be described as a co-ordinated sequence of actions towards a common goal. Behaviours in companies are not random or improvised; on the contrary, they are regulated by rules and procedures that indicate what is to be done in different circumstances. During periods of change, procedures are often modified, but they are seldom modified to the extent the situation requires. Partial changes in procedures result in confusion and inefficient practices. In this transition stage, the company is no longer what it used to be, but not yet what it needs to be.

■ **Structures.** These reflect decisions about the division of labour (who does what in the company) and the division of power (who manages whom). During change efforts, it is common to see modifications to the structures of organisations, but the deeper elements of the structure very often remain the same. As a result, the organisation keeps dividing tasks and authority in the old ways in spite of the new names and divisions.

■ **Culture.** This acts as a powerful mechanism to integrate the organisation and create a sense of belonging to a common group with shared objectives and a unified view of the world. Unfortunately, strong cultures are notorious for resisting change, especially when that change challenges directly the common understandings in the organisation. Witness the dominant culture of US airlines: it is mostly about hub and spoke, wide networks and full service airlines, and less so about increasing productivity, which is the true hallmark of a low-cost producer. While many companies are challenging the viability of that business model, some airlines are actively resisting any change, hoping that growth in passengers will counteract the inefficiencies that arose from the high prices of the past, which themselves are now very prominent thanks to the emergence of efficient low-cost competitors.

Conclusions

The link between organisational learning and competitive advantage is clear: companies that are skilled at learning are better positioned to take advantage of emerging opportunities and deal with emerging threats, especially ones that require significant organisational change. Companies that create new knowledge are able to innovate more effectively and adapt to changing and uncertain environmental conditions.

Yet, there is one important dimension of knowledge in organisations that deserves much more attention: how knowledge is destroyed. Our research shows that dealing with uncertainty is not just about learning; it is also about forgetting the right things at the right time.

Current stocks of knowledge can prevent new learning, and can even act as barriers to the opportunity to create a new product, service or business model. Too often, we are prisoners of the past. Unneeded stocks of knowledge require expensive management and can consume critical executive attention, leading to difficulties with adapting to the environment and a loss of competitiveness.

We believe that businesses and the managers in charge of them must become as skilled at managing the process of forgetting as they have become at managing learning. Without the ability to destroy knowledge, most change efforts will fail. Four dimensions are particularly important: assets, procedures, structures and culture. Together, these explain why most change efforts fail. Yet, as our research shows, actively managing the process of knowledge destruction increases the likelihood of successful adaptation to new conditions, a crucial feature for companies facing uncertain environments.

Pablo Martin de Holan is professor of strategy and new venture creation at Instituto de Empresa and professor of strategy and organisation at INCAE Business School.
pmdeh@ie.edu

The ghost in the machine

Chaos in supply chains is more likely to be generated by the systems we use than by external events, writes **Richard Wilding**

Today's marketplace is increasingly dynamic and volatile. Globalisation and its resulting market pressures are forcing a fundamental rethink of the way business is conducted. Trade-offs between factors such as labour costs, transportation costs, inventory costs and response time to customers are becoming increasingly complex. At the same time, it is no longer possible for an individual organisation to secure competitive advantage on its own. Increasingly, it is recognised that success is dependent on the performance and reliability of the various suppliers, partners and customers that make up the supply chain.

Coping with uncertainty within supply chains has become a simple fact of doing business. And as companies make efforts to reduce their supplier base, centralise distribution and outsource activities such as manufacturing, levels of uncertainty are likely to increase.

As managers, we seek cause and effect relationships between the many issues and variables we juggle on a daily basis. We hope to be able to predict market conditions with some degree of accuracy, thereby enabling us to plan effectively the resources we manage across the supply chain. But if we expect certainty in the supply chain, we are likely to be disappointed.

Sources of uncertainty

Uncertainty in supply chains is often blamed on external events, such as bad weather or machine breakdowns. Although these are common, they may not be the biggest contributor to supply chain uncertainty. Indeed, research shows that the most common causes are "institutionalised" decision-making policies and information systems.

Institutionalised uncertainty is the result of the internal systems and methods our organisations use. For example, some organisations in the supply chain may have four-week/four-week/five-week accounting periods while others use calendar month periods. This incompatibility between accounting systems can cause deceptive increases in demand, because a schedule for a five-week period may be interpreted as a monthly schedule.

Meeting cycles can also generate uncertainty in demand. For example, a monthly sales meeting may result in sales representatives overselling in the preceding week in order to have some "good news" to present at the meeting.

Deterministic chaos

Uncertainty in supply chains is frequently generated by a phenomenon called "deterministic chaos", which refers to dynamics within supply chains that are determined by fixed rules but that generate random behaviour. A characteristic of deterministic chaos is its sensitivity to initial conditions, which means that tiny changes over time can become dramatically amplified. This is analogous to the famous "Butterfly Effect", whereby the flapping of a single butterfly's wings generates a tiny change in the state of the atmosphere. Over time, this becomes amplified into a major disturbance to weather systems, such as a tornado in another part of the world.

In the context of the supply chain, something similar to the Butterfly Effect can be observed in the our use of decision-making and information systems. Over time, small alterations to these systems can have a significant impact on the supply chain. In theory, these changes should be predictable, because chaos is generated by fixed rules that involve no element of chance. But in practice, the non-linear effects of many causes make the system less predictable. Decision-making and information systems are also extremely sensitive to initial conditions, so an infinitesimal change to a variable can result in a completely different response.

This raises a fundamental issue about the impact of chaos on computer systems. An identical program run on two different makes of computer, or different standard software packages doing the same calculations can, under certain circumstances, produce significantly different results. Simple chaotic behaviour can even be found with commercially available spreadsheets.

How decisions can create chaos

Research into stock management decision-making undertaken by John Sterman at MIT has demonstrated that the more complex forms of deterministic chaos occur when managers are over-ambitious with setting low target inventory levels. The research also found that, when such policies are applied, costs were 500 per cent greater than the optimum. This phenomenon can be witnessed in practical industrial environments, where driving inventory down to low levels can result in problems caused by products being out of stock, rapid and erratic reordering and poor customer service levels.

Supply chains do not reach a stable equilibrium – small changes will always prevent this state being achieved

This contributor recently witnessed an example at a soft drinks company, where electronic data were passed to a supermarket buyer whose goal was to minimise inventory. Because there were so many different products in the range, the buyer had to make rapid decisions in order to keep "on top of things". This meant that, at times, a purchasing decision would have to be made within 15 seconds of receiving the data.

Research by the author demonstrates that commonly used inventory control algorithms, which are automated and use mathematical smoothing techniques in an attempt to reduce volatility, can also result in the generation of chaos. These algorithms create an order based on a forecast, and then the old forecast is fed back into the calculation for the new forecast. This creates a feedback loop which, over time, can cause random spikes in demand, much as feedback in an amplifier can distort sound. It is this feedback that makes it difficult to forecast beyond a particular horizon.

The implications of this work are that a system that is meant to control fluctuations, and consequently buffer the system from instability, can create dynamics that turn a stable, predictable demand pattern into one that is unpredictable with occasional explosive changes in demand.

Removal of deterministic chaos

The key to the removal of chaos is the use of systems that do not have direct feedback loops. This is the approach taken by many just-in-time manufacturing systems. The basis of these techniques involves focusing on the uninterrupted flow of products "pulled" by the customer and then matching the demand. In doing so, feedback is eliminated and, as a result, so are the conditions that generate deterministic chaos. However, the misapplication of just-in-time, using techniques such as wholesale reduction of inventory and lead times, can result in the system exhibiting increased deterministic chaos.

Effective management of uncertainty requires communication between all organisations within the supply chain. Once this has been established, companies should consider taking the following steps:

■ Look for new data sources and leading indicators
■ Use common components in products to reduce complexity and keep things simple
■ Compress lead times so you do not have to forecast too far ahead
■ Increase flexibility by producing to order and configuring the product at the last minute.

If these efforts do not reduce uncertainty to satisfactory levels, then there are two main options left. First, companies can buffer with inventory – remember that too much inventory is far less costly than too little. A second option is to carry excess capacity, which in some environments may be the most cost-effective solution.

When planning for uncertainty within the supply chain, managers should consider the following:

■ Dramatic change can occur unexpectedly. Spikes in demand can be generated by the system and not as the result of external events
■ Long-term planning is very difficult. If long-term plans are made, they need to be reviewed on a regular basis
■ Supply chains do not reach stable equilibrium – small changes will always prevent this state being achieved
■ Because long-term forecasts cannot be accurately made, it is better to allocate resources to the development of effective short-term decision-making processes
■ Treat the supply chain as a complete system. Small changes made to optimise one part of the supply chain can result in massive changes in other parts
■ Driving down inventory and lead times may not always improve performance. It could result in the system slipping into chaotic behaviour
■ Remove uncertainty by focusing on the customer
■ Communicate demand information as far upstream as possible
■ Use simple just-in-time approaches
■ When changing critical hardware or software platforms, undertake detailed validation because computers are prone to deterministic chaos
■ Simulation of systems and analysis of key outputs should be a mandatory part of any supply chain re-engineering proposal.

Before blaming uncertainty on external events, managers would do well to look more closely at their business. Although uncertainty in the supply chain can be generated by external events, it is the ghost in the machine of our decision-making and information systems that is more likely to be at fault.

Richard Wilding is professor of supply chain risk management at the Centre for Logistics and Supply Chain Management, Cranfield School of Management. He also hosts the Supply Chain Risk Forum at Cranfield. For more details, see www.supplychainriskmanagement.co.uk
www.richardwilding.info