SHOULD WE BE MANUFACTURING CLOSE TO HOME OR FAR AWAY? THE ANSWER IS: BOTH!

"Where should we be manufacturing? Locally, or further afield, in low-wage countries? This is a question with which many companies struggle", says **Professor Robert Boute**. The answer is dependent on a number of factors. Using a theoretical but realistic stock model, he has worked with Professor Jan Van Mieghem from the Kellogg School of Management to develop an elegant mathematical formula with which companies can calculate exactly how much they should manufacture locally, and how much they can manufacture offshore. The formula offers a clear insight into the impact of the various factors that play a role in the decision.

Assessment

Manufacturing locally is generally more expensive, but the cost advantage offered by manufacturing in low-wage countries should be weighed up against higher transport costs, and the need to keep larger stocks to enable a rapid and flexible response to demand in the face of longer delivery times.

"It is more relevant than ever to carry out this kind of assessment", Robert explains. "Over the last few decades, companies have moved their manufacturing en masse to low-wage countries, attracted by lower wage and material costs. However, we are increasingly seeing companies reverse these decisions. Wages in these countries have risen, particularly in China, and transport has become more expensive. Furthermore, speed and flexibility are essential: many products have a shorter life cycle, demand is becoming more volatile and customers expect ever-faster lead times."

Does this mean that companies will have to revert entirely to local manufacturing and supply chains? Robert does not think so: "It's a mistake to put all your eggs in one basket. Ideally, you can combine a number of different locations or suppliers. Which then prompts the following question: "How much should you produce or source locally and how much elsewhere?"."

New approach

Robert and Jan have developed a formula for calculating the optimal – i.e. cheapest –split, taking into account the characteristics of the (two) available locations:

Lead times;
Factor costs – variable costs such as direct material and wage costs, energy and import taxes;
Capacity costs – fixed costs such as investments in machines, wage costs and other overheads that cannot be directly attributed to any one product; and
Capacity flexibility.

This approach is new. Robert explains: "As a rule, existing models for stock optimisation questions only take into account factor costs and stock costs. However, today companies are taking into account capacity costs, and especially the flexibility of that capacity – the flexibility to produce more and to work overtime – when they make their decision. In certain parts of the world, there is quite simply more flexibility."

Simulations

In their paper, Robert and Jan describe how the formula is applied to a situation in which a company is able to use two complementary suppliers (or manufacturing locations) – one place that is more expensive, but offers shorter lead times; and a cheap location abroad whose downside is that the delivery times are longer – whilst employing various ordering rules to counterbalance any fluctuations (order smoothing policies). They explore the impact of differences in lead times, factor costs, capacity costs and capacity flexibility. The results for dual sourcing – producing in two different locations or sourcing supplies from two different suppliers – are compared to those for single sourcing.

"With dual sourcing, although you need to manage two different suppliers (or locations), the advantage is that you can make optimal use of both parties' strengths. On the one hand, you can partly take advantage of lower salary and material costs, and on the other hand – by also manufacturing or sourcing part of your stock locally – you can respond quickly and flexibly to fluctuations in demand", says Robert. "It is also important to consider the impact of the difference in lead times. The greater that difference is, the greater the benefits of dual sourcing and order smoothing will be."

Inflexibility as a cost disadvantage

"The rising volatility of market demand means that it is increasingly unwise to shift your manufacturing offshore to low-wage countries entirely, unless the difference in wage costs is so great that it compensates for all the other differences. I cannot pretend that our wage costs are not a problem, but it is a mistake to become fixated on wage costs alone", Robert believes.

"The great thing about our formula is that it explicitly expresses both the various different factors that help determine overall costs, and the relationship between these factors. It also shows that inflexibility in terms of capacity – the inflexibility of staff to work overtime or of machines to produce larger volumes – has the same effect as a (wage) cost disadvantage. That sounds logical, but now we can also prove this mathematically."

An American phenomenon?

Since wage costs in China have nearly doubled, an increasing number of American companies are relocating their production back to their own country, as The Economist reported in January 2013. However, the magazine noted that this reshoring is primarily an American – rather than a European – phenomenon. According to The Economist, the explanation lies in the rigidity of the European labour market. In response to the euro crisis, a number of European countries have taken steps to reform their labour markets and to make them more competitive (for example, night shifts in the automotive industry). Therefore, the situation could change.

Robert explains: "Our simulations confirm that measures like this can indeed encourage reshoring. To return to the wage cost issue: in the debate about economic growth and employment, we should therefore pay attention to the wage cost handicap as well as to the flexibility or inflexibility of our labour force.'

He concludes: "We have succeeded in finding a simple formula that gives a nuanced picture and allows businesses to strike a well-informed balance between costs and the ability to react quickly to demand and to changes in the market."

The maths behind the results

For anyone who is interested in the maths behind the results: the allocation problem dealt with in the paper is an optimisation problem. The idea is to minimise the overall cost, bearing in mind a difference in lead times, direct costs, capacity costs and flexibility with regard to capacity. This optimisation problem gives rise to a polynomial, a higher-grade comparison with a degree greater than four. For these types of polynomials, the answers can no longer be calculated exactly, only approximated. This is why Robert and Jan used Lagrange's inversion theorem, so that things could be condensed into a simple quadratic equation that is analytically solvable. This is the first time that Lagrange's inversion theorem has been used for stock optimisation purposes.

Source: The paper "*Global Dual Sourcing and Order Smoothing: The Impact of Capacity and Lead Times*" was published in Management Science, Articles in Advance, p. 1-20, 2014. You can obtain the paper from the authors, along with a 64-page Companion with deductions from and justifications for the formulas used.

About the authors
Robert Boute is Associate Professor in Operations Management at Vlerick Business School. He is also a professor at KU Leuven. Jan A. Van Mieghem is Harold L. Stuart Distinguished Professor in Managerial Economics and Professor in Operations Management at the Kellogg School of Management at Northwestern University (USA).