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IMPROVING QUALITY OF GOVERNMENT THROUGH MASS EMPOWERMENT

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Abstract

There is an immediate need to improve quality of government (QoG) in Pakistan. Exaggerated information asymmetry and depleted civic norms have resulted in frustration of development goals. Public policy design and promulgation initiatives need to be augmented with modern day computer and media technologies in order to improve QoG. This paper identifies reasons behind ineffective policy initiatives and discusses the role of media in addressing them. Citing the example of Pakistan, this paper introduces the concept of mass empowerment and suggests how it can be affected in the developing world through the use of System Dynamics simulation models.
Key Words: *Policy Design and Promulgation, Quality of Government, System Dynamics, Simulation Modeling.*

Quality of Government and Social Capital

The quest for reasons behind frustration of development goals has shifted focus in recent times. Contemporary research is emphasizing more towards the phenomenon of Quality of Government (QoG) rather than the familiar variables of capital, labor and productivity. QoG is conceptualized in terms of prevalence of democracy, rule of law and the effectiveness/efficiency of government policies (Kaufmann, Kraay, Zoido-Lobaton 1999). Inefficient/ineffective policy initiatives in the developing world impede economic development and undermine democratic stability. Putnam (1993) postulated that a primary determinant of QoG is the existence of higher levels of social capital. Social capital of a society is defined in terms of the level of social integration, civic norms and a prevailing sense of trust among human beings. La Porta et al. (1997) and Knack and Keefer (1997) present empirical evidence of higher QoG in societies having a larger stock of social capital. Higher levels of social capital are believed to affect QoG by:

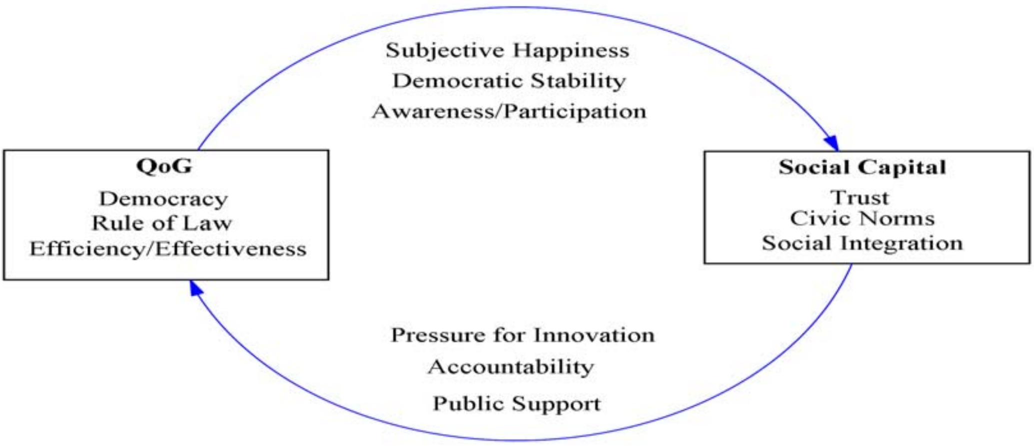
1) Making the government accountable for their policies.
2) Pressurizing the government to innovate in the wake of new challenges.
3) Providing better support of government initiatives through public participation.

A competing school of thought suggests, however, that it is higher levels of QoG that increase the level of social capital (Delhey and Newton, 2005). A higher quality of government institutes, and the resultant success of their policies, has a number of important social outcomes for societies and individuals alike:

1) Successful policies ensure democratic stability.
2) Perception of a higher QoG results in higher levels of awareness, understanding and participation among citizens.
3) Higher QoG leads to higher levels of subjective happiness.

Eventually, an increase in civic-mindedness, trust and social integration results with the increase in QoG. With the help of research cited above, we can conclude that social capital plays a significant role in ensuring higher QoG as well as measuring its results. Figure 1 summarizes the concepts discussed so far.

Figure 1: The Relationship between QoG and Social Capital



This paper aims at suggesting a mechanism for effective design and promulgation of public policies. Use of simulation models based on the System Dynamics methodology will ensure high quality of policy design and promulgation resulting in significant improvement in QoG. Additionally, use of this methodology will enhance the level of trust, promote civic norms and improve the levels of social integration within a society.

Organized in six sections, this paper draws out the links between System Dynamics, TV media, social capital and QoG. Section two identifies reasons behind ineffective/inefficient policy initiatives by governments in the developing world. Section three discusses the role of media in addressing policy issues and introduces the concept of mass empowerment through simulation. Section four elaborates upon the rationale for use of simulation models for policy design and promulgation. The fifth section demonstrates, with the help of an example, how System Dynamics models can aid mass empowerment. We conclude our discussion with recommendations for future research in the sixth and final section.

Issues in Policy Design and Promulgation

1) Complexity

Jay W. Forrester (1965) tests innate human assumptions about how the world works by asking a question: "Who are the most important people responsible for safe operations of aircraft?" Most people think that it is the pilots, their performance is most crucial for safe operation. Forrester argues that, although well trained and skilled pilots are critical, it is the designers that are most important. It is the responsibility of the designer to ensure that the aircraft is "stable, robust under extreme conditions, and that pilots can fly safely even when stressed, tired, or in unfamiliar conditions." In the context of public policy, policymakers play the role of both the pilot and the designer. As pilots, they make decisions that alter the course of their nations' progress. As designers they develop new policy structures and strategies that change underlying methodology governing the decision making process of those responsible for policy implementation.

The policymaker's job is confounded by the complexity of economic and social issues, the number of stakeholders involved, conflicting goals of those stakeholders and the uncertainty due to a constantly changing environment. The effects of policies on social and economic state of a country can never be forecasted accurately. In reality, projected policy outcomes are, at best, optimistic conjecture. A great amount of uncertainty exists when it comes to evaluating policy outcomes as policy design essentially involves both scientific as well as value judgment. Policies can never be the panacea the developing world expects them to be, as there is simply no such thing as a single best policy. In reality, an overwhelming majority of policies in developing countries turn out to be mere placebos, at least as long as the current government is in power.

Although the complexity involved in modern day policy making is by no means less than that of an aircraft, the use of simulation and modeling, while prevalent in aircraft designing, is non-existent in policy design settings. Even though things have changed dramatically in the developed world since the 60s, governance and policymaking environment in the developing world is still quite primitive. Policymakers mostly rely on trial and error, so called best practices, political influences, their own mental models or value judgments while designing new policies and making decisions.

2) Normativeness

Policies are essentially a set of decisions, strategies and plans intended to work in synergy in order to achieve an objective. Some stakeholders, although overtly committed towards the goal, might still be justified in criticizing some of these strategies. Owing to their normative nature and inherent uncertainty, even competently formulated and well-intended public policies may elicit criticism from political adversaries and the general public. The procedures for policy making and its promulgation adopted in the developed world are fundamentally primitive, rooted in methodologies of the pre-computer-age era. These procedures can be safely termed as outdated as they do not contain elaborate mechanisms to record the evolution of the policy making process. There is no sound basis within these procedures to document the circumstances prevalent at the time of policy design, in terms of pressures, threats, opportunities and uncertainties. The brainstorming effort done by a group of policy makers, and hence the premise behind their choices, remains inaccessible to the stakeholder. In the absence of proper documentation and rendition of the policy making process, it is hard for evaluators to appreciate its innate limitations and assumptions. Therefore, the general public has an elusive, if at all any, picture of the policy making process and the policy itself.

Consequently, policies made at a given point in time, no matter how 'good' they are, can easily be rejected as ineffectual when evaluated at a later time. It is often very hard for the policy makers to defend themselves when faced by questions such as "what was going through your minds while formulating this policy? Why wasn't it obvious that it won't work?" This inability of policymakers to defend their policies eventually affects the stability of democratic governments as the general public loses trust and views government initiatives as inefficient and ineffective. It is hard to convince such enquirers because they usually evaluate the success or failure of a past policy against the benchmarks of the present day. They fail to realize that conditions, under which the decisions were made, have changed significantly over the course of its implementation. The human mind is unable to transcend the boundaries of time and space and make able decisions by comprehending the dynamic nature of economic and social policy making process is a well documented fact (Hogarth, 1987; Simon, 1947 and 1979).

3) Asymmetry of Information

Citizens are imperfectly informed about government actions. This is a natural phenomenon termed by Nobel laureate Joseph Stiglitz as "asymmetry of information" (Stiglitz, 1999). In the context of developing countries, however, this asymmetry is found to be amplified to epic proportions. Factors such as low media penetration, restrictions on speech, secrecy laws and illiteracy are the major contributors towards egregious asymmetry. This asymmetry of information leads to "political agency" problems of "hidden action" and "hidden type"; much akin to the agency problems between corporate managers and shareholders (Besley and Burgess, 2001). These problems, along with a long history of failed policies and in-grained corruption has completely eroded citizens' trust in the government. Furthermore, the general public is usually less interested in policy issues because of their inability to extricate themselves from challenges of everyday survival and fulfillment of their basic needs. There exists a widespread belief that the policy makers are neither accountable to the public nor are they empathetic towards their needs. The estranged public views policymakers' interest to be directly in conflict with their own. Hence, the general public in developing countries remains disinterested, alienated, dissatisfied and skeptical towards public policies. This situation explains predominantly low level of social capital within developing countries.

Common outcome of all these problems is policy failure. Even the most efficient, and clearly beneficial, policies face stiff resistance at the implementation stage, hence frustrating the government's goals. The issue, therefore, boils down to lack of trust and civic norms within the developing world. Governments must elicit public trust in their policies by enabling people to participate in the policy making process. William Ruckelshaus (in Baden and Noonan 1998, xi-xii) argues that the major cause of public policy failure is the lack of stakeholder involvement. Meadows and Robinson (1985) discuss the same problem stating:

"A key source of frustration [regarding public policy] … [is that] The logic, if there is any, leading to a social policy is unclear to most people affected by the policy."

Citizens have the right to accurate and up to date information regarding changes in various social and economic phenomena that directly affect their lives. However, media coverage of trends and changes in these phenomena is, at best, narrative in nature. Information regarding population growth, demographic changes, inflation, GDP, trade deficit, remittances, government spending and foreign aid inflow etc. is conveyed in the form of simple numbers and graphs. Dissemination of these facts and figures does not aid the public to track the same back to government policies. Merely reporting a set of indicators, extracted from published reports, without presenting their interdependencies and dynamics is, more often than not, misleading and confusing. These excerpts are noting but snapshots of the state of the country; they do not inform the audience about what particular decisions or actions (policies) led to the current state. Similarly, verbal commitments and policy statements ensuring to 'improve the sate of economy' do not provide any solid basis for evaluating the effect of these policies. Hence the general public is fundamentally, and perhaps deliberately, incapacitated to judge the quality of governance being provided to them.

How do policy makers' decisions in a given year (or a number of years) translate into the economic and social indicators? This vital question needs to be publicly debated upon for all development policies formulated by the government. Unfortunately, it seems as though economic and social policy matters within the developing world have been implicitly declared to be too complex for the general public to comprehend, debate upon or participate in. A natural consequence of this belief within bureaucratic and political spheres is the "decide-announce-defend" approach towards public policy, used so often in the developing world (Walesh, 1999). Post announcement debates on public policy continue to remain mostly the domain of the politicians, analysts, economists or bureaucrats. Little effort has been made to educate and hence empower the masses to participate in policy debates.

Mass Empowerment

Industry, government and the general public are three primary stakeholders of mass media. Media serves the industry by informing manufacturers, traders, investors and consumers about commercial activities and opportunities. The government benefits from dissemination of its incentives and policies. And finally, the media enables people to express their opinion and examine the actions of both industry and government. Efficient fulfillment of this ternary role of media has great development implications. The World Development Report (World Bank, 2002, 181-182) provides examples of a number of untraditional and innovative ways in which the media has helped the greater cause of development. For example, in Nicaragua and Panama, media initiatives designed to leverage scholastic education improved student performance in underdeveloped areas. Similarly, in Botswana, media played a key role in civic education. Campaigns about civil rights, bureaucratic procedures and government policies empowered the public by increasing their knowledge and helped the government in gaining support for these issues.

Over the past few years, mushrooming growth and phenomenal success of private news channels bears testimony to demand of information and knowledge in Pakistan. The number of TV viewers increased form an estimated 63 million in 2004 to 86 million by 2009. Moreover, a majority of these viewers resides in small towns and villages. Viewership of news, socio-political political talk shows and infotainment programs of popular news channels is greater in volume as compared to programming purely focused towards entertainment (Gallup Pakistan, 2009). The exponential growth of TV media in terms of number of channels, viewership and quality of programming production is catalyzed by a number of factors. The first catalyst is a predominant cultural attribute of the nation: a strong need for social and political information. This need, although being met partially, was not completely satisfied previously by print and broadcast media. The broadcast media was under state control hence its credibility is perceived to be dubious. This skepticism is due to a combination of the low level of trust within the society and a history of political agency problems. Hence the perceived freedom of private electronic media served as the second major driving factor behind growth of TV media. Improved quality of information delivered by private media served as the third growth facilitator.

This enhancement was attained essentially due to the relative difference in operating efficiency of a private versus a public organization. Print media, although highly pervasive and having a higher degree of perceived freedom, is limited only to the literate. TV media does not impose such restrictions on its consumers hence greatly enhancing its consumer base. The final driving factor, and perhaps the most important one, is the way information is presented on TV. The quality of information delivery in modern day television is enhanced manifold by the synergy of audio, video, text and computer graphics. Augmented by all the factors described above, television media has diffused within the society at a phenomenal rate, gained faster and widespread popularity and a great amount of power.

These conditions are now prevalent in a majority of developing countries due to advancement in information and communication technologies. Hence, highly favorable conditions exist for TV media to fulfill its supreme objective: development through empowerment. The authors believe that a massive initiative to build social capital in developing countries is an impending phenomenon waiting for selection of appropriate methodology by the media. A phenomenon we term as “mass empowerment”. Such mass empowerment, once realized, provides stimulus for greater public debate. Structured, guided and well documented debate can gain enough momentum to ensure effective scrutiny of government policy and its alignment of with public interests. The result, therefore, is addition to the stock of social capital within the society. A mass empowerment initiative is essentially a three step process:

1) Communicating precise policy objectives to the public, i.e. what the policy is and what specific issues it aims at addressing.
2) Educating the public about the policy making procedure and the logic behind decisions.
3) Involving the public in decision making by incorporating an efficient participatory framework within the policy making process.

It is imperative that public policies, which are financed by public money, may be approved only after eliciting popular support from the primary stakeholders. Instead of being designed by bureaucrats and approved by politicians behind closed doors, these programs and their impact on the lives of the stakeholders needs to be discussed. However, before the general public in developing countries can be successfully involved in the policy making process, there is a need for effective information dissemination and civic education. A comprehension of the true structure of socio-economic systems is necessary before the cause and effect relationship between various policies and their outcomes can be understood. The primary question that arises here is: how to involve major portion of a vastly illiterate public in policy debate regarding complex socio-economic issues? The answer is: through System Dynamics based simulation models.

Why Simulate?

The Latin verb 'simulare' means to imitate or mimic (Microsoft Encarta, 2007). Simulation models are built in order to create a "laboratory replica" of a real system, termed as "micro-worlds" (Morecroft, 1988). Simulation modeling techniques use a methodology rooted in the iterative interplay between the real world and the virtual world. A model is meant to be an abstraction, and not the exact replica of real world systems. Any attempt to replicate the real world within a model will result in an entity as complex and messy as reality. Acquiring any sort of knowledge or insight from these models will hence be impossible. The main idea behind modeling is to perform experiments that are otherwise impossible, unethical, or prohibitively expensive to carry out in the real world. After an initial model has been constructed, participating stakeholders use it to test alternative policies through simulations. The benefit of being extricated from bounds of time and having significant computational power at their disposal, allows stakeholders to analyze both long and short run effects of countless policies. Once the suitability of a certain policy for the intended purpose has been ascertained, it can be implemented in the real world. Implementation of a policy, and real time comparison of its outcomes with those simulated earlier, helps stakeholders to gain further insight about the problem. This knowledge can then be used to reformulate or augment the model. Hence it is a cyclic process to continually improve our understanding of complex socio-economic problems. Evidently, very few of us will be model builders and a majority will eventually be model consumers. In order to actively participate in policy debates and decision making in a complex modern day world, everyone including economists, politicians and the general public must have the ability to understand and use computer based simulation models. The authors deem this ability to be imperative for building social capital in the developing world.

Thankfully, comprehension of System Dynamics simulation models does not require any special skill as every human mind is already familiar with models. Our event oriented view of the world is actually a model that resides in our mind. Although imperfect, this "mental model" is our own rational interpretation of how things work. Our everyday decisions and actions are based on these mental models and we are continuously refining these models. John Sterman (1991) cites some important benefits and shortcomings of mental models and discusses how computer simulation models can be used to aid and augment our mental models. Among the major benefits of mental models is their flexibility and adaptability to new situations. Furthermore, mental models can use information in the form of qualitative as well as quantitative variables. On the other hand, major drawbacks arise from the inherent difficulty to communicate mental models to others. Additionally the underlying assumptions of mental models are hard to examine and hence there can be contradictions and ambiguities within these assumptions that can remain unexplored. Without the use of simulation models, these contradictions surface only when the individual's mental models lead to wrong decisions and failure (Meadows, Meadows and Randers, 1992).

Herbert Simon, a Noble Prize winning economist, has explored the use of mental models and the nature of human decision making process (Simon, 1947 and 1979). He points out that we take only a small number of factors into account while making decisions suggesting use of a rather simple array of mental models. Factors like bounded rationality, judgment error, bias, and dynamic complexity cloud the human decision making process. Scarcity of available information also plays a major part in limiting our capabilities to build effective mental models, and consequently, our faculty of effective decision making. Additionally, there is never enough time to collect the requisite information before deciding the best course of action in a problem situation. As a result, we are unable to develop a comprehensive and correct structure of our mental models, rendering them unsuitable for effective decision making (Hogarth, 1987).

Having entered the 21st century, it would be extremely naïve (or perhaps criminally negligent) of policymakers to bank just on their mental models while designing complex and multifaceted entities like public policies. Fortunately, these shortcomings of mental models can be conquered by augmenting our mental models and policy making process with computer based models. The first and foremost benefit of computer models is their explicitness; i.e. their underlying assumptions, biases and judgmental errors are well documented and/or evident in the model structure. Unlike mental models, a computer model can be easily communicated to others; hence it is available for analysis and criticism. Computers generate results based on the model's underlying assumptions and embedded logic. Any discrepancy in either logic or assumptions will result in unexpected or false outcomes, often even in the most basic of settings. Additionally, computer models can make use of the immense computational power available and can simultaneously account for the effects of innumerable interrelated variables within the system. Computer and mental models are "not polar extremes, but rather overlapping and mutually reinforcing ways to understand reality" (Forrester, 1997).

System Dynamics in Action

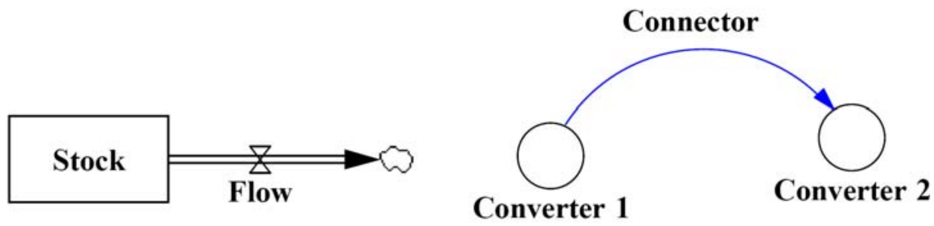
1) A Brief Introduction

System Dynamics is an academic discipline created in 1956 by Jay W. Forrester at Massachusetts Institute of Technology. This field was developed in order to enable decision makers to tackle significant, multidisciplinary and complex problems. Important problems which, once successfully solved, can lead to greater rewards. As a research methodology, System Dynamics is less related to the methodologies of the social sciences than to those of engineering. In this approach, management research methods have been extended and improved by those developed in the field of engineering (Forrester, 1975). System Dynamics models are used for experimentation to gather insights about the underlying systems and to eventually design effective policies for improved system performance. The term 'System' means an interdependent group of elements (variables and constants), which continually interact with each other to form a unified whole. The term 'Dynamics' refers to change over time. If something is dynamic, it is constantly changing. A dynamic system is therefore a system in which the variables interact to stimulate changes over time. Based on these definitions, System Dynamics can be described as a methodology used to understand what systems are and how do they change over time.

The underlying relationships and connections between the components of a system are collectively termed as the 'Structure' of the system. The way in which the constituent elements or variables of a system vary over time is referred to as the 'Behavior' of the system (Martin, 1997). In the System Dynamics method, the structure of a model is represented by a combination of stocks, flows and converters (Figure 2). These are the basic elements of a model. Stocks are things (variables) that accumulate over time, for example, the national debt is a stock variable and so is the inventory of a certain firm. A flow is the rate of change of a stock. It represents entities or variables that bring about change in stocks by moving things into or out of a stock. A converter is a secondary or augmenting entity in the model. It can be thought of as a 'transformer' or gain (as the term is used in control theory). These converters are used when variable data has to be manipulated or some sort of operation has to be performed at each time step during simulation. A converter can also be used to represent different variables and constants within the model. Another augmenting entity, a connector is an arrow that allows information to pass between all entities within a system dynamics model. InFigure 2, the connector to converter 2 from converter 1 signifies that converter 2 is a function of converter 1. In System Dynamics, there are defined set of rules as to how different entities can and can not be connected to each other and how information travels from one to another.

System dynamics has been used to address significant policy issues and it has succeeded in reaping great rewards for model users. A vast body of literature bears testimony to the success of System Dynamics models used to aid policy design and analysis in various fields and disciplines. Development Studies, Economics, Environmental Sciences, Health Sciences, Defense and Strategic Studies, Strategic Management and Operations Management are few such examples (Sterman, 2000).

Figure 2: Building Blocks of a Model: Graphical Notation in System Dynamics



2) The Model

There is ample evidence within System Dynamics literature regarding success of general, fairly simple and highly aggregate socio-economic models in eliciting public participation, enhancing public learning and providing valuable inputs for policy formulation (e.g. Stave 2002, and Rayston et al, 1999). Stave notes that use of System Dynamics models proved to be effective even in situations where the participants did not have knowledge of System Dynamics or the technical details of the policy issue under discussion (environmental issues in that case). The model presented in this paper is an attempt to develop a simple, fourth order, nonlinear, dynamic model representing the population of Pakistan. This model building effort is specifically aimed at demonstrating the power of System Dynamics in augmenting policy design, policy analysis and mass empowerment. All aspects of this effort: its specification, formulation, use and interpretation of its results, are guided by this particular aim.

Table 1: The Model Boundary

No.	Variable	Type	Description
1.	P014	Stock	Number of people between ages 0-14
2.	P1564	"	Number of people between ages 15-64
3.	P65plus	"	Number of people between ages 65+
4.	PEFR	"	Policy Effected Fertility Rate
5.	Births	Flow	Number of people born per year
6.	Deaths	"	Number of deaths per year of people above 65 of age
7.	Maturity1415	"	Number of people maturing to the age of 15/ year
8.	Maturity6465	"	Number of people maturing to the age of 65/ year
9.	Deaths014	"	Number of deaths per year of people between the age of 0 and 14
10.	Deaths1564	"	Number of deaths per year of people between the age of 15 and 64
11.	NCFR	"	Net Change in Fertility Rate
12.	Fertility Rate	Converter	No. of children a woman bears throughout her reproductive life

No.	Variable	Type	Description
13.	Total Pop	"	Total Population
14.	RCFR	"	Rate of Change in Fertility Rate
15.	HFR	"	Historical Fertility Rate
16.	Labor Force	"	Available Labor Force
17.	PercFem	Input Data	Percentage of Females in Population
18.	MortalityAdult	"	Average Adult Mortality Rate
19.	ParticipationRat e	"	Labor Force Participation Rate
20.	Fert	"	Fertility Rate Data
21.	Mortality65plus	" e	Avg. Mortality Rate of people above 65
22.	FertrtChngH	" e	Historical Change in fertility rate
23.	Mortality014	" e	Avg. Mortality Rate of people ages 0-14
24.	TRIP	Constant	Time Required to Implement Policy
25.	TFR	"	Target Fertility Rate
26.	FertileYears	"	Total Fertile Years of a woman
27.	PopPolicy	Input Sim.	Population Control Policy Impact

Note: 'e' = authors' estimates.

Purpose and Boundary: Purpose of this model is to elucidate the impact of government's population policy initiatives. Pakistan's population problem is at its worst since independence. Recession, inflation and unemployment have created a sever crisis in the country. Lack of basic necessities like food, power and fuel bears testimony to a long history of failed policies, democratic instability and a predominant gap between population growth and resource management. Cognizant of the fact and unable to manage resources, policymakers in Pakistan are pondering over imposing a tax on third child in order to curb population growth (The Nation,2009). Just like its predecessors, this initiative is not expected to produce intended results in time if policy design and promulgation is not carried out on scientific grounds. Better knowledge and appreciation of population growth phenomenon and its impacts on economy can guide public opinion, political initiatives and policies. In fact, public awareness and support is the only factor that can guarantee policy effectiveness when it comes to population control as the decision is in the individual's hand. This support, however, has not been forthcoming as Pakistan's is a conservative society greatly influenced by religious leaders (Hakim 2001).

Population control policies, once viewed in terms of simple cause and effect relationships, can lead to enhanced understanding and appreciation of their importance. Once it is clearly understood how peoples' lives are directly being affected by population growth, participation and support for government policies is expected to improve. Use of such models for generating debate on all government policies will lead to an eventual buildup of social capital within a society. All the variables included within the model represent its boundary. Table 1 gives a complete list of model variables with their type and description.

Figure 3: A Simple System Dynamics Model of Population of Pakistan

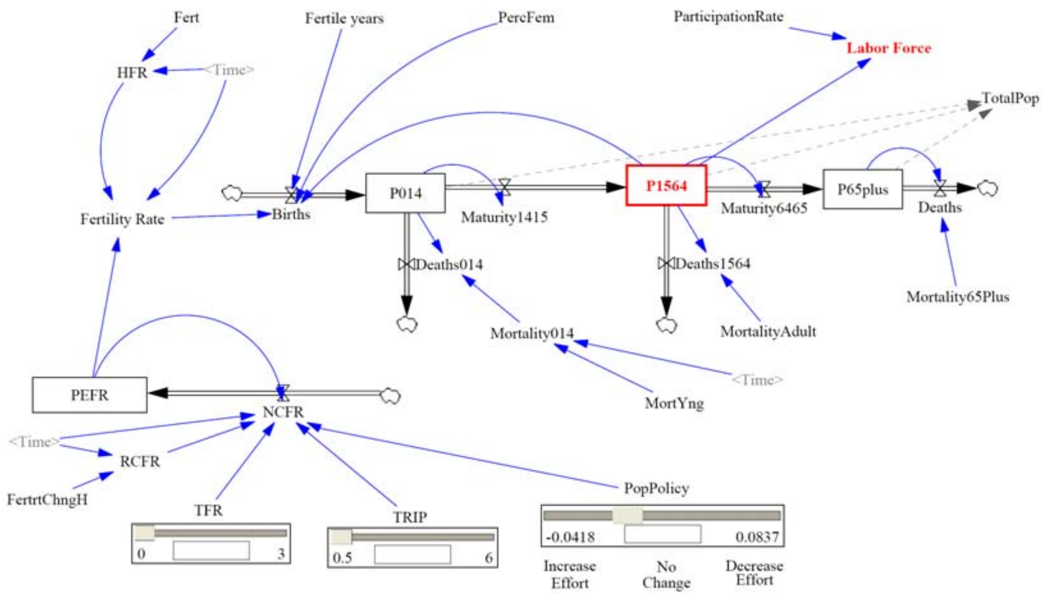


Figure 3 is a System Dynamics representation of the model. It shows the stocks, flows, connectors and converters included within the model. It is a simplified representation of the model as some auxiliary variables and constants have been removed in order to reduce clutter and improve legibility. Additionally, variable names displayed are more descriptive (and hence lengthy) in order to facilitate understanding. Developed using the VENSIM simulation environment (Ventana Systems, 2006), this graphical representation of a real world system makes it possible for model users to understand the cause and effect relationships between different model variables. Furthermore, VENSIM provides a platform for model users to interact with the model, varying the values of different parameters and viewing the result of changes they make in real time.

Overall population has been divided into three cohorts. One each for ages 0 to 14, 15 to 64, and 65 plus, respectively. Hence the population is represented as an aging chain formulated as a third order material delay with perfect mixing at each stage. There are two main reasons behind selection of this formulation. First, explicitly modeling for these cohorts makes this model re-usable in future extensions of the model containing labor, health care and education models etc. Second, data on these cohorts is readily available to validate model output. Each of the three cohorts is represented by a stock variable representing accumulation of 'people' in each stock. Outflow from these stocks is through either maturity or death. The first stock variable represents the adolescent population. Inflow to this stock is through the flow or rate variable named births. The birth rate, in turn, is dependent on the number of adults within the population, the prevailing fertility rate and the percentage of females within the adult population. These dependencies are signified by three arrows emanating from these three variables and terminating on the births variable. Inflows to the remaining two cohorts are through maturity in the cohorts immediately preceding them and are specified by the flow variables labeled 'MaturityXXXX'. Outflows due to death are determined by cohort specific mortality rates. The only remaining stock variable is 'Policy Effected Fertility Rate' formulated to capture the effect of population control policy.

Data, Formulation and Estimation: Annual time series data for input variables in the model, as well as reference data for model output validation, have been taken from the World Development Indicators (WDI) database (World Bank, 2008). A comprehensive definition of each input data variable and details about its source can be found in the WDI handbook. The stock variables are initialized using values from the WDI database in both the modes. Data on some of the variables is not available for Pakistan and author's estimates are used for these variables where specified. Similarly, initial values of all stock variables have been taken from the WDI database. The language used for development of this model is specific to the VENSIM modeling software. However the language is easy to understand and is similar to many common programming/scripting languages. Never the less, we present VENSIM equations here in a reader friendly format.

The value of population aged 0 to 14 is calculated by integrating the net rate of change in this cohort (Eq.1). The same equation can be represented in differential form as in Eq. No. 2. This stock variable is being affected by birth, death and maturity flows (Eq. 3 to Eq.5). Equation No.5 shows the simple formulation used for outflow through maturity. Equation No.6 signifies that historical fertility rates are used for simulation up to 2006 after which the estimated fertility rate is used for calculation of birth rate. Equation No. 8 gives the formula for calculation of Net Change in Fertility Rate (NCFR) under historical conditions as well as user defined scenarios. In case of historical time period (time less than 46) this variable takes historical values. In case the fertility rate has reached the limit of Target Fertility Rate (TFR), this variable is assumed to have a zero value. Otherwise, NCFR is computed by exponentially smoothing the value of current RCFR plus the effect of policy. The time duration used for smoothing is equal to the assumed value of Time Required to Implement Policy (TRIP). It is logical to assume that any new policy initiative takes time to come into full effect and bear fruit. In our case, this time is assumed to be five years. Rate of Change of Fertility Rate (RCFR) is computed by differentiating the

Historical Fertility Rate (HFR). The variable Fertile Years refers to the total number of years in reproductive life of a female. This value is set to 35 years, i.e. from ages 15 to 49, in accordance with national demographic data as specified in Pakistan Demographic Survey (Pakistan, 2005). Equations for remaining variables are similar to those explained above and are omitted for the sake of brevity. Complete model documentation can be obtained from the authors on request.

$$P014 = \int_0^t Births - (Deaths014) - (Maturity1415)dt \text{ ....Eq.1}$$

$$\frac{d(P014)}{dt} = Births - (Deaths014) - (Maturity1415) \text{ ....Eq.2}$$

$$Births = P1564 * PercentFemale * FertileYears * FertilityRate \text{ ....Eq. 3}$$

$$Deaths014 = P014 * Mortality014 \text{ ....Eq.4}$$

$$Maturity1415 = (P014)/14. \text{ ....Eq. 5}$$

$$FertilityRate = IF\ THEN\ ELSE(Time <= 46, HFR, PEFR) \text{ ....Eq.6}$$

$$PEFR = \int_0^t NCFR\ dt \text{ ....Eq.7}$$

$$\begin{aligned} NCFR = & \ IF\ THEN\ ELSE(\ (PEFR >= TFR), \\ & IF\ THEN\ ELSE(\ (Time < 46 : OR : PopPolicy = 0), RCFR, \\ & SMOOTH(\ (RCFR + PopPolicy), TRIP)), 0\ ) \text{ ....Eq.8} \end{aligned}$$

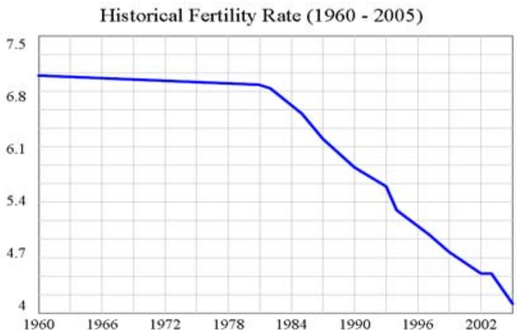
$$FertileYears = 35 \text{ ....Eq.9}$$

Having discussed the computed variables, we now describe the data and estimated variables used in the model. Historical Fertility Rate, expressed in terms of total number of births during reproductive lifetime of a female is presented in Figure 4. Panel (b) of the same figure shows historical data used for percentage of female population. A sharp decreasing trend is observable in both the variables after 1984. This decline signifies the effects of government health and population control policies. These policies, although conceived in the late 50's (Hakim, 2001), managed to have a considerable effect on the society only by the mid 80's. Contraceptive prevalence and better understanding of reproductive health issues were the major factors leading to decrease in fertility rate. Gender selection, through use of advanced medical facilities, might have played an important role towards decrease in the proportion of female population in the midst of increasing economic pressures.

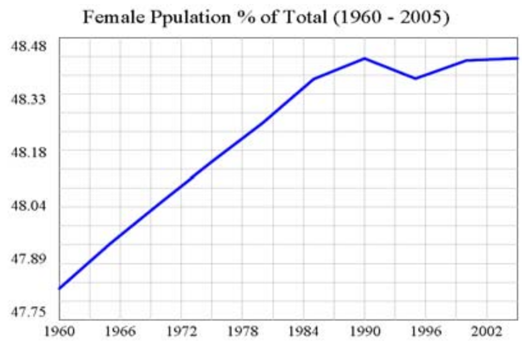
A major benefit of use of System Dynamic modeling methodology is its inherent explicitness; i.e. the model builder's estimations, assumptions and biases are well documented. Making the assumptions visible in a clear graphical manner allows them to be available for analysis and critique. The System Dynamics modeling environment also serves as a joint platform for all stakeholders to estimate variable values where no data is available. Authors' estimates of mortality rate for the first cohort (Mortality014) are shown below (Figure 4 panel (c)). These estimates are based on available data on adult mortality and fertility rate which point at a sharp decreasing trend after 1984.

Figure 4: Data Variables

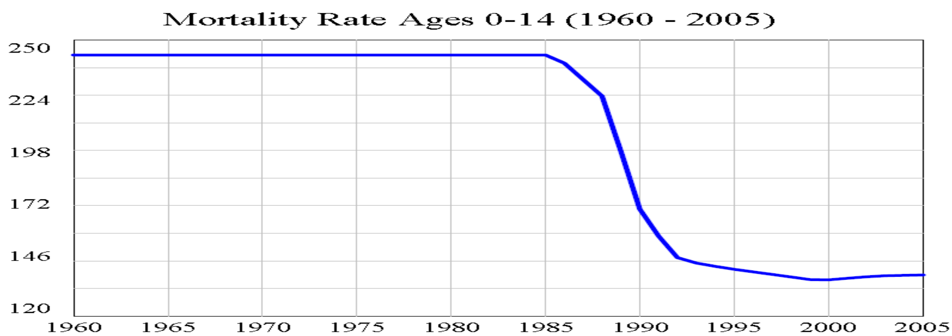
(a) HFR (Births per female)



(b) Percent Female (Dimensionless)



(c) Estimated Mortality Rate (Deaths per 1000 per year)



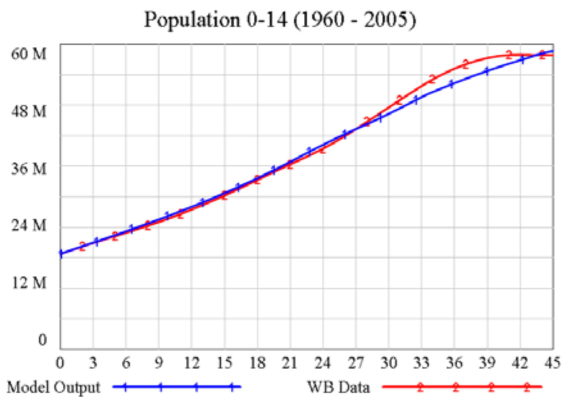
Results and Scenario Analysis: Model results can be viewed in two modes, historical and scenario analysis. Historical mode can be used to view results from 1960 to 2005. Validation of model formulation and parameter estimation is done in this mode. Actual data for output variables is available for this time period thus the model's performance can be verified. Visual comparison of model output with actual data serves as the validation mechanism used for this modeling effort. Additionally, statistical correlation of model output and reference data is also calculated. Figure 5 (Panel (a) to (d)) shows behavior of major model variables with respect to actual data from the WDI database. As visible in the figure, the model reproduces historical trends fairly accurately.

Linear regression β values for all these output variables are also high (around 0.9).

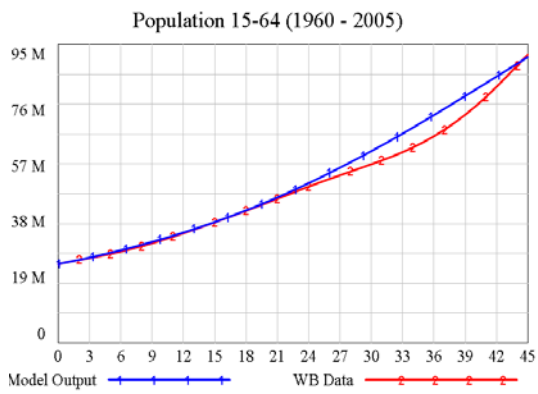
Next we discuss the impact of variation in population control policy on key model parameters. By doing so, we demonstrate the scenario analysis capability of System Dynamics methodology and the power of VENSIM simulation environment. In order to define meaningful scenarios for analysis of policy alternatives, we have to first quantify their impact on some physical phenomenon.

Figure 5: Model Output Validation

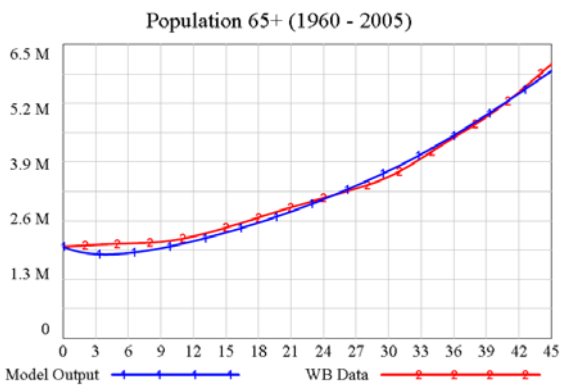
(a) Population 0-14 (People)



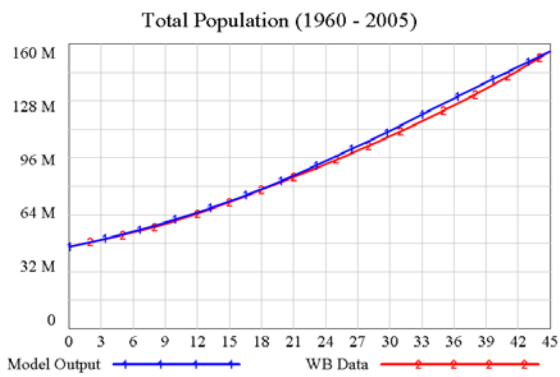
(b) Population 15-64 (People)



(c) Population 65+ (People)



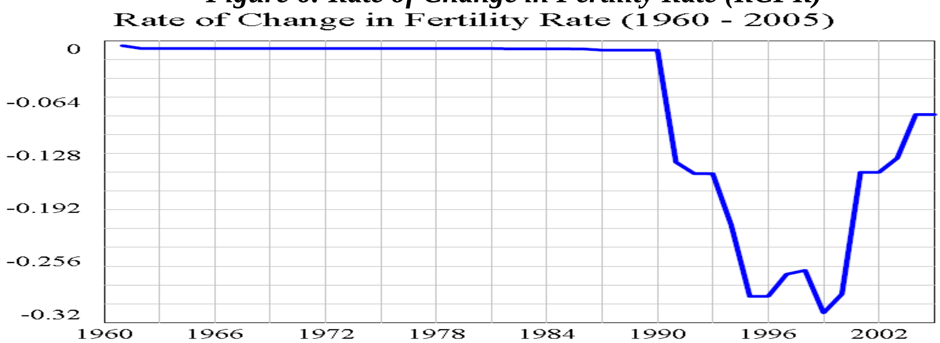
(d) Total Population (People)



This quantification has been achieved here with the help of historical data. The historical impact of population control policy on the rate of change in total fertility rate has been computed by differentiating HFR with respect to time (variable RCFR Figure 6). Governments devise policies, in terms of healthcare expenditure, awareness campaigns and contraceptive availability etc., in order to bring down the fertility rate. Change in the value of RCFR is used to quantify the contribution of government efforts in bringing down the population growth rate over time. As visible in the graph, population control efforts did not produce significant results until the 90s. The fertility rate was decreasing at a record rate of .3 per year by 1999. After that period however, impact of government efforts to reduce fertility did not prove to be as effective. The fertility rate did not decrease at the same pace and climbed up to a value of -0.0837 by 2005. An important point to observe here is that it took almost ten years for RCFR to reach from -0.0837 to the minimum recorded value of -0.3. Whereas the movement in the opposite direction (-0.3 to -0.0837) has taken only five years.

This observation has serious implications for population control policy. Although the fertility rate in the country is decreasing, it is decreasing at a decreasing rate. The upward push on fertility rate is becoming stronger by the day as compared to the downward pull. This essentially means that, if not redesigned, the policy might not be able to achieve its targets fertility rate in time. The population problem may well be out of control if initiatives are not taken right now to revamp the policy redesign and implementation efforts.

Figure 6: Rate of Change in Fertility Rate (RCFR)



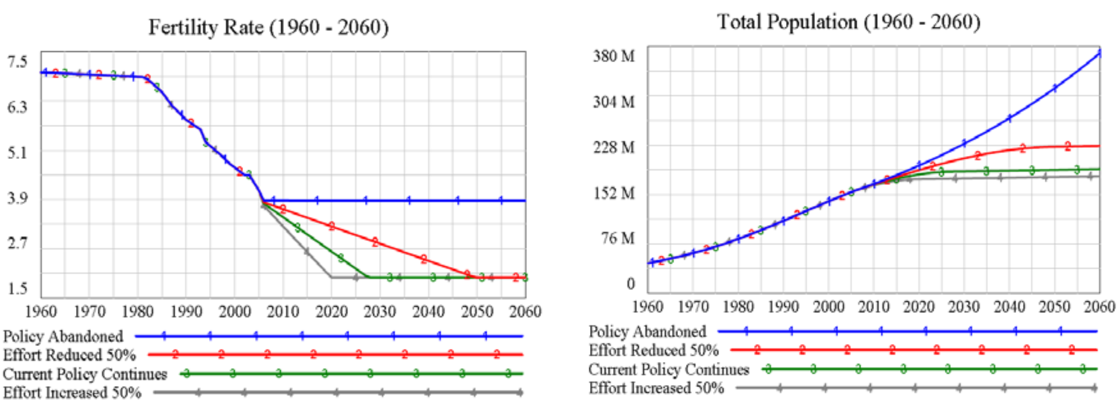
An increased emphasis on population control efforts within the country and the subsequent success in achieving policy objectives is greatly dependent on public awareness and participation. System Dynamics representation of a problem, within an environment that facilitates stakeholder participation in discussing policy alternatives, has been proved to increase awareness and gain support from stakeholders. As shown in Figure 3, a user friendly interface can be used to underscore the effects of policy efforts. Different outcomes of aggressive or lax population control policies in terms of change in fertility rate and total population can be assessed. The slider bar titled 'Population Control Policy' varies the rate of change of fertility rate and the model user can see, in real time, the effects of change in policy on any of the output variables according to the scenario selected. The Population Policy impact variable (PopPolicy) is assumed to take four different values which can be chosen by the user according to predefined scenarios:

1) Policy Abandoned: PopPolicy = 0.0837. i.e. NCFR = 0; Fertility Rate is assumed to remain constant at last historical value of 3.87.
2) Effort Reduced 50%: PopPolicy = 0.04185 i.e. NCFR = - 0.04185; Fertility Rate is assumed to decrease but at a lower rate.
3) Current Policy Continues: PopPolicy = 0. i.e. NCFR = RCFR; Fertility Rate is assumed to decrease at last historical value of -0.0837.
4) Effort Increased 50%: PopPolicy = - 0.04185 i.e. NCFR = - 0.12555; Fertility Rate is assumed to decrease at a higher rate.

Even if the government manages to reduce fertility at the current rate, target fertility rate (assumed to be 2 children per female) will be achieved by 2027 (Figure 7 Scenario 3 panel (a)). However, the total population will eventually reach to 190M in this scenario. The scenario analysis clearly suggests drastic efforts to further reduce the net rate of change in fertility rate (NCFR). It is important to note, however, that the model does not take into consideration the effect of population increase on fertility and mortality rates. Similarly, the feedback loop addressing the effect of increase in population on the country's economy and the resultant repercussions on population are also not considered. It is quite possible that, if population is not controlled in time, the society comes under immense pressure well before the population reaches to levels shown in scenario one and two. An unintended consequence of a vigorous population control policy might be reduction in proportion of females in the population (Figure 4 panel (b)). Increasing pressures to reduce the family size impacts societies like Pakistan to exercise gender selection. This phenomenon, not incorporated within the model, will generate a positive feedback effect and overall fertility might be reduced at rates faster than expected.

Figure 7: Scenario Analysis

(a) Fertility Rate (b) Total Population



Conclusion

System Dynamics provides an efficient platform to aid policymakers in their design efforts. The multidisciplinary nature of a policy, multiplicity of interconnected variables and the intricacy of feedback processes add to its complexity. System Dynamics, being a multidisciplinary methodology, with its ability to handle and present large number of variables and analyze complex relationships is a powerful tool to handle policy complexity. Additionally, this methodology provides efficient procedures for documentation of underlying assumptions, governing principles and prevailing environmental conditions guiding the policy making effort. Comprehensive documentation, coupled with a modular approach helps the policymakers in keeping a record of evolution of their thinking process.

Simple diagrams are used to represent the logic, mathematics and technical details of the problem in the form of a simulation model. The mathematical and scientific knowledge, in the form of equations and decision rules, is concealed at the back of the visual representation. Disassociating the graphical representation of policy from its scientific details is a unique ability of this methodology and the cornerstone of success of System Dynamics models. This ability prevents the models from becoming overly intricate, cluttered or esoteric for model users. At the same time, sufficient mathematical, scientific and methodological rigor can be incorporated within the model. Hence, System Dynamics can be used to develop a model which is highly sophisticated and easy to understand at the same time.

In essence, the model building process is completely decoupled from the model consumption process. This decoupling is actually the separation of understanding the mathematical formulation of a model from appreciation of its behavior. Modeling of socio-economic systems using System Dynamics allows model users to view system behavior both graphically and dynamically. Model users can instantly see and appreciate change in system states (and other variables) as they ‘play around’ with configurable system parameters (usually inputs and constants/multipliers). All this can be done without sound knowledge of mathematical and structural complexities underlying even the simplest socio-economic models. This, indeed, is a valuable capability not on offer within modeling techniques conventionally and contemporarily practiced.

Imagine a talk show host discussing population policy with his panel of experts using simulation models like the one presented here. With people calling in live to question government efforts, suggesting policy alternatives and witnessing the results of their suggestions at once through the use of these simulation models. A greater sense of civic responsibility and interest in government affairs as well as a higher level of trust in decisions made by policymakers can be achieved. As demonstrated in this paper, System Dynamics rendition can effectively elucidate any policy problem. A clear definition of the task at hand, with graphical representation of interdependencies among variables leads to effective and efficient communication of policy objectives. Use of such models of social and economic issues can greatly facilitate TV media in generating public debate, soliciting widespread participation and ensuring civic education regarding these issues. The ultimate goal of building social capital though mass empowerment can hence be achieved effectively with the use of System Dynamics models.

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