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# Systems thinking metaphors for illuminating fundamental policy dilemmas

Khalid Saeed
*Worcester Polytechnic Institute*

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Khalid Saeed
Professor of Economics and System dynamics
Social Science and Policy Studies Dept.
Worcester Polytechnic Institute, USA

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Professor of Economics and System dynamics
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ABSTRACT

Public policy is often is driven by two inputs: measurements that describe a shortfall from a goal, and simplistic policy recipes that strive to overcome the shortfall, often with little attention to how the shortfall was created in the first place. Indeed, measurement has become an important part of policy design. Measurements interpret performance as indicators of growth and the volume of activity. They can be easily fed to complex forecasting instruments generating non-verifiable futures, which drive policy with highly variable efficacy. Should we aim at more precise measurements and more complex forecasting instruments or develop more informed policy paradigms? This paper advocates the later by proposing several metaphorical policy structures that are cognizant of the root causes of the many classes of policy situations. They allow moving away from symptoms to address policy to root causes. They are proposed as an alternative to measurement based policy actions.

Key words: Systems thinking, economic development, development indicators, public policy, forecasting

## Introduction

Policy-making is often driven by relatively simple paradigms addressing immediate symptoms rather than root causes of problems. As illustrated in Figure 1, policy-making process might however be informed by complex computational instruments providing pertinent measurements and their non-verifiable forecasts. Experience shows that policy interventions based on this process work in the short run, but not in the long run. Economic development offers many examples of short run successes and long-run failures. The creation of public sector, selective sectoral and regional development, export specialization, land reform, etc. are some examples of such experiences (Saeed 1996). The simple paradigms these policies are based on represent linear thinking that fail to address the root causes of problems, which are hidden from view. There is, therefore, a need to develop generic models for policy formulation that can allude to the latent structure in comparable situations that drives long-term behavior. These models would not have relevance for any specific situation but they can effectively inform policy design. They offer an alternative to reactive interventions based on measurements and their sophisticated forecasts.

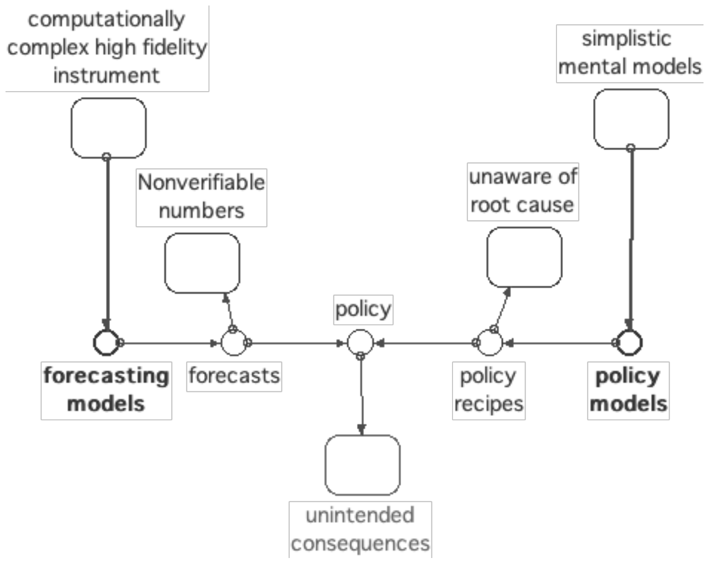


Figure 1: The policy process and its pitfalls.

Jay Forrester has often suggested that a small number of pervasive structures existing across policy domains might be able to give penetrating explanations of the majority of the problems around us. These structures reside in low fidelity systems that may not exactly represent any specific problem but rather appear as metaphors to allude to the root structure of a class of problems. I tend to think such generic structures must be domain specific if they are to be used productively. In this paper, I would like to share with you some 12 structures that I have experimented with, which might fit a variety of public policy agendas. How many more are needed is left open as food for thought. This paper strives only to catalogue these metaphorical policy structures rather than investigate each in detail, which I intend to pursue in future writings on this subject.

**The linear policies and their efficacy**

Table 1 collects three of the many illusive developmental problems: food security, poverty and social unrest, and the broad policies implemented over the past several decades to address them. These problems have however continued to persist or even become worse. The linear response for overcoming them was to facilitate intensive agriculture so more food could be produced, to foster economic growth so aggregate income could be increased and to strengthen internal security and defense infrastructure so public could be protected from social unrest. It was expected that directly attacking symptoms would help alleviate them, and this did show results in the short run. However, the subsequently experienced problems were many, but in most instances, these included a continuation or worsening of the existing problems (Saeed 1996, 1998).

**Table 1 Developmental problems, policies implemented to address them and subsequent problems experienced**

| Initially perceived problems | Policies implemented | Subsequently experienced problems |
|---|---|---|
| Food security | • Intensive agriculture<br>- land development<br>- irrigation<br>- fertilizer application<br>- use of new seeds | • Land degradation<br>• Depletion of water aquifers<br>• Vulnerability to crop failure<br>• Population growth<br>• Continuing/increased vulnerability to food shortage |
| Poverty | • Economic growth<br>- capital formation<br>- sectoral development<br>- technology transfer<br>- external trade | • Low productivity<br>• Indebtedness<br>• Natural resources depletion<br>• Environmental degradation<br>• Continuing/increased poverty |
| Social unrest | • Spending on internal security and defense infrastructure<br>• Limiting civil rights | • Poor social services<br>• Poor economic infrastructure<br>• Authoritarian governance<br>• Insurgence<br>• Continuing/increased social unrest |

Thus, food shortages have continued but are now accompanied also by land degradation, depletion of water aquifers, a threat of large-scale crop failure due to a reduction in crop diversity and a tremendous growth in population. Poverty and income differentials between rich and poor have in fact shown a steady rise, which is also accompanied by unprecedented debt burdens and extensive depletion of natural resources and degradation of environment. Social unrest has often intensified together with appearance of organized insurgence burgeoning expenditures on internal security and defense, which has stifled development of social services and human resources and have created authoritarian governments with little commitment to public welfare.

The subsequent problems experienced are also more complex than the initial problems and have lately drawn concerns at the global level, but whether an outside hand at the global level would alleviate them is questionable. This is evident from the failure to formulate and enforce global public policy in spite of active participation by national governments, global agencies like the UN, the World Bank, the World Trade Organization, and advocacy networks sometimes referred to as the Civil Society. This failure can largely be attributed to the lack of a clear understanding of the roles of the actors who precipitated those problems and whose motivations must be influenced to turn the tide (Saeed 2003).

It is proposed that the policy resilience experienced arose not from the inadequacy of measurements, but from the linear policy paradigms that were not cognizant of the hidden structure creating the problem symptoms. Creating policy paradigms cognizant of the latent structure, not more precise measurements, is needed to create more effective policy designs.

**Generic models as policy paradigms**

Forrester, who originated the system dynamics methodology, has often stated his belief that a small number of pervasive generic structures can describe the majority of real-life situations (Forrester 1980: 18). System dynamics scholars have identified a number of such generic structures, which are expressed as canonical situation models, abstracted microstructures, and counterintuitive system archetypes (Lane and Smart 1996).

Canonical models are representative computer models that incorporate explicit stock and flow structure. Forrester produced a series of early canonical models. The market growth model (Forrester 1968) described a generalized case of new product launch and distribution. The model of urban development (Forrester 1969) was offered as a basic methodology for regional analysis. The "World Model" (Forrester 1971) was a general theory of the resource use on the planet.  Additional examples include canonical models of production cycles (Meadows 1970), product development (Graham 1988), economic growth under an authoritarian regime (Saeed 1990) and manifestations of political economy (Saeed and Pavlov 2008).

Microstructures are representative computer models that also incorporate the stock and flow structure, but are smaller than canonical models. Each microstructure explains some specific mode of behavior: exponential growth, overshoot and collapse, exploding oscillations, damped oscillations, etc. Abstracted microstructures are the building blocks of larger models including the canonical models (Lane and Smart 1996). Richardson and Andersen 1980: 99-100) offered a catalogue of abstracted microstructures (they referred to them as elementary structures). Richmond (2004) referred to them as generic systems. Eberlein and Hines (1996) offered a set of abstracted microstructures that they refer to as molecules.

System archetypes do not include stocks and flows. They are feedback maps representing mental models (Senge 1990). They can assist in understanding the behavior of complex systems and in devising solutions to problems that arise in such systems. An archetype can also facilitate the communication of simulation results, especially to a policy oriented non-technical audience (Lane 1998). To aid in the selection of an appropriate archetype for a given situation, the archetype family tree can be used. For example, the limits to growth archetype can be adapted to explain the Easter Island tragedy (Mahon 1997) and the spotty performance of early peer-to-peer music networks (Pavlov and Saeed 1994).

The canonical forms often contain models that are often too evolved to be flexibly applicable to a variety of situations. Those in the abstracted microstructure category are widely applicable across domains, but are too detached from any meaningful situation to be able serve as metaphors. Those in the archetype category are meaningful, but have been presented as feedback loops rather than formal models. Also, they refer to the specific behavioral characteristics rather than to generalizable situational analogies. I propose that we should develop generalizable models of policy paradigms at a metaphorical level drawing from situations in every day life as well as distant history that should serve as pointers to the latent structures needed to be targeted by policy. In the next section I attempt to catalogue a dozen such generalizable models. Each is given a name to highlight the canonical form it represents.

**Linear policy paradigms and the corresponding latent structures**

Table 2 catalogues a dozen linear policy paradigms driving developmental solutions and the corresponding latent structures causing resilience to policy. This is not an exhaustive list, and not given in any order, but it might appear to subsume a large number of policy situations. I'll use stock and flow diagrams to illustrate the symptomatic and latent structure in each case.

**Table 2: Linear policy paradigms and the canonical situation models proposed to replace them**

| | Symptoms | Linear policy paradigms | Long term policy outcomes | Latent structures causing policy resilience | Alternative policies cognizant of latent structures | Canonical situation model |
|---|---|---|---|---|---|---|
| 1 | Hunger, Poverty | Charity | Intervention burden | Iron Law | Social services | Food relief (Runge 1975) |
| 2 | Under-development, Stagnation | Growth | Overshoot and decline | Capacity limits | Capacity preservation | Sahel, (Picardi & Siefert 1976) |
| 3 | Underutilized infrastructure | Marketing | Recovery and decline | Latent capacity constraints | Latent capacity augment-ation | People express (Sterman 1988) |
| 4 | Pests, crime, dissent, insurgence | Pest control | Problems persist or intensify | Latent capacity support | Latent capacity elimination | Stray dogs, Saeed (2008) |
| 5 | Poverty, subsistence | Pick low-hanging fruit | Famine follows feast | Predator-prey | Interdepend ence preservation | Snake poaching, Saeed (2003): WPI course SD551 |
| 6 | Breakdown | Breakdown repair | Need for heroic interventions | Interconnected conservative system | Watershed management | Watershed, Saeed (2012): WPI Watershed demo |
| 7 | Corruption, non-legitimate production, mafias, anarchy | Winning battles | Loosing war | Dynastic cycle | Resource allocation | Farmers, Bandits, Soldiers (Saeed and Pavlov 2008) |
| 8 | Economic ups and downs, surpluses and shortages, feasts and famines | Firefightin g | More firefighting | Instability | Control with functions of error | PID control, Saeed (2009) |
| 9 | Failing organizations | Preventing failure | Innovation suppressed | Aging chains | Creative destruction | Creative Destruction, (Saeed 2015) |
| 10 | Resource shortage | Digging deeper | Depletion | Resource basket | Severance penalties, Mitigation banking | Resource basket, (Saeed 1985) |
| 11 | Diminishing yield | Harvest more | Unsustainable use | Commons | Commons management | Fishbanks, Meadows (1989) |
| 12 | Low output | Produce more | Stagnation | Low productivity | Balanced investment decisions | Capability Traps (Repenning and Sterman 2002) |

*1. Charity vs the Iron Law: The food relief problem*

Charity for helping the poor and hungry, both at the community and international levels, has been touted for some time as a moral responsibility of the rich. It has manifested in humanitarian international aid programs that have also been used to paddle influence. Even when provided in a pristine form, humanitarian assistance programs have often stifled self-sufficiency and addicted recipient populations to continued relief effort. A simple form of the underlying mechanism for the failure of humanitarian aid manifests in Ricardo's iron law of wages, which pointed out that any affluence created by an increases in household income would actually invoke population growth that would revert the community back to subsistence income. Figure 2 shows a simple canonical form of the policy model that is proposed to replace the humanitarian assistance perspective.

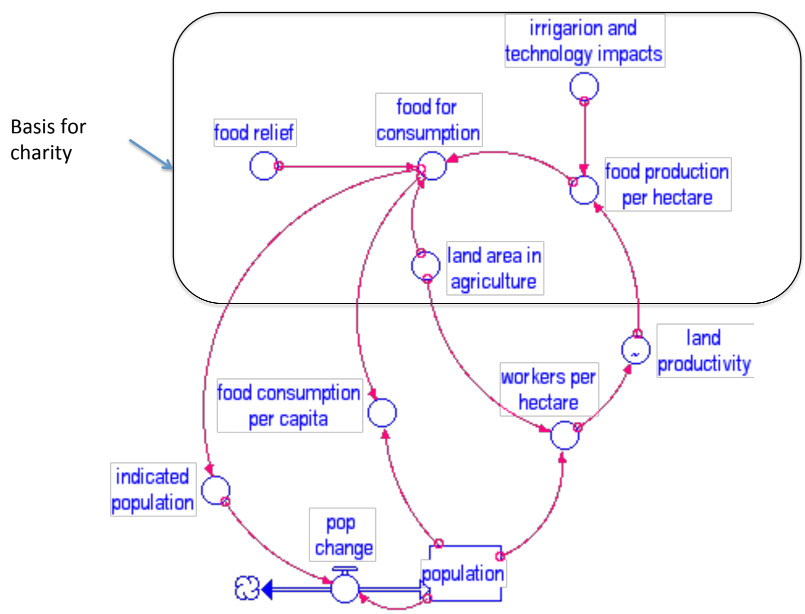


Figure 2: The Food Relief Problem

It is abstracted from Runge (1976) that presented it in the context of the food relief programs. It shows that both external food relief and technological assistance to increase land productivity will in fact cause population growth that will mitigate any temporary gains in munificence. It instead points to population control as an alternative policy measure. For human populations, it calls for organizational, informational and human services interventions rather than charity.

*2. Growth vs capacity limits: The Sahel problem*

Growth is one of the most common policies in economic development. In fact modern economic and organizational systems are designed for growth and homeostasis is equated to stagnation. Growth is affected by creating a positive feedback loop or by enhancing its gain. Unfortunately, growth policies are often not cognizant of the resources that sustain growth as shown in Figure 3. The importance of these resources cannot be perceived unless the slack in them is consumed and the marginal yield of the growth policies begins to decline since the sustaining structure is often hidden from view.

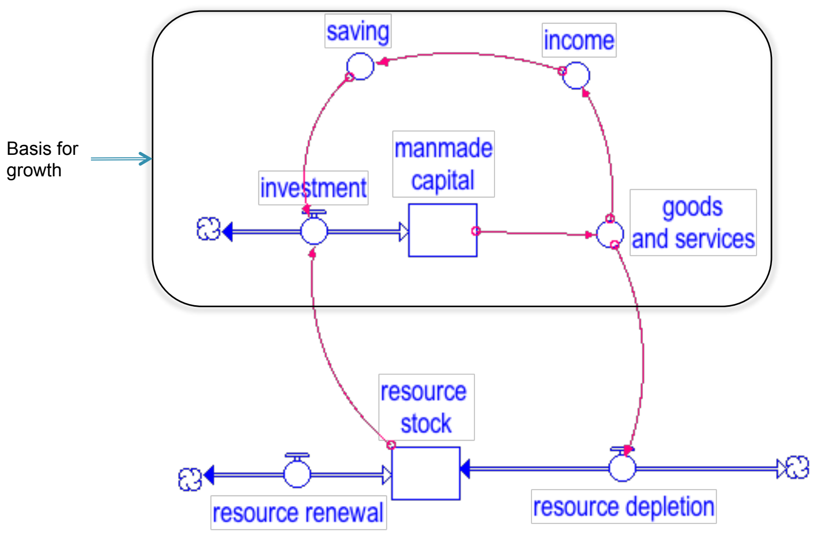


Figure 3: The Sahel problem

Examples include nonrenewable resources, management capacity, working capacity, etc. Due to the resource slack in the resource system and the delays in the appearance of constraints, growth policies can lead to overshoot and precipitous decline. The growth policy paradigm needs to be replaced by a focus on sustaining resource system.

3. *Marketing vs latent capacity augmentation: The People Express problem*

Marketing is a response to capacity underutilization in variety of organizations. Businesses, universities, collectives (milk, beef) and even countries (tourism, investment climate) engage in marketing at one time or another often without understanding the hidden causes of capacity underutilization, which manifest in capacity portfolios hidden from view. These hidden portfolios include a variety of services, non tangible attributes like quality, reputation, risk, operational reliability and the capacity to solve problems that restrict use of a manifest capacity portfolio as shown in Figure 4.

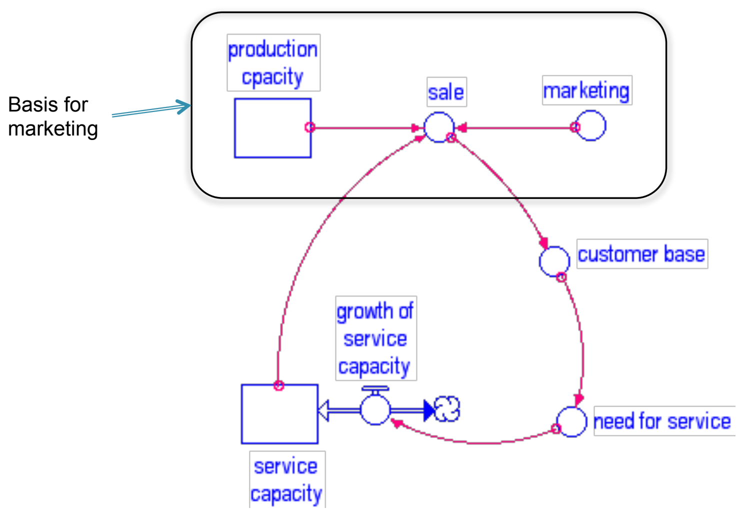


Figure 4: The People Express problems

Marketing might be one of the worst policy options for long run sustenance as it can further overload the frugal latent capacity portfolios. A pro-active policy of augmenting latent capacity portfolios that enhance attractiveness is a sensible alternative to marketing.

4. *Pest control vs latent capacity elimination: The stray dogs problem*

A common response to unwanted activity is Pest control, which is the policy metaphor responding to proliferation of unwanted populations like pests, street gangs, dissidents, terrorists, illegals, etc. Pest destruction or removal is expected to control the undesirable population. Unfortunately these pest populations might be sustained by latent systems that are not evident as shown in Figure 5. Sometimes, the policy actions might even enhance the latent systems. Hence the policy focus should be to curtail or eliminate the sustaining capacity not attack the pest. At the least, the recognition of the existence of such systems would allow digging for root causes that have lead to the creation of unwanted populations. Addressing these root-causes takes away the need for pest control.

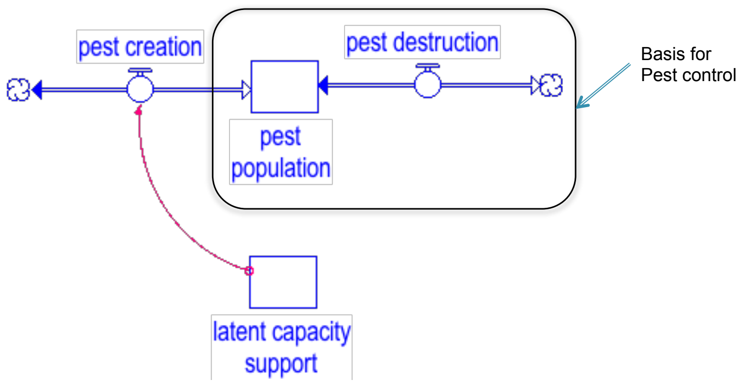


Figure 5: The stray dogs problem

5. *Picking low hanging fruit vs preserving interdependence: The Snake Poaching problem*

The emphasis on least cost alternatives has often invokes Picking low hanging fruit especially for income augmentation for the poor. As illustrated in Figure 6, the low hanging fruit often serves as a critical sustaining infrastructure and its consumption may create permanent damage to the production resource.

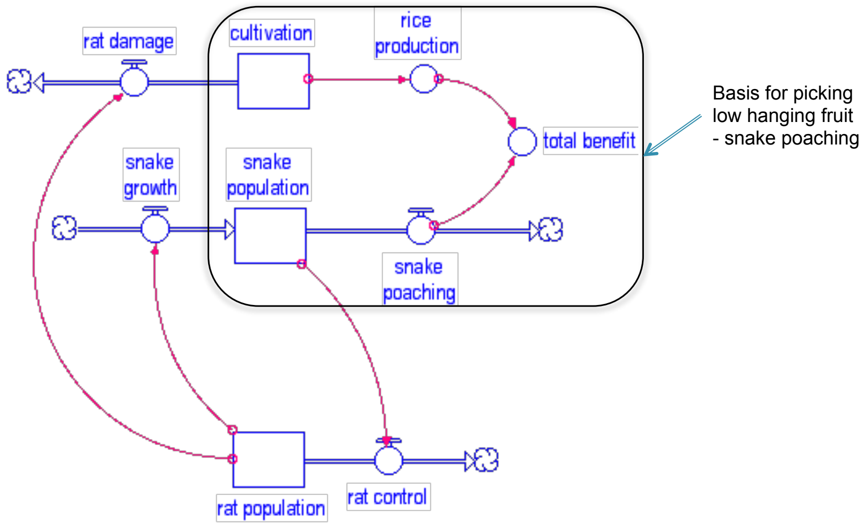


Figure 6: The Snake Poaching problem

Since the interdependence of the various resource infrastructures is not obvious, the cost benefit analyses driving policy are not cognizant of it and end up leading the system to failure after a short period of munificence. Examples include slash and burn agriculture, shrimp farming, and even snake poaching. The alternative policy paradigm is a predator-prey-production system that emphasizes the value of interdependence.

*6. Breakdown repair vs watershed management: The Watershed Management problem*

Breakdown repair is the pervasive model in health and human services provision, which is mostly invoked at the end of life stage and that stage, often offers great challenges. Heroic and expensive interventions arising out of this process might be professionally rewarding to the healthcare providers, but largely yield low value of QALYs. The alternative model suggested is watershed management that subsumes many interconnected stocks and their controlling flows shown in Figure 7. A model based on this metaphor would allow one to design interventions upstream to improve service over the whole conservative system.

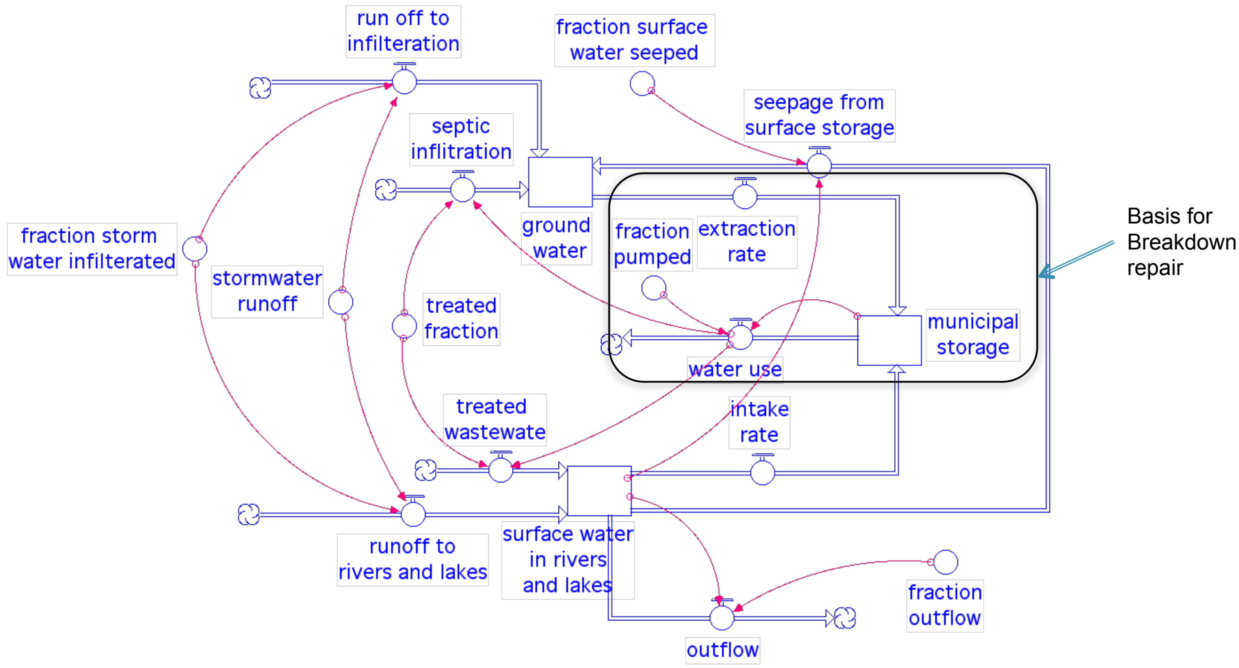


Figure 7: The watershed management problem

*7. Winning battles vs understanding the interplay of exclusive and inclusive institutions: The Farmers, Bandits, Soldiers Problem*

Governance often entails fighting little battles to deliver welfare. The battles involve collecting taxes, maintaining production of goods and services and containing asocial roles and institutions that might engage in corruption or rent extractions or plain loot. An appropriate metaphor for creating a sustainable governance system is "Dynastic cycle" – a pattern observed in Chinese history that elaborates the roles of three institutions: farmers (an inclusive economic institution, bandits (an exclusive extractive institution), and soldiers (a hypothetically inclusive governance institutions that often becomes exclusive). Such a system is elaborated in Figure 8. Understanding the interplay of these institutions can help create policies that keep the system in a healthy balance.

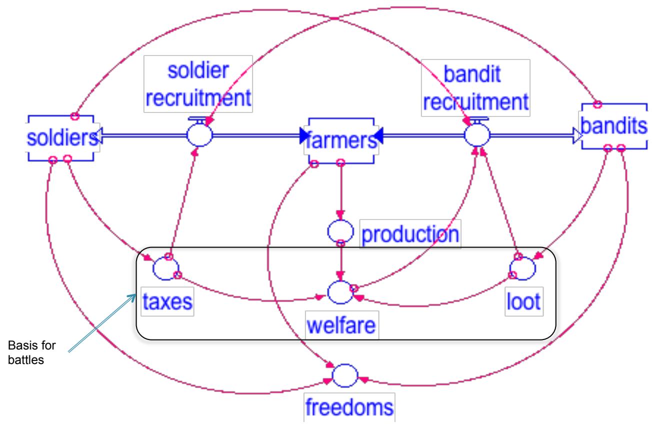


Figure 8: The farmers, bandits, soldiers problem

*8. Preventing failure vs creative destruction: The Creative Destruction Problem*

The community development process is often run as a charitable institution that aims to help failed communities and failed organizations that predominantly reside in low efficiency going concerns, declining industry and disadvantaged populations. The appropriate model for community development is creative destruction outlined in Figure 9.

A policy based on the premise of creative destruction may not attempt to sustain failing institutions but should speed up the demise of failed institutions to proactively facilitate new innovative enterprise. I have elaborated on this theme in my article integrating Schumpeter's concept of creative destruction with Forrester's Urban Dynamics model.

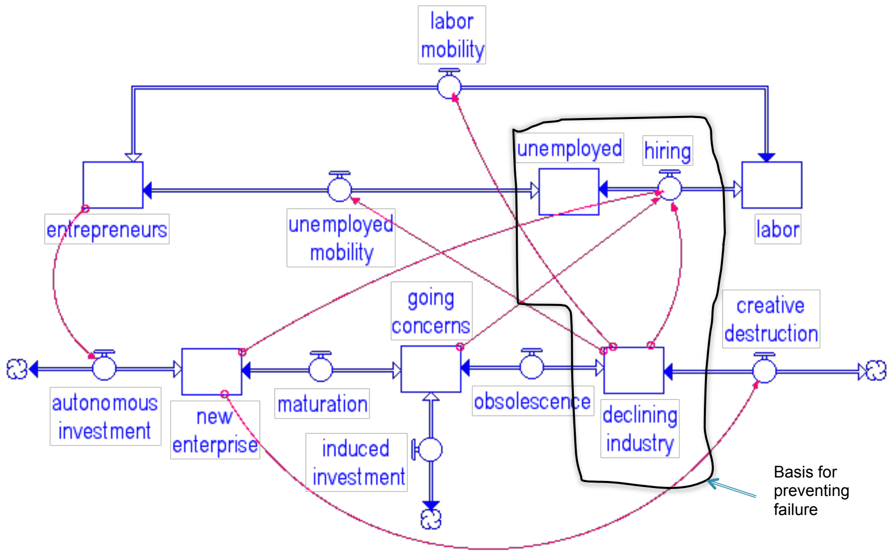


Figure 9: The creative destruction problem

### 9. *Fire fighting vs understanding oscillation: The Control Problem*

Economic management often amounts to firefighting in its efforts to counter internal trends arising out of the long-term cyclical patterns of the economy. Taxation and expenditure are the instruments of such firefighting, but they are predominantly applied to fight short term trends like growth, stagnation and decline, not to correct a continuum subsuming those trends. The alternative model proposed is control outlined in Figure 10 – a concept borrowed from engineering that recognizes the continuum of ups and downs as an endogenous pattern and applies deviation from goal as a signal to modify taxation and expenditure instruments so the cyclical pattern can alleviated. Such a control regime was in fact suggested by Professor Phillips many may years ago, but never caught on. There is a need to revisit it.

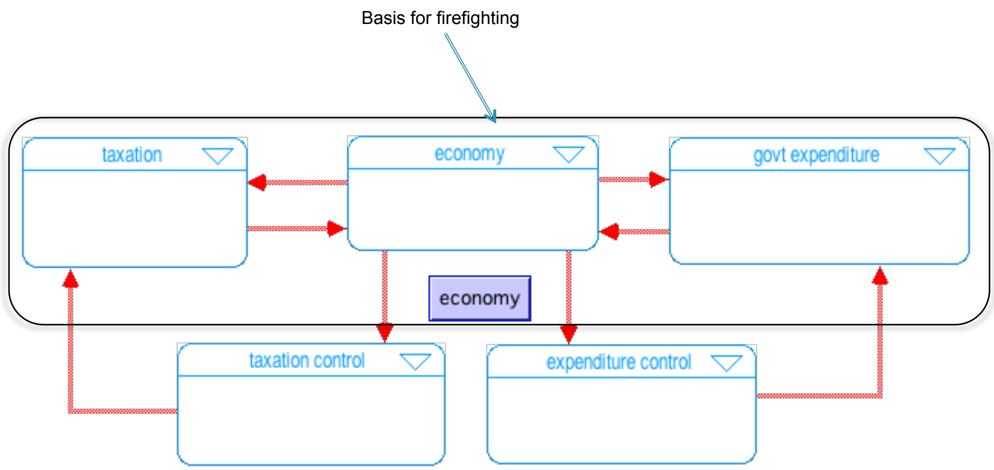


Figure 10: The control problem

*10. Intensifying exploitation vs managing technological change: The resource basket problem*

The shortage of non-renewable or slow-renewable resources, which are needed by the technology used for producing the prevalent basket of goods and services, often invokes intensified efforts to mine those scarce resources. When the complex resource system outlined by Georgescue-Rogen is considered as a policy framework, intensive exploitation may only aggrevate the shortage. Instead the policy problem presents itself as finding ways to continuous vary the resource basket in use so its aggregate consumption rate matches its regeneration. Policies for this are investigated in Saeed (1985), Acharya and Saeed (1996), Saeed (2004) and Saeed (2013)

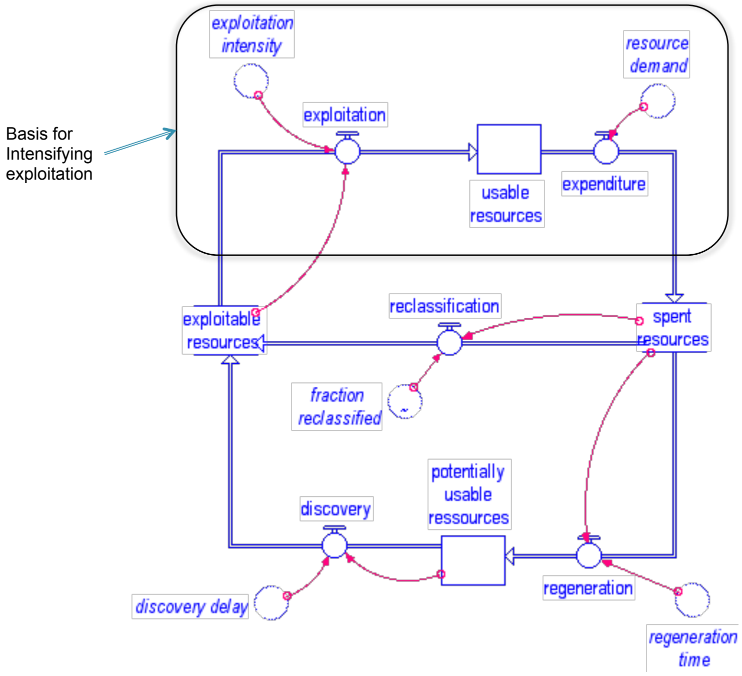


Figure 11: The resource basket problem

*11. Harvesting vs managing the commons: The Fishbanks Problem*

Ecologist Garrett Hardin (1968) eloquently described the commons problem in his seminal article published in Science that highlighted the market failure when returns remain private, but cost can be externalized into a shared commons. The problems of a shared common extend beyond ecology and manifest even in offices and labs sharing common funds and service resources.

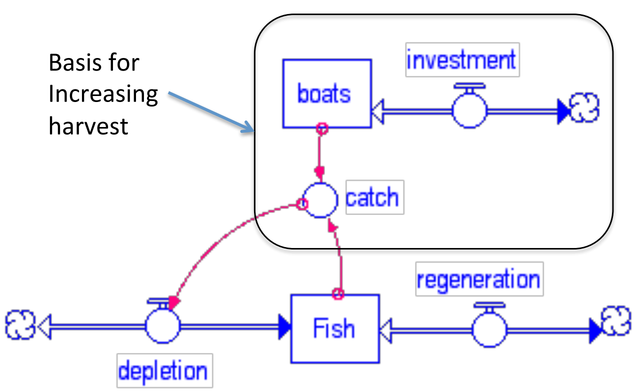


Figure 12: The Fishbanks Problem

Dennis Meadows developed a simple game called Fishbanks to illustrate the problem that has been played world over. The basic structure of his model is outlined in Figure 12. A commons gets overused and depleted when the individual decisions to harvest more are not cognizant of the shared depletion cost, which destroys the common. The game and its underlying model has been widely used to explore strategies for sustaining a common. The Fishbanks problem is offered as a metaphorical structure to understand and manage a common property resource.

*12. Production vs productivity improvement: The capability trap problem*

Economist Paul Romer (1986) pointed out in his seminal work that the economic growth is contingent not on increasing production resources, but managing resource allocation between production and productivity improvement processes. He proposed investment into enhancing capabilities could endogenously create growth. Repenning and Sterman (2002), and Rahmandad (2015) have created simple capability trap models suggesting similar strategies for the growth of a firm and called the phenomenon capability traps. Figure 13 illustrates Romer's original model with the basis of the production growth policy paradigm highlighted. The recognition of both production and productivity infrastructure that creates capability traps will create a superior resource management strategy for enhancing endogenous growth potential.

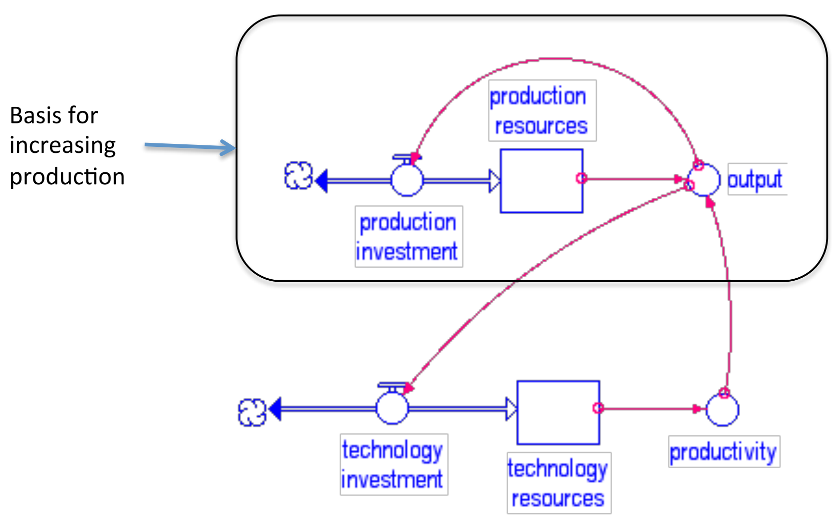


Figure 13: The capability trap problem

## Conclusion

Metaphors in every day use are mnemonic phrases that refer to episodes relevant to a variety of situations. In the modeling contexts, they describe idealized representation with wide application. Within the field of operations research, resource allocation problems are often formalized as mathematical models, which are seen as "idealized representations" of reality. Some well-known metaphorical models are: the diet problem, the shortest route problem (also known as the traveling salesman problem), the transportation problem, and the assignment problem. The metaphorical models serve as prototypes for further extensions suitable for particular situations. For example, the "transportation problem" can be adapted to cases outside of the field of transportation, such as production, or, with some additions, it can become the transshipment problem (Hillier and Liberman 1972).

Metaphorical models are also found in other threads of modeling. As Krugman (1993) points out, economic theory is based on metaphorical models. Indeed, perfect market, competition, monopoly, equilibrium growth, etc., are all highly stylized abstract concepts that are often adapted to more complex situations when applied to address particular problems. Generic structures are also used in system dynamics, although they are not often stated as metaphors. An exception is a model by Morecroft et al. (1995) that describes the behavior of two showers that share a water source. This model, which symbolizes competition for common resource, is used to explain difficulties experienced by a real-life international manufacturing firm.

This paper has attempted articulate several classes of problems germane to economic development and public policy and has catalogued the key metaphorical models that have been proposed to address those problems. An inventory of such models is proposed as a high level systems thinking tool. Further work is needed to enhance and elaborate on the proposed metaphorical structures.

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