Modeling Resource-Based Growth for Development Policy Analysis

Matteo Pedercini

Dissertation for the degree philosophiae doctor (PhD)
at the University of Bergen

Supervised by: Prof. Pål I. Davidsen

January 9th, 2009

To my wife, Arguitxu.

The studies contained in this dissertation were carried out at:

University of Bergen
Faculty of Social Sciences
Department of Geography
System Dynamics Group

And

Millennium Institute
Arlington VA, U.S.A.

Acknowledgements

This thesis is the most tangible outcome of a learning process that extended over the last four years. I am profoundly indebted to all those who turned these years into an extraordinary experience, an intense, enjoyable, sometimes painful, but always constructive process. One to remember in a lifetime. Many more people contributed to this work than I can possibly list here, but I would like at least to name a few without whom it would have all been impossible.

First, this work was possible thanks to the initiative and the constant support and supervision of Prof. Pål Davidsen. If it was not for him, I would have not traveled all the way to Norway, I would have not engaged in this undertaking, and, notably, I would have not met my wife. Prof. Davidsen, Prof. Moxnes, and the colleagues of the System Dynamics group formed a fantastic research environment, in which any seed can flourish. In particular, Dr. Kopainsky, Prof. Qureshi and Prof. Alessi have importantly contributed to two co-authored papers that are part of this dissertation; and all over the process I had the privilege of receiving invaluable help and encouragement from Dr. Kopainsky, to whom I am especially indebted.

Second, throughout these years I worked as modeler and analyst at the Millennium Institute, which generously supported my research. There I had the possibility to collaborate with incredibly talented researchers, and to carry out part of the field work that is required for this thesis. Dr. Weishuang Qu, Dr. Gerald O. Barney (who also contributed to a co-authored paper), Dr. Hans Herren, Dr. John Shilling, Andrea Bassi, and all the staff, have been of great support and the source of inspiration and knowledge. Also, I greatly benefited from cooperating, as part of my work for the Institute, with planning professionals from several countries, who shared their experience and provided a concrete view on many key development issues.

Finally, and most importantly, I owe this thesis, and much more, to my family, who supported me and stood beside me when I needed it the most. Arguitxu, Mamma, Papà, and Luca, you were always there for me. Thank you.

Abstract

This dissertation focuses on the design and implementation of simulation models for development policy analysis, to support a broader understanding of the development process and the identification of effective development strategies. Development is a complex transformation process. Some countries undergo this process rapidly and successfully, while others fail to do so. Research in this field indicates that policies that are inefficiently designed and implemented can affect the ability of a country to succeed. We argue that policy-makers require appropriate quantitative models to understand the development process in their country and to support the design of effective policies, and we propose a comprehensive analytical framework for the analysis of development issues.

The studies presented in this dissertation illustrate how we develop, test, and implement a resource-based approach to development policy analysis. The resource-based approach, originally developed and broadly applied in the field of firms' strategic management, has so far known little application to the development field. We adopt a quantitative and dynamic resource-based approach, in line with current research in strategic management, and we further develop it and apply it to the analysis of development policies. We practically implement our approach through the development of System Dynamics (SD) models that we apply to policy analysis. The use of the SD method enables us to properly represent the elements of complexity that characterize the development process. We emphasize in particular how, by focusing on resources' dynamics, our approach allows for the recognition of the key development mechanisms, to identify the relevant constraints, and to design effective policies.

A key aspect of computer models for development policy analysis is the way they represent the process of growth underlying development. This first chapter initially describes the context and purpose of the work carried out as part of this dissertation. Section two discusses some limits to the applicability of current growth research – theory and empirical work alike – to development policy analysis. Subsequently, in section three we report the results of a survey recently conducted among government officials from 12 sub-Saharan countries. The survey indicates that growth theory is not consistently applied in practical medium and long term planning exercises in most of the surveyed countries, also due to some limits of the modeling methods used. In sections four and five we argue that a dynamic, resource-based approach can complement current growth research, and can provide a broader perspective on development policy analysis; and that the SD method is well suited for the implementation of such an approach. In section six, we provide an overview of our studies on the application of the resource-based approach and the SD method to various development issues. Finally, the last section of the chapter summarizes our findings and points to the need for further research in this area.

The results of the analyses presented in this dissertation point to the value of the resource-based approach as a framework for development policy analysis. In each study, the causes of development failure or unintended policy outcomes are identified in the characteristics of the mechanisms of resources' accumulation. A variety of alternative scenarios are analyzed, and, based on their results, policy recommendations are provided. Such recommendations, although derived in different contexts, have some similarities: they generally tend to stress the importance, for effective policy design, of characterizing development beyond the purely economic perspective; and of considering its strong links with the social and human dimensions. Also, our results stress the value for development policy analysis of considering

the inherent difficulties, including time lags, involved in the cumulative processes that bring about development.

Most of the studies collected in this thesis have been carried out for – and often in collaboration with – policy-makers, international organizations, and field's experts from developing countries. This not only allowed us to design our models around the needs and questions of the development stake-holders, but also gave us the opportunity to observe how – beyond the mere appreciation of the analytical results produced – the process of applying our approach contributed to stimulating the development debate. Designing effective policies is a learning process, in which the learning that occurs during the process is as important as the analytical outcomes themselves. Our last study investigates ways to enhance such learning, and we believe this to be a fertile area for further research.

Table of Contents

Research Overview

Dubium sapientiae initium.

René Descartes, *Meditationes de prima philosophiae*

Research Overview

1. Context and Purpose

Developing countries face the challenge of managing a socioeconomic transformation process towards a number of development goals. Development is about realizing very fundamental human values (Cypher and Dietz 2004). These values include, but are not limited to: Access to meaningful employment and the possibility to provide for one's self and family; sufficient food, clean water, shelter and other amenities for a decent life above the poverty line; the opportunity to pursue education and the increased quality of life that promises; access to a reasonable level of health care and to social security for old age; democracy and political participation in the life of the community and society; equal treatment under the law and in the economy for all, regardless of race, gender, religion, nationality, or other characteristics; and individual dignity. While some countries undergo this transformation process rapidly and successfully (e.g. South Korea and Mauritius), others struggle and progress very slowly (e.g. Mali and Ghana) – and in some cases even regress (e.g. Dem. Rep. of the Congo and Zimbabwe) (UNDP 2003).

A variety of actors contribute to this transformation process. They are involved in the development process in different ways, and their choices and actions ultimately determine a country's development path. In this context, the role of national governments is particularly important: not only do governments provide services and infrastructure that are fundamental for development, but they also design the institutional framework within which the other actors operate, influencing the allocation of resources in the economy (WB 1997). Since the end of Second World War, national governments in developing countries have engaged in the formulation of so-called "National development plans", defining strategies and policies to achieve stated development goals. The actual contents of such plans may vary considerably across countries (Lewis and Lewis 2003 (1966)). Here we define national development planning in the following way: It is a planning process at the central government level; it defines the strategic plan for a country's medium/long term development; it is based on the long term objectives and forms the basis and framework for shorter term decision-making. Throughout this dissertation we consider the role of development planning, and in particular of development policy analysis, i.e. the analytical component of planning, as a fundamental instrument to facilitate development.

It is our hypothesis that the inherent complexity and cross-disciplinary nature of the development process make such process difficult to observe and interpret, and thus reduce the ability of decision makers to design and evaluate effective strategies and policies.

This hypothesis is based on Saeed's (Saeed 2003) overview of policies implemented to solve initially perceived development problems such as food security, poverty and social unrest. These policies have created unexpected results because the causes leading to the existing conditions and their future projections are not adequately understood. The well intended policies addressing problem symptoms only create short term benefits that are often overcome by the reactions of the system, i.e. by the interplay of feedback loops that go beyond the narrow boundary of the policy sector and by the effects of time delays in the long term. For the case of food security, for example, policies such as intensifying agriculture, developing more agricultural lands and irrigation systems, applying fertilizer and using new seeds have led to a range of subsequently experienced problems such as land degradation, depletion of

water aquifers, vulnerability to crop failure, population growth and continuing or even increased vulnerability to food shortage.

This dissertation focuses on the design and implementation of simulation models for development policy analysis, to support a broader understanding of the development process and the identification of effective development strategies.

In the context of development planning, the purpose of a simulation model is to enhance the ability of decision-makers to design and evaluate development policies. Simulation models mimic some critical aspect of the real system, so that its behavior can be studied. In other words, the model is a laboratory replica of the real system. By creating a representation of the system in the laboratory, a modeler can perform experiments that are impossible in the real world (Sterman 1996). A simulation model derives behavioral outcomes of structural assumptions, and it provides a means for better understanding the impact of alternative policies – i.e. structural changes – and designing more effective ones.

In this initial chapter of the dissertation we explore in more detail how simulation models can be designed to better support development policy analysis. In particular, we discuss the characteristics that this type of models and their underlying theory should have to fully support effective policy-making. The following section discusses why modern growth research is only partially useful to development policy analysis; section three illustrates some issues inherent to the common modeling methods used to implement models for development policy analysis; the fourth section illustrates the advantages of applying a resource-based approach in this context; the fifth section describes the benefits deriving from using the system dynamics (SD) method to implement a resource-based approach, and provides some examples of successful application of SD to development issues; the sixth section provides an overview of the series of studies carried out as part of this dissertation, which apply a resource-based approach and the SD method to a variety of development issues; and the final section summarizes our findings and indicate potential areas of interest for future research.

2. Limitations of growth research for development policy analysis

"The typical policymaker or advisor—whether politico or technocrat—wants to know the likely consequences of concrete public sector actions (not necessarily limited to policies) over their relevant time horizon. If growth research is a quest to satisfy this need, the journey is far from over".

Lant Pritchett, The Quest Continues, 2006

Economic growth is essential to development, as it provides the means– not only goods and services, but also employment and participation to social life – that are necessary for this transformation process to be successful. Economic production employs a broad range or resources – social, economic, and environmental – and generates further resources that fuel development. Although per se not sufficient to guarantee development, economic growth is intertwined with the other aspects of the development process, and is at the heart of it (Ranis et al. 2000). In order to understand the broad development process, and to be able to design effective development policies, it is therefore necessary to understand the process of economic growth and its impacts on development.

Growth research aims at defining theories and analytical models that explain growth phenomena; and at providing evidence that substantiate such models. Growth research is therefore essential to establish the theoretical foundations of models for development policy analysis, providing the fundamental description of the mechanisms underlying growth. Thus,

such models would normally incorporate the most recent findings and formulations from growth research, and implement them in actual settings, in a user-friendly and transparent way.

In practice, in the eyes of an increasing number of researchers, growth research – theory and empirical work alike – appears to have limited applicability to development policy analysis. The debate on the usefulness of growth theory for policy analysis in developing countries is not a new phenomenon, but one that can be traced back at the early criticisms of Solow's model in the late 1950s (Solow 1956). Fifty years after Solow's famous articles, many technical problems being solved and a few assumptions relaxed, growth research is still facing major problems when the task is to provide concrete policy advice to policy makers in developing countries. In the following paragraphs, some relevant limitations to the applicability of growth research to development policy analysis are reported and discussed, considering first issues related to the scope and perspective of growth theory, and subsequently at empirical growth research-related issues.

2.1 Limits to the applicability of growth theory to development policy analysis

"It is certainly the case that growth theory is now a much more powerful tool than it was before Solow put pencil to paper. […] But at least at the more practical end of things – how do we make growth happen – things have turned out to be somewhat disappointing"

Dani Rodrik, Growth Strategies, 2003

The roots of the limited applicability of growth theory – and new growth theory in particular – to practical development policy analysis can be found in some of the assumptions that form its basis, as well as in the particular direction and scope of the theoretical work carried out. Set aside the more technical considerations on the underlying assumptions (for a broad review, see Barro and Sala-i-Martin 2004; Helpman 2004), more attention has recently been given to the more fundamental issues related to the scope and perspective that characterize modern growth theory.

In this regard, three major arguments, in particular, have been thoroughly discussed in the literature. A first argument relates to technological development, a key process in determining long-run growth rates. Recent growth models focus mainly on innovation and on the expansion of technology frontier (Pritchett 2006), a typical issue of industrialized countries. This is however of little interest for developing countries, whose primary focus is on technological catch-up and adaptation of existing knowledge.

A second argument stems from the fact that growth theory is constructed at a very high level of aggregation, leaving no room for country specificity. What can be inferred from such theory are therefore generic statements on what can boost growth, and it is then left to the analyst to identify the relevant areas of intervention for a specific country (Rodrik 2003). Unfortunately, strong theoretical methods for such analysis at the country level do not yet exist.

The third argument relates to the time-frame used in modern growth theory. Assuming that a steady state exists, growth theory mainly focuses on how to alter such steady state in the very long run (Pritchett 2006). Transitional dynamics and emergent growth bottlenecks, which are key areas of interest for developing countries policy-makers, are not well taken into account.

Considering the points above, some broadening of the scope and perspective of growth theory appears necessary, to make it useful to policy-makers in developing countries. Key researchers at IMF and the World Bank now recognize that "our knowledge of economic growth theory is

extremely incomplete" and that the complexity of economic growth is not "amenable to simple formulas" (Zagha et al. 2006). Some propose turning to more qualitative diagnostic methods to investigate bottlenecks for growth in specific countries (Hausmann 2006; Leipziger and Zagha 2006). Let alone this pessimistic view, we believe that there is need for quantitative approaches to support policy-making in developing countries. In the fourth section of this paper we describe how a resource-based approach can enhance, operationalize, and complement current growth theory. Specifically, by focusing on levels, such an approach allows for the representation of economies with different structural characteristics. Also, it adopts a dynamic perspective, and thus supports the analysis of transitional dynamics and emerging growth bottlenecks.

2.2 Limits to the usefulness of empirical growth research for development policy analysis

"Despite its extensive use within industrial countries, growth accounting has done surprisingly little to resolve some of the most fundamental issues under debate in the development literature".

Barry Bosworth and Susan M. Collins, The Empirics of Growth: An Update, 2003

Due to the inherent complexity of the development process, empirical investigation of such process and of its drivers is a very challenging task. Empirical growth research – including growth accounting and growth regressions – has substantially expanded in recent years, and attempts have been made of associating economic growth to a broad range of national indicators. Nevertheless, results from such work have proven to be of limited value to policy makers in the developing world. We report below some of the most discussed possible causes for the limited applicability of the insights provided by growth empirics to development policy analysis.

A first argument refers to the concrete meaning of growth regressions and growth accounting. These techniques aim at identifying correspondence in behavior patterns of observable empirical variables, e.g. between years of schooling and economic growth rate, but cannot be used directly to infer any statement about causality between variables (Bosworth and Collins 2003). Unfortunately, policy makers also need insights into causality among variables in order to take informed decisions. Excessive reliance on regression techniques may also keep researchers from considering important non numerical information (Sterman 1996).

A second argument relates to the fact that growth regressions and accounting ultimately constitute an assessment of past correlation: When not supported by an understanding of the structure of the system, no guarantee can be provided for such relationships to hold in the future. As Romer highlights when comparing economic production to cooking, *"To create valuable final products, we mix inexpensive ingredients together according to a recipe. The cooking one can do is limited by the supply of ingredients […]"* (Romer 2007). Empirical growth research attempts at measuring how historically the value of final products increased as one or more ingredients became more readily available. Eventually, it can point us towards the ingredient that has had the largest impact on output in the past. This, however, brings no guarantee that a continuous increase of the amount of the same ingredient in the mix will always lead to a proportionally better final product.

A third argument derives from the fact that most empirical work on growth focuses on rates, e.g. growth rate of capital, rather then on levels, e.g. capital itself. As Senjadi points out (Senhadji 1999), focusing on rates weakens the analysis, as it disregards all long-run historical

information in the data, perhaps the most valuable part of information available. In addition, looking at rates rather then at levels eliminates any possibility to properly represent countries' specific structural characteristics, one of the limitations also mentioned for growth theory.

These limitations to the applicability of the insights from empirical growth research to development policy analysis do not diminish the importance, perhaps the necessity, of this type of research. We argue that additional insights can be obtained through this type of research when it is coupled with a resource-based understanding of the underlying system's structure. Such understanding should drive the focus of empirical growth research towards the most significant variables – levels in particular. Levels carry fundamental historical information; they capture the inertia of the system and provide a realistic perspective on delays; they represent the actual state of the system; and they provide a way to introduce countries' specificity in the analysis. Comparisons across countries would become more representative, and the identification of bottlenecks, i.e. the most binding constraints, easier.

To properly manage the development process, policy-makers require an understanding about the underlying structure, i.e. of the causal mechanisms driving development. As correlation does not provide information about causation, then we should look for such information somewhere else: As Robert Solow suggests in his Nobel Prize Lecture, our analysis should "*include information that is encapsulated in the qualitative inferences made by expert observers, as well as direct knowledge of the functioning of economic institutions*" (Solow 1988).

3. Applied tools for development policy analysis

Growth research attempts at providing evidence for the relevance of specific factors in growth; and based on this insights develops analytical models that should explain growth phenomena. The direct contribution of growth research to development planning is then to be found in the quantitative models that are applied to development policy analysis across countries. Simulation models that are used to inform the national development planning process are implemented with various methods (Robinson 1989) and software (Barney et al. 1991). These applied models should embed the findings and formulations from growth research, and implement them in a way that makes running alternative scenarios for policy analysis simple and effective.

In order to investigate whether the limits to the applicability of growth research to development policy analysis are perceived only within the research environment, or also by professionals in the field, we run a survey on government officials form 12 countries in Sub-Saharan Africa. Participants included 17 between technicians and policy-makers from: Botswana, Ethiopia, Kenya, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, Zanzibar, and Zimbabwe. This survey was run in the context of a regional workshop organized by the United Nations Development Programme (UNDP) in Johannesburg in June 2006 to illustrate the capabilities of a particular simulation model. The participants were surveyed before being exposed to the contents of the workshop.

The questionnaire contained five questions (see Appendix 1). First the officials were asked whether their governments run long-term planning exercises. The general answer to the question was "yes". It also appeared from some answers that some of the participants considered "long-term" what is generally regarded as a medium-term, five-year time horizon.

The second question related to the frequency of these long-term exercises. Although there was great variation in the responses (from one year up to 15 years), the most frequent answer (the

mode) was five years, and the arithmetic average was also just around five years. From the answers to the first two questions, we deduced that medium and long-term planning exercises are regularly implemented and constitute an integral part of the planning process in the countries surveyed.

The third question was whether any formal simulation model was being used to support such exercises. Three quarters of the countries surveyed used formal models in order to support the planning exercise with a quantitative analysis. The remaining quarter did not use any formal models, although one of the countries was in the course of developing one. For the majority of the countries surveyed formal models are therefore relevant to support long-term planning.

The officials were then asked to describe the type of models they were actually using to run these exercises. Out of the nine countries using formal models, only two used a model with a fully dynamic production function with endogenous – or at least partially endogenous – total factor productivity (TFP). The first of such models is the World Bank's MAMS (Bourguignon and Sundberg 2006), a long-run, dynamic, general equilibrium model. The other model is a System Dynamics-based model developed by the Millennium Institute, known as Threshold 21 (Barney 2002). All the other models used were either static, or contained exogenous assumptions about economic growth rates[1]. Thus, for the majority of the countries surveyed, exogenous assumptions about growth were preferred to any formal production function for projecting growth in the future or analyzing alternative policies. These results highlight that the concerns regarding the limits to the applicability of the insights from growth research are not confined to the research environment, but are somehow reflected in the characteristics of the applied models.

The last question asked the surveyed officials what were, according to them, the three more important characteristics a long-term planning model should posses. We grouped the total 48 answers by the participants (three of the 17 subjects provided only 2 criteria each) in 7 broad categories: (1) simple/transparent; (2) simulation/dynamic character; (3) comprehensive/cross sector linkages; (4) realistic; (5) flexible; (6) based on available data; (7) other[2]. Table 1 provides a quick overview of the results based on this classification. 42 of the 48 answers provided fall into the first 6 categories, while the remaining 6 answers are too heterogeneous to provide any specific insights and are grouped under "other".

Table 1: Most desired characteristics of a long-term planning model: Summary of results from a survey on 17 policy and technical staff from planning institutions in southern African countries

Category	Number of related answers
Easy/transparent	14
Dynamic/simulation	8
Comprehensive/cross-sector	7
Realistic	6
Flexible	4
Based on available data	3
Other	6
Total Answers	48

The criteria simple/transparent appears 14 times among the preferences of the officials surveyed, and is by far the most common preference emerging from the survey. Across the

[1] Note that for some of the indicated models only partial information is publicly available, and their classification is based on such information

[2] These categories have been constructed ex-post.

countries surveyed, officials demand models that are easy to use, easy to understand, easy to update, easy to interface with other tools, user-friendly and transparent. The second most common desired characteristic is dynamicity. The capability of models to run simulations and capture the dynamic character of the system appears 8 times among the preferred qualities of a long-term planning model. Comprehensiveness of the model and cross-sector linkages appears 7 times in the preferences of the officials. The ability of a model to represent interactions among economic sectors, and beyond, with social and environmental sectors, is thus highly desired. The model should also be realistic (6 preferences) and flexible (4 preferences). These two characteristics are fundamental for the model to correctly represent country specific circumstances. Finally, it has been indicated in 3 cases that the model should be based on available data. Data availability is often a central issue in developing countries, but it does not seem to be among the main concerns of the officials surveyed.

These results highlight a clear call for transparency and easy to use of simulation models. A recent assessment of some of the most widely used models for development policy analysis indicates that most of these are not quite transparent in their structure, and not user-friendly (Pedercini 2003). The issue of transparency does not necessarily emerge from the theoretical foundations of the model, i.e. from its key assumptions, but it can also arise from the way theories and assumptions are practically implemented. The modeling method used and the related software thus become key aspects for the practical usability of models for development policy analysis. For example, Computable General Equilibrium (CGE) models and Macro-Econometric (ME) models are among the most commonly used tools for development planning. CGE models are based on a matrix of flows concept, where actors in the economy interact according to a specified set of rules and under predetermined equilibrium conditions (Robinson et al. 1999). This type of models is normally implemented in software such as GAMS[3], which is hardly readable by non-experts (Löfgren et al. 2002). The resulting models are not transparent and difficult to use and interpret. ME models are developed as combinations of macroeconomic identities and behavioral equations, estimated with econometric methods (Fair 1993). ME models are mostly implemented with software such as EVIEWS[4], TROLL[5], and others, which are programming-intensive and difficult to interpret for non-experts (MacKie-Mason 1992; Holly and Turner 1998). These issues of transparency are crucial for policy analysis models: It is difficult for planners to build confidence in such tools without a proper understanding of their assumptions and functioning (Größler et al. 2000); and it is also difficult to interpret the resulting policy recommendations. It is not surprising that often experts' guesses are preferred to black-box models that are eventually abandoned.

Transparency is of key importance for a modeling method, but it is not the only relevant characteristic when assessing the suitability of the method for the implementation of development planning models. In the answers from the sample analyzed, planning models also need to be dynamic, comprehensive, and realistic: These characteristics cannot be given up in favor of transparency. A modeling method must allow for the representation of the dynamic complexity that characterizes the issues under analysis, while maintaining a certain degree of transparency. Development processes are rich in feedback loops, delays, and non-linear relationship that both CGE and ME are ill-suited to represent. Similarly, implementing a comprehensive approach requires a method that allows for the representation of economic,

[3] http://www.gams.com/ visited on October 31, 2008
[4] http://www.eviews.com/ visited on October 31, 2008
[5] http://www.intex.com/troll/ visited on October 31, 2008

social and environmental aspects of development within the same model. The methods described above do not provide support for such a comprehensive approach.

The survey reported in this section was run on a limited number of country officials from 12 countries, and the results obtained should not be generalized. Nevertheless, the answers obtained point to some short-comings of the most common methods used to develop simulation models in addressing the needs of the surveyed officials. The next sections of the paper illustrate how a resource-based approach and the System Dynamics method can integrate growth theory and implement it in effective and transparent way.

4. A resource-based approach to development policy analysis

Economics can be defined as the study of how resources are, or should be, allocated (Black 2002). The relevance of resources in all fields of economic research has thus always been recognized. The word "resource" or "resources" has however earned different meanings at different levels of analysis of economic activity. At the firm level, resources are generally intended as the total means available to a company for increasing production or profit, e.g. its staff, its production capacity, etc. At the aggregated national level, resources are generally intended as the total means available for economic and political development (HMC 2000), e.g. the country's overall labor force, the total physical capital available, etc.

In the field of firms' strategic management, over the last 50 years there has been increasing research on the role that resources play in firms' growth. Following the pioneering work of Penrose (Penrose 1959) research on the subject has flourished, leading to the formalization of a new theory of the firm, now known as the resource-based view (RBV) (Wernerfelt 1984; Barney 1991; Peteraf 1993). Most of this research has focused on the characteristics of the resources that can lead to a sustained competitive advantage and to monopoly or quasi-monopoly rents. More recently, Warren has introduced a framework for quantitative and dynamic resource-based analysis, focusing not only on the resources themselves, but also on the related processes of accumulation and depletion, and on the interactions among resources (Warren 2002).

More specifically, Warren's approach stresses the relevance of studying how resources affect performance through time, i.e. he uses a dynamic perspective. Still recognizing the relevance of intangible resources, he argues that the focus of the analysis should be primarily on tangible resources, as the former affect performance only through changes in the latter. Warren emphasizes the importance of the feedback processes that govern the accumulation of resources, and of the complementarities among resources. Overall, he applies a systemic perspective on resources, and highlights how performance is determined by the mix of resources as a whole, and not by individual factors.

Despite the broad diffusion of the resource-based approach at the level of firms' growth analysis, this approach has not been extended to growth analysis at the country level. We believe that this approach provides a different and useful perspective on many development and growth-related issues. In particular, a dynamic resource-based approach as that proposed by Warren could complement current growth theory and address some of the most critical needs of policy-makers in developing countries.

From a resource-based perspective, development is a resource-driven process. A fundamental set of key resources defines the development state of a country, and development happens as such resources are gradually accumulated. At the same time, growth in resources happens as a result of employing those resources that already in place, so that the development of the

system depends on its own state. This kind of accumulation process requires time, i.e. it involves major delays, and can respond non-linearly to changes in the state of the system or to exogenous inflows. In this perspective, development is a dynamic, complex, phenomenon, building up the fundamental resources over time. The following paragraphs discuss more in detail the fundamental characteristics of the resource-based approach, and illustrate how these characteristics make the approach well suited to integrate current growth-theory.

First, the resource-based approach focuses on the key resources, i.e. levels, or stocks, that determine performance. Levels characterize the state of the system at any point in time, and by integrating flows over time, they carry fundamental historical information: They are the *memory* of the system. By explicitly focusing on stocks, the resource-based approach allows for the representation of countries' specificity and provides a basis for identifying bottle-necks. Moreover, it can support the setting of clear benchmarks for cross-country comparison.

Second, a resource-based approach such as the one developed by Warren studies dynamics of stocks, i.e. it studies how stocks change over time as a result of the accumulation of flows. The accumulation of resources can respond non-linearly, and often with major delays, to changes in policies and in investment. It is essential to analyze such delays and non-linearity in order to properly capture the transition of a country from a development state to another; and to study the gradual processes of knowledge and technology diffusion that is part of the development process.

Third, a dynamic resource-based approach emphasizes the importance of focusing not only on how resources contribute to production, but also on how production contributes to the accumulation of resources. Such approach thus provides a dynamic perspective on the feedback processes that drive growth and supports the identification of the leverage points in these mechanisms, which is essential to the design of effective policies.

The data necessary to implement the resource-based approach can be drawn from a variety of sources. The identification of the key resources should not be driven solely by statistical analysis, but should integrate all reliable information available on the key causal mechanisms involved in the growth processes (Forrester 1980). Identifying and filtering this type of information is not any easy task, and one that can imply a certain degree of subjectivity when the structure analyzed is not easily observable, e.g. in the case of intangible resources. However, ignoring such information is an equally subjective choice. Lately, an important body of surveys of entrepreneurs and investors is being accumulated, which provide a substantial amount of verified qualitative information on the binding constraints for growth in various countries (WB 2005).

The question remains open of how to practically implement this approach, which involves the analysis of elements of dynamic complexity, enabling policy-makers to perform the quantitative scenario analysis that is essential to support national development planning. The following section identifies some advantages and of using the System Dynamics method to implement a resource-based approach to development policy analysis; and illustrates several successful applications of SD to a broad range of development issues.

5. The System Dynamics method

The previous sections of this paper highlight the importance for development policy analysis models to represent the dynamic characteristics of the development process while maintaining a certain degree of transparency and ease to use. For an effective implementation of a resource-based approach, in particular, a modeling method is required that can take into

account the elements of complexity that characterize development, including non-linearity; accumulations and delays; and feedback processes. Such method must allow for the representation of the non-economic characteristics of the development process and should support the use of qualitative inferences to complement empirical information. Finally, the method needs to be transparent and accessible, if it is to earn the confidence of policy-makers.

The System Dynamics (SD) method provides the ideal tools to undertake this challenge of developing and analyzing simulation models that address the needs of policy makers in developing countries, and thus supplement the commonly used modeling methods illustrated in section three. The SD method SD is a method developed to analyze complex, dynamic systems and was initially conceived at the Massachusetts Institute of Technology (MIT) in the late 1950s. System Dynamics simulation models are built to analyze the relationship between the structure and the behavior of dynamic systems. The innate technical characteristics of the SD method make it well suited to implement a resource-based approach to development policy analysis.

The stock and flow (SF) language used in SD explicitly represents the mechanisms of resources accumulation and depletion that govern the development process. This type of representation also highlights the central role of resources – i.e. stocks – in determining the state of the system and its consequent change. In addition, the SF language also allows for the representation of theories from a variety of scientific fields[6] (Sterman 2000) and their synthesis, providing a means for establishing the coherence and consistency in a set of theories. In addition, the SF language supports the representation of non-economic resources, such as social and environmental resources, and thus facilitates the adoption of a broad perspective on development.

SD is also well suited to represent the elements of dynamic complexity that characterize the development process. The SD method provides an accurate and intuitive way to represent feedback loops, non-linearity, and time delays. In the words of Jay Forrester, SD models "*can accept the complexity, nonlinearity, and feedback loop structures that are inherent in social and physical systems*" (Forrester 1994).

A variety of software tools to build and analyze SD models exists that are very effective at solving high order non-linear systems[7]. Such software also supports a high degree of flexibility in the formulation of relationships between variables. Researchers are thus not bound to using unrealistic formulations for the sake of mathematical tractability, but reasonable assumptions can be introduced in a variety of ways, including by way of graphical table functions. Specific techniques designed to facilitate the elicitation and incorporation of qualitative inferences and experts' knowledge in the model have also been developed (Andersen et al. 1997; Ford and Sterman 1998).

SD allows for full transparency of the structure of the model and of the resulting behavior. In SD models, relationships between variables are graphically evident, and complex mechanisms are broken down into small components, so that the contribution of each component to the behavior of the model may be identified. Equations are written in plain algebraic form, and can be easily read by non-experts. Moreover, commonly used SD software includes specialized output tools to track the system behavior at any time, and provide accurate statistical information. The ability of SD models to represent complex systems in a transparent

[6] The System Dynamics Review also provides an account of the successful implementation of the System Dynamics method in a variety of fields.
[7] See for example: www.vensim.com; www.powersim.com; www.iseesystems.com.

form and thus support informed decision making in both the private and the public sectors has been broadly illustrated (Richardson 1996).

Since its origin, the SD method has been applied to a variety of development issues. In the late 60s, a group of researchers at MIT developed a model know as World3, to analyze some of the most pressing development issues for humanity. The analysis culminated in the book "Limits to Growth", one of the most controversial studies in the field at that time (Meadows et al. 1972). The study was repeatedly updated, but, perhaps due to the harsh criticisms received, the amount of SD research in this area did not expand substantially over the following decade.

In the early 80s, Forrester and Sterman produced interesting studies on national economic performance, focusing mostly on economic cycles and energy transitions (Forrester 1980; Sterman 1985). Starting in the mid-eighties, Saeed produced a series of studies on specific development issues, demonstrating the applicability of the System Dynamics method to this field of research. Throughout hid research that covered a broad range of themes, from poverty (Saeed 1987) to income distribution (Saeed 1988), from food security (Bach and Saeed 1992) to political instability (Saeed 1986), he maintained a focus on sustainability. His work culminated in a book collecting some of his most influential studies (Saeed 1998). While this covers the most prominent SD research applied to specific development issues, the body of SD research in this area expands well beyond the works mentioned above.

Besides the above-mentioned studies on specific development issues, a set of broader national development planning models were constructed during the second half of the nineties by way of the System Dynamics method. The most widely used model of this kind is the "Threshold 21" (T21) model, developed by the Millennium Institute (Barney 2002). T21 is a System Dynamics national planning model that integrates social, economic and environmental aspects of development. The model has been implemented to-date in over 15 developing and industrialized countries, and is being used for planning purposes in a number of nations. Another example of development planning model implemented by way of the System Dynamics method is the Population-Development-Environment (PDE) model developed by the International Institute for Applied System Analysis (IIASA) (Sanderson et al. 2001; Sanderson et al. 2001; Wils et al. 2001). PDE has been applied to a limited number of countries and focuses mostly on issues of sustainable development.

This variety of successful applications indicates how well the System Dynamics method lends itself to the creation of models for quantitative development policy analysis. The following section provides a synopsis of the studies carried out implementing the resource-based approach by way of the System Dynamics method.

6. Overview of Research Studies

This section provides an overview of the results obtained and insights gained from the series of studies carried out as part of this dissertation. Such studies cover a broad variety of development issues, from generic problems of economic growth and human development, to more specific issues such as income distribution and migration. We identified such issues, and carried out analyses, involving a variety of governmental agencies, international organizations, and other stakeholders.

Throughout all these cases, we applied a resource-based approach, which we implemented by developing a System Dynamics model for each policy analysis. The approach evolved to some extent through application and testing in the various settings. In most cases, we applied the approach using at first a high level of detail, concerned with the point precision of the

simulations generated. We then gradually moved towards less detailed structures, distilling the essential development mechanisms involved in the dynamics at stake, in order to facilitate the analysis of such mechanisms and support a better understanding of the underlying system. The analysis provided us in each of the cases with different types of insights. In all cases, the approach and method proved effective in offering a broad, dynamic perspective on many well known and recurrent development issues, which unfortunately several countries are still facing.

6.1 A resource-based approach to development planning: a cross-country analysis

by Matteo Pedercini

The paper applies the resource-based approach to the analysis of fundamental growth disparities for a panel of 100 countries. The countries are grouped into six categories, based on their initial income and their growth performance. The analysis identifies the most common types of resources that play a key role in the development process; it describes the major reinforcing feedback loops that are responsible for economic growth and development through growth in the key resources; it highlights some relevant delays and the non-linearity involved in these mechanisms; and it provides a framework to investigate the possible causes of malfunctioning in these mechanisms.

The paper is based on a system dynamics model with a focus on the contribution of seven key resources to development. The results of the analysis illustrate how the same growth mechanisms can work differently in countries with different initial endowments and with different development strategies, leading to substantially different performances. The paper provides insights on some key aspects of effective development strategies for countries at different stages of development. Finally, we argue for the need of country-specific models in order to design effective country-specific development policies.

6.2 A resource-based growth analysis in Mali

by Matteo Pedercini

This paper illustrates a country specific application of the resource-based approach to development policy analysis. The approach is applied to Mali, one of the least developed countries in the world. The analysis focuses in particular on the identification of the key accumulation processes that drive development in Mali, and on the possible reasons for their malfunctioning. The initial low level of some key resources and the delays in the accumulation of such resources appear to be critical factors limiting the country's overall growth performance.

The system dynamics model developed for this analysis is based on the Millennium Institute's Threshold 21 model (T21). The T21 model is developed to investigate a broader range of development issues than economic growth alone, and uses a high level of detail to provide policy-makers with a realistic set of country-specific policy options. Results from the analysis indicate that the new policy course that the country has recently engaged in is likely to be more effective than the strategy adopted over the previous 5 years. Nevertheless, even under optimistic external conditions, Mali is unlikely to reach its growth and development objectives over the next two decades.

The results from this analysis were used as input into the preparation of the second-generation Poverty Reduction Strategy Paper in Mali.

6.3 Dynamic analysis of Millennium Development Goals interventions: the Ghana case study

by Matteo Pedercini and Gerald O. Barney

This paper illustrates how the resource-based approach is applied to analyze development beyond mere economic growth, with a particular focus on the ability of a country to achieve the Millennium Development Goals (MDG). Using the case of Ghana, the paper illustrates the importance for MDG-related planning of properly taking into account the dynamics of the key resources involved in the development process, and the feedback relationships among them. The paper compares the proposed dynamic approach with the most commonly used linear MDG-costing approach.

The model used for this analysis is also based on the Millennium Institute's T21 model, expanded to provide an additional focus on the MDG. Results highlight that the proposed large-scale interventions generate a substantial change in the country's development pace. Such interventions affect, at different moments and with different intensities, the accumulation of the various resources, creating positive and negative synergies between these interventions. Compared to what a linear approach would indicate, a substantial amount of resources needs to be reallocated overtime to compensate for the unfavorable consequences of the synergies between the interventions, and to profit of their favorable effects. We conclude that, by using a more dynamic and broader perspective, more realistic policy recommendations and estimations of the financing needed may be identified.

The results from this study were presented to the special economic advisor to the Secretary General of the United Nations, Dr. Jeffrey Sachs, and its team, to inform the development of UNDP's MDG strategies. The paper has been accepted for publication in *Socio-Economic Planning Sciences*.

6.4 A resource-based approach to income distribution: the case of Pakistan

by Matteo Pedercini and Muhammad Azeem Qureshi

This paper analyzes the distributional aspects of growth and development. It applies the resource-based approach to development policy analysis at the household level, demonstrating how different households within the same country can follow different growth paths depending on their initial endowment of resources and their saving/investment behavior – just as different countries would do. The analysis focuses in particular on the processes of accumulation of human capital and physical capital, and on the constraints to such processes.

The system dynamics model developed for this analysis disaggregates households into 100 classes based on the amount of human and physical capital they own, and endogenously determine the income distribution. The application to the case of Pakistan indicates that it is possible, in the long run, to bring the economy towards a more equitable income distribution without harming economic growth. In particular, results indicate that public investment in education and microcredit facilitates pro-poor growth.

This paper is currently being reviewed for publication in the *Journal of Income Distribution*, and is also part of Qureshi's dissertation (Qureshi 2008).

6.5 A resource-based approach to migration

by Matteo Pedercini

This paper addresses the issues related to the uneven distribution of resources between industrialized and developing countries. It highlights how migration can work in some instances as a balancing force that helps reducing the gap in resources between countries or, in other instances, as a source of further divergence. The resource-based approach applied allows for the integration of a variety of development and migration theories into a single framework, and to analyze the development-migration nexus.

The system dynamics model developed for this analysis represents only two types of resources that can be transferred from one country to another: Physical/financial capital and human capital. Using a case study representing two virtual countries (one industrialized and one developed) we analyze a broad range of migration policies and their impact on the overall development of the two countries. Results indicate that migration may potentially serve as a development catalyst, eventually leading to a convergence between the two countries, under some specific policy settings.

An applied migration-development analysis was carried out based on the model presented in this paper, and has been accepted for publication in a forthcoming edited book from the International Organization for Migration (tentative title "*The MIDA experience and beyond. Operationalizing Migration for Development across regions").*

6.6 Blending planning and learning for national development

by Birgit Kopainsky, Matteo Pedercini, Steve Alessi, and Pål Davidsen

This paper illustrates how the complex theory developed in this dissertation can be effectively transferred to policy makers, so as to enrich their perspectives on development and growth issues. We develop an Interactive Learning Environment (ILE) that allows users to experiment with alternative development policies and learn about the underlying structure of the system. The ILE exposes the users gradually to the key resources involved in the development process and to the feedback loops mechanisms underlying growth.

The system dynamics model underlying the ILE is based on the Threshold 21 model, but is simplified to a great extent to represent only the central development mechanisms, with a low level of detail. The ILE was preliminary tested with government officials from a variety of countries, providing encouraging results. Eventually, we expect users to become more aware of the elements of dynamic complexity involved in the development process, enhancing their capacity for effective development policy design.

The paper has been accepted for publication in *Simulation & Gaming*.

7. Conclusions

Development policy analysis engages policy-makers in the design and evaluation of interventions that aim at improving a country's performance. The complexity of the development process implies a need for policy makers to have at their disposal quantitative tools that allow them to understand such a process, and to develop effective policies that can favorably affect it. Throughout this dissertation we develop and apply a resource-based approach to development policy analysis, as a tool to support the identification of effective interventions to promote development, based on an understanding of the fundamental mechanisms underlying such a process.

We implement the resource-based approach by developing simulation models for policy analysis using the system dynamics method that allows us to adequately represent the elements of complexity inherent to the development process; to simulate alternative scenarios; and to compare and evaluate policy options. The studies carried out and presented as part of this dissertation provide a series of examples of the application of our approach to a broad variety of development issues. Such examples illustrate the applicability and usefulness of the resource-based approach to development policy analysis, and provide relevant insights for practical decision-making.

In spite of the fact that the case studies address a variety of issues, in various contexts, and have different boundaries and levels of aggregation from one another, the insights we derive have some commonalities.

First, most of our analyses tend to underline the importance to development of those resources that are not strictly of economic nature. Human resources, physical infrastructure, and governance for example, all play a substantial role for economic growth and development. Although the long time delays involved in the accumulation of such resources imply that they can only grow slowly over time, they essentially contribute to creating a thriving ground for the accumulation of the more dynamic economic resources.

Second, our analysis highlights the high degree of interrelation between the mechanisms of accumulation of the various resources. In the simplest cases, increasing investment in one resource might imply the need for reducing investment in another. In more complex cases, our ability to accumulate a specific resource depends on the level of other resources, so that policy interventions targeting one resource might generate synergies (positive of negative) with other interventions.

Third, it emerges from the various case studies undertaken that the lags and delays in the accumulation of resources fundamentally affect the development potential of any country. Rapid growth phenomena can result when the fundamental resources are readily in place and some incidental constraint is being removed. However, when the fundamental resources are not available, substantial development requires decades of vigorous investment in the key areas to build up an adequate amount and mix of resources. This type of insights is of guidance in the design of long-term development strategies, and can support the identification of adequate development goals.

Throughout all the applications, the understanding of the fundamental development mechanisms emerged as an increasingly important condition for the design of effective policies. Such understanding, sometimes clear to researchers, is often difficult to transfer to policy makers. Understanding of the fundamental development mechanisms considered in the analysis is essential for policy makers to build confidence in the results produced; and also allows them to re-contextualize the insights obtained and use them in other circumstances. The purpose of the last study reported in this dissertation is that of investigating how model simplification and gaming can facilitate the knowledge transfer to policy makers, and sensitize them to the need for simulation-based decision support.

Although applications of the system dynamics method to development issues, if not abundant, existed well before this dissertation was prepared, the application of a dynamic, quantitative resource-based approach in this field is new. As such, our research opens the way for further analysis in at least two directions. First, the approach developed here is tested in a limited number of instances, and additional research in this sense is required to further apply, test, improve, and formalize the approach. Second, we have only begun with the experimentation

on using Interactive Learning Environment (ILE) as tools to facilitate knowledge transfer to policy makers. The overall planning process, to which policy makers take part, is fundamentally a learning process, where policies are designed, implemented, and, through experience, improved. By providing a transparent interpretation of the development process, and the ability to test alternative policies, ILE can enhance such learning process. We believe this to be a potentially fertile area of research, and one that could bring considerable improvements in the way we design our future.

References

Andersen, D. F., G. P. Richardson, et al., 1997, "Group Model Building : Adding More Science to the Craft", *System Dynamics Review,* 13(2): 187-201.

Bach, N. L. and K. Saeed, 1992, "Food self-sufficiency in Vietnam: a search for a viable solution", *System Dynamics Review,* 8(2): 129-148.

Barney, G. O., 2002, "The Global 2000 Report to the President and the Threshold 21 model: influences of Dana Meadows and system dynamics." *System Dynamics Review,* 18(2): 123-136.

Barney, G. O., W. B. Kreutzer, et al., Eds. 1991, *Managing a Nation: The Microcomputer Software Catalog* Boulder, CO, Westview Press.

Barney, J., 1991, "Firm Resources and Sustained Competitive Advantage", *Journal of Management,* 17(1): 99-120.

Barro, R. J. and X. Sala-i-Martin, 2004, *Economic growth (Second edition),* Boston, MIT Press.

Black, J., 2002, A Dictionary of Economics, Oxford, Oxford University Press.

Bosworth, B. and S. M. Collins, 2003, "The Empirics of Growth: An Update", *Brookings papers on economic activity,* (2), Brookings Institution, Washington D.C.

Bourguignon, F. and M. Sundberg, 2006, "Constraints to Achieving the MDGs with Scaled-Up Aid", *DESA Working Paper,* (ST/ESA/2006/DWP/15), United Nations - Department of Economic and Social Affairs.

Cypher, J. M. and J. L. Dietz, 2004, *The Process of Economic Development,* London, Routledge.

Fair, R. C., 1993, "Testing Macroeconometric Models", *The American Economic Review,* 83(2): 287-293.

Ford, D. N. and J. D. Sterman, 1998, "Expert Knowledge Elicitation to Improve Formal and Mental Models", *System Dynamics Review,* 14(4): 309-340.

Forrester, J. W., 1980, "Information Sources for Modeling the National Economy", *Journal of the American Statistical Association,* 75(371): 555-574.

Forrester, J. W., 1994, "System Dynamics, Systems Thinking, and Soft OR", *System Dynamics Review,* 10(2/3): 245-256.

Größler, A., F. H. Maier, et al., 2000, "Enhancing Learning Capabilities by Providing Transparency in Business Simulators", *Simulation & Gaming,* 31(2): 257-278.

Hausmann, R., Dani Rodrik, Andrés Velasco 2006, "Getting the Diagnosis Right, A new approach to economic reform", *Finance & Development,* 43(1).

Helpman, E., 2004, *The mystery of economic growth,* Cambridge, MA, Belknap Press of Harvard University Press.

HMC, 2000, The American Heritage Dictionary of the English Language Houghton Mifflin Company.

Holly, S. and P. Turner, 1998, "Software Reviews", *The Economic Journal,* 108(450): 1621-1639.

Leipziger, D. and R. Zagha, 2006, "Getting Out of the Rut, Applying growth diagnostics at the World Bank", *Finance & Development,* 43(1).

Lewis, W. and W. A. Lewis, 2003 (1966), *Development Planning: The Essentials of Economic Policy,* New York, Routledge.

Löfgren, H., R. L. Harris, et al., 2002, "A Standard Computable General Equilibrium (CGE) Model in GAMS", *Microcomputers in Policy Research 5,* International Food Policy Research Institute, Washington D.C.

MacKie-Mason, J. K., 1992, "Econometric Software: A User's View", *The Journal of Economic Perspectives,* 6(4): 165-187.

Meadows, D. H., D. L. Meadows, et al., 1972, *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind,* New York, Universe Books.

Pedercini, M., 2003, "Potential Contribution of Existing Computer-Based Models to Comparative Assessment of Development Options", *Working papers in System Dynamics,* University of Bergen, Bergen.

Penrose, E., 1959, *The Theory of the Growth of the Firm,* Oxford, Oxford University Press.

Peteraf, M. A., 1993, "The Cornerstones of Competitive Advantage: A Resource-Based View", *Strategic Management Journal,* 14(3): 179-191.

Pritchett, L., 2006, "The quest continues, After decades of growth research, what can academic economists really say about policy?" *Finance & Development,* 43(1).

Qureshi, M. A., 2008. Financial Policy Structuring for National Development Planning. *System Dynamics Group, Geography Department*. Bergen, University of Bergen. PhD.

Ranis, G., F. Stewart, et al., 2000, "Economic Growth and Human Development", *World Development,* 28(2): 197-219.

Richardson, G. P., Ed. 1996, *Modelling for Management : Simulation in Support of Systems Thinking*, Aldershot, U.K., Dartmouth Publishing Company.

Robinson, S., 1989, Multisectoral Models, *Handbook of development Economics*, T. N. S. H. Chenery, Amsterdam, Elsevier Science Publishers B.V., II**:** 885-947.

Robinson, S., A. Yunez-Naude, et al., 1999, "From stylized to applied models: Building multisector CGE models for policy analysis", *The North American Journal of Economics and Finance* 10(1): 5-38.

Rodrik, D., 2003, "Growth Strategies", *CEPR Discussion Paper,* (4100), Centre for Economic Policy Research, London.

Romer, P., 2007, Economic Growth, *The Concise Encyclopedia of Economics*, D. R. Henderson, Indianapolis, IN, Liberty Fund.

Saeed, K., 1986, "The Dynamics of Economic Growth and Political Instability in the Developing Countries", *System Dynamics Rev.,* 2(1): 20-35.

Saeed, K., 1987, "A Re-evaluation of the Effort to Alleviate Poverty and Hunger", *Socio Economic Planning Sciences,* 21(5): 291-304.

Saeed, K., 1988, "Wage Determination, Income Distribution and the Design of Change", *Behavioral Science,* 33(3): 161-186.

Saeed, K., 1998, *Towards Sustainable Development: Essays on System Analysis of National Policy,* Aldershot, UK, Ashgate Publishing Company.

Saeed, K., 2003, "Articulating development problems for policy intervention: A system dynamics modeling approach", *Simulation and Gaming,* 34(3): 409-436.

Sanderson, W. C., B. Fuller, et al., 2001, "Namibia's Future Modeling Population and Sustainable Development Challenges in the Era of HIV/AIDS", International Institute for Applied Systems Analysis IIASA, Laxenburg, Austria.

Sanderson, W. C., M. E. Hellmuth, et al., 2001, "Botswana's Future: Modeling Population and Sustainable Development Challenges in the Era of HIV/AIDS." International Institute for Applied Systems Analysis IIASA, Laxenburg, Austria.

Senhadji, A., 1999, "Sources of Economic Growth: An Extensive Growth Accounting Exercise", *IMF Working Paper Series,* (WP/99/77), International Monetary Fund, Washington, D.C.

Solow, R. M., 1956, "A Contribution to the Theory of Economic Growth", *The Quarterly Journal of Economics,* 70(No. 1): 65-94.

Solow, R. M., 1988, "Growth theory and after", *The American Economic Review,* 78(3): 307-317.

Sterman, J. D., 1985, "An Integrated Theory of the Economic Long Wave", *Futures,* 17(2): 104-131.

Sterman, J. D., 1996, A Skeptic's Guide to Computer Models, *Modelling for Management*, G. P. Richardson, Aldershot, UK, Dartmouth Publishing Company, 1**:** 3-23.

Sterman, J. D., 2000, *Business Dynamics: Systems Thinking and Modelling for a Complex World*, McGraw-Hill Higher Education.

UNDP, 2003, "Human Development Report 2003 - Millennium Development Goals: A compact among nations to end human poverty", United nations Development Programme, New York.

Warren, K., 2002, *Competitive Strategy Dynamics,* Chichester, John Wiley & Sons Ltd.

WB, 1997, "World Development Report 1997 - The State in a Changing World", The World Bank, Washington D.C.

WB, 2005, "World Development Report 2005: A Better Investment Climate for Everyone", World Bank, Washington D.C.

Wernerfelt, B., 1984, "A Resource-Based View of the Firm", *Strategic Management Journal,* 5(2): 171-180.

Wils, A., M. d. C. Gaspar, et al., 2001, "Mozambique's Future Modeling Population and Sustainable Development Challenges", International Institute for Applied Systems Analysis IIASA, Laxenburg, Austria.

Zagha, R., G. Nankani, et al., 2006, "Rethinking growth", *Finance & Development,* 43(1).

Appendix 1: Planning Models Questionnaire

Dear participants,

Before we begin the training, we would appreciate if you could provide some information regarding long term planning in your country. This information helps us better understanding your planning needs and design training courses and planning models accordingly.

1. Country name:

2. Does your country's government run long-term planning exercises?

3. How often?

4. Is any model used to run long-term planning exercises?

5. What kind of model?

6. What do you think are the three most important characteristics that a long-term planning model should have?

Thank you for your help!