Standard Cases: Standard Structures: Standard Models.

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> "*Seldom, if ever, should a person model the specific situation of interest but, instead, should model the family of systems to which the specific one belongs*" (Forrester, 2013)

> "*We do have things in common, but … they have not been enough for us to be able to project a comprehensible "sameness" as other modeling disciplines have managed to do*" (Homer, 2013).

ABSTRACT. *Increasing concern has been expressed about the quality and reliability of work done in system dynamics, based largely on papers presented at the field's annual conference and submitted to its journal. The thin stream of high-quality publications also suggests that the method is not widely used. However, since there is no incentive for leading practitioners to present or publish their professional work through those channels, it is entirely possible that a substantial volume of high-quality work is, in fact, being done, but remains unseen. Those practitioners, along with leading academics in the field, tend to focus their effort on specific application domains – natural resources, health-care, business and so on – and scrutiny of the limited published work in those domains suggest that valuable and reliable work is indeed being carried out on a significant scale. Those streams of work feature models with relatively standard structures that are replicated – with appropriate adjustments – from case to case. Consideration of the fundamental principles of the field suggests that there is considerable further scope for developing and codifying more such standard structures. This would both provide a platform for a greater volume of high-quality work for an increasing number of user organisations, and also offer an accessible and reliable source of guidance for young professionals trying to develop their system dynamics skills.*

Introduction

Concern has been building over recent years that the quality of most system dynamics work is poor (Forrester, 2007; Homer, 2013), and that this is holding back the field's progress. Evidence comes largely from the stream of work presented at the International Society's annual conference, and submitted for publication in its journal, since these are the only significant sources of visible work. However, there are reasons to suspect that these sources do not represent the bulk of work being done in the field.

First, providing a platform for early-career professionals to expose their work to the scrutiny of a wider audience is an important purpose of the conference. It is to be expected, then, that most of this material will be work-in-progress and of unformed quality, just as in other fields.

Secondly, skilled practitioners who are carrying out high-quality work to address substantial, real-world challenges have little incentive either to present such work to the conference or to publish in the field's journal, or any other academic journal. Academics may rely on such publications to advance their careers, but no such benefit accrues to non-academic practitioners, and the non-remunerated effort required to produce such material is a substantial drain on time that could otherwise be spent winning and delivering further work.

It is entirely possible, then, that a substantial quantity of strong work is being performed but remains unseen, a suspicion with some supporting evidence. First, some highly active groups of system dynamics practitioners are engaged in continuing streams of work for demanding users. Indeed, some are in such demand that they cannot respond to more than a small fraction of the demands for their expertise. If each such group produced just six strong pieces of work each year, as some clearly do, then the cumulative total of such work would far out-weigh the quantity published. Secondly, in spite of the limited incentives, some such practitioners do publish their work (see for example Carter and Moizer, 2011; Paich, Peck and Valant, 2011; Lyneis and Ford, 2007; Homer, 2012), and such publications frequently hint at or actually describe additional work that has been carried out. Lastly, many leading academics are also experienced practitioners, and their time and expertise too is in high demand, for example Ford (2009) in water and power resources, and Moxnes (2004) in renewable resources. It is not implied here that these are the only, or the best examples of successful practitioners and academics. Many others could also have been listed.

The fact that such skilled practitioners have emerged and prospered implies that their experience might provide insight as to how good, reliable work is carried out, and suggest means both to raise the overall quality of work done in the field and accelerate its wider adoption.

The output from these successful professionals suggests that they tend to specialise in certain domains. Furthermore, their bodies of work exhibit the kind of "sameness" called for by Homer (2013) and typical of work in other successful fields. This sameness is not merely some generalised commonality of cases on which they have worked,, but a pattern of recognisably similar structures, repeated across those cases. Frequently, those structures have emerged from the earliest days of the field, and have also been extended and exploited by other professionals.

Sample common structures

The work of Thompson, Tebbens and others on infectious diseases, for example (Thompson and Tebbens, 2007), builds on a structure well known and accepted in that field – the Susceptible-Infected-Recovered (SIR) model (figure 1, from Sterman, 2000, p.304). Paich, Peck and Valant (2009) and others have built strong practices around a pipeline for patients who progress through stages of drug or other treatments (figure 2, from Paich, Peck and Valant, 2011), whilst Cavana and Clifford (2006) exploit a related movement of individuals through affected states in the case of smoking cessation, recognisably related to earlier work on cocaine use (Homer, 1993).

Figure 1: The Susceptible-Infected-Recovered model of infectious diseases

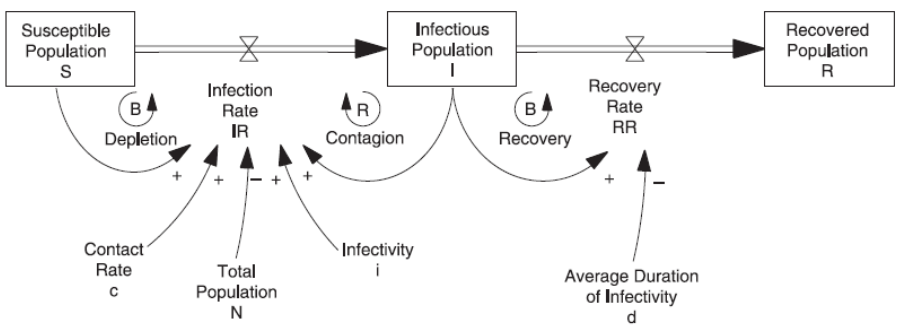
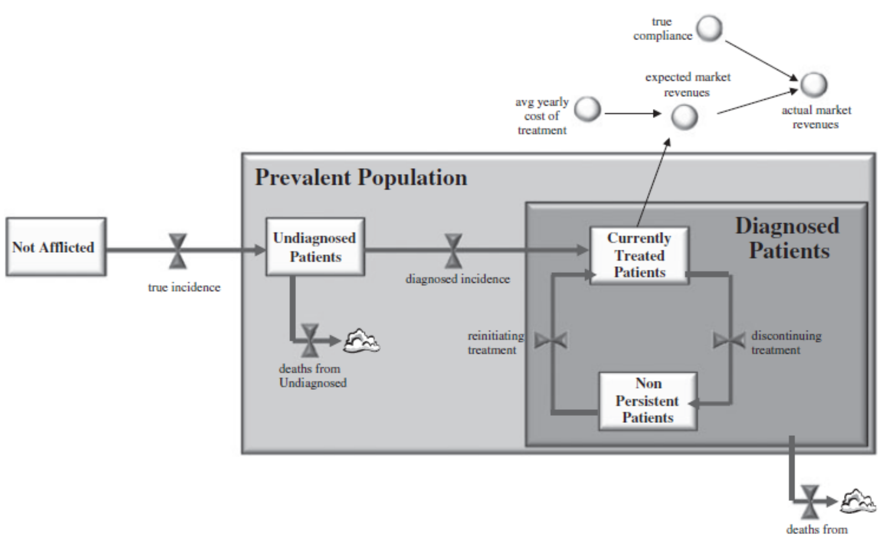


Figure 2: The treatment pipeline for patients on a drug



In project management, many groups have built on a central structure, again tracking movement of material between connected stocks – work, in this case (figure 3, from Lyneis, Cooper and Els, 2001). This core structure is embedded in a set of causal relationships and other stocks that also repeats, with adaptation, in many other cases.

Central to the dynamics of supply, demand and price in the power industry is a core 2-stock structure of capacity under construction and capacity in operation (Zepeda, 1975). This core element, together with much of the surrounding causal structure, and physical and policy feedback remains recognisable in much subsequent work (Ford, 1996; 2001). Water-resource modelling also exhibits common structures, traceable back to Hamilton (1969) and built on by many practitioners (Ford, 1996, Fernández and Selma, 2004 and Ford, 2009). Moxnes (1998) sets out a simple core structure for the exploitation of fisheries, adaptable to many other renewable-resource cases (figure 4).

Figure 3: The work/re-work structure in project management

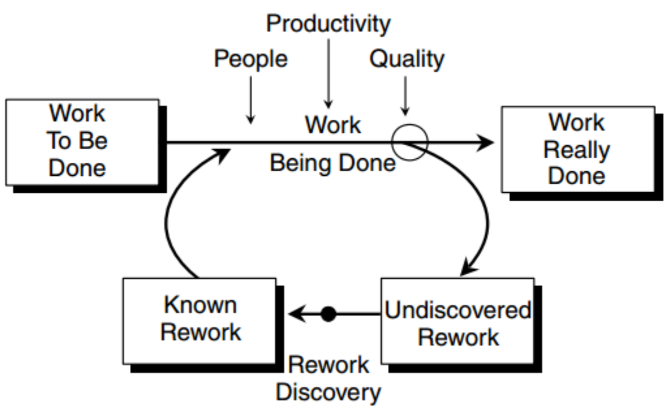
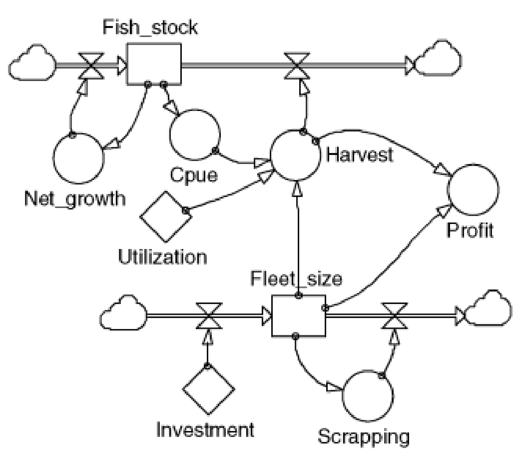


Figure 4: Basic structure of fishery management, adaptable to other renewable resources



These and other cumulatively successful steams of work raise the question at to whether there may be many more opportunities for specifying and leveraging standard structures for other common settings. Work in the business domain suggests that this is indeed the case, and the resulting structures appear also to be adaptable to other domains.

Standard business architectures

Academic work in business strategy first consolidated around the concept, based on micro-economics, that a set of competitive forces determine both the scope for an entire industry sector to be profitable, and for individual firms within a sector to achieve above-normal profitability (Porter, 1980). Subsequent research, however, showed that those forces are less significant than the attributes of particular firms, so it is possible both for some firms to be successful in intensely competitive industries, and for others to fail in more benign sectors (Rumelt, 2006). Additional research identified that this performance advantage is attributable to a firm's possession of superior "resources" – factors that are useful in some way. This notion is now formalised as the resource-based view of strategy (RBV; Barney, 2001), now taken as axiomatic in the strategy field.

Work in this very extensive body of research suffers two limitations, however. First, being largely based on regression analysis of hypothetical causes for profitability, the findings are almost wholly static. Secondly, the finance field has long known that business owners or investors should be concerned with growth in cash flow generated by a business, rather than with static profitability or other ratios (Copeland, Koller and Murrin, 2005). Since growth in cash flow emerges from the workings, over time, of the business system that generates it, it is an inherently dynamic concept for which static explanations cannot be valid or useful. Gary, Kunc, Morecroft and Rockart (2008) describe ways in which system dynamics might contribute to more dynamically insightful theories of strategy. However, this paper too takes profitability as the performance indicator of interest, and focuses on managerial decision-making mechanisms rather than on the rigorous representation of the business operating system itself

System dynamics can readily operationalize a functioning business model, since the resources described in the RBV are clearly recognisable as accumulating stocks. Indeed, the strategy field itself has long appreciated the importance of asset-stock accumulation (Dierickx and Cool, 1989), but has made little progress in incorporating the concept in its theories or practice. A further gap in the RBV of strategy is its rejection of simple, tangible factors as playing any part in explaining superior performance, on the basis that such factors are obvious and easily copied – a notion that the Dierickx and Cool article strongly calls into question.

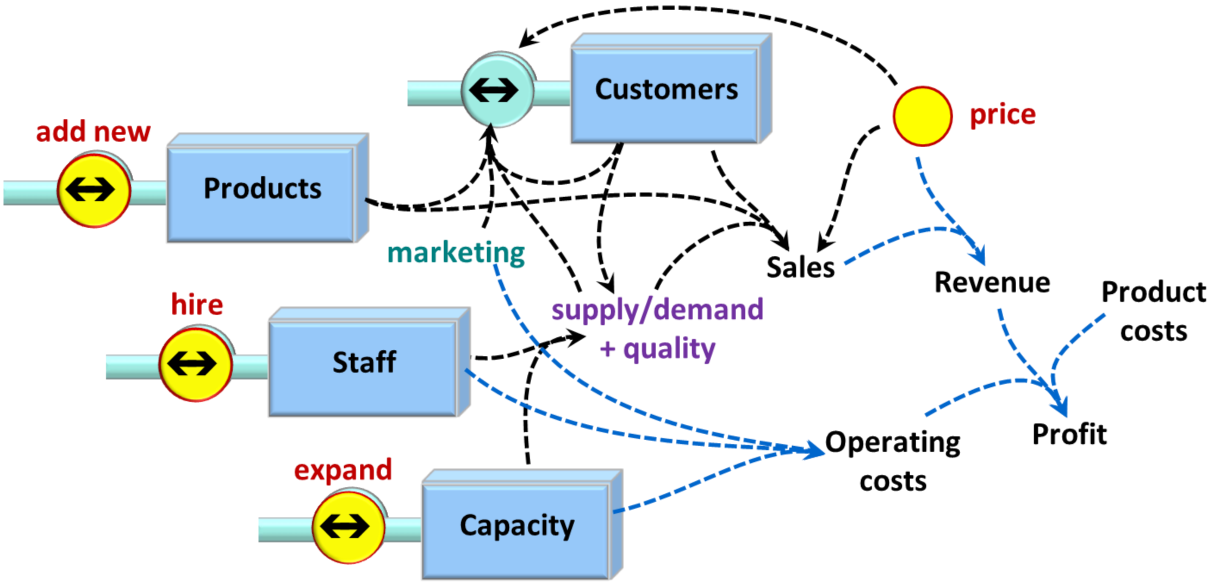
Working back from the absolute streams of profit and cash-flow generated by a business readily identifies simple, tangible factors that are the *direct* cause of those outcomes, and leads to rigorous initial models of business performance and strategy – not only do the performance outcomes mirror those observed in reality, but so too do all other significant factors in the system.

The resulting models bear striking similarities across industries. In most cases, a company's revenues are driven by a population of ***customers*** – the dominant stock on the demand-side of the business. Those customers must be won and retained, by driving the inflow and limiting the outflow for that stock. This requires three standard forms of resource (also stocks) on the supply-side of the business – a range of ***products or services*** that customers want, the physical ***capacity*** needed to produce and supply those products or services (or sometimes data-processing capacity, as in banking), and various categories ***of staff***.

The supply-side resources are costly, both to acquire and to possess, so these drive the costs in the company's income statement, along with discretionary external expenditures such as marketing. A principal decision in this system concerns pricing for the goods or services – a higher price enhances immediate margins, but at the risk of slower growth and faster loss of customers, and lower rates of purchase. Other decisions concern acquisition or disposal of resources (hiring or firing staff, adding or closing capacity, launching or dropping products), or else indirect choices aimed at similar purposes, notably marketing spend to win customers. The revenue of the business, minus its costs, explain the profits of the business.

Assembling the interdependencies amongst these supply-side and demand-side resources results in the parsimonious, generic business architecture in figure 5. Not shown in this figure, for simplicity, is the stock of cash (and/or debt), some of which is spent to sustain and grow the system's resources, whilst other proportions pay interest and taxes or are returned to the business owners as dividends.

Figure 5: The minimal generic business architecture



(Dashed lines indicate that the causal links have been summarised).

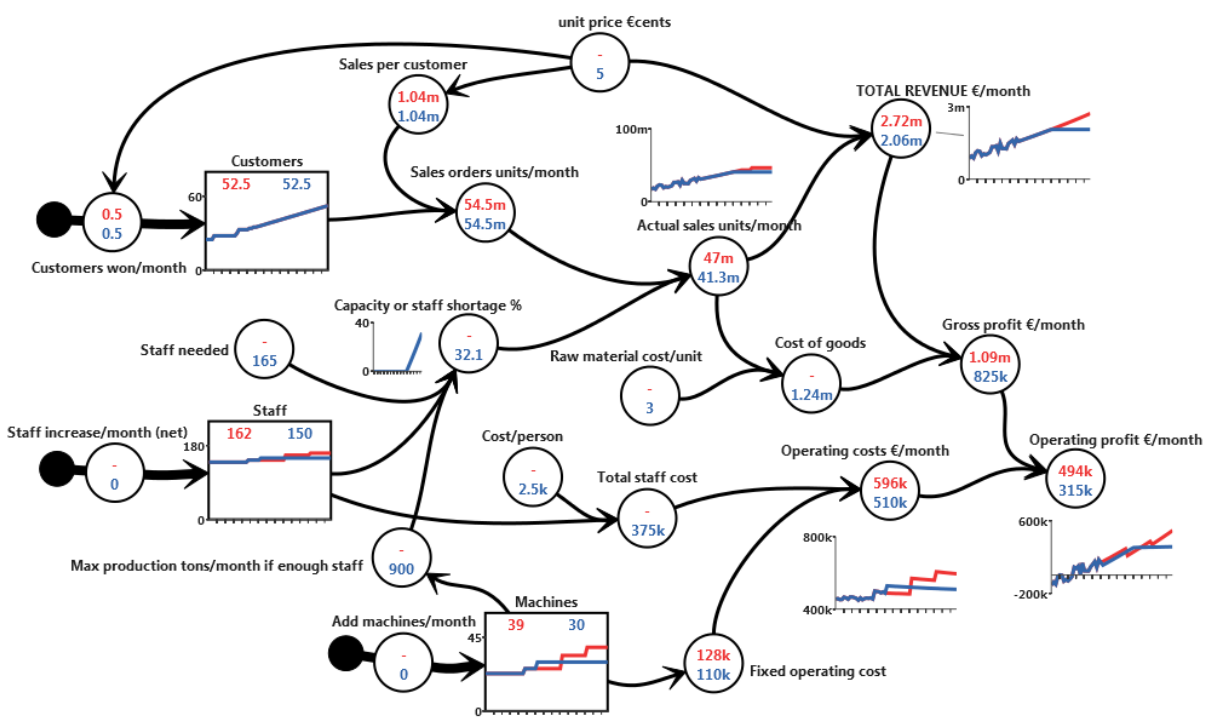
There is considerable scope for feedback in such systems. Some feedback is relatively direct, such as the tendency for customers to drive the flow of new customers, or for staff shortages to lead to the loss of more staff. Other feedback mechanisms (omitted for clarity) are less direct; cash generated by the business can finance its own growth, for example, and accumulating sales can drive down costs through experience-curve and scale effects. Many balancing feedback mechanisms also arise, especially in cases where supply-side resources are inadequate to support demand-side growth, leading to many manifestations of the well-known "growth and under-investment" archetype (Forrester, 1968; Senge, 1990, Appendix 2).

The minimal architecture in figure 5 can be modified and extended to provide further generic models for different types of business. For law firms and other professional service businesses, for example, the professional staff *are* the capacity of the business to serve clients, so physical capacity is insignificant. Other types of business may sell through retailers, dealers or other intermediaries, which constitute an additional demand-side resource. For project-based businesses, those projects themselves are an important stock. For large-item producers such as aircraft or ship builders, the order-book may be a significant resource, while reserves are a vital resource in the extractive industries.

These and other adaptations, however, can readily be applied in order to arrive at a rigorous and repeatable architecture for any particular type of business (Warren, 2008; chapter 4). An example of how this structure is manifested for a simple manufacturing business is shown in Figure 6. The charts cover a 2 year period of history, plus two scenarios for the following 3 years. The working model is at http://sdl.re/m4b01[1]. Since this model deals only with the core issues from Figure 5, it captures little feedback, but richer models dealing with policy feedback for capacity expansion and pricing are at http://sdl.re/m801 and http://sdl.re/m802, respectively.

Other working models reflecting this generic structure, include the airline, Ryanair PLC, (http://sdl.re/ryanair-model), a newly-launched restaurant (http://sdl.re/m4b12) and an IT-support company (http://sdl.re/m821). These examples and others are sufficiently generic to their sector to be transferred with little change to a very large number of other cases in the same or similar sectors; all manufacturing companies, for example, offer a range of products which they sell to customers for those products, which require capacity and staff for their production; all passenger airlines gain revenues from travelling customers, operate route-services between airports, and employ aircraft and staff to fulfil the resulting demand; all restaurants offer a menu of products to regular or passing customers, and employ food preparation and (usually) seating capacity and staff to fulfil demand. All service-providers generate revenue from clients who are attracted by the services they offer, and employ professional staff in order to serve that demand.

Figure 6:The result of applying the generic business architecture to a plastics-processing firm



[1] This model link, and all others, require the latest version of any browser.

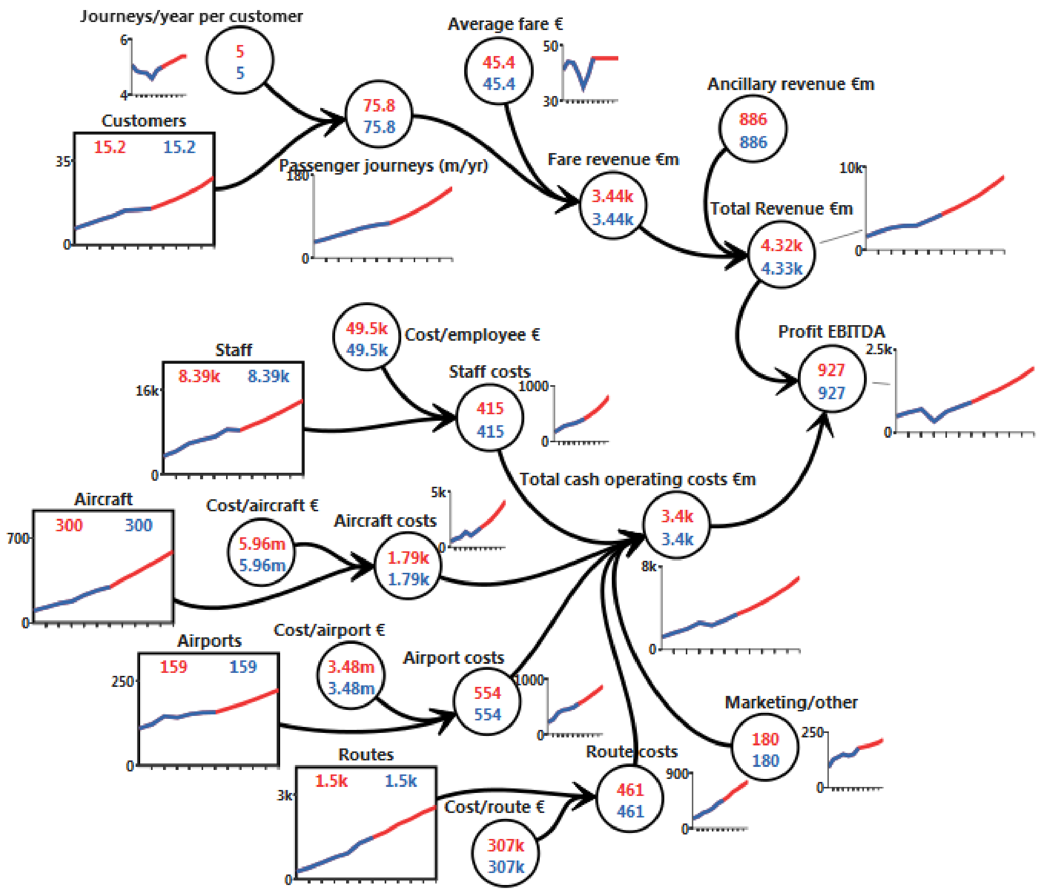
Adapting and extending standard systems

Professional work does not simply “photocopy” structures from one case to the next, but adapts and extends them so as to capture, to the degree required, the specifics of each situation. Figure 1, for example, led to the model-based policy for the eradication of poliomyelitis (Thompson and Tebbens, 2008) , but only after substantial adjustments to deal with different types of imperfect immunity, and a latent period for the disease, as well as segmentation of populations by age-group. Many of Homer and colleagues’ healthcare models (Homer, 2012) likewise represent substantial developments on standard core structures. The wealth of models in project management, too, have evolved around the core structure in figure 3 to capture the reality of a wide variety of project management contexts, often to a considerable extent and in considerable detail (Lyneis and Ford, 2007).

Developing the generic model for any business sector to specific cases also requires considerable adaptation and extension, particularly if that model is to be used for detailed planning. The Ryanair model, for example, was chosen specifically because the company operates a completely standard service and, until recently, a single model of aircraft. Figure 7 shows the core of the business model, prior to the addition of lows and feedback, where resources drive profits, including data from 2006 to 2012 from the company’s accounts and plausible projections to 2017.

A model for a full-service, international airline would be significantly more complex, requiring segmentation of the different service classes offered and the different types of customer who use them, the diversity of route-types served, and the different aircraft types employed. But such detailed extension of models should prove just as possible and valuable in the business domain as it has done in project management and health policy. Indeed, Paich and others’ work in pharmaceuticals shows that exactly such development is already in progress.

Figure 7: Resources driving profits at Ryanair; 2006-2017



Transfer and adaptation of models to different cases need not be limited to the specific industry in question, but can even be extended to other sectors with similar characteristics. The airline model needs little modification to reflect a bus-service business, a rail company or a ferry operator, and the core system of the restaurant business needs little change to capture any other store-based retailer – its menu becomes the range of products on the store's shelves, and its seating capacity is replaced with shelf-space, checkouts and parking.

Extending the generic architecture to non-business domains

Although the essential elements of demand-side and supply-side stocks shown in Figure 5 emerged from for-profit business cases, it seems – intriguingly – that highly analogous principles and structures are applicable to many public-sector and non-profit domains.

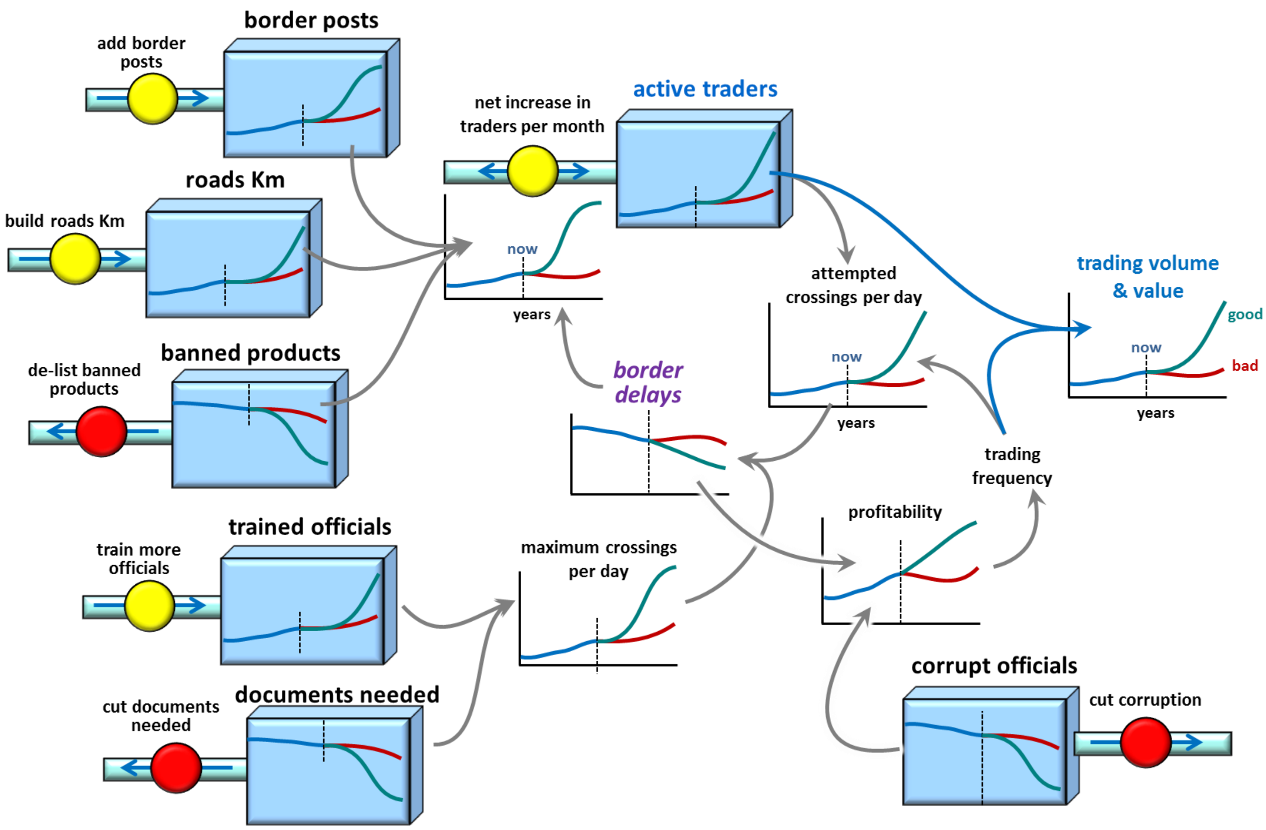
Take the example of a country's export trade. Foreign aid from richer countries to poorer is generally divided between humanitarian aid, to deal with crises such as civil conflict or hurricanes, and development aid, aimed at raising a population's living standards. In addition to infrastructure investment (roads, power and so on), and support for private sector growth, encouragement of export activity is seen as highly effective in boosting employment and living standards for a country (The World Bank, 2013).

The generic components of the business architecture in figure 5 map directly onto this issue. Export activity is carried out by traders, so efforts to boost export activity need to enable new traders to start, retain those who already exist, and encourage those traders to trade more often. These imperatives are exactly analogous to the three aims that businesses have towards customers; to win them, retain them and encourage each to buy more. On the supply side, physical capacity is needed – roads to access borders, and the border crossings themselves at land borders and sea/airports, along with staff such as customs and immigration inspectors. "Products" are replaced by the services exporters require, such as efficient procedures for getting goods through the border crossings and the provision of export finance. Self-reinforcing feedback arises from the commercial success of active traders encouraging others to start. Any success in encouraging more traders is constrained by balancing feedback, however, if inadequate capacity or staffing causes delays.

The system described so far would be applicable almost exactly to the export trading system for any country; advanced or developing. However, in developing situations, a variety of "negative" stocks can act to depress export activity. The export of certain products may be banned, documentation and processes may be excessive (7 documents are needed, for example, to export simple agricultural products across Nigeria's minor land borders), and corrupt officials may extract profitability from traders and impose unnecessary delays (it can take 3 days for a truck to cross from Nigeria to Benin). In contrast to advanced economies, therefore, much effort is needed to remove these negative stocks as well as to boost the positive resources.

Figure 8 summarises the resulting structure, and contrasts a good future in which export trade grows with a bad future in which it does not. A working model of this system for a small land-border crossing is at http://sdl.re/DFIDtradeM1, and a training game based on the structure is at http://www.simudyne.com/nigeria/.

Figure 8: The core export-trade system in development situations

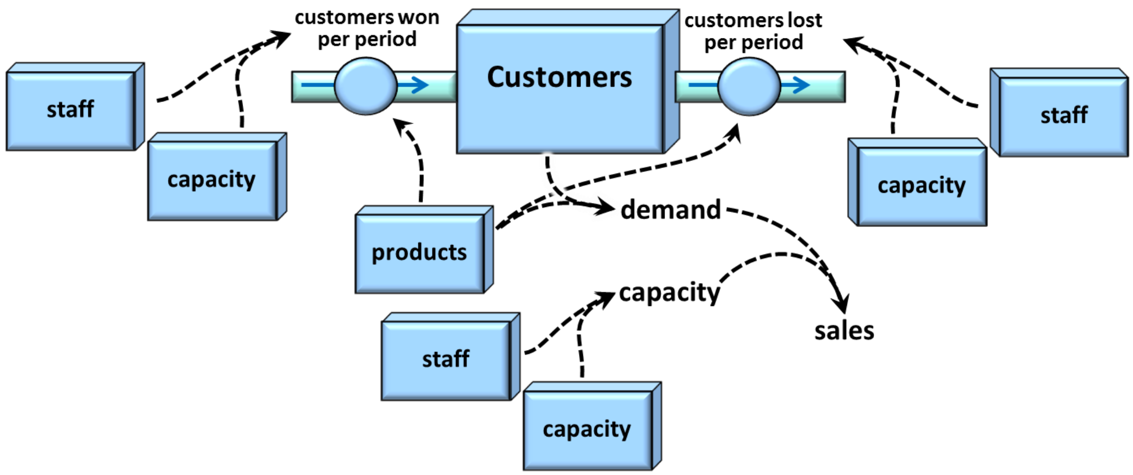


The case of export trade has an important feature in common with business cases – growth of the population driving demand (traders or customers) is essential to achieving the objective. It is exceedingly common in other settings too for "demand" to be driven by some population, which is added to by new joiners and depleted by leavers. Demand for law-enforcement, for example, is driven by the population of criminals who exist at any time, and just as a company's sales reflect the frequency and scale of its customers' purchase activity, so too is law-enforcement demand driven by the frequency and seriousness of criminals' activity. Likewise, demand for schooling is driven by the school-age population, demand for restorative health-care is driven by the ill and injured population, demand for poverty-alleviation reflects the numbers of those in poverty, and so on.

In many cases, however, the objective is not to *increase* activity and demand, but to reduce it. We want less crime, lower demand on health services, and less poverty. This implies that we want to *slow* the in-flow to the demand-driving population and *increase* the out-flow.

The minimal generic business architecture in figure 5 implies that capacity and staff on the supply-side are largely devoted to satisfying the demand from customers, but a fraction of supply-side resources are also deployed to manage the flow-rates. Some sales staff and product-range are intended to win customers, and service staff and capacity help to retain them (figure 9).

Figure 9: Products, staff and capacity deployed to win, retain and serve customers

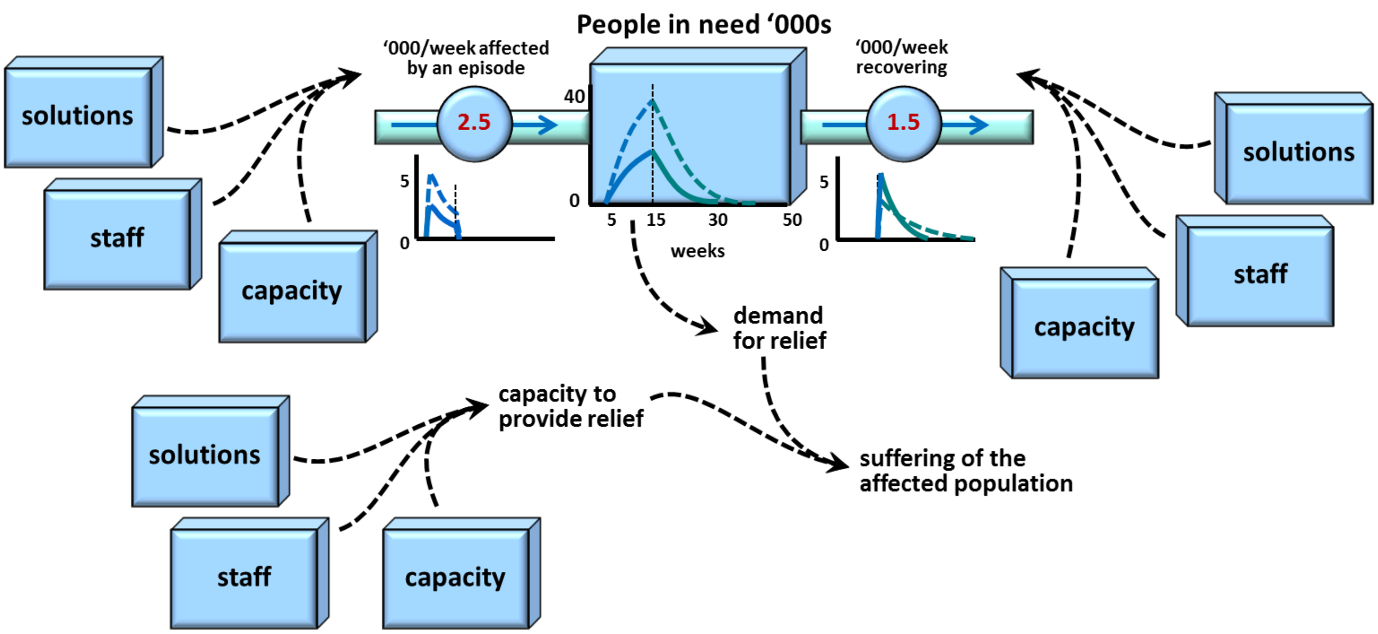


The same observation is found in non-business settings, and in cases where the aim is to reduce some harmful outcome, this deployment of resources to the flow-rates can take on particular significance. Demand for policing, for example, can be avoided if young people can be deterred from taking to crime in the first place, and demand for healthcare reduced if people are helped to stay healthy.

The case of foreign aid offers a further example to demonstrate these additional principles. Issues causing demand for humanitarian aid divide broadly between event-driven disasters, such as floods or earthquakes which quickly shift large numbers of people into a state of need, and slow-burn cases such civil conflict which can drive an in-flow to the population-in-need over extended periods. In either case, aid agencies respond to meet "demand", that is to alleviate the suffering of people who are in the state of need (providing food and shelter, for example). However, efforts are also required to *remove* people from that needful state back to a safe and healthy state (reopening food supplies and markets and rebuilding housing). Frequently, after the initial out-outpouring of sympathy and support, this out-flow is neglected. Three years after the Haiti earthquake that claimed between 230,000 and 300,000 lives and left 1.5 million people homeless, the country is still devastated and as many as 400,000 people still do not have robust accommodation (see for example Hudson, 2013). A third imperative, however, is to reduce the number of people who are impacted by disasters in the first place, so that efforts to alleviate suffering and help the population recover can be avoided or reduced.

Humanitarian aid therefore has "3R" imperatives: Resilience, Relief and Recovery. Just as in the business case, some staff and certain capacities are devoted to reduce the in-flow to the affected population and certain solutions (analogous to products) are deployed, such as flood-proof buildings or “hardened” water and power supplies. When the disaster strikes, other solutions and capacities are deployed to alleviate suffering, such as tents and feeding stations, though some of the same personnel previously working on Resilience may now be employed, with many others, on Relief. After the disaster, yet further solutions, staffing and capacity, such as construction equipment, are employed to recover people from their troubled state. Figure 10 illustrates how 3R efforts towards a slow-burn disaster reduce the in-flow of people to the state of need, provide the relief for those who nevertheless reach that state, and then remove people from that state.

Figure 10: Solutions, staff and capacity deployed to boost Resilience against disasters



Business cases must pay attention, not only to the customer-growth and demand consequences arising from the resource-commitments shown in Figure 9, but also to the costs arising from those commitments. A common claim in the marketing field, for example, is that “*it costs 10 times more to win a customer than to retain one*”. Although this assertion is meaningless in its specifics, since customer retention is a continuing effort whereas acquisition is a one-time event, the remark nevertheless highlights the principle that the contrasting costs of acquiring, serving and retaining customers require attention. Public services and other non-business organisations may not be profit-oriented, but they too must pay attention to the financial costs of policy and resource-deployment in figure 10. Resilience and Recovery are typically resource-intensive, costly and continue for long periods, as compared with the resources and costs needed to provide relief – an explanation for the devastation that persists so long after the Haiti earthquake. It is especially remarkable, then, that the system dynamics work on polio-eradication resulted in continued effort at problem *prevention*, in the face of cost-driven concerns pushing policy-makers towards mitigation (Thompson and Tebbens, 2007).

Partial system structures.

Not only is it possible to transfer full-system structures from case to case and sector to sector; so too are many sub-structures, which may be valuable on their own, as well as when they are incorporated in wider system models. Carter and Moizer's (2011) work on patrol policing, for example, features a very common example concerning the hiring, training and career progression for staff. Virtually all organisations of significant size need to manage similar staff pipelines, so versions of that sub-structure are ubiquitous, both in business and non-profit cases.

Other common sub-structures arise in numerous business cases. Highly standard structures capture rivalry for customers and staff, important attributes of such resources (customer profitability and staff experience, for example), and intangible factors such as staff morale, information and capabilities (Warren, 2008; chapters 5-10).

Such substructures, too are frequently transferable from business to non-profit domains. Public service and non-profit organisations cannot avoid competition for scarce staff, and may even feature an aim equivalent to competition for customers. An organisation that can show it supports large numbers of people suffering from a terminal disease is better able to win the competition for financial donors, thus raising more money that other such groups, and hence serve still more people who need its services.

Stock "pipelines" are not limited to staff development, but also feature in product development and market development, where potential customers must be taken from a state of being unaware of a product or service to awareness and understanding before becoming active consumers. Such an "adoption" pipeline is not just applicable (with suitable modification) to most business cases, but is also features in other domains, so this particular sub-structure will be used to illustrate the transferability of sub-structures.

Adoption challenges are widespread, and have serious consequences. Hospitals in the UK National Health Service, for example, are beset by operational problems, even though proven solutions to those problems have been tested and deployed elsewhere in the Service. It is also known that developed economies could reduce carbon emissions by a quarter or more – and *profitably* – simply by adopting all known energy- and emission-saving options that are already developed and economically attractive (McKinsey & Co, 2010).

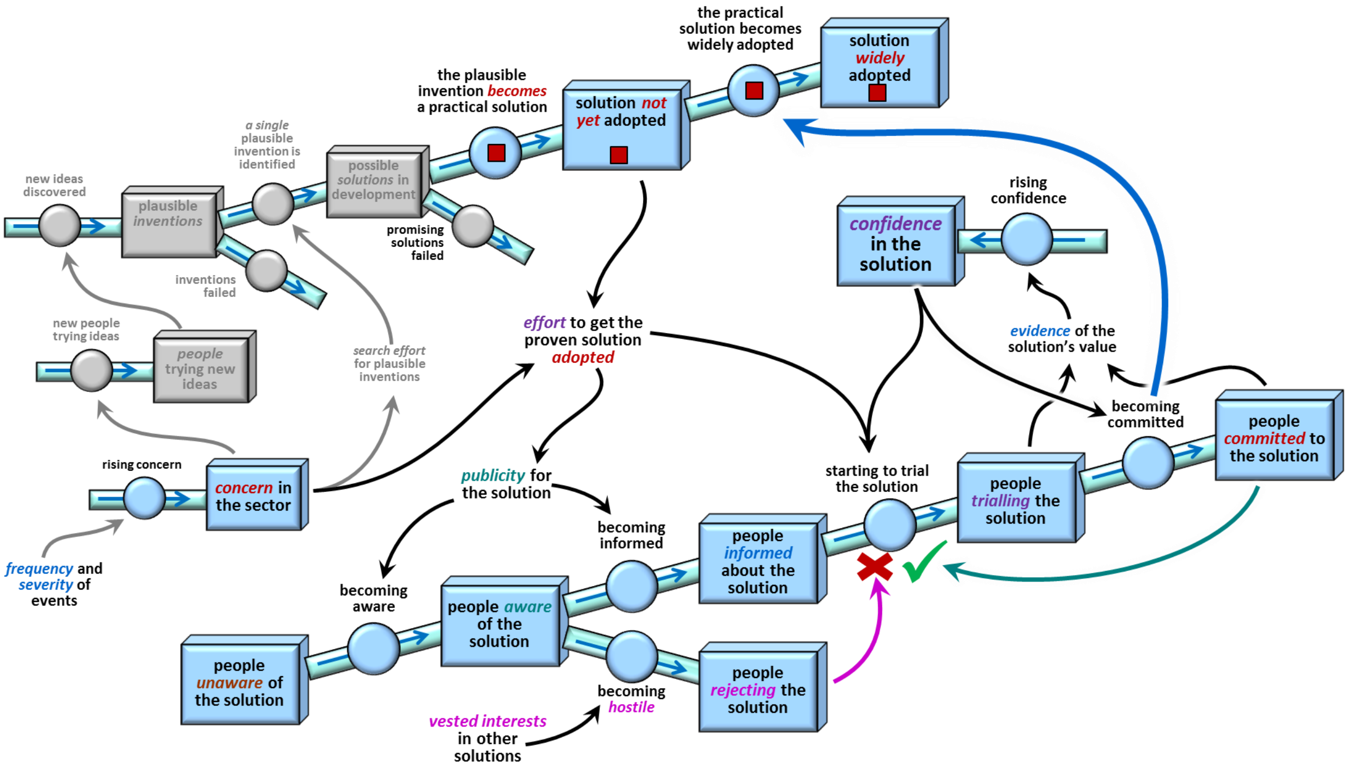
The humanitarian aid domain also offers an illustration of this adoption challenge, and the opportunity to employ a standard sub-structure to deal with that challenge. Aid interventions, whether for Resilience, Relief or Recovery, involve the application of certain “solutions” – more or less complex combinations of physical products (food or tents, say), logistical delivery, and operational procedures, sometimes known as standard operating procedures (SOPs).

Innovation in this setting promises many important improvements to the efficiency and effectiveness of aid interventions, but requires research, development and adoption of new solutions (UN Secretary-General, 2013; p.18). Managing innovation is a well known and widely studied challenge in the corporate world and other domains (Tidd and Bessant, 2013), and achieving innovation in humanitarian aid faces similar adoption challenges (Ramalingam, Scriven and Foley, 2009). An example of those challenges concerns the provision of food after disasters strike. For many decades, this was achieved by establishing central feeding stations to which people hit by a disaster would come to collect food. However, not only were many of those most in need of food not capable of reaching such centres, but those centres themselves became transmission centres for diseases that led to illness or death not only among those who visited them but also among the communities to which they returned. An alternative, community-led, distributed system for food provision addressed these challenges, but adoption of the method took many years, in spite of well-documented evidence of its efficacy.

The slow progress of this and other innovations in humanitarian aid, as elsewhere, is well-explained by the generic adoption pipeline. In figure 12, an innovation has been “invented” at upper left (whether by an explicit research effort or simply by informal solution-finding on the ground) and then developed into a viable solution, but it is not initially adopted. Efforts to find a solution are motivated by concern amongst the aid community, which concern is added to (at left) by more frequent and severe incidents of the type causing the need for the solution. An increasingly influential factor in this setting is that climate change is already increasing this frequency and severity of many types of damaging event, and thus motivating a more urgent search for better aid solutions.

Initially, all potential users of an invented and developed solution are unaware of it (bottom left of figure 12), but publicity efforts – also motivated by event-driven concern – make them aware of its existence. Further publicity informs those users about the solution’s features and benefits, leading some to trial its use. However, that trialling requires some confidence in the solution, which is initially low. As trialling continues, however, evidence of the solution’s value accumulates, building confidence in its use, so more people go on to trial and commit to its use.

Figure 12: The adoption pipeline for innovations in humanitarian aid



Several things can go wrong in this process. First, concern to find and adopt new solutions may be heightened when a severe event occurs, but then depletes as no further need arises, leading to less effort being devoted to the issue. Secondly, if initial trials are slow, it may take many years for sufficient evidence to build for the confidence of potential users to grow to the point where they, too will trial or adopt it.

Lastly, various mechanisms may cause potential users to actively *reject* the solution (bottom of figure 12), even though it can be objectively shown to work (as occurred in the case of distributed feeding). This rejection may seem perplexing, but is evident in many settings. The reasons may include professional investment in the existing solution (people who have made their name as experts in its use face loss of employment or status), professional rivalry (the not-invented-here phenomenon), lack of respect for innovators from outside the field, and financial incentives to continue with the old solution (foreign aid monies are often spent with suppliers from the donor country). It is also possible that good solutions are rejected because they are simply politically unacceptable to key stakeholders, as appears to be the case with certain counter-measures against drug dependency (Kain E, 2011). Whatever the causes, a rising stock of people who reject the solution acts to discourage others from trying it.

The structure and mechanisms in Figure 12 are currently the subject of a project sponsored by the UK Dept for International Development, and a provisional working model has been developed to support the project (see http://sdl.re/AidInnovationM1). The framework and model are guiding case-study research to identify how the various mechanisms have functioned in successful and less successful examples, in order to develop policies to enhance future adoption of aid innovations.

Professional and pedagogical implications

This paper has made the case that the use of proven, standard structures, sub-structures and models is already common in the practice of many successful professionals in system dynamics. It has also argued that many more such helpful resources already exist or could readily be developed and, furthermore, that such items are often transferrable across numerous domains, including many which at first sight appear to have little in common.

Recognisably similar solutions to similar challenges are a common hallmark of strong and successful professions (see for example the Supply Chain Council's SCOR frameworks, the Balanced Scorecard Institute's Nine Steps to Success, and INCOSE's Systems Engineering Handbook). If that is the case, then efforts to identify, test and codify such solutions in system dynamics might significantly boost the impact and progress of the field. However, for this to be accomplished requires the community to tackle its own adoption challenges – first, within the field itself (persuading our own colleagues to trial and deploy standard solutions) and then, amongst our target users across all domains where the method is valuable.

Significant additional assistance to the adoption of system dynamics could also arise from the pedagogical implications of such standard solutions. With few strongly documented examples of standard structures and models, current educational methods must attempt to teach novices how to build models from first principles. Since those methods start with largely qualitative problem mapping (Lane, 1994; Vennix, 1996; Sterman, 2000, p. 86; Maani and Cavana, 2000; Morecroft, 2007), it is only to be expected that such training will result in a persistent stream of models that are unique to every project, no matter how similar the project's setting may be to other cases. The availability of a "body of knowledge" containing an extensive library of high quality, proven and impactful structures, sub-structures and models might largely eliminate this randomness of modelling activities, building stronger skills, more quickly, amongst novices, reducing the volume of poor work, and further boosting the field's impact and progress.

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