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# A Latent Variable MIMIC Approach to Inferring the Quality of Life

By

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**Abstract:** This paper makes three principal contributions. *First*, we propose a new estimator for the unobservable variable models with endogenous causes. We show that under factor analysis type of assumptions, Robinson and Ferrara (1977)'s procedure is not fully efficient, and a more efficient procedure can be obtained by merging Robinson and Ferrara' procedure with that in Joreskog and Goldberger (1975) procedure. The asymptotic properties of the new estimator are compared with these two estimators and results indicate that, with our mixture approach, significant efficiency gains can be achieved. *Second*, we model the Quality of life (QOL) as an unobservable or latent link variable between observable causes and observable effects, which mitigates problem of bias, inconsistency, and arbitrary weightings of explanatory factors. *Third*, we estimate and compare QOL indices for 43 countries for the year 1990s, noting differences between countries and over time.

**JEL Classification:** I31, D60, D63

**KEY Words:** quality of life, latent variable, well-being indices, MIMIC model

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## **1. Introduction**

In the presence of overwhelming consensus that per capita income or related measures of income are substantially insufficient measures of well-being, the emphasis has now shifted to the identification of alternative measures. Quality of life (QOL), social indicators and basic needs are alternative approaches that are being discussed (see, Hicks and Streeten, 1979; Hicks, 1979; Drenowski, 1974; Morris, 1979; Sen, 1973; Streeten, 1979; Dasgupta, 1990b; Dasgupta and Weale, 1992; Kakwani, 1993; Ram, 1982; Slottje, 1991). All these approaches are related to the concept of the standard of living. Sen (1985, 1987) has made a thorough investigation of the concept of standard of living. Improving QOL is now a common aim of international development. However, identifying robust QOL indicators, or providing a coherent and robust definition of the concept, remain problematic. Researchers have faced four distinct issues: first, the method by which QOL is measured; second, the domains of human existence that are included in the measurement; third, at what scale the measurement is carried out, whether for individuals or groups; and fourth, how to provide outcomes that have practical value for end-users, by allowing comparisons across individuals, groups, and over time.

Over the years life expectancy, literacy rates, per capita income, mortality and morbidity statistics have been widely employed to construct various indices of well-being. Probably the best-known composite indices of well-being are the Human Development Index (HDI), developed by the United Nations Development Program (UNDP), and the Physical Quality of Life Index (PQLI), developed by Morris (1979). These alternative approaches are recognized improvements in terms of capturing various dimensions of QOL, but they are still substantially limited by their inability to capture

diverse domains of QOL, arbitrary weights, data used not being subjected to empirical testing and arbitrary selection of variables, noncomparability of measures over time and space, measurement errors in variables, and estimation biases due to omission of feedback effects with various indicators as environmental quality and political and civil liberties.

Many researchers have employed alternative weighting methods including Factor Analysis, Principal Component Analysis, instrumental variables, and the hedonic approach in an attempt to overcome the problem of arbitrary weights. However, it is often difficult to draw any defensible implications for policy planners on the basis of such QOL indices in the face of such unanswered criticisms. Even within the context of evaluating and comparing the QOL of different communities, little progress seems to have been made in constructing and estimating a statistical model that can be rigorously defended conceptually. Scholars in the new growth literature have generally found that QOL improves when economies grow. Barro (1996, 1997) finds QOL indicators like civil liberties and democracy to be positive functions of per capita income across countries. Grossman and Krueger (1993) find that higher income eventually lowers pollution. Boone (1996) showed that political, gender, and ethnic oppression decline as countries become richer. However, all these results are based on implicit assumptions that there is no feedback effect to the economy or QOL from environment, and political and civil freedoms. Estimation of single-equation relationships when there are actually simultaneous feedback effects, as we contend exists, can introduce bias, and inconsistency (Stern et al, 1996).

## 2. Motivation

As Partha Dasgupta (1999) noted, measures of well-being are needed for at least five purposes. *First*, there is need for an aggregate index of economic activity of a kind that would help one to summarize the overall activity of a macro-economy. *Second*, one may wish to compare the states of affairs in different places, or between different groups of people at various points of time. *Third*, QOL indices are needed to make welfare comparisons over time amongst people in the same location. *Fourth*, it is useful to estimate the economic standard of living an economy is capable of sustaining based on alternative programs. *Finally*, QOL indices are needed to evaluate alternative economic policies.

Given the importance of measures of well-being and complex interactions among its determinant, a QOL index should meet at least three requirements. *First*, it should reflect various dimensions of well-being. *Second*, it should recognize various feedback effects among the components of QOL. *Third*, it should not be based on arbitrary assignments of weights to various components. Earlier indices of well-being such as the Human Development Index (HDI) and Physical Quality of Life Index (PQLI), have failed to meet at least one of these requirements, and other measurements have often failed to meet all three. It has been difficult to draw any clear implications for both policy planners and for the purposes that measures of well-being were needed in the first place.

This paper is intended to mitigate these deficiencies and fill a notable portion of the empirical gap that exists between the welfare economic theory that underlies QOL and attempts at defining empirical measurements of QOL. A specific target of this paper is to identify functional linkages between QOL and government policy that can be used to

facilitate and guide formulation of future health, environmental, and economic policies of governments in order to improve well-being of people throughout the world.

This paper makes two principal contributions: *first*, we model the QOL as an unobservable or latent link variable between observable causes and observable effects, mitigating problem of bias, inconsistency, and arbitrary weights; *second*, we estimate, compare, and analyze QOL indices for 43 countries of the world for the year 1999.

We interpret the QOL as a latent variable,  $Q^*$ , embedded within a multiple indicators and multiple causes (MIMIC) model. This approach employs systematic relations between various *indicators* of QOL and the QOL itself, and between QOL and various related *causes*, leading to the identification of the determinants of QOL and an index of the quality of life. The model proposed is a variant of the Goldberger (1973) and Joreskog and Goldberger (1975) models of multiple indicators and multiple causes together with Robinson and Ferrara (1977)'s model for an unobservable variable with endogenous causes. In particular, the latent variable ( $Q^*$ : the QOL index) is conceptualized as a function of a vector of *causal* variables,  $x$  as,  $Q^* = f(x, u)$ , where  $u$  is a stochastic discrepancy. The model also specifies a set of equations corresponding to observable *indicators*,  $y$ , that are hypothesized to be affected by both  $Q^*$  and other exogenous variables,  $z$ , as  $y = g(Q^*, z, v)$  where  $v$  is a vector of stochastic discrepancies in the equations. The vector  $x$  contains elements that can be jointly dependent with  $y$ . On the basis of observations on  $y$  and  $x$ , and also observations on other exogenous variables,  $z$ , the goal is to consistently and efficiently estimate the latent model structure, and ultimately, infer an estimate of the latent quality of life  $Q^*$ .

Reliable and comprehensive cross-sectional data is available on indicators and causes relating to the QOL for 43 countries of the world for the years 1999. The data was collected from various sources including the Human Development Reports, World Development Indicators, and Gastil's Freedom in the World.

The estimated index,  $Q^*$ , is used to rank countries of the world in terms of their well-being achievements and in monitoring their progress over time. The estimated structure of the latent variable model quantifies the varying marginal impacts changes in well-being *causes* on the level of QOL index as well as on the levels of the various well-being *indicators*. The methodology results in readily interpretable estimates of the quality of life index and its determinants across countries. Utilizing the more structured MIMIC-type analysis of QOL results in efficient estimates of the interrelationships between causes and indicators of QOL derived from explicitly accounting for the complex interactions that are possible among causes, indicators, and the QOL. The approach represents an improvement in the empirical basis for evaluating development and related policies of countries.

Regarding post-estimation evaluation of the methodology, treating QOL as an unobservable or latent link between observable dimensions of well-being and observable causes mitigates problems associated with indices in the development literature including the problem of arbitrary weights, and the inability to account for feedback effects among various determinants of QOL. Also unlike previous approaches to measuring QOL, the current approach is more rigorously grounded in well-established theory relating to cause and effect relationships. In particular, for public policy applications, the paths and mediating variables by which policy variables will affect domains of QOL is specified

explicitly so that policy makers can analyze the effects of new programs and assess the impacts of existing policies. Since the model incorporates indicators of environmental quality and of political and civil liberties as well as other economic factors, we have operationalized Sen.'s concept that other factors besides per capita income should be incorporated into any QOL analysis.

This paper is organized as follows: Section 3 provides a MIMIC model for measuring the quality of life. A brief review of the econometric procedures for the estimation of MIMIC model is presented in section 4. Section 5 provides discussion on the choice of indicators-causes variables of the QOL and their rationale for inclusion. The empirical results are discussed in section 6. We provide concluding remarks in Section 7.

### **3. A Latent Variable MIMIC Model of Quality of Life:**

The MIMIC model postulates the latent variable (i.e.,  $Q^*$ : the quality of life index, in the present case) as function of causal variables, say  $x_1, \dots, x_K$  :

$$Q^* = f(x_1, \dots, x_K, \mathbf{e}) \quad (1)$$

where  $f(\cdot)$  indicates the form of the relationship and  $\mathbf{e}$  is the stochastic error in the equation. The model also specifies a set of equations corresponding to the indicator variables (such as life expectancy at birth, the mortality and morbidity rates, the likes):

$$\begin{aligned} y_1 &= f_1(Q^*, u_1) \\ &\cdot \\ &\cdot \\ &\cdot \\ y_G &= f_G(Q^*, u_G) \end{aligned} \quad (2)$$



where  $f_1(\cdot), \dots, f_G(\cdot)$  indicate the form of the relationships and  $u_1, \dots, u_G$  are stochastic errors. The MIMIC model (1)-(2) represents a set of interdependent structural equations.

In order to complete the specification of the model, we must specify the form of the interdependent structural equations (1)-(2), and we must also specify the form of the probability distribution of the errors  $\mathbf{e}, u_1, \dots, u_G$ .

Suppose the latent variable  $Q^*$  is linearly determined by  $K$  observable causal variables  $x_1, \dots, x_K$ . Let  $y_1, \dots, y_G$  be a set of observable indicators of QOL of a country. Now suppose that the QOL of a country, or community,  $Q^*$  is not directly observable but determines the observed indicator  $y_i, i = 1, \dots, G$  subject to a stochastic error  $u_i, i = 1, \dots, G$ . Then we may write equation (2)

$$y = \mathbf{b}Q^* + u \quad (3)$$

where the  $y$  is the  $G \times 1$  vector of deviations of  $G$  indicators  $y_i, i = 1, \dots, G$  from their respective means,  $Q^*$  is the QOL measured as deviations from its mean, and  $\mathbf{b}$  is  $G \times 1$  vector of parameters and  $u$  is the  $G \times 1$  vector of random error terms. The idea behind specification of equation (3) is that various observable indicators of QOL are correlated with each other, and their correlation can be explained by an underlying unobserved or a latent QOL ( $Q^*$ ) variable that is in turn determined by the observable causes and we may write

$$Q^* = \mathbf{a}'x + \mathbf{e} \quad (4)$$

where  $x$  is  $K \times 1$  vector of deviations of  $K$  observable causes from their respective means.  $\mathbf{a}$  is a  $K \times 1$  vector of parameters and  $\mathbf{e}$  is a  $K \times 1$  vector of random error terms.

#### **4. Estimation of MIMIC Model:**

The methods of estimation that are used will reflect the way in which  $\alpha$  and  $\mathbf{b}$  are identified. As we shall explain, there may be grounds for identifying (3) and (4) in a way that differs basically from the approach taken in Zellner (1970), Goldberger (1972), Robinson (1974), Joreskog and Goldberger (1975), and Robinson and Ferrara (1977). As a result, we propose a different type of estimator. But before we suggest a different type of estimator, in the following we briefly discuss the Goldberger and Joreskog (1975) and Robinson and Ferrara (1977)' estimators of the MIMIC model.

From (3) and (4) we can eliminate  $Q^*$  by constructing

$$y = \mathbf{b}\mathbf{a}'x + (\mathbf{b}\mathbf{e} + u) \quad \text{Or}$$

$$y = \Pi'x + v \tag{5}$$

$$\text{where } \Pi = \mathbf{a}\mathbf{b}' \text{ and } v = \mathbf{b}\mathbf{e} + u \tag{6}$$

#### **Case I: Maximum Likelihood Estimation of MIMIC Model**

When  $E(xv) = 0$ , the null matrix which is so if

$$E(\mathbf{C}\mathbf{u}\boldsymbol{\vartheta}) = \mathbf{0}; E(\mathbf{X}\mathbf{e}) = \mathbf{0}; E(\mathbf{e}\boldsymbol{\vartheta}) = \mathbf{0} \quad \text{and } E(uu\boldsymbol{\vartheta}) = \hat{\mathbf{a}}, \text{ (diagonal)} \tag{7}$$

The covariance matrix of  $v$  is given by

$$\mathbf{W} = E(vv\boldsymbol{\vartheta}) = E[(\mathbf{b}\mathbf{e} + u)(\mathbf{b}\mathbf{e} + u)\boldsymbol{\vartheta}] = \mathbf{b}\mathbf{b}'\boldsymbol{\vartheta} + \hat{\mathbf{a}}, \tag{8}$$

adopting the normalization condition,  $\mathbf{s}_e^2 = E(\mathbf{e}^2) = 1$ .

Under the assumption of (7) and (8), equation (5) can be described as the reduced form of equations (3) and (4), and it follows that equation (5) satisfies certain classical

assumptions (non-linear, stochastic regressor) multivariate regression. In other words the problem is merely one of estimating the matrix  $C$  defined by  $E(y/x) = Cx$ , subject to restriction that  $C$  be of unit rank, and therefore finding estimates of  $\alpha$  &  $b$ . This case has been considered in Goldberger (1972), Joreskog and Goldberger (1975), Robinson (1974) and Zellner (1970).

The reduced form coefficient  $\Pi_{ij}$  measures the marginal impact of the causal variables  $x_j$  on the indicator  $y_i$ . Joreskog and Goldberger (1975) have worked out maximum likelihood estimators of parameters of the structural system, where errors in equation (3) and (4) follow a multivariate normal law. The authors have obtained the mean and variance of the conditional distribution of  $Q^*$  given the values of  $y$ 's and  $x$ 's. The estimator of the conditional mean of  $Q^*$ , given the values of  $y$ 's and  $x$ 's is used as an estimator of  $Q^*$ . The maximum likelihood estimator of  $Q^*$  possesses optimal properties for large samples. However, the likelihood equations are found to be highly non-linear, which can be solved numerically but not analytically. Thus, it is not possible to obtain an explicit analytical expression for  $Q^*$ , even though the value of  $Q^*$  can be numerically solved for a function of  $y$ 's and  $x$ 's. In this case one must adopt an efficient iterative algorithm that guarantees speedy convergence to the true parameter values.

We estimate the parameters of the present MIMIC model with the help of the algorithm given in Goldberger (1974). A brief outline of the algorithm is as follows:

Under normality, the likelihood function for a sample of  $T$  joint observations on  $y$  and  $x$  is, apart from irrelevant constants, given by

$$L^* = |\Omega|^{-T/2} \exp\left(-\frac{1}{2} \sum_{t=1}^T [\mathbf{u}(t)' \Omega^{-1} \mathbf{u}(t)]\right) = |\Omega|^{-T/2} \exp\left[-\frac{1}{2} T^* \text{tr}(\Omega^{-1} W)\right],$$

where  $W = (Y - X\Pi)'(Y - X\Pi)$  is the sample covariance matrix of reduced-form disturbances. To maximize  $L^*$ , we can equivalently minimize

$$F = \log |\Omega| + tr(\Omega^{-1}W) \quad (9)$$

The first order conditions (FOCs) for a maximum are

$$\frac{\partial F}{\partial \mathbf{a}} = 0, \quad \frac{\partial F}{\partial \mathbf{b}} = 0$$

Solving the above two FOCs gives us

$$\mathbf{a} = (\mathbf{b}'\Sigma^{-1}\mathbf{b})^{-1}\mathbf{P}\Sigma^{-1}\mathbf{b} \quad (10)$$

where  $\mathbf{P} = (X'X)^{-1}(X'Y)$ .

$$(R\Sigma^{-1} - \mathbf{I})\mathbf{b} = 0, \quad (11)$$

where,  $S = (\mathbf{U} - \mathbf{C}\mathbf{R})\phi(Y - X\mathbf{P})$ ;  $Q = \mathbf{P}'\mathbf{C}\mathbf{C}'\mathbf{R}$ ;  $R = [f/(1+f)]S + Q$ ; and

$$\mathbf{I} = \left(\frac{f}{1+f}\right) + \frac{fg}{(1+f)^2} + \frac{h}{f}; \quad f = \mathbf{b}'\Sigma^{-1}\mathbf{b}; \quad g = \mathbf{b}'\Sigma^{-1}S\Sigma^{-1}\mathbf{b}; \quad \text{and} \quad h = \mathbf{b}'\Sigma^{-1}Q\Sigma^{-1}\mathbf{b}$$

Now substituting from (10) and (11) into (9), we get the new expression of  $F$  as

$$F = \log |S| + tr(\Sigma^{-1}S) + tr(\Sigma^{-1}Q) + \log(1+f) - \mathbf{I}$$

which is decreasing in  $\lambda$ . Thus conditional on  $f$ , to minimize  $F$ , we should take  $\lambda$  as large as possible.

Now to estimate the parameters of MIMIC model discussed above, we use the following iterative procedure used by Rao and Bhat (1991).

Step 1: Compute the following moment matrices from the set of observations on  $Y$ 's and  $X$ 's:  $\mathbf{P} = (X'X)^{-1}X'Y$ ;  $S = (\mathbf{U} - \mathbf{C}\mathbf{R})\phi(Y - X\mathbf{P})$ ;  $Q = S - \mathbf{P}$ ; and  $\Sigma = S - \mathbf{b}\mathbf{b}'$ .

Step 2: Start with an initial value of  $\mathbf{b}$  say  $\mathbf{b} = \delta \text{std}(Y_1 \dots Y_g)$ , where  $\text{std}(\cdot)$  denotes the standard deviation and  $\delta$  is initially chosen to be 0.5. Compute  $f = \mathbf{b}'\Sigma^{-1}\mathbf{b}$ . If  $f$  lies

between 0 and 1, the initial value of  $\mathbf{b}$  chosen is acceptable. If not, we make  $\delta=0.25$  and rework.

Step 3: Continue in this way each time reducing  $\delta$  by half until an acceptable value of  $\mathbf{b}$  is achieved.

Step 4: Compute  $\Sigma = S - \mathbf{b}\mathbf{b}'$ ;  $f = \mathbf{b}'\Sigma^{-1}\mathbf{b}$ ; and  $R = [f/(1+f)]S + Q$ . Find the largest characteristic root of  $R\mathbf{a}^{-1}$  and take its associated characteristic vector as the revised value of  $\mathbf{b}$ . If the revised value of  $\mathbf{b}$  is component wise close to original value of  $\mathbf{b}$ , proceed to step 5. If not, rework step3 with the revised value of  $\mathbf{b}$ .

Step 5: Compute  $\mathbf{a} = (\mathbf{b}'\Sigma^{-1}\mathbf{b})^{-1}\mathbf{P}\Sigma^{-1}\mathbf{b}$ .

Then we compute  $q^* = \mathbf{a}\mathbf{C}$ .

As we can see at the end of step 5 we have already estimated the vector of deviations of our unobservable QOL index,  $Q^*$  from its mean. But we note that it is not possible to estimate  $Q^*$  values from  $q^*$ . Therefore, we compute the index as follows:

$$\tilde{q} = 100 \left( 1 + \frac{q^*}{3\mathbf{s}_{q^*}} \right), \mathbf{s}_{q^*} \text{ is the standard deviation of } q^*.$$

$E(\tilde{q}) = 100$ , and  $(q-100)$  measures the distance of  $Q^*$  from its mean value measured as percentage of  $3\mathbf{s}_{q^*}$ .

Case II: When  $X$  contains elements which are jointly dependent with  $Y$

Robinson and Ferrara (1977) showed that the assumption that every element of  $E(XV)$  be zero may be unwarranted. This would be so if  $X$  contains elements that are jointly dependent with vector of indicator variables  $Y$ . Without making any assumptions

on the structure of variances and covariances of  $u$  and  $\varepsilon$  that would enable us to identify them from the knowledge of variances and covariances of  $V$ , Robinson and Ferrara (1977) suggested an alternative type of estimator and procedure which is similar to the non-linear two-stage least squares estimator of Amemiya (1974).

**Case III:** Suppose model consists of (1), (2) and (3). Let we have additional information and reasons to believe that

- (a) When  $X$  contains elements which are jointly dependent with  $Y$ ;
- (b) Covariance matrix of  $u$  is diagonal;
- (c)  $u$  and  $\varepsilon$  are uncorrelated.

Then, we can show that Robinson and Ferrara (1977)'s procedure is not fully efficient, and a more efficient procedure could be obtained by merging Robinson and Ferrara' procedure with that in Joreskog and Goldberger (1975) procedure outlined in Case I.

## **5. Description of Indicators and Causes Variables of the QOL**

Quite often many statistics are available that might be regarded as either causes (inputs) or indicators (effects or outputs) of QOL. Life expectancy, infant mortality rates, and death rate are among the most well known indicators of QOL that have been widely used in the construction of indices of well-being, including by United Nations Development Program (UNDP) in its development of Human Development Index (HDI) and by Morris (1979) in his physical quality of life index (PQLI). Indicators such as life expectancy, infant mortality rate, and death rate are more like outcomes of development rather than causes of development. In other words these are outcomes of environment,

public policy, and individual choices made in a particular country or community. Thus distinction can be made between indicators and causes of QOL that a particular country, or community enjoys. In the context of MIMIC model we assume that QOL is measured by several indicators and explained by several causes.

Three indicators of QOL that we consider in our empirical analysis are life expectancy at birth, infant mortality rate, and death rate. QOL is a multidimensional construct which has many distinct domains. It is determined by the interaction of various cause variables between and within its domains. Here we make an attempt to measure QOL across countries as comprehensibly as possible. In the following, we briefly discuss various domains and data sources of QOL.

#### Domain 1. Relationship with family and friends

Satisfaction with family life is an important element of an individual's well-being. It is quite reasonable to argue that, in most cases, an individual with strong family ties will be a happier person than someone without any family relations. Therefore, relationship with family and friends should be considered in any measure of QOL. There can be many indicators to represent the domain of *relationship with family and friends*, but it is extremely difficult to find many objective and quantitative indicators, which are necessary for cross-country comparisons.

Therefore due to the limitation of data availability, we consider only one indicator to characterize the first domain, viz., incidence of divorce rates. Increasing divorce rate is an indication of failing marriages and eroding relationships with family and relatives.<sup>2</sup>

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<sup>2</sup> It can be argued that the incidence of divorce rate is not a good indicator of relationship with family and friends. One can dispute it on the ground that a marriage not ending in divorce does not mean that people in the marriage are happy. For instance, many researchers have argued it that low rate of divorce in countries like India and Islamic countries can be partly explained by the low status of women in the society where

The data for this variable has been obtained from Gulnar and Nugman of the Heritage Foundation. The data is for the year 1999, or the nearest available date. The divorce rate is reported as the number of divorces per thousand people.

### Domain 2. Emotional Well-Being

Although measures such as crime statistics, health status, and indicators of wealth are surely related to QOL, these indicators cannot capture what it means to be “happy”. How happy an individual is not only depends on his/her income and consumption, but is also affected by intensity of stress, depression, and psychology. Emotional well-being, like physical health, can be judged on a variety of dimensions. Yet, in both realms, it is difficult to say which of these dimensions are essential for overall well-being. We use estimates of both male and female suicide rates to focus on emotional well-being. Teenage suicide rates were used in the construction of the index of social health (ISH) by Miringoff of the Fordham Institute for Innovation in Social Policy (1996, 1999). Jungeilges and Kirchgasser (2002) examined the link between suicide rates, and economic welfare (economic growth and per capita income) and civil liberties. They found a positive relationship between suicide rates and economic welfare, and a negative relationship between suicide rates and civil liberty. Thus we assume that economic welfare does not guarantee a better emotional well-being, and a higher incidence of suicide rates by either gender is an indication of weaker emotional well-being. We have obtained data for both male and female suicide rates from the Mental Health Data of the World Health Organization (WHO).

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women are traditionally supposed to be playing the role of homemaker. However, we strongly emphasize that in these countries people attach higher importance to joint family system, social status, and marriage is considered as a *social value* rather than a *contract*, and divorce is viewed as the social *taboo*. Thus, we



### Domain 3. Health

Good health should result in a better QOL. Health has both direct and indirect positive effects on QOL. Improvement in health has an immediate impact on a person's QOL, but may also indirectly increase it by acting on other variables that in turn also have a beneficial effect. One of the most studied relationships is between health and income. Higher income leads to better health, but better health also leads to higher income because of better productivity and labor force participation.<sup>3</sup> To focus on the domain of health a balance has to be struck among various components of a healthy society: demography, longevity, mortality, morbidity, and health infrastructure. We use population growth rate (representing demographic pressure); life expectancy at birth (longevity); infant mortality rate (mortality); the number of AIDS cases and tuberculosis cases (representing morbidity); government expenditure on health as a percentage of GDP, and doctor/population ratio (representing availability of health facilities) to capture the domain of health in our measure of the QOL. The data on these indicators have been obtained from HDR, 1999.

### Domain 4. Material well-being

The elements of material well-being have both direct and indirect positive and negative impact on a person's QOL. For instance, rising national income due to industrialization raises QOL on the one hand, but on the other hand decreases it for those living in polluted areas. The latter may suffer further indirect effects if increased pollution raises the incidence of disease and chronic illness. Aspects of material well-

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argue that low divorce rates in these countries are not only a result of the low status of women in the society, but also it is a reflection of a strong joint family system and relationship with family and friends.

being have been most widely used to construct various indices of well-being. One of the main reasons for its use is the availability of good data on various indicators. Traditionally measures of income or related measures of material well-being were considered adequate indicators of standards of living. To capture the extent of material well-being in our QOL we use per capita GDP (at purchasing power parity, PPP), daily per capita supply of calories, the commercial use of energy, and telephone lines per thousand people (both representing infrastructure).<sup>4</sup> The data for these indicators have been obtained from the HDR, 1999.

#### Domain 5. Feeling part of one's local community

Feeling part of one's local community and society in general depend on factors like educational attainments, political rights, and civil liberties, among others. Many people in different countries of the world are systematically denied political liberty and basic civil rights. It is sometimes claimed that the denial of these rights helps to stimulate economic growth and is "good" for rapid economic development. However, comprehensive inter-country comparisons have not provided any confirmation of this thesis, and there is little evidence that authoritarian politics actually helps economic growth. As Sen. (1999) argued:

"----political liberty and civil freedoms are directly important on their own, and do not have to be justified indirectly in terms of their effects on economy. Even when people without political liberty or civil rights do not lack adequate economic security (and happen to enjoy favorable economic circumstances), they are deprived of important freedoms in leading their lives and denied the opportunity to take part in crucial decisions regarding public affairs. These

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<sup>3</sup> See for example Lee (1982), Ettner (1996), Pritchett and Summers (1996), Luft (1975), Grossman and Benham (1980), Bloom and Malaney (1998), Bloom and Sachs (1998), Bloom and Williamson (1998), Bloom and Canning (1999).

<sup>4</sup> Since daily per capita supply of calorie is much influenced by income; one can argue we will be counting income twice. However, we note that the quality of consumption does not only depend on the level of income, but also how income is being used by the individual, which in turn depends on his/her level of

deprivations restrict social and political lives, and must be seen as repressive even without their leading to other afflictions. Since political and civil freedoms are constitutive elements of human freedom, their denial is a handicap in itself.” (Sen. (1999, p. 16-17))

Concurrent with this realization, economists who previously assumed that measures of income are the sole and reliable indicators of human well-being finally have begun to understand that political liberties and civil freedoms are as important elements of QOL as any other elements of QOL. Moreover, Jungeilges and Kirchgasser (2002)’s finding of a negative relationship between suicide rates and civil liberty reinforces the assertion that dimensions of freedom are very important for human well-being. Thus we emphasize that any measure of current well-being that does not include political and civil spheres of life will be incomplete and misleading for intercountry comparisons of QOL. Here we use indices of political and civil liberties along with both male and female adult literacy rates to characterize this domain of QOL. The indices of political rights and civil liberties are taken from Gastil, R. D. -Freedom in the World: Political and Civil Liberties (For definition see Taylor and Jodice 1983). It is also available from various human development reports of UNDP. Rights to political liberty measures citizens’ right to play a part in determining their government, and what laws are and will be. Countries are ranked with scores ranging from one (highest degree of liberty) to seven (lowest degree of liberty). On the other hand, the index of civil liberties measures the extent of people’s access to an impartial judiciary, access to free press, and liberty to express their opinion. Countries are ranked with scores ranging from one (highest civil liberty) to seven (lowest degree civil liberty).

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education. Moreover, it is an easy matter to redo all our computations by deleting data on either of our

### Domain 6. Work and productive activity

Estimates of unemployment rate; combined first, second and third level school gross enrollment ratio; and female economic activity rate are used to capture the “extent of work and productive activity” that exists in countries included in our sample. At any point in time, citizens of a country can be productively engaged either in work employment, or be engaged in the process of learning in school. The female economic activity rate is used to capture the intensity of gender equality in productive activity.

### Domain 7. Personal safety

For the well-being of people, personal safety is as important as any other domain of the QOL. In a society where incidence of crimes is less, people can enjoy their living much better than in a society where criminal offences are high and very common. This is very important because an individual derives utility not only from the commodity bundles in her/his consumption basket, but also from her/his ability to walk, and from being able to live free from crimes on streets and material theft, and enjoy good law and order situations in the neighborhoods. To characterize this domain of well-being, we use two different indicators, viz., the total number of offences per 100,000 inhabitants contained in the national crime statistics, and expenditure on military as percentage of GDP. Total number of offences includes cases of murder, sex offences, serious assaults, theft, fraud, counterfeit currency offences, and drug offences. We believe that the higher is the total number of offences per 100,000 inhabitants; the lower will be the well-being of people. Similarly, we argue that the expenditure on military is an unproductive expenditure, and

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material well-being indices.

therefore it has indirect adverse effect on the QOL<sup>5</sup>. We have obtained data on total offences from the International Crime Statistics of the Interpol. The data refers to the year 1997. Data on military expenditures were obtained from HDR, 1999.

#### Domain 8. Quality of Environment

Most indices of human well-being have ignored the interrelationships between the QOL and environmental changes. Quality of the environment has direct and indirect long-term effects on the health status of the citizens, and consequently it affects the quality of life of people in the region. As we can see from Figure 1, the elements of material well-being have an impact on the quality of the environment; and the quality of the environment has a direct and an immediate effect on QOL as well as an indirect effect on QOL through its effect on health. To capture the extent of the quality of environment, we use a measure of greenhouse gas emissions- carbon dioxide (CO<sub>2</sub>); a measure of water pollution-access to safe water supplies (ACH<sub>2</sub>O); and a measure of the depletion of environmental resources-deforestation. Emissions of CO<sub>2</sub> are primarily a by-product of industrialization, and attract more attention in middle and upper-income countries. Deforestation and depletion of local water supplies attract the most attention in low-income countries. Water pollution is a major concern because of its immediate effects on human health and productivity. Deforestation is important because it affects the hydrological cycle, and it is linked with the depletion and pollution of water supplies. We have obtained data on these variables from the World Development Indicators, 1999; and HDR, 1999.

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<sup>5</sup> One can argue that why wouldn't this have a positive effect as well---making citizens feel safe from foreign attack or occupation? This argument seems more logical in the light of current increase in international terrorism across borders. However, there is no clear empirical evidence that increasing military expenditures enhances national security. Moreover, given very high opportunity cost of military

## 5. Discussion of Empirical Results

Using data on various indicators and causes variables of QOL, we estimated the MIMIC of QOL. Consistent with our discussion on estimation of MIMIC model in section 4, we estimated the MIMIC model of the QOL by three alternative methods. Our sample was 43 countries of the world for the year 1999. Our three models involved 26 variables, all measured from sample means. Description and definition of variables are listed in Appendix A. Table 1 contains the estimated values of the parameters of the MIMIC model using three alternative estimation methods. Table 2 presents the estimated values of the QOL index. Table 3 presents the rankings of countries based on estimated QOL index. Finally, in Table 4 we present correlation between the estimated QOL index and its various indicators and causes variables.

## 6. Concluding Remarks and limitations

In this paper we presented a latent variable MIMIC model of QOL. This paper makes three principal contributions. *First*, we proposed a new estimator for the unobservable variable models with endogenous causes. We show that under factor analysis type of assumptions, Robinson and Ferrara (1977)'s procedure is not fully efficient, and a more efficient procedure can be obtained by merging Robinson and Ferrara' procedure with that in Joreskog and Goldberger (1975) procedure. The asymptotic properties of the new estimator were compared with these two estimators and results indicated that, with our mixture approach, significant efficiency gains can be achieved. *Second*, we modeled the QOL as an unobservable or latent link variable

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expenditures (this is truer in less developed countries), we feel that increasing military expenditure does not contribute positively towards enhancing well-being of the people.

between observable causes and observable effects, which mitigates problem of bias, inconsistency, and arbitrary weightings of explanatory factors. *Third*, we estimate and compare QOL indices for 43 countries for the year 1990s, noting differences between countries and over time.

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