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# Participatory agent-based modelling of childhood poverty in Vietnam

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**Abstract:** In recent years, Vietnam has achieved rapid economic growth since from 1990 to 2004, its GDP nearly tripled and the percentage of poor households decreased from 58% in 1993 to 24% in 2004. However, economic growth has not been shared by all segments of the population, especially those in rural areas and children. Of a total Vietnamese population of 85 million, there is an estimated children population of 30 million, 24 million of which are estimated to live below the poverty line.

In this paper, we report a work-in-progress project, the objective of which is to create a computer-based model of childhood poverty in Vietnam using a participatory agent-based modelling approach for two main purposes: (1) for exploring the causes and consequences of childhood poverty, and (2) for evaluating the effects of a range of scenarios and policies related to the Millenium Development Goals (as set out by the tripartite initiative between the United Nations Economic and Social Commission for Asia and the Pacific, the Asian Development Bank, and the United Nations Development Programme) in view of determining policies that are robust and effective over a wide a range of conditions.

A participatory modelling (PM) approach based on the agent-based modelling (ABM) paradigm is used to create a model of childhood poverty due to the complexity of the system, the involvement of multiple stakeholders with limited resources and often competing objectives, and the multiple levels of interactions inherent in such a system. In participatory modelling, members of the public and stakeholders of the system participate in the modelling process to ensure that the model incorporates accurate information on the system as this information is difficult to obtain by other means.

ABM is increasingly becoming popular for simulating social systems because they can represent important phenomenon difficult to capture in conventional mathematical models. Using agents to model childhood poverty is a novel approach with distinct advantages over conventional modelling techniques such as micro-economic theory whereby economic agents are assumed to be: (1) rational (have well-defined objectives and are able to optimize their behaviour), and (2) homogeneous (have identical characteristics and rules of behaviour). In ABM, these assumptions are relaxed; for example according to Simon, decision-makers often select a satisfactory alternative rather than an optimal one. An ABM can capture quantitative as well as qualitative factors and can also capture their complex interactions in an intuitive way (at agent level).

The strategy in this research is not to collect data directly from a sample of Vietnamese children; rather the intention is to make use of the Young Lives data made available to the project courtesy of the Vietnam Academy of Social Sciences. The Young Lives data and other secondary data sources (e.g. the General Statistics Office of Vietnam, etc.) will be analysed to extract the relevant behaviours, interactions, statistical, and economical for the model. Since the analysis of secondary data alone cannot provide a comprehensive set of factors that accounts for childhood poverty in Vietnam, collection of data from other sources is envisaged. Workshops will be organized to collect data from basically two groups of people: (1) adolescents and people working with children (teachers, health care workers, social workers, etc.), and (2) policy-makers from Vietnamese government institutions (Ministry of Education and Training, Ministry of Health, Ministry of Agriculture and Rural Development, Ministry of Labour, Invalids and Social Affairs, various programs and committees at National and Provincial levels, etc.), staff of Non-Governmental Organisations operating in Vietnam (World Vision, Vietnam Save the Children, etc.), UNICEF, UNDP, World Bank, Asian Development Bank, etc.

The expected outcomes of the project include: (1) a model that includes a comprehensive range of factors affecting childhood poverty, (2) a list of scenarios and policies related to the Millenium Development Goals and relevant to childhood poverty, (3) a model capable of simulating these scenarios and policies, and (4) a list of robust policies for poverty reduction in Vietnam.

***Keywords:*** *participatory modeling, agent-based modelling, childhood poverty, poverty reduction, policy evaluation*

## 1. INTRODUCTION

In recent years, Vietnam has achieved rapid economic growth since from 1990 to 2004, its GDP nearly tripled and the percentage of poor households decreased from 58% in 1993 to 24% in 2004 (UNDP 2009). However, economic growth has not been shared by all segments of the population, especially those in rural areas and children. Out of a total Vietnamese population of 85 million (General Statistics Office of Vietnam 2007), there is an estimated children population of 30 million (UNICEF 2009), 24 million (Save The Children 2009) of which are estimated to live below the poverty line. An evidence-based approach for formulating policies and programs to address childhood poverty requires the development of models upon which scenarios and impacts of possible interventions can be simulated and evaluated. We propose an agent-based modelling of childhood poverty to assist this process.

In this paper, we report a work-in-progress project, the objective of which is to create a computer-based model of childhood poverty in Vietnam using a participatory agent-based modelling approach for two main purposes: (1) for exploring the causes and consequences of childhood poverty, and (2) for evaluating the effects of a range of scenarios and policies related to the Millenium Development Goals (as set out by the tripartite initiative between the United Nations Economic and Social Commission for Asia and the Pacific, the Asian Development Bank, and the United Nations Development Programme) in view of determining policies that are robust and effective over a wide a range of conditions.

## 2. LITERATURE REVIEW

There is no single accepted definition of poverty. The tendency nowadays is to move away from concepts based on physical amenities towards a more social and relative understanding. While poverty is multi-dimensional and not just about minimum income to afford basic needs (Tuan et al. 2003), many countries still use an official definition based on income. It is also widely acknowledged that there is an inherent subjectivity and social specificity to any notion of "basic needs" as the perceptions of well-being of an individual are relative to others in a reference group (Pradhan & Ravallion 2000). Thus, in addition to objective measures, there is a need to use subjective measures (e.g. perceived consumption needs) as well.

Childhood poverty relates to major deprivations during childhood years (e.g. nutrition and health, education and work). Some children may be exposed to multiple risks and be vulnerable to exploitation, violence, discrimination and stigmatisation. Poverty experienced during childhood makes children vulnerable to a lifetime of poverty and may be transmitted to the next generation. The loss in human potential and adult income has formidable implications for national development. Thus, childhood poverty is unacceptable in both human and economic terms.

Childhood poverty is the result of multiple rather than single sets of factors. It is a complex, dynamic phenomenon subject to both specific contextual factors and multiple interacting causes. Poverty is due to the interaction of complex social processes over time and include: poor nutrition and healthcare, low levels of education, insecure livelihoods, insufficiency of assets, cultural norms and social practices, risk and uncertainty, power imbalances and abuses, etc. As a result of the multidimensional nature of poverty, recent research on poverty (e.g. Schischka, Dalzie & Saunders (2008), Waglé (2008)) makes use of Sen's Capability Approach (CA) (1992; 1993). According to Sen, an individual's quality of life can be assessed in terms of the individual's "capabilities" to function, that is what the individual can do or can be. Capabilities are not considered as physical or mental abilities, rather they are regarded as practical opportunities and are not directly observable. Given the "capabilities" or practical opportunities available to the individual, what is actually achieved are called "functionings" by Sen. Thus, "capabilities" lead to "functionings" and "functionings" are a subset of "capabilities". "Functionings" can be elementary (e.g. being healthy) or complex (e.g. being socially integrated). Poverty occurs when an individual is deprived of practical opportunities. Sen argues that public policy should deal with capabilities rather than "functionings", however, since in practice a person's capabilities are difficult to observe and data are usually available for "functionings", policy makers have to settle for "functionings".

One difficulty with CA is the complexity of selecting the right capabilities that define chronic poverty. According to Sen, selection of capabilities should depend on the purpose of the study and the values of the referent populations. Furthermore, selected capabilities should be explicit and open to public debate and scrutiny. Nussbaum (2000) defines a fixed list of ten core capabilities while in the literature several

researchers use up to five capabilities (Alkire 2007), and Alkire (2007) suggests the use of participatory approaches to select capabilities.

## 3. PARTICIPATORY AGENT BASED MODELLING

Agent-based models (ABM) (Arthur 1991; Bonabeau 2002; Lempert 2002) are increasingly becoming popular for simulating social systems because they can represent important phenomenon difficult to capture in conventional mathematical models. In particular, they can relate the heterogeneous behaviour of agents (i.e. children in this research) with different information, different decision rules and different situations to the macro behaviour of the overall system. Using agents to model childhood poverty is a novel approach with distinct advantages over conventional modelling techniques such as micro-economic theory whereby economic agents are assumed to be: (1) rational (have well-defined objectives and are able to optimize their behaviour), and (2) homogeneous (have identical characteristics and rules of behaviour). In ABM, these assumptions are relaxed; for example according to Simon (Simon 1947), decision makers often select a satisfactory alternative rather than an optimal one. An ABM can capture quantitative as well as qualitative factors and can also capture the complex interactions between the factors in an intuitive way (at agent level).

Creating an ABM of childhood poverty not only helps to develop a deep understanding of the causes, effects and dynamics of childhood poverty in Vietnam. Since the model is computer-based, it is also useful for simulating a wide range of scenarios and policies in view of determining robust policies that are effective over a wide a range of scenarios. The scenarios and policies that we intend to simulate are the Millenium Development Goals (MDGs) that are closely related to childhood poverty, namely: (1) eradicate extreme poverty and hunger, (2) achieve universal primary education, (3) promote gender equality and empower women, (4) reduce child mortality, (5) improve maternal health, and (6) ensure environmental sustainability.

Since poverty is due to the interaction of complex social processes over time, a participatory modelling approach is more appropriate than the traditional researcher-centered approach whereby data collection is viewed merely as a collection of facts about the system and the biases of the researcher/modeller probably rarely questioned. A participatory approach is one in which members of the public and/or stakeholders of the system being investigated participate in some ways in the decision making process. There exists a variety of participatory methodologies for public participation ranging from passive participation (information about already made plans and decisions are communicated to the public) to active participation (Giupponi, Mysiak & Sgobbi 2008). In active participatory research, members of a community identify a problem, collect and analyse data and act upon the problem to find solutions and promote social and political transformations (Selener 1997). The rationale for participation is that the public is more likely to accept a policy when they are consulted beforehand or when they take an active part in the definition of the policy. Since decisions are based on shared knowledge and vision as well as experiences, scientific evidence or subjective but informed judgements, participatory approaches have the potential to improve decision making (Giupponi, Mysiak & Sgobbi 2008). Furthermore, a participatory approach has the potential to promote the social learning (Bandura 1977) needed for an in-depth analysis capable of accommodating the breadth and depth that characterise the scope and complexity of childhood poverty. Information emerging from an active participatory process is constantly checked for accuracy by feeding it back to the persons who provided it and by cross-checking with other stakeholders for agreement.

Participatory modelling is a form of participatory research in which a model is the medium used for representing and communicating ideas for the purpose of generating useful insights about complex issues and improved decision making. It is a process in which the formulation and formalisation of a conceptual model is performed by disciplinary experts with the direct involvement of stakeholders (Giupponi, Mysiak & Sgobbi 2008). In order for modelling to be effective under a participative approach, the models used must be transparent and simple enough to be easily understood by stakeholders who may not be familiar with technical models (Mendoza & Prabhu 2006). At the same time, the modelling technique must be of sufficient rigour to accommodate the complexity of the system under investigation. Agent-based models consisting of a set of agents with simple behaviours and their interactions fit into these criteria.

## 4. METHODOLOGY

Agent-based modelling is a relatively new methodology, particularly well suited to research in the social sciences in general, and for modelling childhood poverty in particular, as an agent-based model can be used to simulate the actions and interactions of a collection of children and the people they interact with. The

research methodology is innovative and builds upon the traditional approaches used in the social sciences since after the data collection and analysis stages, additional activities are conducted. These are: computer-based modelling, scenario building, and policy generation and evaluation. Furthermore, since we are dealing with human beings, identifying the relevant behaviours and interactions to include in the model is not a straightforward and easy task. Thus, agent-based modelling is very often an iterative process, the number of iterations being related to the complexity of the model and the availability of the relevant data.

The strategy in this research is not to collect data directly from a sample of Vietnamese children; rather the intention is to use the Young Lives data[1] made available to the project courtesy of the Vietnam Academy of Social Sciences. The first round of the Young Lives data was collected in 2003 and it includes two sets of data (both qualitative and quantitative) collected from : (1) a sample of 1000 8-yr old Vietnamese children and their households, and (2) a sample of 1000 1-yr children and their households. The latter children will be surveyed in several rounds when they are 4, 8, 11 and 14 years old. In addition to the collection of data on children and their households, data was also collected on what was going on in the communities they lived at that time and policies from several government institutions were monitored and recorded using a policy matrix. Thus, the Young Lives data is a very rich dataset, richer than any dataset that can be possibly collected in a single research project.

The Young Lives data and other secondary data sources (e.g. the General Statistics Office of Vietnam, etc.) will be analysed to extract the relevant behaviours, interactions, statistical, and economical data for the model. Since the analysis of secondary data alone cannot provide a comprehensive set of factors that accounts for childhood poverty in Vietnam, collection of data from other sources is envisaged. In line with the participatory modelling approach, focus groups or workshops will be organized to collect data from basically two groups of stakeholders: (1) adolescents and people working with children (teachers, health care workers, social workers, etc.), and (2) policy makers from Vietnamese government institutions (Ministry of Education and Training, Ministry of Health, Ministry of Agriculture and Rural Development, Ministry of Labour, Invalids and Social Affairs, various programs and committees at National and Provincial levels, etc.), staff of NGOs operating in Vietnam (World Vision, Vietnam Save the Children, etc.), UNICEF, UNDP, World Bank, Asian Development Bank, etc.

When using a participatory approach to create an agent-based model of childhood poverty, a variety of multilevel interactions come into play and these issues need to be adequately handled to in order to extract accurate information for creating a valid model. With stakeholders from several sectors of the Vietnamese government, NGOs, public, etc. a first issue to be addressed is the issue of representation of stakeholders in the workshops. Given the hierarchical and multiple levels of decision making of the Vietnamese government (administrative units are: central, province, district and communes), it is imperative that these units be adequately represented in the focus groups. Similarly, the same concern applies to the NGOs with their multiple levels of decision making. However, since there is no agreed mechanism to help select among stakeholders (individuals or groups) (Swyngedouw, Page & Kaika 2002), various mechanisms will be devised to maintain a balanced stakeholder representation. Tools for ensuring stakeholder engagement include: stakeholder analysis, social mapping, Venn diagrams and social networking analysis as they are useful for identifying where power and influence lie in the groups. Furthermore, the services of expert/professional facilitators will ensure that no group dominates the discussion to generate a distorted view of the system. Constant monitoring of the workshops will ensure that no group of stakeholders is under-represented.

Due to financial and time constraints, mixed-stakeholder-represented workshops of about 20 participants will be used for the following purposes: (1) collecting qualitative and quantitative data required for modelling, (2) demonstrating the model in order to collect feedback, and (3) generating scenarios and policies. In order to ensure adequate spatial representation of stakeholders, workshops will be organized across several locations in Vietnam, namely Hanoi, Ho Chi Minh City, Lao Cai, Hung Yen, Da Nang City, Phu Yen, and Ben Tre. Hanoi and Ho Chi Minh City are the main cities and hence represent ideal locations for meeting with government officials and staff of NGOs. Together with Da Nang, Hanoi and Ho Chi Minh City represent urban environments while the remaining locations represent rural provinces with high levels of poverty. Furthermore, the selection of workshops sites for data collection is consistent with the selection procedure used for collecting the Young Lives data.

[1] www.younglives.org.uk/countries/vietnam

When dealing with complex dynamic social systems such as childhood poverty, choosing a policy from a set of alternative ones is limited by our capacity to process the relevant information and manage trade-offs between competing values and objectives (Giupponi, Mysiak & Sgobbi 2008). Furthermore, difficulties dramatically increase when multiple actors are involved in the decision making process. In situations involving multiple, conflicting interests and beliefs, decision analysis methods are helpful in avoiding biases in judgement in order to make better decisions. A variety of methods are available for synthesizing various sources of information, opinions, expectations and aims when assessing different policy options. These methods include: cost-benefit analysis, cost effectiveness analysis, cost utility analysis, multiple-criteria analysis, game theory, utility theory, risk benefit analysis, operation research (Toth 2000).

In this project, we shall use the analytical hierarchy process (AHP) (Saaty 1980) for evaluating multiple objectives. AHP is a form of multiple-criteria analysis that takes into account both objective and subjective factors in order to arrive at a cardinal ranking of alternatives. It is widely used for multi-criteria decision-making as it provides a means of decomposing the problem into a hierarchy of sub-problems that can be easily comprehended and subjectively evaluated. AHP requires that the decision-making criteria be organized into a hierarchical structure. Each level of the hierarchy consists of a few critical criteria that influence the quality of the decision. Having done this, the next step is to determine the relative importance of each of the elements at every level of the hierarchy through a pairwise comparison of each pair of elements with respect to the element directly above. The responses of the decision maker (in the form of a numerical rating in the range 1-9, where 1=equally important and 9=extremely important) are placed into a comparison matrix from which local priorities are determined at each level and synthesized to determine the cardinal ranking of the alternatives.

As previously mentioned, the model building process is incremental and iterative. Thus, the functionalities of the model (the MDG-related scenarios and policies to be simulated) will be built progressively. At any one time, previously built functionalities can be revised and improved in the light of new information being made available.

Given the above explanations, the research methodology is: (1) a proof-of-concept model is first built using information available from the Young Lives data, the literature and secondary sources, (2) workshops are held in Vietnam to demonstrate/validate the model and collect data to refine the model and enhance it with additional functionalities (i.e. the selected set of MDG-related scenarios and policies), and (3) the model is refined using data collected from the workshops (and Young Lives and secondary data). Creating and refining an agent-based model is a programming-intensive job as the model is programmed using a computer language (such as the Java programming language) for maximum flexibility. Steps 2 and 3 are repeated to successively generate several refined versions of the model (i.e. insight model, detailed model, model for directly usable by non-experts) and until all the desired functionalities are implemented, tested and validated. Unlike other projects, the final products (the computer-based model with simulation capabilities, the scenarios, the policies, etc.) are not delivered at the end of the project. Instead, they are constantly improved and demonstrated to policy makers all along the duration of the project. Thus, the chances of delivering an unsatisfactory product are greatly reduced.

## 5. PROOF-OF-CONCEPT MODEL

The proof-of-concept model is shown in Figure 1. The ABM is made of a number of agents randomly interacting with each other and with their local and global environments. In the model, agents represent children evolving within their socioeconomic environments. Agent behaviours are modeled after Sen's Capability Approach (CA) (Sen 1992, 1993) in order to reflect the multi-dimensional approach to evaluate quality of life (or poverty). In the actual implementation of agent behaviour, CA is coupled with a simplified version of the well-known Adaptive Control of Thought-Rational (ACT-R) (Anderson & Lebiere 1998) computational cognitive architecture. ACT-R uses chunks of declarative knowledge and condition-action production rules that operate on these chunks. In order to conform to CA, declarative knowledge is used to encode factual knowledge such as: agent's personal characteristics, environmental conditions of the agent and the basic commodities available to the agent. Procedural knowledge consists of production rules representing procedural skills that manipulate declarative knowledge as well as the environment. These rules will determine the "capabilities" and the "functionings" of the agent according to Sen's approach. Thus, the cognitive architecture allows agents to perceive their environment, use their cognitive skills to process information to find out opportunities available to them ("capabilities") and as a result decide on the course of action to take ("functionings"). When children interact and evolve in their environment, they grow up, their

factual and procedural knowledge evolve, and their "capabilities" and "functionings" change (improve or worsen).

As explained in the methodology section, a range of primary and secondary data (workshops, statistical data, Young Lives data, etc.) will be used to estimate probability functions for key agent characteristics, basic commodities required by children, local and global environmental conditions, procedural rules, range of "capabilities" and "functionings" appropriate for the Vietnamese context. Due to the limited availability of data (what is already available plus what will be collected in workshops), Monte Carlo techniques will be used to model the data collected in order to generate a greater set of data for parameterising a sufficient number of agents required by the model for more accurate representation of the system (Berger & Schreinemachers 2006). Another useful method for deriving agent behaviours from empirical data collected is the use of stylized facts (Janssen & Ostrom 2006) i.e. using broad generalizations from statistical analyses of the data to define agent behaviours (production rules).

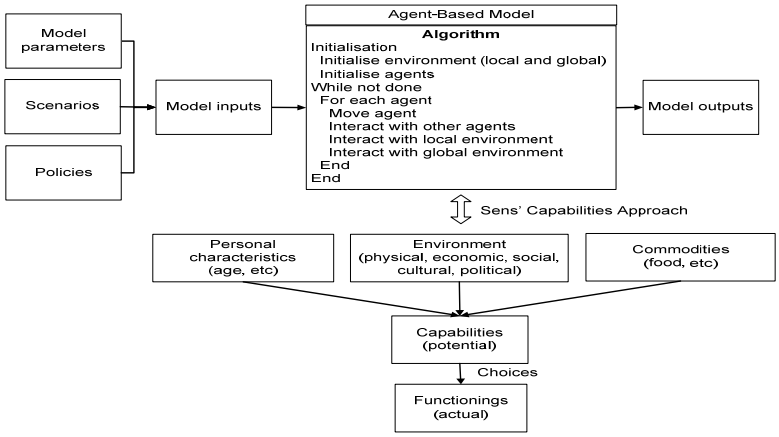


**Figure 1: Agent-based model of childhood poverty**

Three sets on inputs are required when simulating the model: model parameters, scenarios and policies. Instead of hard-wiring the values of various values in the model, these values can be supplied to the model as parameters via a user-interface or as a parameter file for ease of modification between simulation runs. Scenarios and policies are very similar since they are both combinations of various parameters or variables used in the model. The only difference is that scenarios can be viewed as possible (or imaginary) current or future states of the childhood poverty system not under the control of decision makers whereas policies are combinations of variables that can be influenced by decision makers. During simulation runs, variables of interest (various socio-economic indicators of poverty e.g. UNDP's Human Development Index (HDI), cost of policies, etc.) are computed, recorded and used for further analysis to gauge the robustness of proposed policies across a range of scenarios.

Before model outputs can be used with confidence, extensive verification and validation tests are required and these are normally challenging for agent-based models. Verification of the model can be performed in several ways: (1) careful examination of model components and linkages between them, (2) vetting of model structure and rules by effective communication of model design to stakeholders, and (3) sensitivity analysis of parameters used in the model (Parker et al. 2003). Validation can be performed by comparing model outputs with real-world observations of childhood poverty in Vietnam to find out how well real world behaviour is reproduced.

## 6. CONCLUSION

This paper reports work-in-progress on a project using a participatory agent-based modelling approach to model childhood poverty in Vietnam for the purpose of exploring the causes and consequences of childhood poverty and for evaluating the effects of a range of scenarios and policies related to the Millenium Development Goals. The use of a participatory research approach is justified because the issues surrounding childhood poverty are complex and useful domain knowledge in this area can only be elicited in group settings involving multiple stakeholders that also facilitate social learning. An agent-based modelling approach is appropriate to model childhood poverty within the context of a participatory framework since

agent-based models are intuitive, simple and transparent enough for the average non-technical stakeholder to understand.

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