changed and the overall economics became less attractive than before. This was not the result of a shoddy calculation of the "expected" cost, but the result of well-known human biases of dealing with uncertainty. People will anchor around the perceived most likely value when calculating a point estimate: it is most likely that no Asian country's economy will collapse, most likely the plan to ensure quality will be adequate, most likely no transport hub will be disrupted by a labor dispute. However, the small likelihood, but large impact, of each of these events chips away at the expected value. What is more, where enough separately unlikely risks accumulate, it becomes quite likely that one or more of them will strike. Financial institutions have lived this reality for a long time, and make allowances for credit write-offs, for example (though as the recent subprime crisis has indicated, they have sometimes not gone far enough!). The thinking about risks and uncertainties in many industrial companies, however, has lagged behind, and this lag is one reason for the familiar experience of nearly all major projects going over schedule and over budget. Going through the process of quantifying such important risks at the stage when the footprint choice is being made is much better than facing nasty surprises later on.[2]

The stealth benefit of flexibility

A compensating factor to manufacturing footprint risk is often equally neglected. Companies will calculate the economics of their footprint – indeed, of any strategic move or major investment – using the best possible assumptions about uncertainties. As these uncertainties are resolved, however, the management team will respond with value-maximizing decisions. A mining company reacting to high commodity prices today by investing in the opening of another mine will slow the project down or reduce its scope if commodity prices decrease faster than expected. If instead they zoom up even faster, the company will rationally invest more in bringing the mine up to full production faster than planned. This flexibility implies the mine is more valuable than what would be suggested by merely plugging in the new commodity price assumption into the original model.

In the case of project investments or strategic decisions, this is the idea behind "real options" (see, for instance, the book *Real Options* by Lenos Trigeorgis). The calculated value of the mine we are discussing (NPV of future cash flows) should be increased by the value of a curtailment or abandonment option (basically, not throwing good money after bad), and also

[2] Of course unforeseeable risks also exist, and these may also affect one or all footprint choices.

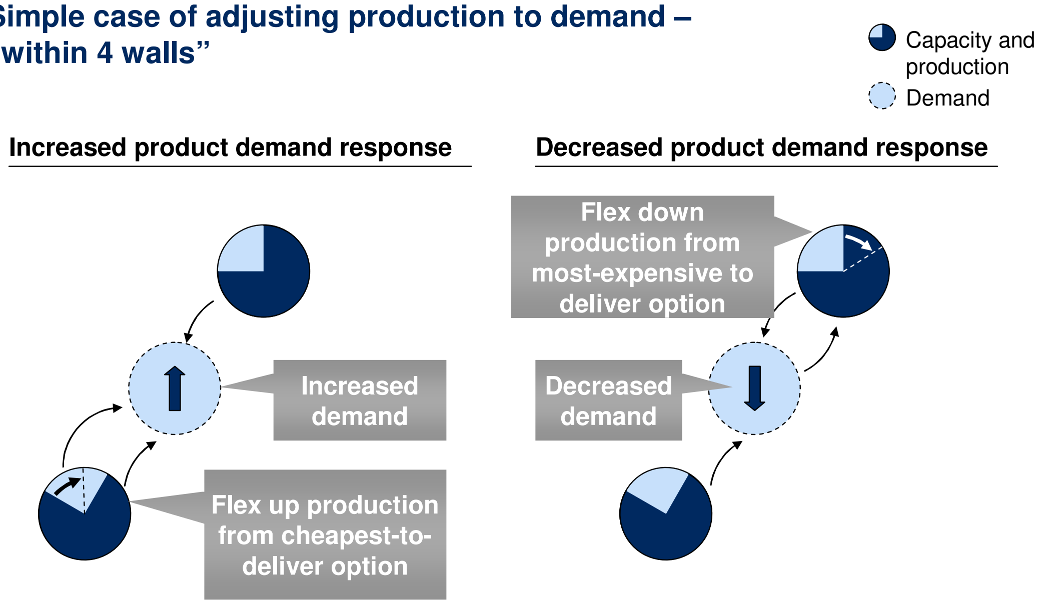
by an acceleration/expansion option. In the case of one specific mine we have looked at, these two options added another 50% to the value of the project.

Ramping up or down in response to demand “within four walls”

In addition to these standard real options, further significant “stealth” value is often hidden within manufacturing footprints in their operational flexibility – the ability to ramp production up and down in different areas of the network and move output around the globe based on demand. Energy companies do this is a systematic way, for instance by making refineries optimize their output mix based on current prices for different petro products. Any manufacturing footprint has this type of flexibility. If, for example, a product is manufactured in two locations and demand is lower than expected, the more expensive location (on a landed cost basis) is the one that will scale down. If demand is higher, the less expensive location will scale up. We call this “within four walls” optimization – a simple decision taken in one office by a manager in one demand geography, who calls up one plant manager and they together adapt rationally to changing conditions (Exhibit 3).

EXHIBIT 3

Simple case of adjusting production to demand – “within 4 walls”



This flexibility – choosing how to respond to demand uncertainty based not on currently expected production economics but on an ongoing basis in the true evolution of costs and demand – is a real option that increases the value of a more flexible footprint. If several footprint options are being considered, this flexibility needs to be valued along with risk in order to make the best footprint choice.

Rather than valuing real options by a closed-form formula, we have had the best experience by actually incorporating a simple optimization algorithm within the probabilistic footprint risk model, implemented with a Monte Carlo simulation. In each iteration of the Monte Carlo model, the algorithm – just like the regional and plant managers – decides which plants should produce more or less than planned. As a result, the probability distribution for cost and profit coming out of the risk model is reshaped, reducing the downside and enhancing the upside. In many cases, the best framing for the decision maker is not "how much expected value does the flexibility generate" but "how much of the risk does it compensate for." In the example in exhibits 1 and 2, flexibility "within the 4 walls" reduced the overall level of risk in the new footprint by 20 percent.

Ramping up or down in response to demand – portfolio reoptimization

Let's consider a more complex case. A manufacturer with plants around the world wants to optimize production based on how demand, transportation costs, and Forex evolve in different regions. Such an optimization goes beyond what can be done "inside four walls," requiring a dispatch model that recalculates the flows across the whole portfolio. Individual decisions taken by regional and plant managers are not enough.

EXHIBIT 4

More complex portfolio optimization – a portfolio approach

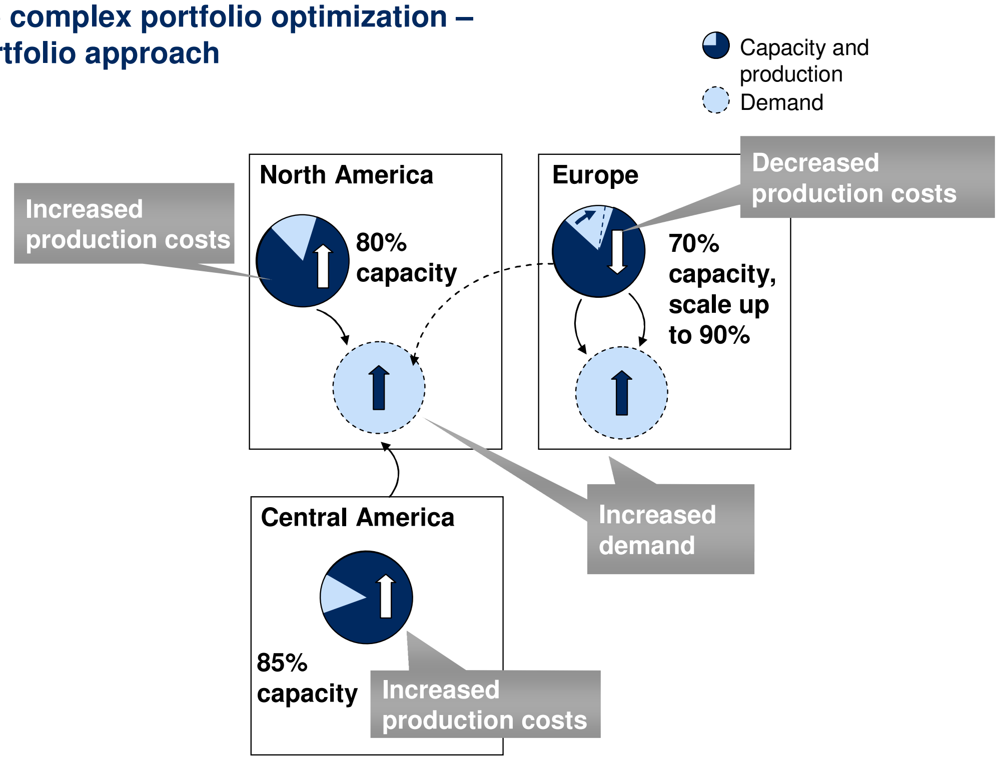


Exhibit 4 illustrates such a complex optimization, across three regions. In this case, demand and production costs are up around the world. In a "within four walls" optimization for North America, excess demand would be served with additional production from either North

America or Central America (whichever would have lower landed cost). In this interregional example, however, the economics are better if European production is ramped up drastically to service both increased North American and European demand. This would involve shipping some European production across the Atlantic, which was not previously economically advantageous. The change is a result of the specific balance of production and transportation costs in each of the three plants. In a slightly different situation it might instead have been better to increase production in Central America and ship to both North America and Europe.

Once again, one method to compare the level of flexibility of this sort across different footprint options would somehow value "portfolio flexibility" as a standalone real option. However, the more regions there are, the harder it is to formulate this clearly. A better solution is to include a more sophisticated optimization step within the probabilistic risk model. When the actual decisions will be made by management in real time, the optimization criteria are likely to be quite sophisticated, including ramp-up and ramp-down times and marginal costs, likelihood of costs and demand staying close to current levels for a reasonable length of time, etc. However, in our experience, to capture the hidden value of flexibility in comparing potential future footprint models, even a relatively simplistic analysis – within each probabilistic iteration of the risk model – of where is there excess demand and excess supply and how it is best optimized "on the margin" given the level of costs in that iteration, is enough to highlight a large part of the incremental value or risk reduction potential.

In the extended example in exhibits 1 and 2, we remarked that optimization "within four walls" reduced the level of risk in the new footprint model by 20 percent. Adding a simple portfolio dispatch module within the risk model showed that optimizing beyond the four walls reduced the level of risk in the new footprint by a total of 32 percent – demonstrating conclusively in this case that while the new footprint had additional risks compared to the old one, the increased risk diversification combined with the additional flexibility it offered more than made up for it.

The example is not a unique one. Experience shows that this flexibility usually makes a difference and can affect the determination of the "right" footprint in a variety of ways. A recreational products manufacturer traditionally estimated demand for its products each year in the pre-season. It ran a short single-production run and shipped the product to dealers across the country. Actual demand, however, was highly dependent on the weather in each area, and hence significant sales were lost from having shortages of product in one area and surpluses in others. It turned out that a split production run, with a percentage of output manufactured at significantly greater expense in mid-season and delivered to where demand was high, was a more economical approach, due to the greater flexibility it allowed.

Footprint risk and competitive positioning

Fear is one of the more common reasons why manufacturers are willing to take the risk to move to a new footprint – fear that the competition is further ahead on the drive to lowest-cost production, and that one needs to follow (or leapfrog) to remain competitive.

Not all companies, however, take the time to understand the competitor's footprint in terms of the risks it involves, and its place in the competitive landscape of the industry as a whole. The fact that a competitor has an advantaged cost position may be unfortunate, but if industry structure is stable, it may not be worth the investment or risk of playing an endless game of catch-up. In fact, in some industries such a response might provoke a rational or irrational competitive reaction that could easily destroy much more value than the original cost savings at stake. In technologically evolving commodity industries, however, there is no escaping “Moore’s Law” for long – for computer components manufacturers, keeping up or ahead comes with the territory.

An full exploration of the impact of industry structure on risk – an impact that can be both enormous and hidden – is beyond the scope of this paper. We only cite one well known example from the auto industry.[3] In 2000, General Motors had minimal direct yen currency risk, since sales and production were primarily in the U.S. Yet were the yen to depreciate, Japanese car makers’ cost structure would become significantly more attractive; if the Japanese passed this advantage through to the price of their cars, G.M. share could erode significantly if it did not react. Ultimately, therefore, the difference between G.M.’s American footprint and its competitors’ Japanese footprint turned out to carry a hidden but real economic exposure to the yen for G.M., ten times as much as its direct exposure. The level of this indirect exposure has been changing due to industry conduct. By diversifying production around the world – in projects such as the joint Toyota-G.M. NUMMI venture in California – Japanese car makers have been reducing their direct exposure to yen appreciation, and as a result indirectly decreasing U.S. automakers indirect competitive exposures to the yen.

What should companies do?

The examples given in this paper are meant to demonstrate that appropriately taking into account risk and flexibility in making manufacturing footprint decisions is not just a bean-counting exercise. First, proper valuation of these factors can change the decision. An apparently lower-cost footprint may no longer be as attractive once significantly greater risks are taken into account. Conversely, an apparently more costly or more risky footprint might provide sufficiently more flexibility to be worth it. Competitive factors may change the cost, risk, and flexibility picture altogether.

Second, the effort of looking at all these factors itself focuses management attention on value-creating areas. Understanding the risks, sources of flexibility, and competitive dimensions in particular allows management to focus greater attention on issues that will sway the optimal choice, and once a decision is made, deploy attention precisely to the areas where value leakage might occur.

Since companies face a wide range of footprint choices no single path will lead to the right answer. A number of approaches and tools can be useful, but to know which one(s) to apply, and to maximize the usefulness of your choice, we have found that it is best to subject each company’s footprint process to a three-phase screening, with a “decision gate” at the end of phases 1 and 2.

[3] See the HBR case, *Foreign Exchange Hedging Strategies at General Motors: Competitive Exposures*, by Desai and Veblen (2005).

Three-phase screening process for footprint decisions

Phase 1: Framing the case for change and key constraints

The first goal is to understand the issues with the current footprint. What concerns about capacity, cost, risk, flexibility, or competitive positioning are driving the desire to explore footprint options? A key step in this phase is comparing one's own current footprint with those of competitors. This involves preparing reasonably detailed cost build-ups, including breakdowns of suppliers' costs, for one's own company and as far as possible for competitors as well. The capacity and cost comparisons follow immediately from this fact base, but it also allows the comparison of the risks and flexibility opportunities between footprints as well. Is your company more sensitive to an economic downturn or to Forex devaluation than a competitor? Can one competitor respond with more flexibility to differences in regional demand? Workshops designed around careful risk mapping and prioritization of risks can help bring the key issues and differences to the surface.

At the same time, it is helpful to articulate clearly the constraints against pursuing a new footprint. Is moving production to a low-cost country a feasible option, or do labor constraints imply the only freedom is in deciding where eventually to build a new plant? Is it feasible to change product mix on the fly or not? Is there an upper limit on the investment cost or disruption time frame that any considered option must respect?

Decision gate 1. To continue to Phase 2 of this process, the existing level of risk and uncertainty, and/or the levels of additional footprint flexibility in the options being considered, need to be relatively high. In addition the constraints need to be sufficiently mild to allow further exploration of genuinely different footprints. Otherwise, if the constraints are overwhelming, and there is not enough freedom for a more extensive footprint optimization to be helpful, it makes more sense instead to focus analysis on targeted improvements in the status quo. With the additional information available after Phase 1, building a robust business case for such improvements is usually easier than before.

Phase 2: Comparing footprint options

Phase 2 is the stage where a handful of new footprint options, compatible with the constraints identified, are explicitly identified, and compared to the status quo and to each other on capacity, cost, risk, flexibility, and impact on competitive positioning. A key tool at this point is a probabilistic model for footprint economics, including risks and flexibility, whose goal is exemplified in the output of exhibits 1 and 2. Where applicable, the logic demonstrated in exhibits 3 and 4 can be included to ensure that operational flexibility is adequately represented. The starting point are the cost build-ups from Phase 1, but frequently some deeper analysis is needed on key risk factors, such as the nature of political and macroeconomic risks in certain countries, or the microeconomic impact on supply and demand of currency risk.

In addition, stress-testing key assumptions with targeted scenarios, above and beyond the probabilistic modeling described above, is often helpful, both to learn more about situations where data are insufficient to allow for probabilistic estimates, and to do "what-if" analysis to give management comfort that any implications would not be catastrophic.

Decision gate 2. By the end of the Phase 2 analysis, a clear winner among the footprint options has often emerged. In such cases, it is best to move straight on to value optimization, drawing conclusions from the analysis to identify which risks should be mitigated, what level of flexibility it makes sense to invest in, and where to invest management time. If execution risks associated with the transition have been identified as a key lever, then piloting or scale decisions need to be made. If there is no clear winner, move on to Phase 3.

Phase 3: Zeroing in on the optimal footprint

In some situations, Phase 2 will have revealed that significant improvement to the status quo can be achieved, but also that the cost-risk-flexibility trade-offs are substantial and the discrete options considered do not appear to have zeroed in on the perfect trade-off. The discussion in this paper has focused on comparing discrete options, but analytical optimization techniques allow for adjustment of the parameters of the footprint options (within constraints) to reach the optimal blend. For instance, the maximum production level to plan for in different plants can be optimally determined to balance the cost of build-out and the value of the additional flexibility from having fewer local production constraints. These techniques are computationally quite intensive (especially when the number of products or geographies in the footprint is substantial), but could uncover significant value where the level of uncertainty and value of flexibility are high.

* * *

Footprint redesign can be the largest-scale and largest-impact transformation that a manufacturer can undertake. If done well, the redesign will find the right balance of capacity and growth potential, cost, risk, flexibility, and competitive positioning. A tailored approach, bringing the best tools and analyses from a variety of operational, financial, and strategic decision making disciplines, is the key to doing it right.

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