Maintaining Professional Competence in Innovation Organizations

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ABSTRACT

Public organizations concerned with planning and implementation of developmental activity, education, research and development, as well as private firms delivering professional services and operating in a rapidly changing socio-economic environment are often concerned mainly with innovation, problem solving and learning rather than with the production of any tangible outputs. The income streams of such organizations also often stem from environmental support rather than from a sale of widgets. Sustaining developmental activity in part requires maintaining such organizations at a high level of productivity, which calls for special design considerations that this paper attempts to delineate. A formal model of the production, knowledge acquisition and governance functions of an innovation organization is developed and experimented with through computer simulation using the heuristical approach of system dynamics. The analysis suggests that professional competence in organizations may atrophy, eventually leading to demise, due to the development of a governance system that is largely driven by manifest authority unless a concerted effort is made to preserve collegial decision roles. In terms of organizational design, this translates into considering constituents other than those used normally for creating mechanistic and organic components of organizational structure. Since professional competence often emanates from collegial rather than manifest processes, an important aspect of the design is to sustain collegial roles. Since collegial roles are undefined, their maintenance calls for placing constraints on manifest roles with prolific expansion potential. A promising design constituent for sustaining an appropriate governance system for an innovation organization appears to be a chartering process that should create an organizational manga carta clearly stating the limitations of the manifest roles. Other possible entry points into the system, albeit external, include bringing in leadership perspectives and linking with market forces that should allow to curtail prolific expansion of manifest roles.

Key Words: economic development, innovation, organizational design, organizational learning, system dynamics, modeling, computer simulation

Introduction

Innovation and technological development have been observed to be the most significant sources of economic growth in the industrialized countries [Abramovitz 1956, Solow 1957, Dennison 1962, Griliches 1963]. These have also been posited by some scholars as powerful means for affecting economic development in the developing countries [Schultz 1979; Hirshman 1958, 1970]. However, the operational instruments to mobilize innovation remain unclear both in the public policy context and in terms of the organizational processes entailed in nurturing the professional competence they require. Consequently, development policy has largely attempted to emulate experience from abroad rather than attempting to mobilize indigenous innovation potential. Barring the establishment of a few S&T organizations, little has been done in terms of promoting innovation activity in the private sector through any public policy levers.

The public policy levers to promote innovation and technological development are explored by the author elsewhere [Saeed and Prankprakma 1997]. This paper deals with the processes affecting the maintenance of professional competence in organizations that should drive innovation and deliver efficient performance. It attempts in particular to understand how such organizations transform themselves into elaborate bureaucracies that severely limits their productivity, and what can be done in terms of organization design to avoid this transformation.

The instrument of analysis of the paper is a system dynamics model of the production, knowledge acquisition and governance functions of an organization concerned with innovation. This model is experimented with using computer simulation to understand the nature of an imminent bureaucratic transformation and to identify entry points to maintain technical competence that should sustain the innovation process.

The analysis suggests that professional competence in innovation organizations may atrophy as the feedback between the resource allocation process and the governance system progressively strengthens manifest roles. This dysfunctional development can be avoided if a mechanism to support collegial roles is in place. In terms of organizational design, this translates into considering constituents other than those

used normally for creating mechanistic and organic components of an organizational structure. Since innovation often arises from collegial rather than manifest processes, an important aspect of the design is to sustain collegial roles. Since collegial roles are not formally defined, their sustenance calls for placing restraints on manifest roles with prolific expansion potential.

A promising design constituent for sustaining an appropriate governance system for an organization concerned with innovation appears to be a chartering process that should create an organizational Magna Carta clearly stating the limitations of the manifest roles. Other possible entry points into the system, albeit external, include bringing in appropriate leadership perspectives and linking with the market forces, both of which should allow to curtail prolific expansion of manifest roles.

Design of innovation organizations, a paradox

Providing for an innovation capability in the design of a formal organization offers a paradox. On one hand, there is overwhelming evidence that innovation is nurtured in an informal setting, which should be unfettered by the rigidities of a manifest role structure [Quinn 1985, Roberts 1991]. On the other, organizational design, by the very nature of the instruments available to it, may only define manifest roles, which are more a hindrance than a help in sustaining an organization's innovation functions.

Innovation organizations have been defined in many ways, all emphasizing the process of organizational learning which entails a conscious management of problem recognition and skill acquisition at the individual level and mobilizing the knowledge so created in meeting the innovation and development remits of the organization [Argyris and Schön 1978, Dixon 1994]. Argyris and Schön (1978) view organizational learning as a process in which members of an organization detect error or anomaly and correct it by restructuring the organizational theory of action, embedding the results of their inquiry in organizational maps or images. Innovation, seen as an important outcome of learning, has been observed to predominantly account for the improvement in organizational performance [Katz and Kahn 1978]. Organizational learning and innovations resulting from it especially become key components of production when the output of an organization cannot be clearly defined as in the case of service establishments exclusively engaged in transactions involving knowledge, such as universities, research and development organizations, hospitals, law firms, software development outfits, consulting firms and the developmental arms of government and public service performing staff functions involving analysis, design, planning and plan implementation.

Organizational learning is a developmental process through which organizations must constantly regulate their production and administrative operations. The learning function of an organization, and also the mobilization of learning for innovation and development are, however, not easy to sustain, particularly in the developing countries. A very large number of attempts to create innovation are met with frustration while organizations in which knowledge acquisition and its application are key processes often transform themselves into rigid bureaucracies that are unable to sustain professional competence and mobilize it for creating innovation [Saeed 1996, Senge 1990].

A wide rage of formal and informal training processes involving information giving and skill practice are used for socializing members of an organization into their respective roles [Van Maanen 1976]. Learning being an important part of the role in innovation organizations, their members must also be provided with learning opportunities to develop their cognitive skills, possibly, through various forms of training and self-learning instruments. Even if created through such processes, individual learning cannot be imbedded into the organizational context unless an appropriate organizational environment converging individual and organizational interests is in place [Argyris 1964, Schein 1985], which is easier said than done.

Performance of innovation organizations, the roles of learning and collegiality

Many theses have been posited on the maintenance of performance in organizations. Lawrence and Lorsch (1967) pointed out that performance depends on appropriateness of the organizational structure in relation to the production process and the product created. Thus, while a well defined manifest structure could create an effective organization in the case of simple products and production methods existing in a complacent environment, an integration both with internal and external environmental diversity, which should constantly create learning opportunities for organizational development, was necessary for effectively dealing with a complex line of products, production methods and markets. Recognizing the pace of the impending change in workforce, production methods, products and the environment, and the need for creating an organizational model that should be able to cope with this change, McGregor (1960), Herzberg (1966) and Pfeffer and Salancik (1978) saw an increasing role for knowledge, autonomy and collegial or referent authority in the organizations of the future to nurture learning ability. Such ability would create a possibility of dealing innovatively with the unforeseen problems encountered in a rapidly changing organizational environment as well as in the external environment context.

Argyris and Schön (1978) distinguish between individual and organizational learning in that individual learning in an organization may not represent organizational learning unless members of the organization act as learning agents for the organization, which is possible only when individual learning can be imbedded into a common organizational context. When this context is unclear or conflicts exist in its recognition, organizations will learn much less than its members and will also be unable to mobilize individual knowledge to improve organizational productivity. A common organizational context, which Argyris and Schön refer to as organizational theory in-use, is created by rules, charters, norms and shared common values. It is, however, important that members see a convergence of their individual interest with that of the organization, so their learning context remains relevant to the organization and imbedding of acquired knowledge into the organizational context can occur. This requires integration among the subparts of the total organization, such that the parts are not working at cross-purposes [Schein 1980]. Often, innovation organizations fail to create such an integration, not only precipitating a gulf between individual and organizational knowledge, but also stifling motivation and fueling conflict between the various interest groups formed in the absence of a shared common map of organizational functions [Argyris 1964].

Since autonomy and collegial authority have been seen by the organizational scholars as important elements for supporting an innovation organization, it is necessary also to understand how these values are sustained within a governance system. Innovation organizations consist of groups of professionals working in collegial roles creating intangible goods through a process whose productivity depends both on cumulative knowledge and its mobilization to meet the objectives of the organization. These professionals must, however, be supported by staff working in manifest roles for providing administrative services. The former roles are often adjudicated by external peers while the later must be adjudicated internally. Institutional norms governing the conduct of the actors in such organizations develop out of a balance between the referent authority of the externally adjudicated professionals that upholds value-rationalism and the manifest power of the internally adjudicated administrative staff subscribing often to instrumentalism [Benvensite 1987, Waters 1989]. A university is a typical example of an innovation organization where the referent authority of the faculty must maintain a focus on the long term value of sustaining the innovation functions while the manifest authority of administration provides a structure for reliable day by day functioning, although those two functions might sometimes be in conflict. A lack of balance between the two types of authority will not only prevent the resolution of such a conflict, the dynamics arising from unresolved conflict would also further exacerbate the imbalance between the two types of authority, eventually creating resource misallocation between the two functions both of which are critical to the sustenance of the university [Saeed 1996].

Collegiality, a term used by Max Weber, is in fact an important organizational value recognizing collegial authority in an innovation organization. Weber defined many organizational arrangements under which the monocratic character of manifest authority is limited by the principle of collegiality [Weber 1978]. The consequences of loss of collegiality in an innovation organization manifest both in the economic and value-related indicators since the two are inter-twined.

The propositions concerning the internal causes of success or failure of a collegial system often attribute the loss of value-rationalism, which eventually results in the loss of a collegial culture, to bureaucratization and centralization processes [Waters 1989]. Culture and organizational values are seen to be important determinants of organizational performance, especially in the context of innovation. Culture shapes a latent organizational structure that continuously interacts with the manifest structure, creating a governance system that greatly influences the role system and performance [Schein 1985, Dixon 1994].

Creating a governance system where a balance between manifest and collegial authority can be maintained is, however, not a simple matter since it may easily lead to a power struggle between conflicting interests that may deteriorate collegiality. In particular, organizations that are located in a monopolistic market or a non-competing environment which create internal rather than external terms of reference and those cut off from adjudication by professional peers may rarely be able to maintain collegial roles that sustain them in the long run. Such organizations may run a high risk of failure unless they are able to sustain a culture that recognizes both manifest and collegial facets of decision-making [Saeed 1996].

The literature on the performance of the innovation organization is unfortunately fragmented and provides static views of the organizational processes rather than a coherent theory of action that may explain the diversity of the patterns experienced. Gouldner's seminal work on manifest and latent roles in professional organizations identified two important latent role models, cosmopolitans and locals, which seemed to influence the performance and the inner coherence of an organization [Gouldner 1957]. The former model fits professional roles functioning under the collegial structure, while the later fits administrative roles functioning under the manifest structure. Gouldner did not, however, analyze the dynamics of interaction between those latent roles and how this might affect performance. In a more recent writing, Benvensite (1987) emphasizes the need to cultivate cosmopolitan professional roles to maintain innovation in an organization, although he also does not clearly identify an organizational process that should accomplish this and seems to leave intervention to leadership. Unfortunately, intervention by leadership often requires centralization of decision-making and concentration of power that will often create ruthless pursuit of instrumental interests which is further intensified in the presence of machiavellian attitudes to which leadership roles are often prone [Jennings 1960].

Both latent and manifest relationships in an organization must be carefully examined in the framework of a dynamic decision system to understand how a balance between the manifest and collegial functions can be maintained to sustain an environment conducive to innovation, which is attempted in this paper. An experimental approach is adopted using system dynamics modeling to represent the role system and computer simulation to experiment with this model and search for an operational means for system change [Forrester 1961, Richardson and Pugh III 1981].

A system dynamics model of an innovation organization

An innovation organization must necessarily incorporate a strong interplay of three subsystems - 1) the production system which allocates resources between production and administration activities so the production of intangible goods can be sustained, 2) the learning system which regulates the creation of knowledge and its mobilization in the organizational context which would constantly improve operations affecting productivity, and 3) the governance system which maintains a balance between collegial authority and manifest authority creating an environment in which a largely invisible output which sustains income potential is maintained [Gouldner 1957, Waters 1989, Weber 1978]. An abstract map of the broad information flows occurring between these processes is shown in Figure 1.

All three subsystems in this map are shown to have information exchange with one another forming three high level feedback loops, which create an extended interdependence between the roles played within the context of each subsystem. The cause and effect relationships governing these roles are identified on the basis of the existing, although fragmented, theoretical and empirical information. These relationships form a basis for developing a formal system dynamics model subsuming the three subsystems and the interactions occurring between them, which is presented below. Following the flow diagramming convention of the system dynamics method, the rectangles represent stocks, the valve symbols flows and the circles intermediate computations. The circles containing a ~ represent nonlinear behavioral relationships [Richardson and Pugh III 1981, Richmond et. al. 1987]. This model is implemented on an Apple Macintosh personal computer using *ithink* software.[1] An equation listing of the model is placed at the Appendix.

[1] Apple and Macintosh are trademarks of Apple Computer Co., Cupertino, CA 95104, USA. ithink is trade mark of High Performance Systems, 45 Lyme Road, Hanover, NH 03755, USA

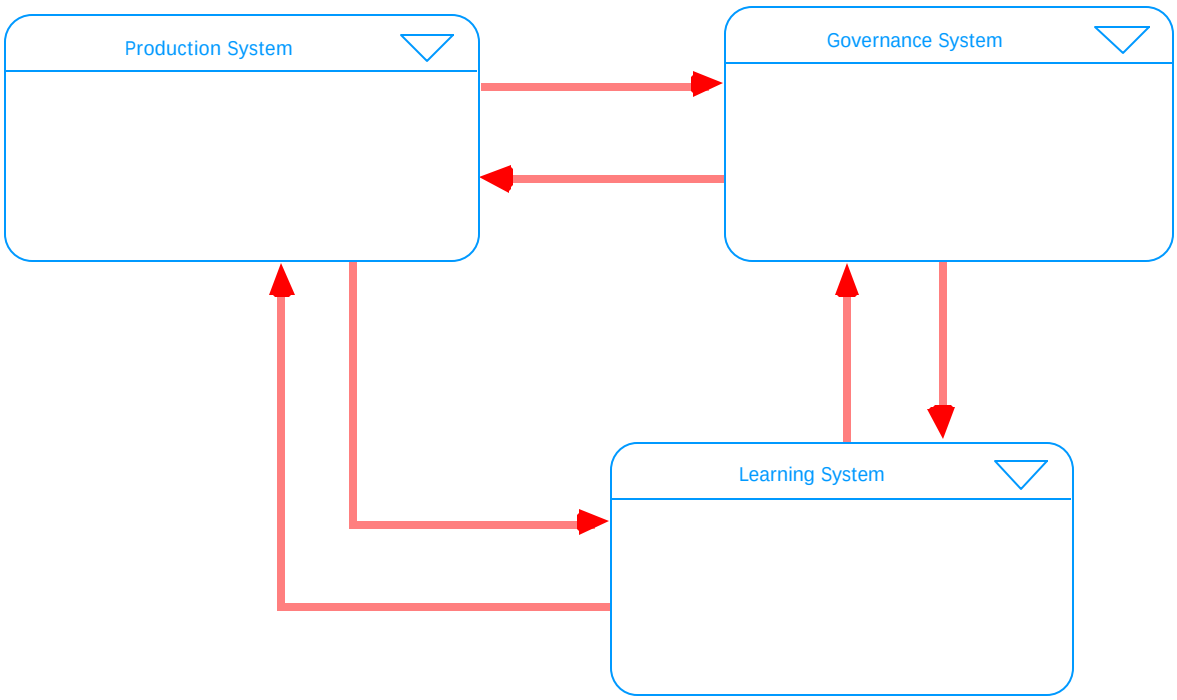


Figure 1 **Map of broad information flows between the various sectors of an innovation organization**

a) Production and resource allocation

The production system of an innovation organization is supported by two types of resources, professionals directly engaged in creating non-tangible goods and services, and administrators supporting professional activity in terms of internal services and the relationship with the external environment [Gouldner 1957, Bevensite 1987]. Figure 2(a) illustrates these processes.

The output of the production process depends on the stock of professional resources (primarily the number of professionals) and their productivity. The allocation of the total budget between these two activities depends on balancing the concern for perceived control need and the prudence exercised for maintaining economic health.

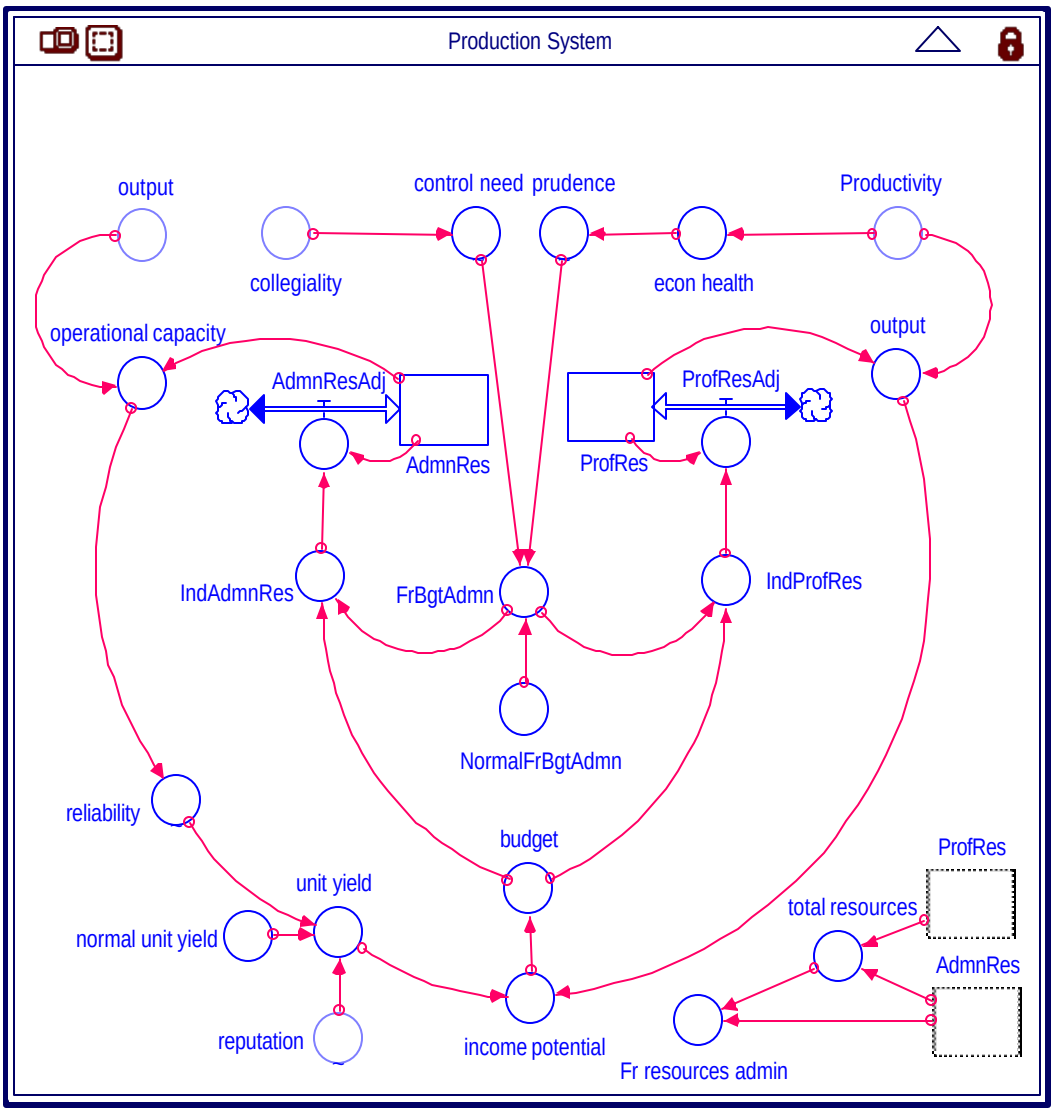


Figure 2(a) Production and resource allocation

When economic health, a measure comparing productivity with a notional normal value, is perceived to be good, prudent governing action will tend to expand administration in preparation for a larger expected size. When economic health is perceived to be poor, such action may call for reduction in administration, although, not directly in proportion to the fall in economic health [Katz and Kahn 1978]. On the other hand, the control need arising from a concern for rising collegiality, which signals a decline in manifest authority, may press simultaneously for increasing allocations to administration irrespective of

economic health - a process widely associated with R&D management whose nature is very relevant to an innovation organization [Roberts 1964, 1974].

The total budget of the organization adjusts towards an income potential after a delay representing the time elapsed between determination of income potential and its recognition by the actors in the support environment. Income potential is determined in the first instance by the creation of mandated output. However, the yield of this output will depend on the professional reputation of the organization as well as on the reliability of its operations. The former depends on the collective professional competence cultivated in the organization relative to its professional workforce, while the later arises from the administrative resources available to support a given level of output.

b) Learning and application of knowledge

The learning system incorporates knowledge acquisition and its application to meet the organizational remits, namely, creating a reputation emanating from professional competence and improving organizational productivity through innovation. Figure 2(b) shows how learning process and the application of knowledge are modeled. Learning rate is determined by professional resources and their learning productivity, which is driven by professional competence through an innovation process it supports. The context of such learning is, however, mostly individual. Professional competence can be mobilized to improve organizational productivity only when there exists a notion of organizational citizenship, which plays a significant role in attaching individual endeavors to the organizational context [Argyris 1964]. Professional competence would also emanate a glow creating a reputation for the organization provided the environment is able to recognize and value professional accomplishment [Organ 1988], which is a function of the slope of the graphical function relating professional competence to reputation in the model.

The stock of professional knowledge decays through an obsolescence process while professional turn over also affects it, since knowledge is mostly embodied in individuals, especially in an innovation organization where neither production nor the production process has any physical counterparts. Thus, knowledge additions occur through new recruitment and the competence level embodied in entering individuals, and attritions take place through separation and the current competence level embodied in the existing professionals. The former competence level depends on the recruitment policy while the later is determined by dividing the stock of professional knowledge by the stock of professional resources.

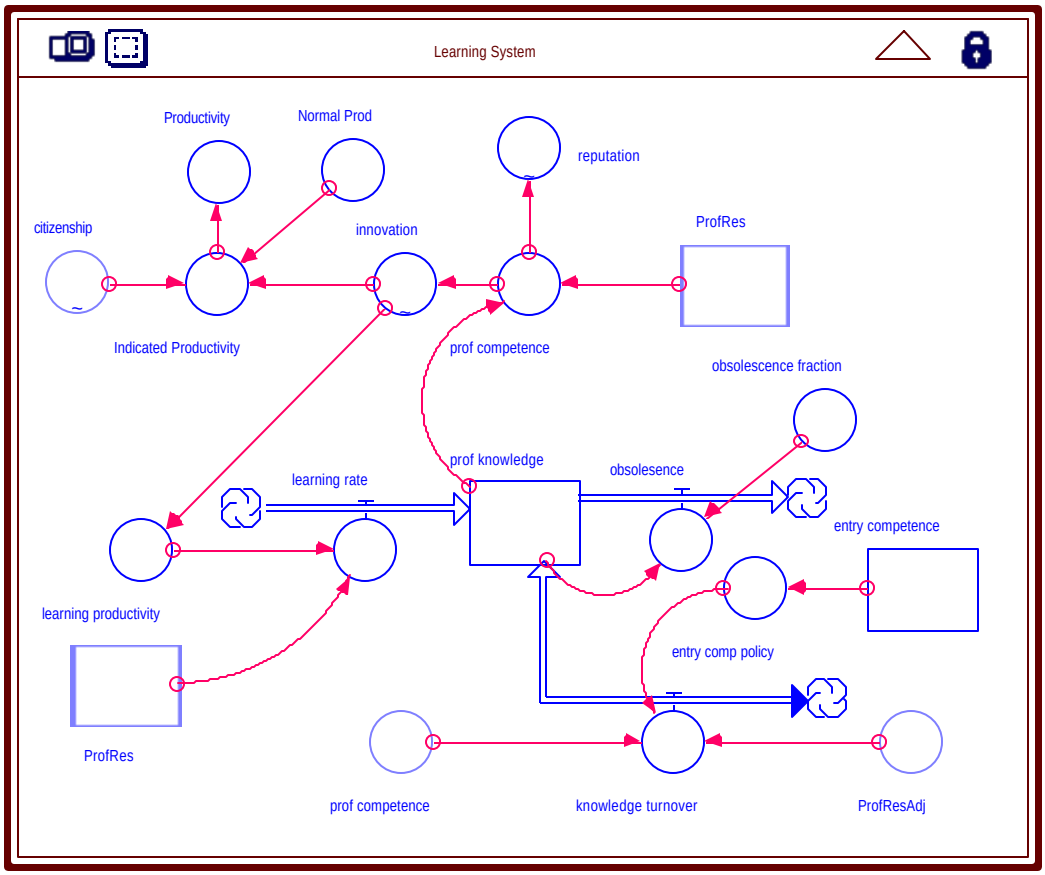


Figure 2(b) Learning and application of knowledge

Governance and value creation

In addition to production and knowledge acquisition functions, an innovation organization must also maintain a level of collegiality - a value that accommodates the collegial authority of the professionals - within its governance system, which would contain both manifest and collegial components. Values and attitudes in an organization must be constantly reinforced, as otherwise they are susceptible to decay. A strengthening of the professional scope will promote collegial authority in the organization, which will tend to give priority to the professional agenda. On the other hand, a strengthening of the administrative scope will fuel manifest authority that will suppress self-actualized behavior and thus alienate professionals [Benvensite 1987, Waters 1989]. Figure 2(c) shows the relationships underlying the value creation and maintenance processes and how these affect the governance system.

An important organizational value defined in the context of the learning subsystem was citizenship, which is closely tied in the value subsystem to the composition of governance in terms of its manifest and collegial components represented by collegiality in the model. Citizenship represents employee altruism for the organization, which cannot be elicited through any manifest process. It rather depends on a sense of ownership and commitment arising from a governance system that delicately balances referent power of collegial authority with the manifest authority, while its expression also requires that individual citizenship prerogatives be in place. In particular, citizenship is suppressed by the practice of authority manifest in a large administrative scope since it limits the opportunities for self-determination [Organ 1988]. Thus, citizenship in innovation organizations may be seriously compromised by a governance system returning a low degree of collegiality.

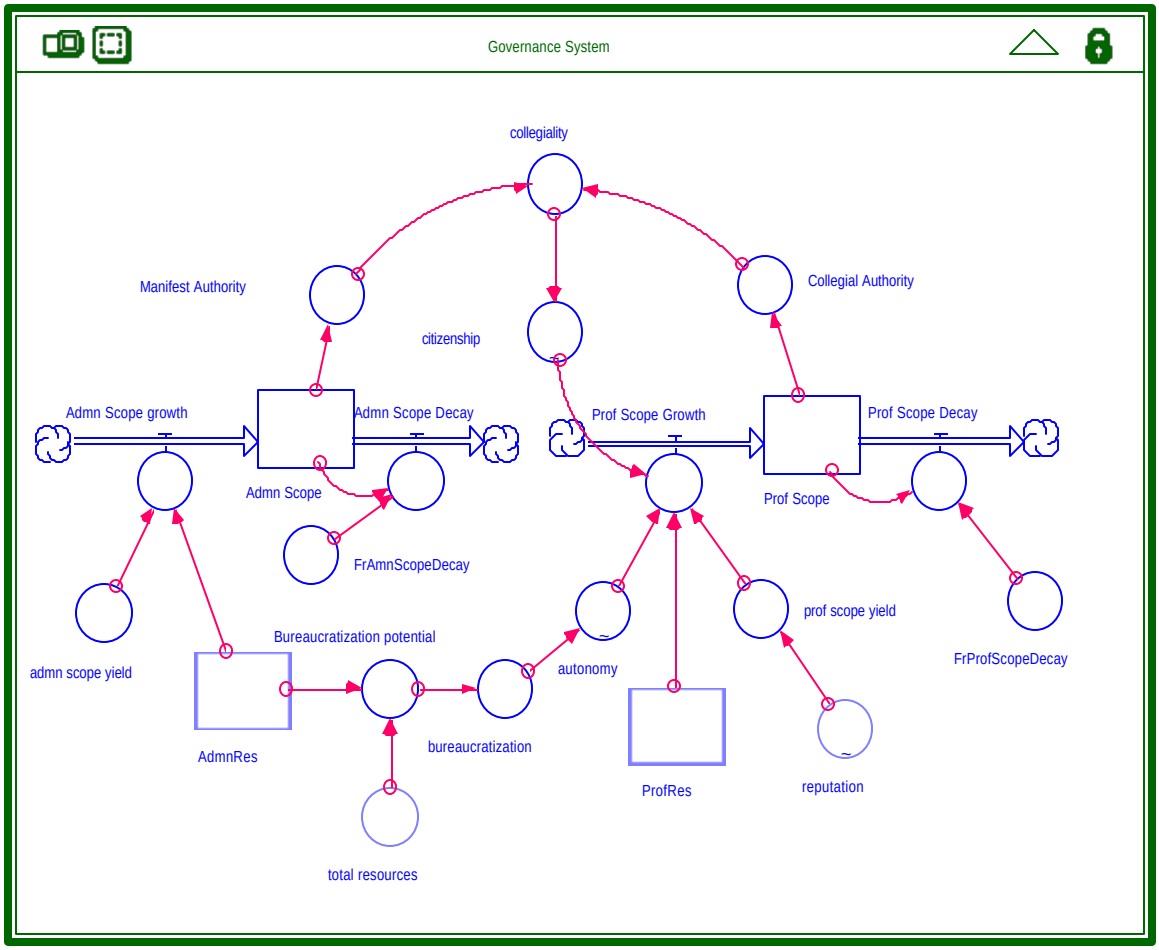


Figure 2(c) Governance system and the maintenance of collegiality

Collegiality is a value, which recognizes the role of the collegial authority relative to manifest authority in the governance system. Collegial authority is created by professional scope, through the institutionalization of referent power. The growth of professional scope requires not only the presence of a reputation emanating from professional competence, but also the presence of autonomy and citizenship prerogatives that elicit professional participation in the decision process. This can apparently be realized only when the organizational environment can support autonomous and self-actualized professional roles. The growth of professional scope would, however, be limited by the rigidities created by a high degree of bureaucratization, which reduces autonomy. It is also further constrained by the alienation of the professionals from the decision process created by a governance system that is low on collegiality and is largely driven by manifest authority, which suppresses citizenship prerogatives as well as citizenship commitment.

Manifest authority is bred by administrative scope, which represents the extent to which the administrative processes govern organizational decisions. Administrative scope is created through the mobilization of the administrative resources when the administrative functions of the organization are unadjudicated by an organizational charter or by censure by external peers or by a restraint originating from leadership. Administrative infrastructure also inevitably bureaucratizes operations through creating rule-based instruments that suppress autonomy, which further limits the growth of professional scope.

It should be noted that most of the variables in the model described above are notional and cardinal measures for these do not exist. Yet, these are real and their existence is widely acknowledged both in literature and by management. An earlier version of the model of this paper, which was specifically addressed to a university context, was widely distributed to university professors and administrators in many countries. As indicated in the informal feedback provided to the author, it seemed to mirror mental perceptions of the readers about the organizations they worked with. One university president even responded in writing defending his role in expanding the administrative infrastructure of his university because of "unique" circumstances, although he acknowledged that the model was valid for "normal cases". The next section describes simulation experiments with the model to understand its behavior and its relevance to innovation organizations. This experimentation is further extended to proposing a framework for organizational design for the innovation organizations.

Experimentation with the Model

Simulation is used as a means for experimentation with the model both for understanding its behavior and its relevance to sustaining an innovation organization, and also for identifying a framework for policy intervention. The first set of simulation experiments is aimed at systematically examining the three subsystems of the model and determining their contribution to the making of an unsustainable innovation organization. This is followed by an examination of the sensitivity of the policy related model parameters, which helps to identify entry points into the system for checking decay in performance. The final set of experiments test a proposed policy framework to sustain professional competence and innovation.

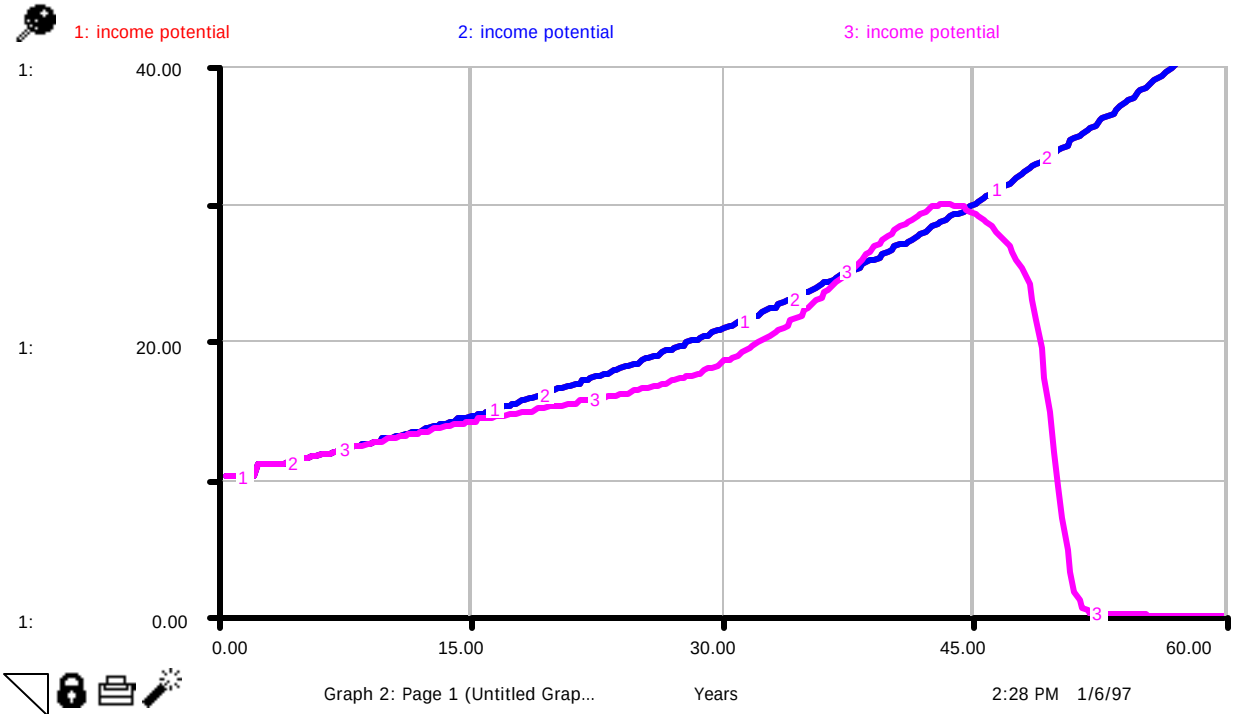
a) The making of an unsustainable innovation organization

The model is parameterized in a way that equilibrium exists in all stocks. The initial values of professional scope, administrative scope and bureaucratization thus issued are assumed to be moderate and are scaled at unity. The total amount of initial resources is assumed to be 10 units. 80% of these resources are allocated to professional activities and only 20% to administration. The system is disturbed by stepping up the normal unit yield implying an autonomous increase in the environmental support.

Figure 3 shows the behavior of income potential in the model with various configurations of its structure. Graph 1 represents the behavior of only the production sector with influences from learning and value systems held constant; graph 2, which exactly coincides with graph 1 represents the behavior of production and learning sectors interacting with each other while the influence of the governance system is held constant; and graph 3 represents the behavior of the whole model with all production, learning and governance systems contributing to it interactively. Thus, the constraints to growth and the down turn in income potential arise only when the governance system is linked with the rest of the model structure, which activates a number of negative feedback loops creating limits to growth followed by an eventual decline.

The behavior of the variables representing organizational competence, productivity, and the levels of collegiality and bureaucratization for the complete model is shown in Figure 4. While the system exhibits a cyclical tendency, the cycles die out rapidly as productivity dips after the first peak. Also, as collegiality declines, bureaucratization shows a sustained upward trend. This is also coterminous with an increasing proportion of resources channeled to administrative activities, which means that the contribution of real output and reputation to income potential will decline while it is increasingly sustained by administrative reliability which, however, can only cause an incremental difference. As output continues to decline due to decreasing allocations of resources to production and declining productivity, income potential eventually turns down, which invokes a rapid collapse in all indicators although bureaucratization continues to increase over the course of the collapse and turns down only when an

eventual demise is inevitable. This pattern of behavior can be understood by examining the key feedbacks existing in the system, which are shown in Figure 5.



1 - production subsystem only
2 - production and learning subsystems
3 - complete model

Figure 3 Contribution of the various systems to determining income potential of the innovation organization

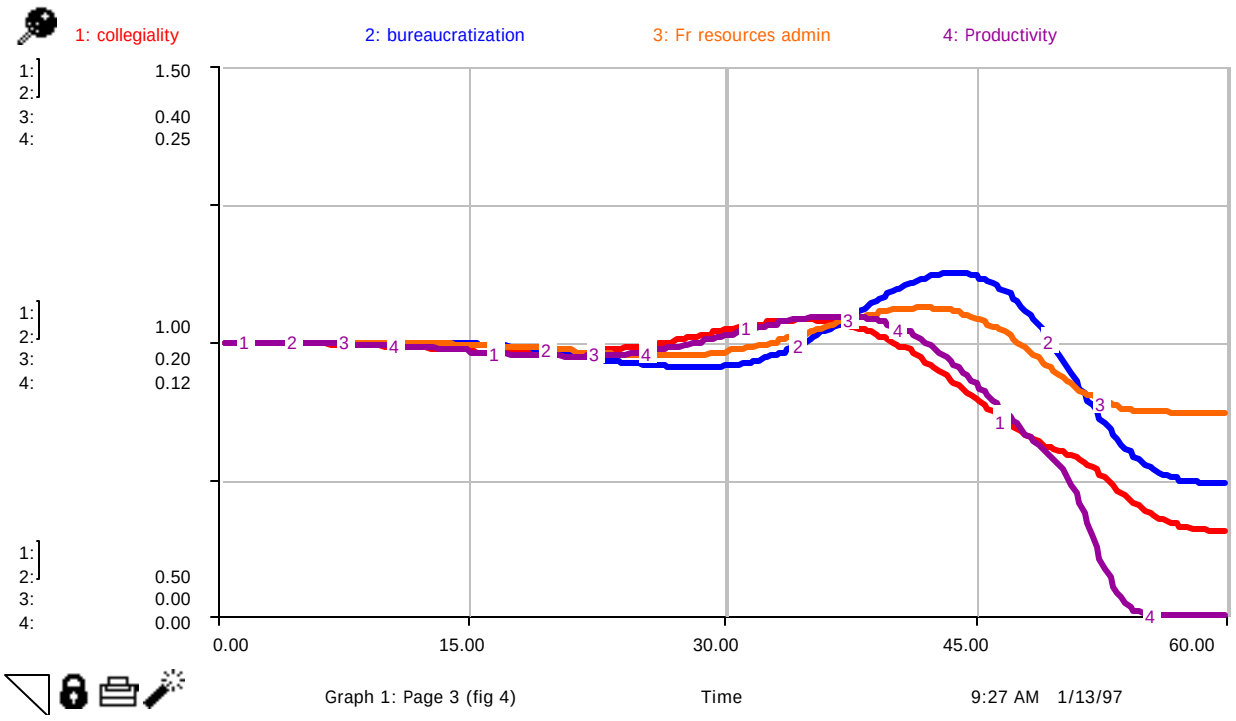


Figure 4 **Behavior of knowledge, value, and resource allocation related components in complete model**

Positive feedback loops towards the bottom left of Figure 5, which arise out of the working of the production and learning systems, are self-reinforcing and create growth profiles 1 and 2 in Figure 4. Since learning and obsolescence rates of knowledge match at all times due to the model specification of structure and the parameters which maintain the gain of the learning-related positive feedback loop at one, a stable stock of knowledge is able to maintain the ambient levels of productivity and reputation. Hence, activating learning process will not affect behavior unless learning rate is stepped up, which can be done by introducing various types of training and learning facilitation programs.

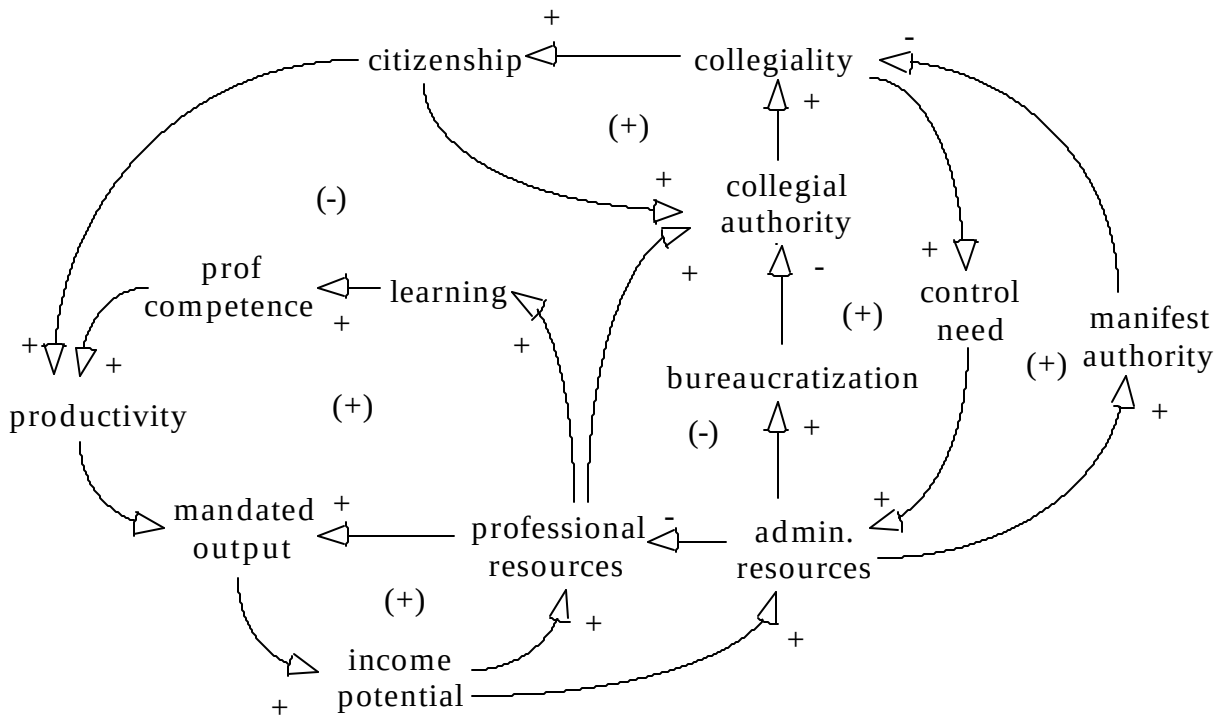


Figure 5 Feedback loops underlying the demise of an innovation organization

When the governance processes are also linked with this system, several new positive and negative feedback loops are formed. The negative feedback loops come to influence the goal of production- and learning- related growth processes since growth also fuels expansionary trends in administration, which not only constrains resource allocations to production, it also supports the growth of administrative scope and bureaucratization. The former promotes manifest authority, which decays collegiality, the later limits autonomy through expanding rule-based decision-making and centralization; both trends impose constraints on invoking commitment to organizational citizenship which is critical to the mobilization of professional competence in the organizational context and thus in supporting innovation and consequently improving productivity.

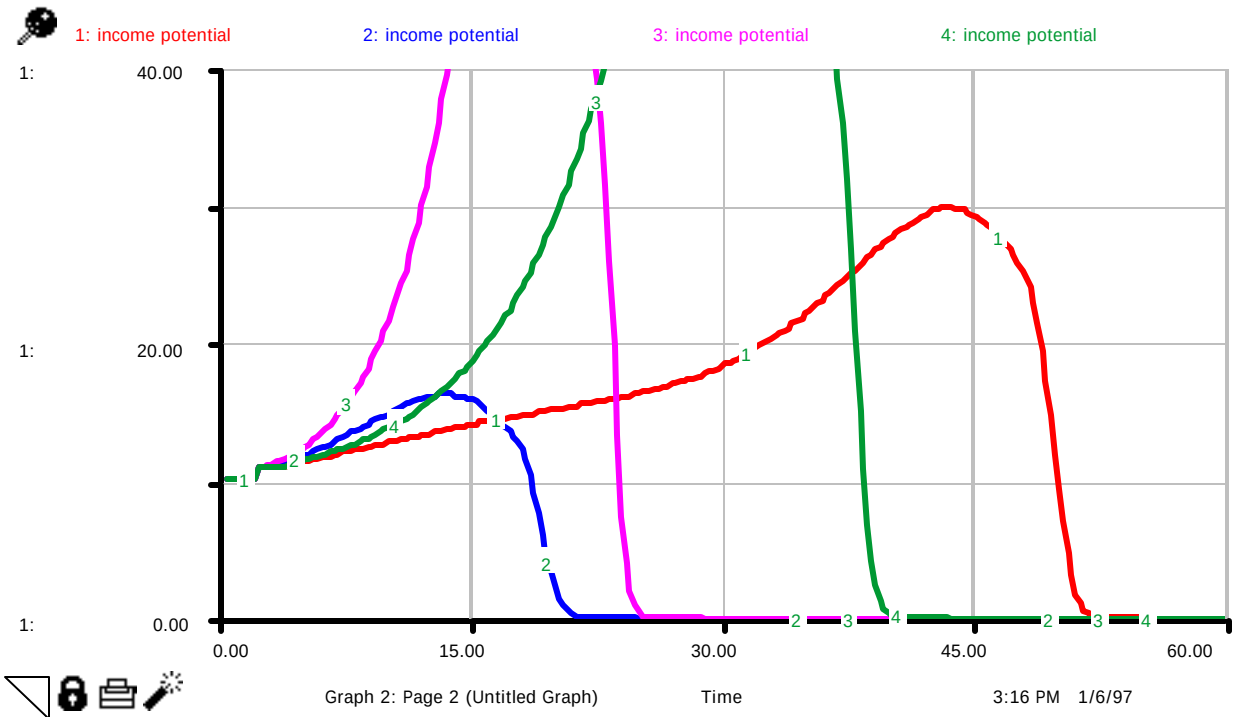
Collegiality is meanwhile further weakened through the local positive feedback loops it forms with control need, manifest authority and citizenship which, through resource allocation process, also push up the level of bureaucratization. These processes accelerate the imminent downturn in income potential. Thus, the functions of an innovation organization cannot be sustained unless changes occurring in the value system can be controlled.

b) Sensitivity of the system to changes in policy-related parameters

Sensitivity analysis is an important process for identifying entry points into a system. Sensitivity analysis was carried out by first carefully identifying candidate parameters and then systematically changing them one at a time by 10%. Each simulation with the changed parameter set was compared with the base run simulation with the standard parameter set to asses the qualitative impact of the parameter changes. Sensitivity experimentation was carried out in two parts. The first part focused on policy possibilities concerning enhancement of knowledge and professional competence, the second on those pertaining to the nature of governance. The results of sensitivity experimentation are shown in Figures 6 and 7. Only income potential is plotted for comparison of the sensitivity runs with the base run since it sums up the impact of all other attributes.

Figure 6 involves stepping up three parameters, interpreted respectively as autonomously increasing productivity, increasing learning effort and increasing entry level competence of personnel concerned with the production of output. The first policy might call for changing working methods and procedures through re-engineering; the second would require introducing training and self-improvement opportunities and the last calls for refining recruitment policy to select better-qualified people to join the organization.

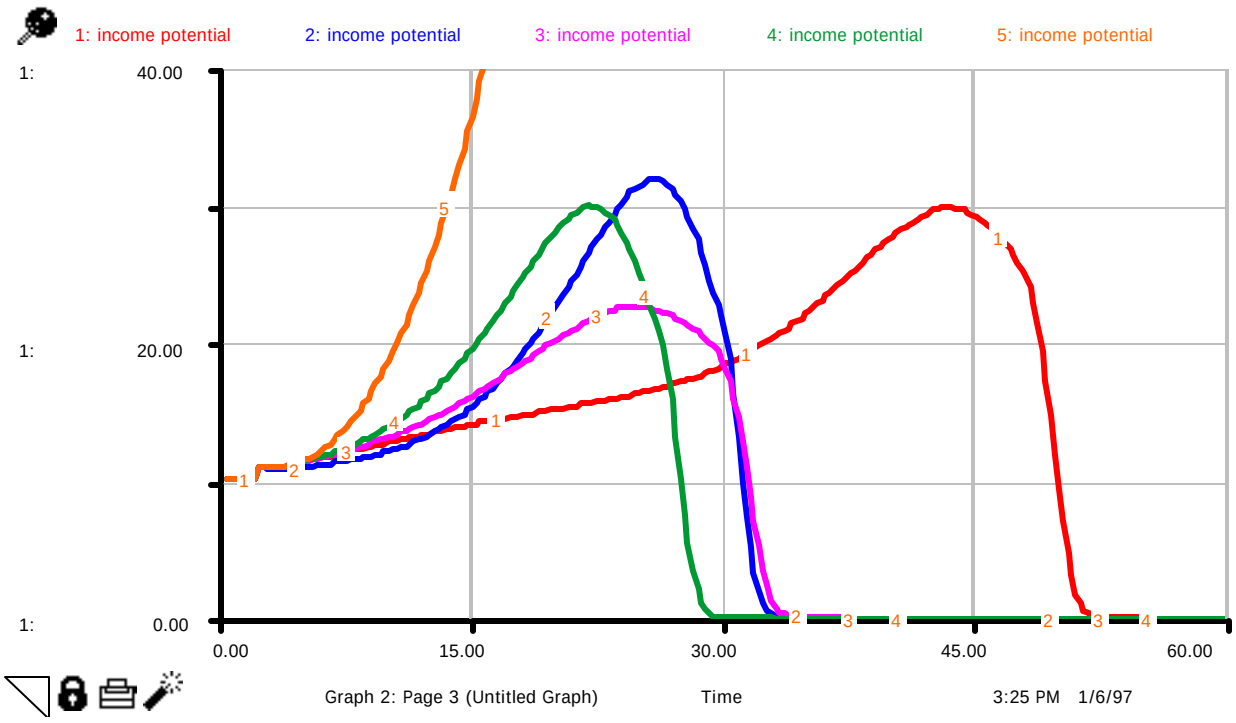
As is evident from Figure 6, none of these policies is able to sustain the income potential. Each creates a further growth impetus that culminates into a sharp down turn. Since the growth impetus inevitably also invokes a growth in authority and bureaucratization, which restrain citizenship and autonomy, a healthy growth of collegial authority is stifled which results in manifest authority dominating the governance system and thus suppressing collegiality. The subsequent decline in productivity and a shortage of resources in production activity constrain production, which creates a downturn also in the income potential.



1 - base run
2 - increased productivity
3 - increased learning effort
4 - increased entry level competence

Figure 6 Sensitivity runs incorporating enhanced learning effort

Figure 7 also involves three parameters, but one of these is also varied in magnitude. Changes in these parameters are interpreted, respectively, as autonomously increasing resource allocation to production, increasing support to the growth of professional scope possibly through consciously eliciting a greater collegial participation in the decision process, and limiting the growth of administrative scope that fuels manifest authority, first incrementally and then completely, possibly through restrictions on autonomous administrative actions. All these parameter changes again provide an impetus to the growth of income potential, although all except the last fail to check stagnation followed by a precipitous decline.



1 - base run
2 - increased resource allocation to production
3 - increased support to professional scope
4 - minor limitation of administrative scope
5 - absolute limitation of administrative scope

Figure 7 Sensitivity runs incorporating value change effort

The last change involves driving down the administrative scope yield to zero, implying that a charter or an institutional norm is in place that checks against the use of administrative infrastructure to increase manifest authority. With this change, growth shown in the simulation is unfettered, although in reality there will be other constraints to growth that are not included in the model. A sanction against the use of administrative infrastructure to further administrative scope is, therefore, critical to sustaining an innovation organization. This really means that an organizational manga carta protecting rights and prerogatives of both manifest and collegial roles in the organization must be drawn up if institutional norms and external peer adjudication are unable to deliver them.

In every day experience, personalities of individuals are often credited or blamed for organizational performance. Personal characteristics are to some extent subsumed in the model in its parameters and

behavioral response functions, the patterns of behavior the model generates are found to be largely independent of a wide range of variation in these behavioral parameters. This implies that the role structure of the innovation organization might be the key determinant of its behavior rather than the personalities of the individuals managing it.

Sensitivity tests with the delay parameters of the model also reveal that unequal gestation periods associated with the changes in collegial and manifest authority bring about a rapid decline while equal gestation periods create an expanding oscillatory tendency. Unequal gestation periods evidently create an imbalance that amplifies corrections towards the system goal of maintaining manifest authority. In practice, however, an organization will not survive violent cycles in resource allocation, income potential and the nature of its governance system and resurgence might only be hypothetical. Hence, an effort is not made to interpret this sensitivity.

c) A policy framework to sustain an innovation organization

The plots of changes in other variables, representing organizational performance and governance structure appear in Figure 8 when administrative scope yield is driven down to zero implying a sanction against the growth of administrative scope. It is seen that while collegiality rises, productivity also surges ahead from the possibility to invoke citizenship behavior that helps to mobilize professional competence to innovate for improving productivity in the organization. The professional competence level does not increase as policies for this are not yet in place, but this is not an impediment to growth in productivity, collegiality and income potential (not shown). The fraction of resources in administration at first declines since production needs take precedence over control needs due to collegial pressure. This fraction, however, recovers since robust growth requires that administrative infrastructure should constantly be upgraded to support the expanding organization. However, since this infrastructure may not be used to expand administrative scope, governance process continues to have a healthy balance of authority and collegiality that invokes good citizenship behavior allowing professional competence to be mobilized in the interest of the organization.

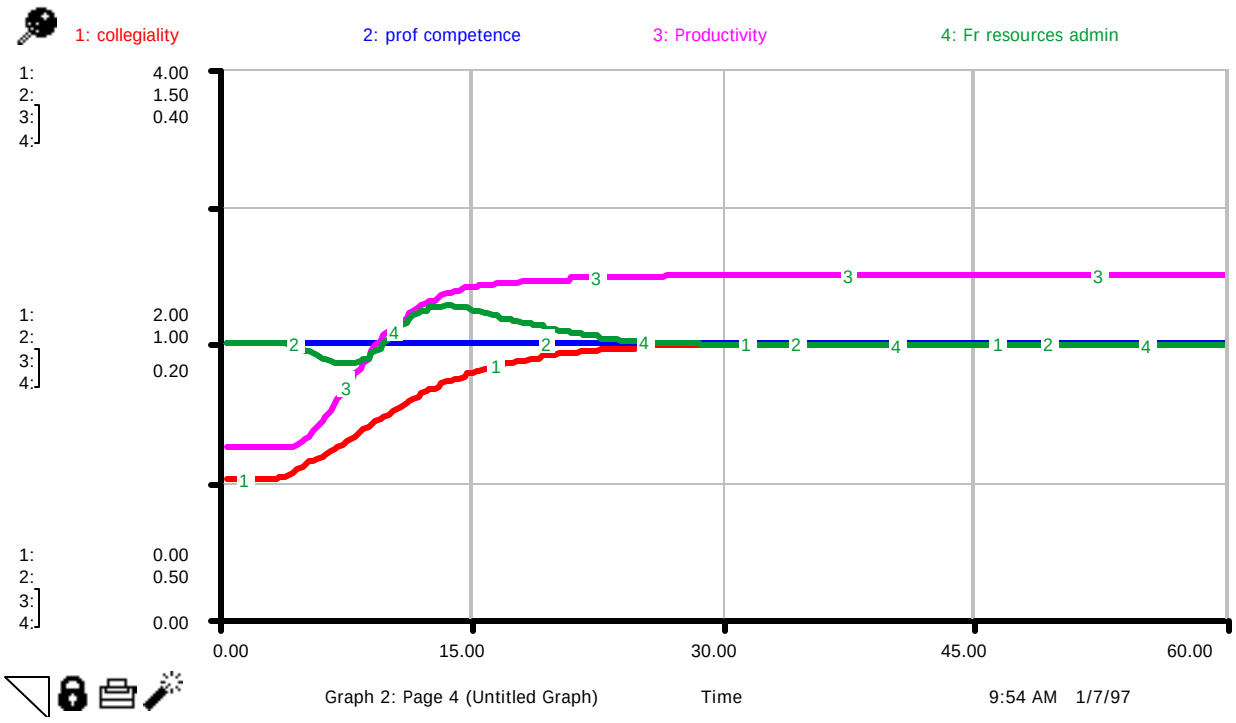


Figure 8 Critical policy run incorporating absolute limitation of administrative scope

Once, the critical policy of a sanction against the growth of administrative scope is in place, instruments to facilitate learning already tested in the sensitivity analysis can further improve performance, although on their own they are quite ineffective. Figure 9 shows a simulation of the critical policy instrument implemented together with three other parameter changes representing respectively a stepping up of the learning effort, an autonomous increase in ambient level of productivity from improving working procedures and an increase in entry level competence from changes in recruitment policy. This policy combination not only causes professional competence level in the organization and the productivity to rise, which gives further impetus to the growth of income potential, it also limits growth in the fraction of the resources allocated to administration thus improving overall productivity, since the collegial nature of the governance system created in this process would give a higher priority to the production activity than in the previous case.

The policy framework issued by above analysis for sustaining an innovation organization calls in the first instance for the creation of an organizational charter that institutionalizes referent authority by placing sanctions against autonomous growth of administrative scope. Once this critical policy is in place, learning facilitation and productivity improvement instruments allow increasing efficacy further. These

two categories of policy instruments are analogous in their functions to Herzberg's motivators and hygienes [Herzberg 1966]. The presentation of a policy specification in this form is an important part of the experimental analysis conducted with system dynamics in author's experience as against drawing an undifferentiated grocery list of policies [Saeed 1996a].

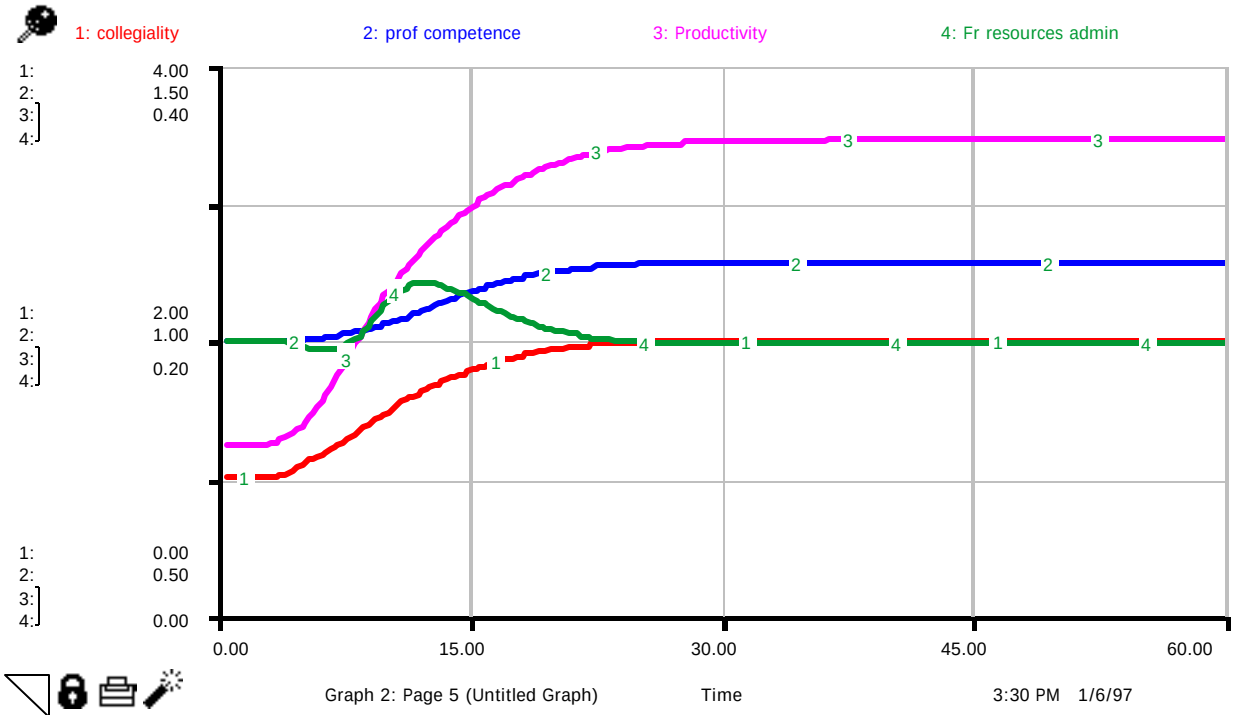


Figure 9 **Best policy run incorporating critical policy of absolute limitation of administrative scope, together with facilitating policies of increased emphasis on productivity, learning and entry competence.**

Implications for the design of innovation organizations

The design of formal organizations has traditionally relied on two approaches, mechanistic and organic and their various combinations to suit the product, the process, the technology and the environmental conditions [Schermerhorn, et. al. 1985]. The design considerations of the mechanistic structure include specialization, hierarchy, span of control, grouping, rule enforcement and external rewards. Those of organic structure include decentralization, autonomy, collegiality, job enrichment and internalized motivation [Simon 1976, pp. 20-44]. Simon also pointed out that producing intangible goods and

services poses different organizational problems from producing tangible widgets, since output quantity and quality are not amenable to cardinal measurements. Therefore, he saw the design of the decision and the resource allocation processes to be of critical importance in such organizations [Simon 1976, pp. 288-308]. Since innovation organizations must also constantly concern themselves with identification and solution of new problems, they must provide for a decision process that allows the organic components of the organization to work effectively, which is not easy as shown by the preceding experimental analysis of this paper. These organizations involve a complex structure in which manifest and collegial parts of the governance must function side by side. A conflict can easily arise between the two types of decision prerogatives, which may often be resolved by strengthening the manifest authority structure, and this may snowball into stifling the collegial processes critical to the sustenance of professional competence and innovation. Hence, another design consideration, that of creating a charter that preserves collegiality and contains manifest authority, must enter the picture [Litwin, et. al. 1996].

At the level of a nation, a charter must define the rights and the prerogatives of the public and the limitations of the government that is charged with the responsibility of delivering them, otherwise, a government would loose commitment to public welfare and allocate increasing amounts of scarce resources to preserving its own power interests [Popper 1977, Saeed 1990, 1994]. Likewise, a charter in an innovation organization must define the rights and the prerogatives of the manifest as well as latent roles. The nature of this charter for a specific application can be discerned through the type of experimental procedure outlined in this paper using system dynamics modeling and computer simulation. Broadly speaking such a charter must define role prerogatives for the collegial context and role limitations for the manifest context of the organization. It will help to keep power interests at bay and maintain an appropriate blend of manifest and collegial forms of authority in the governance system to cultivate an appropriate level of collegiality. The citizenship and autonomy that a charter would invoke should help to mobilize existing professional competencies for meeting organizational remits, which is a key to sustaining an innovation organization.

Although innovation and technological development are proven sources of economic growth in the developed countries while they have also been posited as means for fueling the development process, they are seldom explicitly incorporated into the planning policies of the developing countries [Saeed and Prankprakama 1997]. Thus, the potential of technological development and innovation as policy levers remains underutilized, since it is not clear how human ingenuity can be mobilized in the societal interest. The answer to this enigma evidently lies in directing development effort to the creation of innovative organization designs that not only allow knowledge acquisition, but also its mobilization in the societal context. Institutional development for economic growth should, therefore, seriously considers design considerations outlined for the innovation organization in this paper.

Conclusion

The need for creating designs to sustain innovation and professional competence in organizations is widely recognized since it is critical to the effective functioning of an increasing number of developmental institutions that must undertake to produce increasingly complex and often intangible products in a rapidly changing environment calling for continuous innovation endeavors. The characteristics of the internal environment conducive to innovation are also widely known, but the design parameters for creating and sustaining those characteristics have been unclear. Thus, as Senge (1991) points out, innovation organizations are susceptible to developing a learning disability over the course of their operations even if they started out in good health, unless their members stay alive to the need for continuously upgrading their mental perceptions of the world around them. Creating roles with such motivations is, however, an organizational design problem, which requires looking beyond conventional design parameters.

This paper has attempted to understand the information relationships that inhibit the organizational learning process, which makes innovation organizations unsustainable. The analysis of the paper shows that the use of scope to create manifest authority is a significant factor diminishing the role of collegiality in the governance system. This stifles organizational learning ability, making the innovation organization unsustainable. Adherence to a charter limiting manifest authority and assuring the exercise of collegiality are, therefore, the key to sustaining professional competence in an innovation organization. Chartering is identified as an important design tool for creating a sustainable innovation organization. Experimentation using system dynamics modeling subsuming pertinent relationships governing key functions of the innovation organization seems to be of considerable value in creating innovative organizational designs.

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APPENDIX

Model Equations

Admn_Scope(t) = Admn_Scope(t - dt) + (Admn_Scope_growth - Admn_Scope_Decay) *dt
INIT Admn_Scope = 1
Admn_Scope_growth = (((AdmnRes)*admn_scope_yield))*.125
Admn_Scope_Decay = Admn_Scope*FrAmnScopeDecay
Prof_Scope(t) = Prof_Scope(t - dt) + (Prof_Scope_Growth - Prof_Scope_Decay) * dt
INIT Prof_Scope = 1
Prof_Scope_Growth = (ProfRes/8)*prof_scope_yield*autonomy*citizenship
Prof_Scope_Decay = Prof_Scope*FrProfScopeDecay
admn_scope_yield = .5*(1+STEP(0,2))
bureaucratization = SMTH3(Bureaucratization_potential,2)
Bureaucratization_potential = (AdmnRes/total_resources)*5
collegiality = (Collegial_Authority/(Manifest_Authority+Collegial_Authority))/(1/2)
Collegial_Authority = SMTH3(Prof_Scope,2)
FrAmnScopeDecay = .125*(1+STEP(0,2))
FrProfScopeDecay = .125*(1+STEP(0,2))
Manifest_Authority = SMTH3(Admn_Scope*1,1)
prof_scope_yield = .125*(1+STEP(0,2))*reputation
autonomy = GRAPH(bureaucratization)
(0.00, 2.00), (0.167, 1.97), (0.333, 1.88), (0.5, 1.73), (0.667, 1.52), (0.833, 1.27), (1, 1.00), (1.17, 0.74), (1.33, 0.51), (1.50, 0.3), (1.67, 0.15), (1.83, 0.05), (2.00, 0.00)
citizenship = GRAPH(collegiality)
(0.00, 0.00), (0.167, 0.02), (0.333, 0.07), (0.5, 0.16), (0.667, 0.31), (0.833, 0.56), (1.00, 1.00), (1.17, 1.41), (1.33, 1.70), (1.50, 1.84), (1.67, 1.93), (1.83, 1.97), (2.00, 2.00)
entry_competence(t) = entry_competence(t - dt)
INIT entry_competence = prof_knowledge/ProfRes
prof_knowledge(t) = prof_knowledge(t - dt) + (learning_rate + knowledge_turnover - obsolesence) * dt
INIT prof_knowledge = 1
learning_rate = ProfRes*learning_productivity
knowledge_turnover = MAX(ProfResAdj,0)*entry_comp_policy+MIN(ProfResAdj,0)*prof_competence
obsolesence = prof_knowledge*obsolescence_fraction
entry_comp_policy = entry_competence*(1+STEP(0,2))
Indicated_Productivity = Normal_Prod*citizenship*innovation
learning_productivity = (.125/8)*(1+STEP(0,2))*innovation
Normal_Prod = .125*(1+STEP(0,2))
obsolescence_fraction = .125*(1+STEP(0,2))
Productivity = SMTH3(Indicated_Productivity,2)
prof_competence = (prof_knowledge/ProfRes)/(1/8)
innovation = GRAPH(prof_competence)
(0.00, 0.00), (0.2, 0.1), (0.4, 0.23), (0.6, 0.42), (0.8, 0.67), (1.00, 1.00), (1.20, 1.36), (1.40, 1.63), (1.60, 1.81), (1.80, 1.94), (2.00, 2.00)
reputation = GRAPH(prof_competence)

(0.00, 0.00), (0.2, 0.04), (0.4, 0.11), (0.6, 0.26), (0.8, 0.53), (1.00, 1.00), (1.20, 1.41), (1.40, 1.70), (1.60, 1.85), (1.80, 1.95), (2.00, 2.00)
AdmnRes(t) = AdmnRes(t - dt) + (AdmnResAdj) * dt
INIT AdmnRes = 2
AdmnResAdj = (IndAdmnRes-AdmnRes)/2
ProfRes(t) = ProfRes(t - dt) + (ProfResAdj) * dt
INIT ProfRes = 8
ProfResAdj = (IndProfRes-ProfRes)/2
budget = (SMTH3(income_potential,2))*1
econ_health = SMTH3(Productivity/.125,2)
FrBgtAdmn = NormalFrBgtAdmn*control_need*prudence
Fr_resources_admin = AdmnRes/total_resources
income_potential = output*unit_yield
IndAdmnRes = budget*FrBgtAdmn
IndProfRes = budget*(1-FrBgtAdmn)
NormalFrBgtAdmn = .2*(1+STEP(0,2))
normal_unit_yield = 10*(1+STEP(.1,2))
operational_capacity = (AdmnRes/output)*.5
output = ProfRes*Productivity
total_resources = AdmnRes+ProfRes
unit_yield = normal_unit_yield*reliability*reputation
control_need = GRAPH(collegiality)
(0.00, 2.98), (0.2, 2.23), (0.4, 1.77), (0.6, 1.44), (0.8, 1.20), (1.00, 1.00), (1.20, 0.87), (1.40, 0.735), (1.60, 0.63), (1.80, 0.555), (2.00, 0.495)
prudence = GRAPH(econ_health)
(0.00, 0.4), (0.2, 0.43), (0.4, 0.48), (0.6, 0.59), (0.8, 0.76), (1.00, 1.00), (1.20, 1.30), (1.40, 1.63), (1.60, 1.85), (1.80, 1.95), (2.00, 2.00)
reliability = GRAPH(operational_capacity)
(0.00, 0.69), (0.2, 0.702), (0.4, 0.732), (0.6, 0.798), (0.8, 0.894), (1.00, 1.00), (1.20, 1.09), (1.40, 1.15), (1.60, 1.18), (1.80, 1.19), (2.00, 1.20)