A system dynamics framework for simulating sustainable human development according to the capability approach[§]

Abstract

In this paper we model sustainable human development as envisaged by Sen's capability approach in a system dynamic framework. We verify how some achieved functionings change over time because of structural dynamics and variations in the institutional setting and instrumental freedoms (IF Vortex).

The model consists of two sections. The 'Left Hand Side' section shows the 'demand' for functionings in an ideal world situation. The real world one, on the 'Right Hand Side,' indicates the 'supply' of functionings that the socio-economic system is able to provide to individuals.

The general model, specifically tailored for Italy, can be simulated over desired time horizons: for each time period, we carry out a comparison between ideal world and real world functionings. On the basis of the distances between these functionings, the model simulates some responses by decision makers. These responses, which in their turn are influenced by institutions and instrumental freedoms, ultimately affect the dynamics of real world functionings, i.e. of sustainable human development.

Introduction

The notion of welfare used by the utilitarian framework forming the basis of mainstream economics offers only a limited perspective on human well-being. This notion in fact reflects only the class of differences captured by money metric, under the economic rationality of self-interested utility maximization. Moreover, the income approach to well-being does not account for the diversity among human beings and for the heterogeneities of contingent circumstances[1].

It is preferable therefore to enlarge the notion of well-being so that it encompasses other dimensions – social, environmental, institutional, inter-generational - important for the flourishing of human beings but which the utilitarian metric does not account for. This perspective can be viewed as a model of development which advances economic and social justice, protects the environment, strengthens institutional capacities and enhances the freedom of future generations. In brief, this is the notion of sustainable human development as used in Sen's capability approach.

The ultimate goal of this article is to point out a possible way to model and simulate the evolution of sustainable human development by means of system dynamic analysis. To this end, we monitor how certain achieved functionings change over time because of structural dynamics and variations in the institutional setting and in instrumental freedoms.

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[1] Conducting complete critique of the drawbacks of utilitarianism, however, would be beyond the scope of this article.

Section 1 defines the notion of sustainable human development according to the capability approach. Section 2 deals with the operationalization of the capability approach. Section 3 highlights the fundamental properties of the simulation model. Section 4 specifically depicts the architecture of the framework proposed. Section 5 focuses on the simulations' results. The Concluding Remarks consider the main theoretical and empirical implications of the analysis.

1. Sustainable human development

Sen's conception of sustainable human development departs from Bruntland's traditional account[2] insofar as its focus is on the broadening of human freedoms on a sustainable basis, rather than on needs. In fact, Sen has constantly underlined the importance of entitlements, opportunities, and freedoms as conceptual foundations for social choice. Over the past thirty years Sen has developed an approach based on the opportunities available to individuals to pursue their life-projects in terms of doing valuable acts and of achieving valuable states of being. This perspective is the core of the capability approach, whose principal novel features are its definition of a broader theoretical framework for well-being, and its stress on the importance of enjoying enduring essential freedoms to a specific life-project, this being dependent at the same time "on a number of contingent circumstances, both personal and social" (Sen, 1999: 70). Although Sen's interest seems to focus mainly on the role played by the capability approach as a framework of thought in which to highlight the drawbacks of other social choices approaches, his approach can also be considered a method with which to make interpersonal comparisons of well-being. Sen himself, in fact, though acknowledging the empirical difficulties, ascribes significant importance to the practical usability of his theory: "the approach must nevertheless be practical in the sense of being usable for actual assessment" (Sen, 1987 b: 20). We intend to use the capability perspective to explore a number of social issues, such as well-being and poverty, liberty and freedom, living standards and development, gender bias and sexual division, justice and social ethics (Sen, 1993: 30, note 1), and to analyse the evolution of sustainable human development. For the capability approach, human development involves the broadening of people's potential, because individuals are the ends of development, rather than its mere means. In Sen's vocabulary, sustainable human development more closely resembles the notion of agency than the narrower one of well-being: the latter in fact refers to a personal situation in terms of achieved functionings and also includes sympathy and a concern for others' achieved functionings (or others' well-being); while the former, because it takes commitment into account, is more inclusive insofar as it also relates to the willingness to support other individuals in their pursuit of their life-projects regardless of the impacts on one's own well-being.[3] Hence sustainable human development considers a real social commitment, stronger than that implied by the notion of well-being. Consequently, we use the term 'well-being' interchangeably with 'sustainable human development', instead of the more appropriate 'agency', doing so in order to abide with the traditional vocabulary in the literature on the argument. The Senian approach has profound roots in philosophy and classical economic theory, both of which, in fact, are concerned with the issue of human development: "The approach [to

[2] The Bruntland Report (1987) defines sustainable development as a form of development which satisfies the needs of the present generation without compromising the ability of future generations to meet their own needs.

[3] Furthermore, Sen has propounded a narrower notion, namely the 'standard of living', which involves only aspects of well-being regarding «the nature of his own life, rather then [from] 'other-regarding' objectives or impersonal concerns" (Sen, 1993: 37)

human development] reclaims an old and established heritage, rather than importing or implanting a new diversion" (Anand and Sen, 1994 b: 3). More specifically, Sen's work has evident relations with Aristotle's human flourishing and "strong connections with Adam Smith's analysis of 'necessities' and conditions of living" (Sen, 1999: 24) in regard to the ability of people to choose a reasonable life. Furthermore, Sen's critique of utilitarianism comes close to the Marxian approach, which seems to valuate goods themselves as intrinsically good, in what is called 'commodity fetishism'. What Sen seeks to establish is a sort of ethical foundationalism rooted not in a metaphysical principle, but rather in ethical concepts intrinsically important for human lives:

> "We must ask which things are so important that we will not count a life as a human life without them? Such an evaluative inquiry into what is deepest and most essential in our lives…can be a way of looking at ourselves, asking what we really think about ourselves and what holds our history together" (Sen, 1992: 210).

According to Sen's view of human development, individuals are not simply people with needs; rather, they are "agents of change who can - given the opportunity - think, assess, evaluate, resolve, inspire, agitate, and through these means reshape the world" (Sen, 2000: 1). The enlargement of substantive human freedoms is the core of Sen's perspective. In brief, the capability approach requires "a broader informational base, focusing particularly on people's capability to choose the life they have reason to value" (Sen, 1999: 63) and highlighting the social and economic factors which enable people to fulfil this valuable life-project. Thus, the capability approach concentrates directly on the substantive freedoms of individuals. In this regard, Sen suggests that well-being should be considered in terms of human functionings and capabilities. Functionings relate to what a person may value doing or being: they are the living conditions achieved by an individual and represent a set of interrelated activities and states ('doings' and 'beings') that form his/her life. Capabilities concern the ability of an individual to achieve different combinations of functionings, and they define the freedom to choose the life that s/he prefers. These two categories are complementary but nevertheless distinct: "A functioning is an achievement, whereas a capability is the ability to achieve. Functionings are, in a sense, more directly related to living conditions, since they are different aspects of living conditions. Capabilities, in contrast, are notions of freedom, in the positive sense: what real opportunities you have regarding the life you may lead" (Sen, 1987: 36). It is not the aim of this paper to reconsider all the theoretical issues concerning this approach, since they have been thoroughly analysed in the literature. Rather, here we intend to define a model for monitoring the evolution of sustainable human development according to Sen's view. Sustainable human development, as said, can be generally defined as an increase in the quality of life which is both equitable and durable. In this sense "[the human development approach] applies …to the freedom to lead lives that people today and in the future value" (Anand and Sen, 1994b: 6). Accordingly, Sen himself defines sustainable development "as development that promotes the capabilities of present generation without compromising capabilities of future generations" (Sen, 2000: 5). This is in fact a point of view strictly consistent with the extension from the fulfilment of needs to the enhancement of human freedoms on a sustainability basis. At the same time sustainable development as envisaged by Sen owes a great deal to the Bruntland notion: the latter, too, includes considerations on the quality of life of each future generation, combined with concerns of intragenerational equity, and pays attention to the ability of meeting ones' own goals. The difference between the two approaches lies in their evaluative conceptions.

The Bruntland approach views human beings only in terms of needs and fulfilment; Sen's underlines the importance of freedom in enhancing human capabilities:

> "[So. That is,] if you broaden sustainable development as sustaining the freedoms that people have, expanding freedoms and sustaining the freedoms that we have, I think we can get an adequately broad view of it. And that is the direction I would like to push the sustainable development literature to go. And it is an important distinction because quite often on the ground that ends justify the means - a very bewildering sentiment - people do things, recommend policies in the name of sustainable development, that begin by obliterating something very worth sustaining, namely human freedom." (Massarenti, interview with A.K. Sen, 2000).

To sum up, Sen suggest that human development coincides with the expansion of capabilities ("..[a] development that promotes the capabilities of present people…", Sen, 2000: 5). If this enlargement of the space of choices is expected to hold in the future ("…without compromising capabilities of future generations", ***ibid***: 5) it is possible to refer to it as sustainable (human) development. Finally, from a practical perspective, Sen recommends that "In detailed application, a general idea of this kind [i.e. sustainable development] can, of course, be combined with more precise articulation (taking contingent note of the availability of data and information", ***ibid***: 3). On this ground, therefore, in the following sections we outline a possible model for measuring, through system dynamics analysis, sustainable human development as defined by the capability approach.

2. The operationalization of the capability approach

Operationalization involves the translation of theoretical concepts into empirical ones which eventually become empirical variables usable in quantitative and non-quantitative analysis.

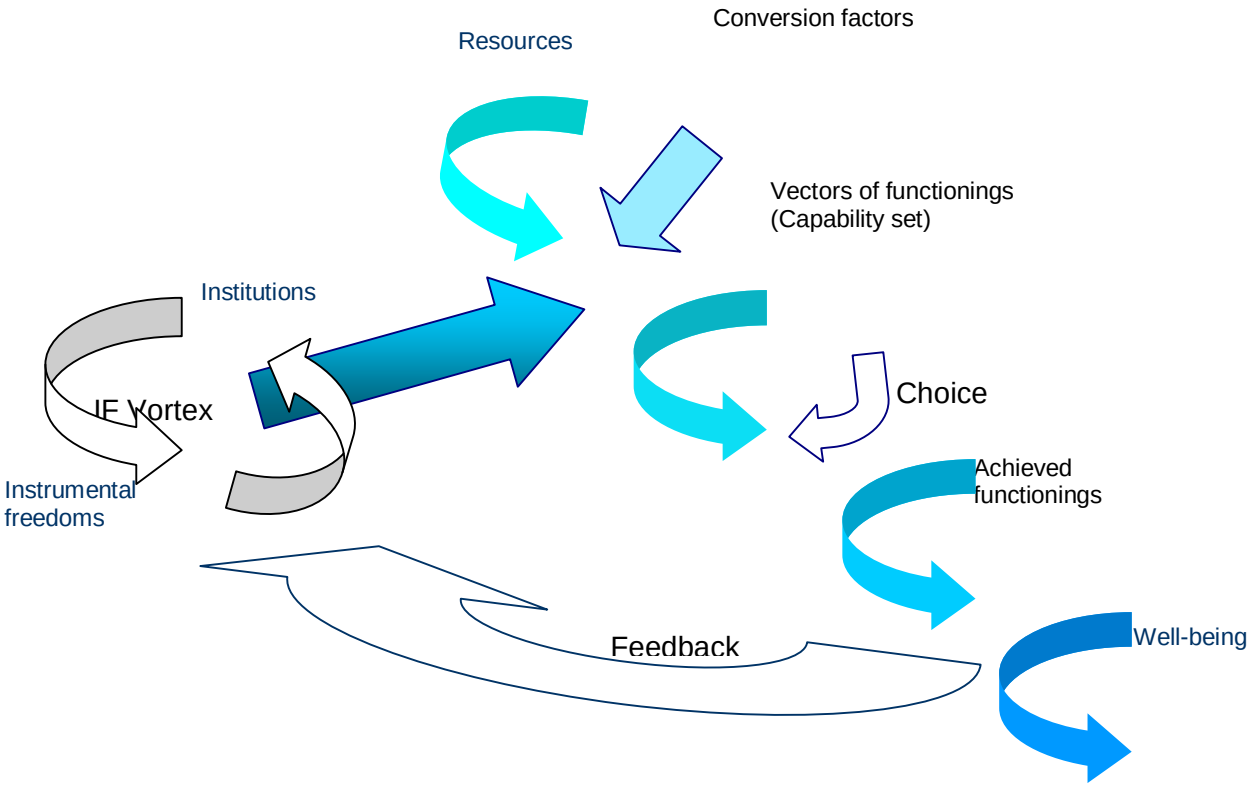
We consider the capability approach primarily as a method with which to make interpersonal comparisons of well-being. As said, in Sen's view it has far wider implications: it is first of all a framework of thought which aims to highlight the drawbacks of other approaches to identifying and defining well-being and human development. Since Sen's interest seems to be mainly concerned with this foundational level, he has never provided a formula or a procedure for carrying out welfare and development measurements and comparisons.[4] Vagueness, in fact, is a distinctive feature of the capability approach, for it depends on the context, which is as ambiguous and complex as human life and values are.

In Sen's approach, resources, sifted by conversion factors, allow the attainment of a number of beings and doings which can be represented by the vectors of achieved functionings (or the capability set). Moreover, the conversion of resources into functionings is supported by the intertwined nexus of relationships between instrumental freedoms and institutional efficiency and effectiveness: we call this complex connection 'the Institutions-Freedoms – or IF – Vortex'.[5] The different contingent circumstances

[4] To the great disappointment of those who have looked for these 'recipes' in Sen's writings.
[5] The expression 'Institutions-Freedoms Vortex' is taken from Chopra, Duraiappah, 2001.

represented by conversion factors and the IF Vortex "make opulence ……a limited guide to welfare and the quality of life" (Sen, 1999: 71).
Finally, the achievement of a specific subset (a vector) of functionings generates a given level of well-being, which in turn may eventually 'fine-tune' the IF Vortex and its responses.

Figure 1 - The capability approach: a general view



We consider this schematic and intrinsically dynamic representation as the capability approach itself, and as quite consistent with Sen's view of well-being:

> "We use incomes and commodities as the material basis of our well-being. But what use we can respectively make of a given bundle of commodities, or more generally of a given level of income, depends crucially on a number of contingent circumstances, both personal and social" (Sen, 1999: 70).

These different contingent circumstances "make opulence ……a limited guide to welfare and the quality of life" (ibid: 71).
In order to operationalize the capability approach we must introduce a major simplification[6]: we restrict the model to the space of the chosen vector of functionings. In doing so, we avoid the issue of the measurement of capabilities and bypass the problem of their unobservability[7]. Therefore, we take up Basu's suggestion reported in Brandolini and D'Alessio (1998: 15): "…to go along with Sen and evaluate well-being on the basis of functionings, but be content with achievements, instead of capabilities". Sen himself

[6] We are aware of other areas of incompleteness with respect to the foundational theory. For thorough and yet synthetic analysis of the capability approach, see for instance Gasper (2002), Robeyns (2000), Saith (2001).
[7] In fact their potential nature can become actual only after an individual's process of choice.

suggests that at a practical level the most appropriate focus of attention should not always be the measurement of capabilities: "Some capabilities are harder to measure than others and attempts to put them on a 'metric' may sometimes hide more than they reveal" (Sen, 1999: 81). Furthermore, the chosen vector of functionings could be seen as an elementary valuation of the capability set, which, depending on the appropriate choice of the elements of the vector (e.g. assuming a maximizing behaviour), can in turn be considered as the maximally valued one[8]: "the focusing on a ***chosen functioning vector*** coincides with concentration on the ***capability set***, since the latter is judged, ultimately, by the former." (Sen, 1999: 76 – emphasis in the original). In fact, although Sen claims that it is necessary to specify deprivation or achievements in terms of capability, he provides no definitive argument for this point. So we can say that a universal need for A can be a proxy for a universal capability to A, considering A sufficiently general in order to permit different specifications in different contexts (as we try to do in our model).

From a theoretical point of view, the reference unit of the capability approach is the individual, given that functionings and capabilities are in fact properties of individuals. More specifically, Sen moves in the space of moral individualism and considers the individual to be the only unit that counts when evaluating social states, avoiding at the same time a reduction of society to the mere sum of individuals and their properties, as in the case of ontological individualism. In other words, the use of different units of analysis (groups based on age, gender, administrative boundaries or other elements) in empirical work points out intergroup variations, but according to Sen (1992: 117, n.1) the focal point of the analysis is still the individual, since interest in groups is only derivative (i.e. with regard to the differences among individuals placed in different groups) and not intrinsic (i.e. with regard to the differences between groups seen as unique bodies). Nonetheless, Sen's moral individualism does not forget that a human being is a ***zoon politikon***, insofar her evaluative process is shaped by a number of social elements, such as social conversion factors and, mainly, the IF vortex. Indeed, Sen has a deep interest in the institutional basis of human life, and his concern for the individual seems rather formal, or at least instrumental, insofar as individuals are member of a community. For these reasons it is possible to use the capability approach to assess social well-being, that is, some form of aggregation of individuals' well-beings[9]. In other words, focusing the capability approach at a macro level implies loss of the keener in-depth perspective of individual analysis. But this is the price we have to pay to obtain a policy tool which hopefully furnishes deeper understanding of sustainability dynamics over time.

In applying the capability approach, Sen himself refers to regional, national, sub-national, or group data. For instance, when examining poverty and deprivation in India and Sub-Saharan Africa (Sen, 1999: 99-104), he draws on national and sub-national level data. Or, when dealing with gender inequality, he works both at different territorial levels and with group data (Sen, ibid: 104-107).

[8] In this perspective the value of the capability set is that of a single element of the set itself, the maximally valued one. But this view holds if freedom is considered mainly in its instrumental meaning, and not in its substantive one. In this latter case we would inevitably have pushed our analysis to the capability set, with all the problems deriving from unobservabilty and from the larger amount of information required.

[9] Sen (1991: 15-16) points out that this is a non-welfarist approach to the assessment of what standard economic theory calls 'social welfare'.

3. Fundamental properties of the MiSS model

3.1 The consistency between the MiSS Model and the Senian Approach

The MiSS (MeasurIng Sustainability in Sen's framework) is a quantitative model simulating the workings of an economic and social system. It starts from the conventional general equilibrium approach in order to incorporate some features of the Senian approach to human development. The economic literature has often stressed the difficulties of operationalising the Senian approach. Sen himself says:

> "I am not under any illusion that the capability approach to the standard of living would be very easy to use. It is particularly difficult to get an idea of a person's positive freedom of choice – what he or she could not have done or been. What we observe are the actual choices and realizations. But the case for using the capability approach is not, of course, logistic convenience but relevance" (Sen, 1984: 87).

This quotation should stand as a permanent warning to anyone who ventures into building Sen-inspired quantitative models. It should be made clear from the outset that the best a model can do is try to establish quantitative relationships among observable factors whose values define the boundaries within which individuals are free to choose. A school in a village is not culture, even less is it happiness springing from cultural achievement: it is a material condition of the freedom to pursue cultural achievement . Hence, rather than describing actual human development, a quantitative model of social and economic interaction is able to describe how limits to human development are removed (or tightened) over time.

Within this severe limitation, a wide array of modelling strategies are still available, some of them more consistent with the Senian approach than others. In the next sections we shall show how MiSS departs from the conventional view, and the extent to which it relates to Sen's approach. As a matter of fact, MiSS cannot be considered a conventional model of the economic system. There are two reasons for this: firstly, to some extent it goes beyond the customarily set boundaries of economic models, in that it attempts to model variables and phenomena which are usually attributed to the broader realm of social science; secondly, even its purely economic component is rather eclectic as far as theory is concerned. The latter feature is not unrelated to the former.

An orthodox approach to economic modelling should proceed through the following three main steps:

1. Determine, for a given set of preferences, technology and initial endowments, the Pareto-Optimal (paths of) resource allocation.
2. After defining the set of markets, and the distribution of endowments, market power and information, determine the equilibrium allocation.
3. Define the optimal (least distortionary, second best) policies to bridge the gap (if any) between Pareto optimal and equilibrium allocation.

This would be the standard approach if it were assumed that the only important freedom is that of choosing a private consumption basket under the budget constraint of the selfish individuals, interacting only through competitive markets: a standard CGE model would

be computed with little or no relation to Sen's theory (and the growth of individual income would be a satisfactory index of 'human' development).

In the next section we will examine how MiSS deals with the definition of socially desirable allocations, the equilibrium notion and the role of policy.

3.2 Socially desirable allocations

Using the general equilibrium approach we are able to distinguish between efficient and inefficient allocations, not between 'just' or 'fair' allocations and allocations which are not. By way of example, a certain amount of drug addiction may be ***Pareto optimal*** (in the sense that at least one agent would be strictly worse off at all alternative allocations), but this is different from judging that amount as socially ***desirable*** from an ethical or philosophical point of view.

In our approach, instead, an individual agent is not represented in the first instance by a preference ordering, but rather by a set of ***ideal functioning levels***, depending on his/her status as a human being living in a specified place at a specified time.

Ensuring that these ideal functioning levels are attained does not coincide with development, as we argued above: it simply means creating a set of necessary conditions for the individual to be free to pursue his/her development as a human being.

On the other hand, ideal functioning levels, as defined here, do not coincide with demanded quantities, which depend on individual preferences and on budget constraints (and therefore on the initial allocation). Ideal functioning levels may instead depend on simple biological facts (the need for sufficiently clean air and pure water) as well as on complex judgmental issues and the type of social interaction taking place in the society (for instance, the desirability of a rehabilitation-oriented correctional system). In the model, different principles apply to the determination of the ideal levels for different functionings, as the following few examples show:

1. Politically set targets (the Kyoto Target for the environment),
2. International comparisons (the European average for the R&D expenditure/GDP ratio),
3. Maintenance or 'reasonable' improvement of achieved levels (a one-third reduction in the crime rate).

To be sure, this approach requires a statement of 'preferences' on the part of the researcher, who can no longer simply take given individual 'demand' as the only guideline. Individual preferences come into play when the actual use made by individuals of the opportunities available to them is concerned. However, we do not model these choices.

Our starting point is therefore a population, which in this version of the model is a homogeneous, but in principle can be differentiated according to age, gender, nationality, etc. The population (the individuals in the population) comprises a set of ideal functioning levels which change as the population grows and changes in structure. The set of these ideal levels represents what we call the 'left-hand side' of the model (the name derives from the graphical representation we adopt: see figure 2).

3.3 Equilibrium allocations

In a sense, the 'left-hand side', as we have just defined it, takes the place in MiSS which in the orthodox approach is occupied by the set of efficient allocations: that is, an ideal setting which the actual condition of the economic systems may or not reproduce, and with different degrees of approximation. On the general equilibrium view, 'actual condition of the economic system' means market equilibrium and operation, both possibly influenced by policy variables whose values are determined outside the system.

In the MiSS model the actual condition and operation of the economic system is instead described by a set of relationships expressed as ***reduced forms***. By a 'reduced form' we mean some empirically estimated relationship between a set of exogenous and one endogenous variable (estimates are taken from the literature). Such relationships do not necessarily lend themselves to an equilibrium explanation (i.e. they are not necessarily the outcomes of an optimal choice procedure or of market coordination among optimizing agents). One example for all is the mechanism that determines schooling levels. Reinterpreting Checchi and Brunello (2003), we assume that the difference between the schooling levels of two individuals corresponds to one half of the difference between the schooling levels of their parents. Obviously, a complex theoretical story lies behind this empirical relationship (and indeed, more than one sensible story could be told about it): however, we do not discuss the theoretical explanation and simply 'use' the relationship. Similarly, the assumption of a constant marginal propensity to save allows us to skip all theoretical modelling of intertemporal choices.
The specification of these reduced-form relationships constitutes what we call the 'right-hand side' of the model (again, the graphical representation of figure 2 explains the name). The right-hand side is divided into sub-blocks (called 'boxes') corresponding to different sectors of the economic and social system. Boxes are interdependent in ways which are illustrated in section 4.

Despite general recourse to reduced-form representation, some market equilibria in a conventional sense are implicit in the MiSS model. However, the impact of these market interactions is limited by the structure of the model itself. Two sets of markets are implicitly dealt with. The first one is the set of factor markets, where we assume that the existing, previously accumulated stocks of physical and human capital are supplied inelastically, as well as raw labour. The flow of the latter and the accumulation rules of the former depend in turn on price-unresponsive variables: we assume that individuals consume a given, constant share of their after-tax income; human capital is accumulated at no (explicit) private cost, following the above mentioned pattern taken from Checchi-Brunello (2003); the flow of raw labour depends on population and on other price-insensitive variables (see below, par. 5.1 for details). Then we implicitly assume that the wage and the rental rates of physical/human capital adjust so as to equate demand and supply for labour and productive stocks. On the other hand, these prices have no influence on current and even future supply of factors, so that we can disregard them in our analysis.
The other set is the market for private consumption/savings. However, consumption is the residual left after deducting taxes and capital accumulation from income, so that equilibrium in this market is ensured.

3.4 Policy

In the MiSS model, policies are not determined outside the system, but the political process is a part of the operation of the system as a whole. This is how we incorporate a typical Senian issue, namely, the institutional response and the efficiency thereof. The MiSS tries to model the policy process rather than seeking to define a set of optimal policies in abstract. The main idea is that the government reacts to differences between the right-hand side and the left-hand side (desirable social states and actual conditions) by adjusting both the level of taxation and the composition of public expenditure, according to a fiscal rule which can be summarized as follows: funds raised through income taxation are allocated to different types of expenditure according to the weights of different issues on the political agenda. Such weights depend in turn on a (fixed) basic budget share which expresses the general attitude of the government towards that specific issue, and on an index of the distance between the actual and the target level for the associated functioning. The latter element can be seen as an index of the 'pressure' applied by public opinion, the opposition, citizens' mobilisation, etc. to meet that need. Then the institutional response plays a paramount role in the model as a whole. Secondly, private consumption and investment in physical and human capital do not react to this kind of disequilibrium: that is to say, markets do not provide the goods required to satisfy these needs.
Third, there is no ***ex ante*** reason to expect the adjustment mechanism to achieve the equilibrium in the given time period, and in principle not even over a very long time horizon.
To provide some examples, suppose that on some issue (say, environment protection) there is a great deal of pressure (a large perceived difference between actual and target levels of environment protection) coupled with a very low basic budget share: in this case it is possible that even a wide difference between desired and actual levels of environment protection may nevertheless trigger an irrelevant policy effort (some may call this the 'inertial' component of policy making). Moreover, it is not enough that pressures on, again, environmental policies be strong in absolute terms; they must be large relative to the weight of other issues (this alludes to the sensitive issue of 'agenda setting'). Finally, if policies are not too effective, there may be rebounds and cyclical effects: suppose that a great deal is spent, with little effect, on the environment (again purely for the sake of example): since this subtracts resources from policies addressing other functionings, increases in the differences between desired and actual levels for the latter are likely to emerge in the medium run. In turn, this may trigger an increase in pressure for spending on functionings other than environmental protection; in the long run, an early failure in environmental policies may then lead to a squeeze on environment spending, which falls into a sort of 'poor results, small budget share' trap.

Figures 2 and 3 provides a schematic representation of the MiSS model. Figure 2 is a general representation of the model showing its basic structure: on the basis of the distance between ideal and real values, policy responses aimed at closing the gap are generated. Their effectiveness is influenced by the degree of efficiency of the institutions. Figure 3 provides a rather more detailed map of the MiSS model focusing on the main

interactions which act among the boxes of the MiSS model. GDP influences employment, mobility, shelter, environment and health. In turn, it is influenced by employment and education. This latter has a key role in the model: it also affects security and health. Security is also affected by employment. Public expenditure plays an important role in the MiSS model because it finances all the policies aimed at reducing the gap between ideal and real values. The gap closure depends on institutional efficiency, which acts as a filter between public expenditure and policy targets. When it is high, the policy makers are able to translate their expenditures into targets to a large extent; the reverse when it is low. Naturally, feedback exists between GDP and public expenditure: the latter stimulates GDP and is generated by GDP. The details of the boxes and their interactions are given below.

Figure 2 - An overview of the MiSS model

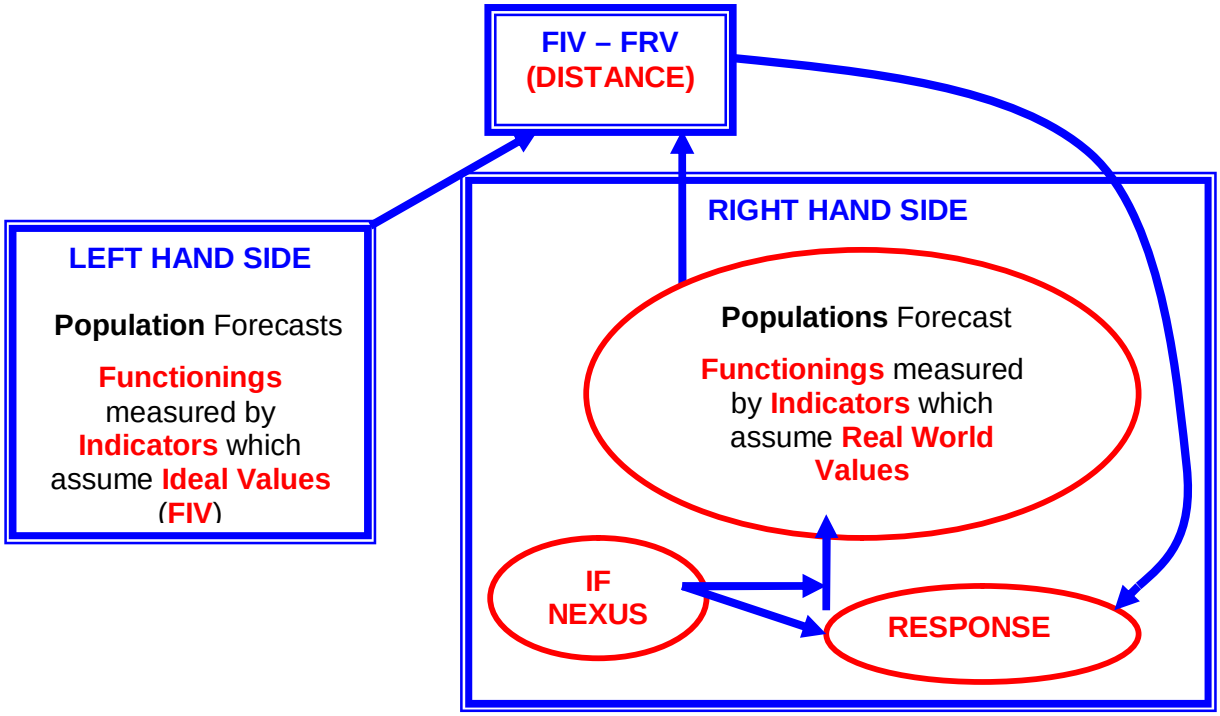
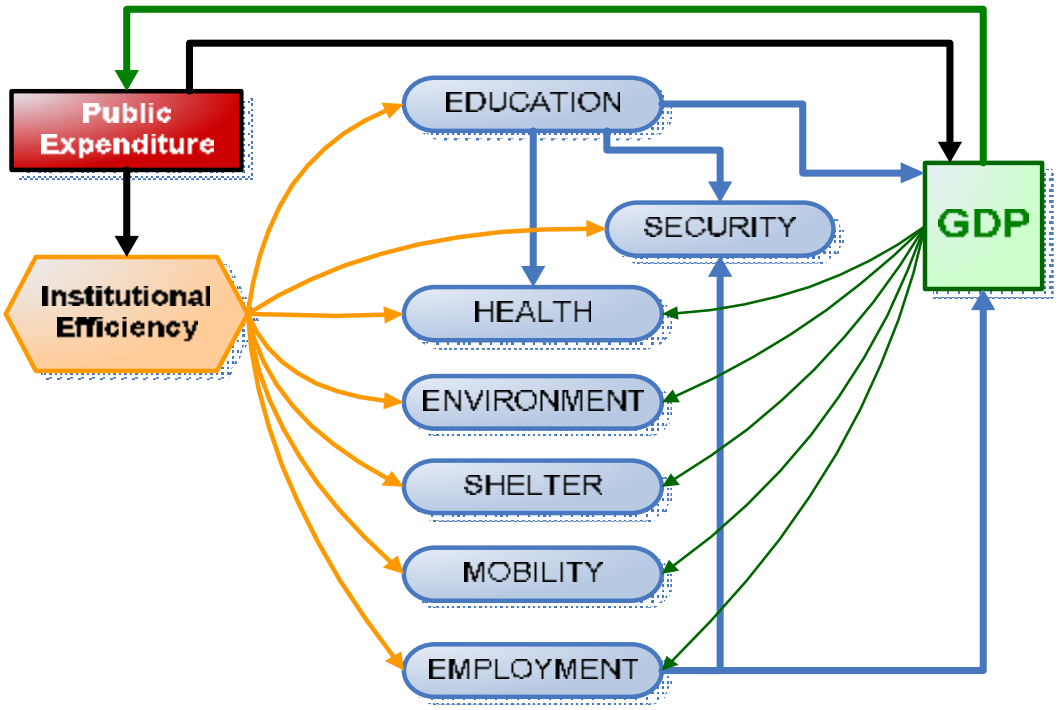


Figure 3 - An overview of the main interactions in the MiSS model



4. The architecture of the MiSS model

In this section we separately describe the different blocks or 'boxes' into which the MiSS model can be divided. Paragraphs 4.1 through 4.9 describe boxes belonging to the right-hand side of the model and specify the reduced-form relationships which drive the actual workings of the system. Paragraph 4.10 instead describes the public policy box, which represents a sort of bridge between the left-hand and the right-hand side, in so far as public policies react to differences between the actual and desired levels of available functionings.

4.1 The Income Box

In the MiSS model, the economic system represents one of the most important 'blocks' of what we call the right-hand side. The (bad or smooth) operation of the economic system determines the size and structure of the flow of goods (consumption/investment, durable/non-durable, material/immaterial, public/private goods) which are inputs or complements to the functionings (and the ill-functionings) on which the MiSS model focuses.

As a consequence, the issue of how to represent the economic system in the model can be hardly regarded as trivial. Let us begin by stating two desirable properties which this representation should have:

1. Long–run: the general setting of the MiSS model is a long-run one, so that the economic 'side' should also allow for growth and accumulation.

2. Policy-sensitiveness: a policy-insensitive economic system would imply that public policies only redistribute resources to different uses, rather than also affecting the production of resources.

4.1.1 Technology

Solow's one-sector model (1956) represents the technology by means of a constant-returns-to-scale, decreasing-marginal-returns production function, and on the simple behavioural assumption that individuals devote a fixed share of their income to savings, which are entirely transformed into new physical capital.
The production function is:

$$Y_t = A_t F(K_t, L_t A_t, H_t)$$

where K is physical capital, L is raw labour, H is human capital and A is the level of total factor productivity. K, H, and A are stocks and the suffix t denotes their levels at the beginning of the period from t to $t+\Delta$, where Δ is the unit of measurement of time (1 year in our model). L_t is the average flow of raw labour during the period between t and $t+\Delta$. More precisely, we adopt a Cobb-Douglas form for the production function:

$$Y_t = A_t K_t^{\ a} L_t^{\ 1-a-b} H_t^{\ b}$$

Capital changes over time according to the equation:

$$K_{t+1} - K_t = s(1-\tau)Y_t - \delta K_t$$

where: s is the marginal propensity to save out of net-of-tax income, t is the average tax rate on income, d is the rate of depreciation of physical capital. The expression for the rate of growth of GDP becomes:

$$\frac{Y_{t+1} - Y_t}{Y_t} = (1+g_A)\left[(1-d)(1+n)^{1-a-b} + s(1-t)A_t\left(\frac{K_t}{L_{t+1}}\right)^{a-1}\left(\frac{H_t}{L_{t+1}}\right)^{b}\right](1+g_H)^{b} - 1$$

Where:

where $n \equiv \frac{L_{t+1} - L_t}{L_t}$, $g_H \equiv \frac{H_{t+1} - H_t}{H_t}$ $g_A \equiv \frac{A_{t+1} - A_t}{A_t}$. These growth rates are determined endogenously to the model. In the next paragraph we discuss human capital accumulation, while the growth of raw labour force is discussed in the Employment Box and g_A is discussed in the Research Box.

4.1.2 The accumulation of human capital

Let us for the moment leave aside the rate of growth of labour and concentrate on the growth rate of human capital. The model comprises the idea that the accumulation of human capital by an individual depends on his/her family background. Checchi and

Brunello (2001) find, in large cross section of individuals, that one additional year of schooling of the parents translates into half an additional year of education for the children. More precisely, if we take two individuals, the difference between their numbers of years in school is estimated to be half the difference between the numbers of school-years of their parents. If we take child s and child s', with parents p and p', we have:

$$H^S - H^{s'} = 0{,}5\left(H^p - H^{p'}\right)$$

Since we were working in time and not with a cross-section, we translated the above result as follows. The stock of individuals living at time t were supposed to have parents who, on the average, were of the same age 25 years previously. Then the difference in schooling between individuals living at time $t+1$ and individuals living at time t was deemed to be half the difference between the school-years of the individuals living at time $t-24$ and individuals living at time $t-25$:

$$H_{t+1} - H_t = 0{,}5\left(H_{t-24} - H_{t-25}\right)$$

and

$$g_H = \frac{H_{t+1} - H_t}{H_t} = 0{,}5\left(\frac{H_{t-24} - H_{t-25}}{H_{t-25}}\right)\frac{H_{t-25}}{H_t}$$

The Employment Box

Because MiSS is a long-run model, a short-run phenomenon such as unemployment due to lack of effective demand is absent. It is the employed labour force which contributes to determining the level of GDP, not the other way around. The employed labour force depends on the population through the employment rate. There are three possible sources of structural unemployment which may prevent the actual employment rate from equalling the target employment rate.

1) Unemployment due to malfunctioning of the labour market
2) Technological unemployment
3) 'Complementarity' unemployment due to a lack of fixed capital.

The equation for employment is:

$$L_{t+1} - L_t = r_t\left(N_{t+1} - N_t\right) + c_k\left(\frac{K_{t+1}}{K_t} - 1\right)L_t - c_A\left(\frac{A_{t+1}}{A_t} - 1\right)L_t$$

where r_t is the rate of employment in the last period and N_t is the population at time t. The term $c_k\left(\frac{K_{t+1}}{K_t} - 1\right)L_t$ means that employment grows to keep the capital/labour ratio constant, to an extent which depends on the c_k coefficient. The c_k coefficient is set equal to 0.1 which means that an increase of ten percentage points in the growth rate of capital causes an increase in the labour force of one percentage point. Finally, c_A is the technical progress coefficient, which is set equal to 0.2, meaning that an increase in total factor

productivity by ten percentage points implies a decrease of two percentage points in employment.
Unemployment was given by the difference between actual employment and the target level of employment, i.e. 47% of the population.
Market labour policies focus on training. Government expenditure, divided by the cost of training one unemployed person (estimated at 8000 Euros) gave the number of trained unemployed persons, of whom we assume 4.5% re-enter the employed labour force.

4.2 The Environment Box

The environment plays a major role in the context of sustainable human development because it affects both intra-generational and inter-generational equity. Like Sen, we do not consider the environment to be a true functioning but rather an important context condition which affects well-being. This is why we decided to include it in our model. There are several indicators that could be used to explore this dimension and each of them could be referred to a specific context: for instance, water, soil air, green areas, waste, pressure on territory and so on. The need for a synthesis induced us to refer to per capita Greenhouse Gases (GHGs) as an indicator of the pressure on the environment. Although it is a partial representation of the environmental dimension, the indicator 'per capita GHGs' has certain advantages: firstly, it captures the connection among energy, economy and environment, and thus allows account to be taken of one of the main pressures on the environment: energy consumption. GHGs are related in fact to the combustion of fossil fuels (coal, oil, gas) which still represent more than 80% of the world's total primary energy supply. In Italy, the economy depends heavily on fossil fuels, their weight being about 93% of the total primary energy supply. Another reason for the importance of GHGs is their increased significance since the signing of the Kyoto Protocol in December 1997 and its recent ratification by Russia. This international agreement obliges Italy to reduce its GHGs emissions by 6.5% under the 1990 level. This target is highly ambitious since, mainly due to the electricity and transportation sectors, emissions are growing, and they are forecast to be about 20% above the Kyoto target level in 2010. This means that if Italy were to choose to meet its Kyoto target by means of domestic policies, a wide impact on the energy system and environment would ensue. By contrast, the greater the dependence either on the purchase of carbon credits in the international emissions trading market or on the generation of carbon credits through projects abroad, the weaker the reshaping of the Italian energy-environmental system. The dynamics of the environment are quite simply stated: we started from GHGs intensity, that is, the ratio between national GHGs emissions and GDP. On the basis of statistical analyses of past data, which show a decreasing trend, we derived a 'de-growth' rate for GHGs intensity. Basically, this rate reflected the decoupling between GDP and GHGs emissions in Italy over the last thirty years: that is, the fact that GDP has increased more than GHGs emissions. We moved to GHGs emissions by multiplying GHGs intensity by GDP, thus deriving a 'business as usual' trend. The difference between this trend and the effect of climate change policies gave rise to a new variable. We subtractrd from this variable the transportation emissions reduced by policies which shift vehicles and trucks from roads to railways (see the Transportation Box). Dividing this new variable by population, we obtained per capita GHGs emissions: this latter variable represents our right-hand side indicator. To be noted is that, since the business as usual trend is driven by GDP, this indicator captures the

relationship between environment and economy. Moreover, as already mentioned, the specific relationship between environment and transportation is considered. As regards climate change policies, these are generated by the distance between the right- and the left-hand side values. Two kinds of policies are implemented: expenditure and administrative policies. Subject to the mechanisms and constraints described in the public finance and governance paragraphs, the former are climate change policies which need funds, e.g. incentives to use renewable energy and energy efficiency interventions. On the other hand, administrative policies do not require funds but simply good laws able to increase the share of renewables in the energy system, energy efficiency, and the capture of carbon emissions by forests. As the distance between the right- and the left-hand side approaches zero, policies slow down.

4.3 The Transportation Box

The relevance of the 'mobility' functioning induced us to devote a model box to the transportation sector. As already said, transport is among the main contributors to GHGs emissions due to their growth. While in 1990 total traffic (road, railway, shipping, aviation) was equal to 235.702 million passenger kilometres, in 2000 it reached 281.951 million, which amounts an increase of about 20% in 10 years. In the same period, the increase in energy consumption associated with the transportation sector was equal to about 52%: which confirms the sector's major role within the energy and environmental systems. For this reason, we also calculated its impact on GHGs emissions. Because Italy is an industrialised country in which people travel a great deal on a wide network of roads, highways and railways, we decided not to explore the degree of mobility, but the quality of mobility. In fact, as in many other developed countries, Italy's transport system is affected by the problem of congestion. This we modelled in the following way: as an indicator of road traffic and congestion (a 'dis-functioning'), for both passengers and freight, we chose the ratio between vehicle kilometres and road kilometres. Italy has one of the highest values for this ratio among the developed countries, about three times above the average. Relying on historical data, we derived a growth rate for vehicle-km and truck-km. To be noted is that this rate was not fixed, because it was related to GDP growth: the higher is GDP, the higher the growth rate.

Given a certain level of institutional efficiency derived by means of the above-mentioned mechanism, the greater the distance between the right and the left side, the stronger the policies to improve the situation. Since the road network is well developed in Italy, and its extension does not solve the problem of congestion, in so far the kilometres travelled by vehicles tend to increase and adapt to the road network, it is not possible to propose policies that reduce the indicator by acting on its denominator to increase it. For this reason, we considered policies which affect the numerator (kilometres travelled by vehicles) and reduce it by shifting mobility from roads to railways. This shift can be encouraged by public expenditure: money should be invested in increasing the railway network in order to facilitate the shift from road to rail, both for passengers and freight.
As the distance between the right and the left-hand side approaches zero, policies slow down.

The Shelter Box

A dimension that must be considered within the context of sustainable human development is shelter, as stressed by Sen (1992) when he points out the need "to be….well-sheltered". As an indicator we chose residential square meters (SQKM) per capita. Although this indicator cannot encompass the quality of life, we believed that it gives a quite good representation of the residential standard. The data show that progress has occurred over the last thirty years in Italy: per capita square meters have increased as per capita GDP has grown. Using statistical analyses of past data, we started from 'squared kilometres intensity', i.e. SQKM/GDP, and multiply it by GDP. This part of the shelter functioning is what we call the private driver for per capita squared kilometres Then we added what we call the 'public driver', which depends on public expenditure, a price index and parameters for political efficiency. The basic idea was that, given a certain public expenditure on shelter, institutional efficiency and a certain price for SQKM, a certain number of SQKM can be built. The right side value in year 2000 is 36 square meters per capita, while the target is 50 square meters per capita.

The Education Box

In a Senian perspective, educational issues perform a key role in the empowerment of human instrumental freedoms: for this reason the importance of this box in the MiSS model is obvious.
As already mentioned, on the left side we use an indicator taken from a study by Brunello and Checchi (2001): the average years of school attended by the population.
The relevant literature on the matter often uses other indicators for human capital, such as enrolment rates or ISCED (level of education and training) specific to different educational programmes. But the use of 'average years' of schooling in this model has the advantage of capturing the distributional effects of educational attainment among the population.
In the regression cited above (Brunello and Checchi, 2001), the dependent variable (average years of schooling) is explained by two different factors: school quality, proxied by the pupil/teacher ratio (the lower the indicator, the higher the school quality) and family background, which measures the impact of parents' level of education on their children's level.
We used a two-steps model to estimate the impact of family background and school quality on returns to education. In the first step we used the following equation:

$$Y = a + bX + gE + e$$

where Y is log annual earnings, α represents region of birth, X is a vector of individual controls, E the years of education and γ the returns to education.
In the second step, we retrieved the estimated values of γ and estimated the relation:

$$g = l + fQ + yW + sQW + e$$

where λ captures the control variables, Q represents school quality calculated as the pupil/teacher ratio, and W represents family background.

The data used in the MiSS model were taken from the 'Survey on the Income and Wealth of Italian Households' (SHIW – Banca d'Italia) and from the OECD online database.
The pupil/teacher ratio was then computed endogenously as follows: the number of pupils attending educational programmes was considered as a decreasing function of Italian Population (with a decrease rate calculated on the basis of historical series) while the number of teachers was obtained by dividing the total amount of public expenditures on education by the average wage level taken from OECD (on which the policy efficiency switches have their impacts).
The empirical study by Brunello and Checchi (2001) also gives the values of the regression coefficients used in the MiSS simulations.
Another important feature of the Education Box is the existence of a connection with the Security Box, which we will describe in the specific subsection: we assume that some of the available public funds for security are spent to finance educational programmes, because educational attainment is presumed to be the most important factor in reducing the crime rate.

4.4 The Health Box

According to the capability approach, some functionings traditionally not measured by analyses which use monetary indicators are able to enhance human freedoms: health is certainly one of the most important of these functionings, with the consequence that the Health Box is crucial within the MiSS model.
The strong interdependences among the functionings described in the model have been already stressed in previous subsections: health plays an important role in the Income Box (healthy people are supposed to earn more than unhealthy ones) but it is also closely linked with educational attainment.
There is a very large body of literature on health policy, but we focused our attention on analysis of health policy efficiency.
However, it is not easy to determine when a health system can be considered efficient: the 2000 WHO Report introduced an indicator – overall goal attainment – intended to capture five dimensions: health level and its distribution among the population; responsiveness of the health system (the non-health components of a health system, such as waiting lists and other elements) and its distribution among the population; the way in which a health system is financed.
Overall goal attainment is then measured by an index which ranges from 0 to 1 (Italy is one of the most efficient countries, with 0.991) and comprises all the above variables. The WHO, however, emphasises the risk of overestimating efficiency. The fact that the countries ranked in the first positions have efficiency indexes above 0.97 does not mean that they can improve their systems only by 3%; it means that they can improve by 3% compared to the most efficient country in the sample.
For these reasons, in the MiSS model we used the results of an empirical study (Evans, 1999) in which health system efficiency is compared across 191 countries for the period 1993-1997.
In terms of output, it is generally agreed that one important goal of the health system is to improve the population's health. We measured health by taking account of both mortality and ill health, rather than using the indicator 'life expectancy at birth', which relates solely

to mortality. Our approach was based on an indicator of healthy life expectancy (DALE), whose measures are constantly updated by WHO.
The choice of independent variables was determined by operational reasons. The first was total health expenditure per capita (public and private) in 1997 international dollars (using purchasing power parities to convert from local currency units) as a summary measure of physical inputs to the health system.
It is widely recognised that health is not solely a function of the services provided by the health system, however broadly it is defined. It is difficult to identify relevant variables available for all countries but which are not closely correlated with health expenditure per capita. For example, income per capita – one of the most obvious indicators of general development – is highly collinear with health expenditure per capita. Although it would be possible to add income per capita directly into the estimated equations, income is not a direct determinant of the production of health. It works through other inputs, such as education and housing, and it is better to capture these inputs directly. The most widely available information on non-health-system inputs to production concerns education, and the most sensitive indicator of the relevant kind of educational attainment is average years of schooling in the adult population. Because this is the same variable as used in the Education Box, it was possible to exploit a feedback loop.
Thus, three data series were used in our model: DALE, health expenditure, and average educational attainment in the adult population.
With regard to the target level, we considered as an optimum for DALE 90 years of healthy life expectancy, as a desirable but feasible goal for the future.
The above-cited study concludes by saying that «efficiency is positively related to the level of health expenditure per capita. Indeed, the result suggests that it is very difficult for countries to be good performers below an expenditure per capita of approximately $60 in 1997 international dollars. This implies that there is an apparent minimum level of health expenditure below which the system simply cannot work well…There is still enough variation in efficiency at all levels of expenditure to suggest there are two critical ways of improving health outcomes. The first is to increase the efficiency of the health sector; the second is to increase health expenditures» (GPE Paper n.6).
This feature stresses the importance of public intervention in such a delicate issue as health and focuses one of the strengths of MISS: the Public Finance Box and the public response determined by the distance between the target value and the real one are indubitably elements consistent with Sen's approach to describing how capabilities can be transformed into achieved functionings.

The Security Box

Another important component of the MiSS model is the Security Box, in which, as in the environment section, a 'dis-functioning' is measured.
Choice of an indicator was particularly difficult in this case because the security functioning is characterised by numerous dimensions: the prevalent types of crime, the efficiency of the judicial system, the nature of security public policies.
We chose the property crimes rate (number of property crimes ***per capita***)as a proxy for the security level in the MiSS model, doing so for the following reasons:

- conceptual reason: because Italy is an industrialized country, property crimes (which are the most common in a rich developed nation) are probably a more effective representation of the incidence of crime;
- operational reason: we could draw on a very precise dataset taken from the International Crime Victims Survey (1996) which contains crime statistics on 19 industrialized countries

The particular nature of the Security Box makes it possible to show the close connection among security, education and employment. A system dynamics approach can then be used to exploit a feedback mechanism. The basic idea is that public expenditures on security consist essentially of two components: one is crime control and repression (not considered in our model), and to the other is support for education programmes, since education is thought to be an important deterrent against criminality. Hence the model calculated the additional number of pupils attending high school and university thanks to educational programmes financed out of the public security budget.

Before the equations in the box are described, another point to be discussed is the choice of a target value: how could the optimum number of property crimes be stated?

We assumed that the target is to reduce the number of property crimes in Italy by 1/3.

On the right side, the theoretical model is an individual's choice model among education, work and crime, and it is inspired by various econometric studies (Buonanno, 2003 – Marselli Vannini, 1997).

As said, our intention was to represent the relationship between the number of property crimes and two variables: the level of education (defined as the number of high school and university students), and the level of employment. In particular, we assumed that an increase in higher education and employment reduces the criminality index. Various studies on this issue provide a wide range of coefficients and elasticities, and it is quite difficult to establish a univocal value. For this reason we assigned two sliders to elasticity values so that the user can simulate different hypotheses on the security functioning.

This relation yielded the effect of education and labour policies on security.

In the Public Finance Box, exactly as for the other functionings, the level of public expenditure on security is calculated as a response to the distance between the target value and real one. We considered only the percentage of public expenditure invested in higher education (around 5% of the total, excluding the expenditure on police forces, crime control, repression and so on) and this percentage was multiplied for the institutional coefficients that measure the efficiency of formal and informal institutions. This money is used to increase the number of students attending high school and university.

But also the public expenditure on labour policies (see Employment Box) may have a positive feedback on security by increasing the number of people in employment. At the same time, bad labour market conditions generate an increase in the property crimes rate. Those interconnections are a strength of the MiSS Model.

Some further observations are in order. First, in the Security Box, the public expenditures and political interventions considered do not have an immediately strong effect on the indicator measured. The main explanation of this is that consideration is not made of public expenditure on police forces and repression, which may be more effective in reducing the crime rate.

Another important aspect to note is the ambiguous relationship between crime and unemployment: although we assume a negative elasticity, some econometric studies point out opposing effects of unemployment on crime: on one hand, it is reasonable to expect

that an increase in the activity rate will lead to a lower level of increased crime opportunity cost; on the other hand, it is likely that the number of crimes will be higher where people are richer. In conclusion, as the literature seems to confirm (see Marselli and Vannini, 1997), there is no clear relationship between unemployment and crime: the relationship appears to be very sensitive to econometric specification.

4.5 The R&D Box

Financing R&D is one way in which governments can enable the economy to cope with changing market conditions and to strengthen its capacity for regeneration. Government plays an important role in stimulating R&D and supporting knowledge creation in all sectors of the economy. Indeed, the economic rationale for government involvement in this area is the existence of market failures associated with R&D. These market failures are twofold. First, the private rate of return to R&D is lower than its social return. Second, a high risk for research raises extremely high hurdles which discourage firms from engaging in R&D. This is especially the case of small firms, for which access to funding is more difficult. For both reasons, the amount invested by firms in research activities in a competitive framework is likely to be below the socially optimal level. In Italy the total expenditure on R&D in year 2000 was around 12.000 million Euros, and almost half was from public funds. The effect of public spending may differ according to the policy instrument, three of which are typically used: public performed research (at public laboratories and universities), government funding of R&D performed by private sector organizations, and fiscal incentives. This box is quite simplified and its structure is very simple, but its role is crucial: the technological level is one of our GDP building blocks and it is fed by R&D expenditure. In other words, R&D public expenditure is one of the main drivers of technological progress. We assumed that there is a lag effect: R&D expenditure takes some years on average to be effective (as usual any user can set the time of his lag effect).

4. 10 The Public Policy Box

The Public Policy Box plays a crucial role in the MiSS Model because it describes the mechanism by which the institutional response seeks to reduce the distances between the ideal and real values for each functioning.

Denote as R the revenue from income tax (not including social security expenditures). The government has a set of 'basic budget shares', $\bar{b}_1, \bar{b}_2, ..., \bar{b}_k$, where k is the total number of functionings , with $\bar{b}_i \in [0,1]$ and $\sum_{i=1}^{k} \bar{b}_i = 1$. These basic budget shares are exogenously given and represent the government's general policy attitude, or its 'agenda'.
A budget share b_i is then allocated to the i-th functioning by the following procedure.
Define

$$d_i = \max\left[0, \frac{F_i^* - F_i}{F_i^*}\right]$$

as the percentage (nonnegative) distance between the desired (left-hand side) value of the functioning (F_i^*) and its actual (right-hand side) value F_i^*.

Then define:

$$D = \sum_{i=1}^{k} \bar{b}_i d_i$$

as a synthetic index of distances, and

$$b_i = \frac{\bar{b}_i d_i}{D}$$

as the actual budget share for i-th functioning. Then $R_i = b_i R$ will be the amount of public expenditure allocated to the i-th functioning. Note that the actual budget share will be larger than the basic budget share if

$$d_i > \sum_{j \neq i} \frac{\bar{b}_j}{1 - \bar{b}_i} d_j$$

i.e. if the distance for the i-th functioning is larger than the weighted average distance for the remaining functionings (the weights being the basic budget shares).

As a consequence, matter-of-fact institutional response does not automatically take place when a particular need emerges in one or more sectors of the system; rather, it is a process in which past trends and traditions in the political regulation of a particular issue must be taken in consideration.
For instance, although a great distance between the ideal CO_2 emissions value and the measured one may emerge, a strong policy response cannot be taken for granted. In Italy, in fact, environmental issues have traditionally been neglected in favour of other, more politically rewarding, aspects of the socioeconomic system. Moreover, given the absence of deep-rooted ecological awareness, we can understand the reasons why public expenditure on environmental issues has never been greater than 3% of total public expenditure.
In other words, the structure of the basic budget shares reflects the cultural dimension of the political system and its capacity to implement specific reforms according to the relative weight attributed to each issue in the 'control room' which is surely an element consistent with the Senian approach in its endeavour to consider conversion factors and their impact on substantive freedoms.

4.11 Governance Box

The MiSS framework also seeks to model the policy level by reproducing the context in which policy making takes place, and by describing the impact of institutional activity on the socio-economic system. This feature is one of the most important and challenging consistencies of the MiSS framework with the Senian approach. Its aim in fact is to include the role of the IF Vortex – specifically the role of instrumental freedoms as facilitators of

the achievement of functionings by individuals – and in the end the ability of individuals effectively to define their life-projects.

In the formalization, we chose to focus on a specific dimension of governance, namely, institutional efficiency. This was measured by the share of resources allocated to a specific goals by the mechanism described in the previous paragraph, which is actually used to achieve such goals, instead of being appropriated by the institutional system in the form of bureaucratic or political rents of various types. In symbols, given a flow

$$r_i = b^i R$$

of public resources allocated to the i-th functioning, institutional efficiency is summarized by a coefficient $s_i \in [0,1]$ such that

$\hat{r}_i = s_i b_i R$

represents the actual flow of resources employed. Obviously, efficiency is greatest when $s_i = 1$.

The value of the s_i coefficient is in principle the outcome of both formal and informal institutional efficiency: the latter includes public opinion's impact on the social environment, while the former is governmental action. Both dimensions have in fact a considerable impact on policy efficiency.

The main problem was finding a convincing estimate for the value of s_i. Quantitative studies exist on both formal efficiency (e.g. Tsebelis, 1999) and on informal efficiency (Almond and Verba, 1963; Inglehart, 1988; Putnam, 1983). Unfortunately, however, the data used by these authors could not be employed to provide an estimate for s_i.

For instance, Tsebelis measures the system's ability to abandon the ***status quo*** (ability to take concrete action on issues) with the number of significant laws passed in a political system. He then provides a ranking of countries according to this criterion: But comparing, say, Italy with Finland is of little help in estimating the value of s_i for either of the two countries.

The other authors just cited instead work on indicators for variables such as interpersonal trust, life satisfaction, propensity to revolutionary change, etc. (mainly constructed using data from Eurobarometer surveys and World Values Surveys). However, these data say more about people's attitude towards the society in which they live than about the actual institutional response to people's demands and needs.

We consequently set the value of s_i exogenously, thereby making the judgmental component in the assessment of institutional efficiency explicit.

5. Results

In what follows we shall analyze the effect on the model as a whole of two basic types of policy change.

The first type of policy change affects the basic budget shares, i.e. the fundamental attitude of the government towards the issues in question. When the basic share is already low (for instance, when in the case of employment policies the basic budget shares is around 1%) we only considered increases with respect to the reference value, while in cases (e.g.

education) where the basic budget share is large, we also considered reductions in the basic share.
The second type of policy change instead affects the efficiency/effectiveness of government, i.e. the ratio between expenditure actually affecting the policy objective and expenditure as formally determined by the current fiscal rule: discrepancies between the two may depend on government inefficiency, corruption, etc. . The default value of this indicator is 1, i.e. we assumed that, in the reference case, government is fully efficient.
The magnitude of change varies accordingly to the policy considered, although in almost all cases we considered a 15 percentage point increase in the basic budget share and a 50% reduction in government efficiency. Two remarks are in order. 1. in the base case, owing to the difficulty of estimating the degree of institutional efficiency, all the simulations were performed assuming perfect institutional efficiency. This meant that the translation of any Euro spent by the government into policies was affected only by technical factors, not by institutional ones. For instance, if the government aims to increase the teacher/pupil ratio and the cost of any new employed teacher is X Euros, the expenditure of NX Euros gives rise to the employment of N new teachers. In other words, with perfect institutional efficiency, no expenditure is lost and wasted due to political and institutional obstacles and constraints. Nonetheless, in some simulations the perfect institutional efficiency hypothesis was abandoned, and this enabled us to study the possible impact and role of institutions. 2. Although the MiSS model is designed to deal with six populations, owing to data problems, we performed all the simulations with a single population.

5.1 Employment

In this case we considered the following policy changes:

1. A 15% increase in the basic budget share of employment policies (the value in the reference case is around 1%, so that this, and the following one, are rather sharp policy changes)
2. A 30% increase in the basic budget share of employment policies
3. A 50% decrease in governmental efficiency in employment policies
4. A 75% decrease in governmental efficiency in employment policies

On considering cases 1 and 2 we found that there were negligible effects on the growth of ***per-capita*** GDP (less than one tenth of a percentage point in the average growth rate over the 2001-2050 period), with no significant changes in the sub-periods either. The main effects were on employment itself, where the convergence to desired levels was faster (distance decreases by 6.2 per year rather than by 1% in the basic case). With the 15 percentage point increase, distance diminished in the final year to 0.01, while the stronger increase caused the distance to disappear by 2047. In the basic case, this final value was 0.13.
There were negligible effects on the trends of other distances. Consideration of cases 3 and 4 showed that the only relevant impact was again on employment, which converged towards the target level at a slower rate than in the reference case. In these last two exercises, the distance for employment reached respectively the final values 0.15 and 0.14.

5.2 Environment

The results for environment functioning's are quite critical. In the base case, we found an increase in GHG emissions and a widening of the distance between the right and the left side. As an exercise, we decided that the 8.4 ton. value was the target for GHGs per capita emissions (left-hand side of the model). This value depended on the hypothesis that emissions are reduced by 50% through domestic policies and measures and by 50% through foreign action. Naturally, this value was only an indication and any model user can change it or conduct sensitivity analysis by assuming other values.

In this case, while in the base year the right-hand side value for GHGs per capita emissions is 9.42 ton, in 2050 it becomes 12.91 ton. In the base case, the distance grows from 0.12 to 0.52. The average annual growth rates of the distance in different periods of time are these: 2000-2050: 0.03; 2000-2012: 0.04; 2012-2025: 0.06; 2025-2040: 0.02; 2040-2050: 0.02. Owing to this an increase in the distance, the share of environmental expenditure rise from about 2.6% to 6%. However, this worrying picture can be substantially improved by increasing expenditure for climate change. If we introduce an increase in environmental expenditure of up to 15%, to be achieved in 10 years (i.e. the share of environmental expenditure increases by 15% of total government expenditure in 2010), the increase in GHGs emissions is strongly mitigated. The distance in year 2050 is now 0.20, vs. 0.52 in the base case. This means that GHGs emissions can be reduced if appropriate policies are specifically targeted on their control.[10] However, if we further increase the share of environmental expenditure, e.g. by 30% in the first 10 years, the GHG distance between the right- and left-hand side begins to oscillate: this is because, as the target is reached, the government expenditure share on the environment is reduced, it being an increasing function of the distance. Similar results can be obtained by simply increasing the share of environmental expenditure on climate change policy. For instance, if it increases by 15% relative to 0.04 (base case), the distance in 2050 becomes 0.29. In other words, a wise and efficient use of public funds can be successful in reducing GHGs emissions. This is a very important finding, since if there is a low degree of governmental efficiency, our result does not hold. For instance, an institutional efficiency equal to 50% (vs. 1 of the base case) brings the distance in the year 2050 to 0.35, even if there is a 15% increase in environmental public expenditure. Unfortunately, the increasing trend of Italian GHGs and the history of the national climate change policy tells us that public programs for reducing emissions are characterised by a very low degree of institutional efficiency. This induces us to conclude that a strong reduction in emissions, even if feasible, is very improbable.

5.3 Transportation

As an exercise, we chose target values close to the average of OECD countries: 0.00247 Mil Vh-km/Road Network and 0.00028 Mil, vs. real values (right hand side) 0.00208 and 0.00019.

[10] It is worth stressing that it would be theoretically possible, at the same time, to reduce emissions and improve the government budget simply by using a carbon tax. We excluded this case owing to public opposition to environmental taxation and its negative impact on social cohesion.

Given these data, the Transportation functioning is characterised by behaviour similar to Environment: i.e. an increasing distance. While in the base year the distance is equal to 0.09, in 2050 it is 0.97, i.e. in the region of 100%. The average annual growth rates of the distance in different periods of time are these: 2000-2050: 0.05; 2000-2012: 0.15; 2012-2025: 0.03; 2025-2040: 0.02; 2040-2050: 0.02. As the distance increases, the transportation expenditure share grows from 6% (2000) to 26%. These results confirm the importance of the congestion problem for Italy. An increase in transportation expenditure of up to 15% in 2010 substantially improves the situation but does not solve the problem. The distance in 2050 is now 0.38, vs. 0.97 (base case), and the expenditure share associated with it is 36%. An increase of up to about 22% stabilises the distance at level 0.20 in year 2027, but owing to the model's dynamic of government expenditure (low expenditure associated with low distance), this result is not stable, and the distance again increases in year 2039. Higher increases in transportation expenditure are able to stabilise the functioning on the target until year 2050. The decrease in road mobility has a negligible impact on GHGs emissions, because they depend on many other variables (e.g. industry, residences, energy sector) and their total magnitude is huge. As a conclusion, we may state that large increases in transportation expenditure may bring the functioning close to its target, but we are forced to admit that the conjectured expenditure increases are huge and not realistic. Moreover, the simulations were affected by the assumptions about institutional efficiency. For instance, a 30% decrease in institutional efficiency would increase the distance associated with a 15% increase in transportation expenditure from 0.38 to 0.57. This confirms the gravity of the Italian mobility problem even in the presence of a realistic target.

5.4 Shelter

The shelter functioning displays very a good trend. The distance between the right and left sides is around 28% and, in the base case, becomes zero in year 2020.
The expenditure share is around 3% of the public budget. An increase in expenditure up to 15% in 2010 implies a moderate acceleration in achieving the target (2018 instead of 2020). This implies that the target is reached mainly due to the intrinsic dynamic of the 'private' side of the model; or in other words, the public sector does not need to build a great many new houses. In fact, owing to GDP growth and population decrease, given the constant ratio SQKM/GDP, per capita square meters increase. This is confirmed by the fact that a very low level of institutional efficiency (e.g. 10% instead of 100%) has a very weak effect on simulations: the target is reached just 3 years later. This means that the result is robust, and unless there are strong migration flows, shelter is not a problem for Italy. Nevertheless, it must be stressed that our model deals with an average value which also reflects the fact that some families own more than one house. In other words, it ignores distributional aspects that may be very important. Especially in big cities, where a high demand for labour induces large inflows of people, a scarcity of shelter pushes up house prices. These very high prices strongly affect people's lives and have negative effects on their welfare. The current structure of the MiSS model does not take such effects into account.

5.5 Education

In this case the following policy changes were considered:

1. Increases of 15% and then 20% in the basic budget share of education policies (the value in the reference case is around 31%)
2. Decreases of 15% and then 20% in the basic budget share of education policies.
3. Decreases of 50%, 75% and 87.5% in governmental efficiency in education policies

The effects of type 1 policies are rather limited as far as the growth of per capita GDP and the achievement of schooling objectives are concerned. The main impact is apparent, for the sharpest increase in the basic budget share, on the evolution of the health variable, which reaches the target value by 2049.
Decreases in the basic budget share such as those at point 2 have more interesting effects. The growth rate of per capita GDP decreases by half a percentage point with the mildest downturn, and by more than one percentage point with the sharpest decrease. With the 15-point decrease, achievement of the target level is slowed down, while with the 20-point decrease, the distance in the final year is even larger than in the initial year.
Cases 1 and 2 display negligible effects on the growth of per-capita GDP (less than one tenth of a percentage point in the average growth rate over the 2001-2050 period), with no significant changes in the sub-periods either. The main effects are on employment itself, where the convergence to desired levels is faster (the distance decreases by 6.2 per year rather than by 1% in the basic case). With the 15 percentage point increase, the distance drops in the final year to 0.01, while the greater increase causes the distance to disappear by 2047. There are negligible effects on the trends of other distances.
In cases 3 and 4, the only significant impact is again on employment, which converges towards the target level at a slower rate than in the reference case. In these last two exercises, the distance for employment reaches respectively the final values 0.15 and 0.14.

5.6 Health

The Health Box performs very well, although this not surprising given that the Italian National Health System is always ranked in the first positions in the WHO Reports thanks to its performance since being founded in 1978.
It is also important to stress that the initial value of DALE (73.7 years) is particularly high; this element, together with the impossibility of fixing an unrealistic target (life expectancy cannot reasonably exceed a natural ceiling) should be considered when conducing sensitivity analysis.
All these factors considered, to be noted is that the functioning performs very well, with a constant decrease of distance in the period analysed and a gradual but continuous increase in the DALE value, both in the base case and on the hypothesis of greater public expenditure.
As regards the simulation results, assuming that the DALE value is 73.7 years in the base year, in 2050 it is 86.85. The annual de-growth rates of the distance are these: 2000-2050, 0.06; 2000-2012, 0.02; 2012 – 2025, 0.05; 2025 – 2040, 0.06 and 2040 – 2050, 0.11.

Hence, if we consider the case of a greater share of net GDP tax revenue spent on health policies (i.e. + 15% of health public expenditure), it is not surprising to find that the results differ little from the base case. The DALE value becomes 87.05 in 2050, and the distance value in the final year decreases to 0.03 compared to the 0.04 obtained on the normal budget hypothesis.
How can we interpret these findings? Because of the strict relationships and interdependencies between health performance and the other functionings considered in MISS model, its dynamics over time can be analysed in a more Senian way: that is to say, the performance of the health system cannot be measured by single factors alone (such as public expenditure or GDP per capita), but must be considered in its multidimensional nature.
The instrumental freedom of being healthy is not only associated with a certain share of the public budget spent on health policy; it also involves literacy, environmental conditions and so on. The interesting conclusion we can cautiously draw, considering the good quality of the Italian health system, is that policy makers can mix their interventions in seeking to achieve multidimensional targets. For example, it is likely that public expenditure on education will also have an impact on the increase in health performances. Social interdependence can thus become an instrument of policy efficiency.

5.7 Security

The model's Control Panel can be used to simulate the effect of a fiscal policy addressed to security issues. What happens if we progressively increase the security tax rate by 15 percentage points over ten years? As said, only considered in the Security Box is public expenditure on educational programmes (together with an indirect effect of labour policies), and this action does not have an immediate strong effect on the indicator measured. Indeed, changing the security tax rate does not substantially change the crime rate.
In fact, the tax rate system is closely interconnected, and a sharp increase in the security tax rate generates a strong decrease in the others. As a consequence, other functionings (especially environment and mobility) tend to worsen because their funds are decreased. Also GDP growth suffers a very slight slowdown. To sum up, in the Security Box the slight positive influence of higher expenditure is off-set by a worsening of the labour market, and the final result is negligible.
It is also possible to simulate what happens with a less ambitious target: if the initial distance is halved, the crime rate does not change.
Assuming a moderate value for the education elasticity of criminality, a decrease in institutional efficiency does not affect the result. If the governance index is halved, also the number of students involved in educational programmes falls by half, but the effect on the crime rate is negligible.

5.8 R&D

This sector is quite reactive to any variation in public expenditure because it influences the indicator directly. For example, a gradual increase in the R&D budget share from 0.04 to 0.12 over 10 years gives rise to a more marked reduction of the distance, especially in the

first decade. As said, the base scenario assumes maximum institutional efficiency, i.e. each Euro levied for R&D expenditure is effectively allocated to that purpose. The MiSS model can be easily used to simulate what happens with different degrees of institutional efficiency. For example: if the governance index is reduced by ¼ or by ½ over the entire period (2000-2050), the trend of R&D index is almost inverted. The result is summarized in the following table: while there is a reduction of the distance of 0.29% per year in the base scenario, on reducing the institutional efficiency the result is a sort of stability in the first case and an increase in the second one.

6. Conclusions

In the current version of the MiSS model not all functionings necessarily converge to target levels. Environment, Transportation, Security, R&D do not converge to their targets and, in the first three cases, the distances increase. By contrast, Employment, Education, Shelter and Health converge. To some extent, this result reflects a general public perception, in that mobility and security are among the problems most strongly felt by Italians. However, their sceptical views of employment and health seem to be wrong. The main policy conclusions of the simulations is that there is some room for improvement in the R&D situation if more of the government budget is allocated to it, while this is not true for Environment, Transportation and Security. These three functionings are critical, and their standard can only be improved by very forceful, and to some extent unrealistic, interventions. Moreover, as a consequence of the high degree of functioning interdependences of the model, these interventions would have as a side effect a large decrease in the budget shares allocated to the other functionings. In other words, correcting the bad situation of Environment, Transportation and Security is only possible by shocking the system and generating negative side effects in other functionings. However, it should be stressed that these results depend on a set of assumptions about both target levels and the effectiveness of policies which are obviously open to question. A lack of convergence should not be interpreted necessarily as a reason for pessimism, but rather as a warning that constant non-market action is required to reduce and control the differences between actual and target levels as economic growth proceeds. Finally, it must be emphasised that we have set very ambitious values, i.e. ideal ones, as targets.

A key role in development is played by the nature of the process of resource allocation to policy targets. Although this mechanism does not affect the achievement of the target level, we have shown that it influences the speed of change in the distances between real levels and target ones.

Interdependences across functionings was a significant feature to emerge in the simulations. They arose through two channels. On the one hand, a change in expenditure level on a functioning may affect a directly related functioning. In this context, the relationship between education and health plays a major role compared with the connection between education-GDP, education-security, employment-security. On the other hand, the MiSS model is characterised by numerous interdependences, since all the functionings are linked through government expenditure. Thus an increase in expenditure which favours one functioning necessarily translates into fewer funds for other functionings. In turn, this mechanism affects the distances between the real and target levels of the functionings and, as a consequence, modifies the government allocation

budget, which again in turn alters the distances between real and target levels, and so on. In the previous section we provided several examples of these interdependences, but we must acknowledge that they are peculiar to the specific set of assumptions made in each single simulation. Roughly speaking, the MiSS model's richness in interdependences induces us to exclude the existence of privileged ones.

Interdependence of policy over time is another key issue. Given the MiSS general policy rule, it is impossible for a government to address problem A first, and not to start spending on problem B until A has been solved. On the contrary, a strong initial effort on one specific target may be followed by an early abandonment of that policy; this may happen if the initial effort has produced an increase in the distances concerning other, temporarily neglected functionings.

To be stressed are some recurrent problems which emerged during modelling and some caveats. 1. There is a data problem especially as regard parameters linking variables. The econometric literature sometimes provide sound and clear estimates, but this is not always the case. For instance, the extent to which a fundamental variable like education influences income, security and health, as well as the relationship between employment and health is far from being clear. Research in the context of the Senian framework will benefit greatly from advances in statistical and econometric studies able to clarify variable relationships. 2. The data problem is amplified by the qualitative dimension of many variables. Some important aspects of the MiSS model, for instance the role of policy and institutions, concern 'soft variables'. The translation of such variables into numerical values which allow modelling and simulating is very difficult. We believe that the MiSS model, as well as future research in this field, will greatly benefit from improved research on the understanding and interpreting of qualitative variables. 3. The need for deeper understanding of the very important issue of institutional efficiency regards not only treatment of its qualitative dimension but also its endogeneity. Although the MiSS model incorporates a quantitative evaluation of institutional efficiency, it relies on estimates imported into the model from outside, on the basis of statistical surveys. Inclusion within the model of a truly endogenous institutional efficiency box is a promising line of future research and possible improvement. 4. Similarly, further improvements to the MiSS model could be made if account is taken of the multidimensional nature of many functionings, whose reduction to a single dimension is a strong simplification. 5. Overcoming the data problems and working with multiple populations is the challenge for the MiSS model in the future.

From the outset of our research, we interpreted the MiSS model as a challenge, an attempt to operationalise Sen's framework by addressing real problems of a modern economy and translating words into numbers. We have probably not entirely succeeded in our endeavour, but months of heavy modelling have certainly shed light on the nature of the main obstacles, and shown future research directions worth pursuing. We consider our model to be a first step in a promising and little explored research field. Future years will tell whether or not the operationalisation challenge can be entirely won.

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