Capabilities measurement: an empirical investigation

HASAN, HAMID

La Trobe University

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Capabilities Measurement: An Empirical Investigation

Hamid Hasan*
hhasan@students.latrobe.edu.au

Abstract

Sen's seminal contribution highlights the importance of positive freedom in the measurement of human welfare. The present paper attempts to measure this freedom aspect in an integrated approach. The main contribution of the paper is the simultaneous estimation of capability, functioning, and conversion efficiency with explicit modeling of freedom by latent variable modeling approach. The knowledge dimension of capabilities is modeled and estimated by integrating exploratory and confirmatory statistical methods in a two-stage procedure. In the first stage, Partial Least Squares method is employed to construct latent variable scores. These scores are transformed to relative scores for the sake of comparison and then used to estimate the proposed simultaneous-equation capability model by 3SLS in the second stage. The results show that capability is inversely related to resources and positively related to freedom and functioning. The computed relative capability and freedom inequality ratios are very high whereas relative functioning and efficiency inequality ratios are at a moderate level. The conventional income inequality ratio is lower as compared to the capability dimensions' ratios and close to the Gini-coefficient. The paper extended the measurement of conversion inefficiency into voluntary and involuntary inefficiency. The paper also suggests criteria for evaluating empirical research within the capability approach framework.

The paper recommends development of specific survey instruments in order to create better indicators for capability dimensions and use of latent variable modeling for constructing latent variable scores, and their subsequent use in estimation. These findings suggest a capabilities-oriented public and education policies for the enhancement of knowledge dimension of capabilities in particular and human welfare in general. The focus of education policy should be extended from investment-oriented (human capital approach) to value-oriented (human capability approach).

Key words

Capabilities; Freedom; Functioning; Conversion Efficiency; Latent variables; Structural equations model; PLS; LISREL; 3SLS.

JEL Classification D39; D63; I31; I132;

* PhD candidate at La Trobe University, Melbourne, Australia. The paper was presented in the conference on New Directions in Welfare held in St Catherine's College, Oxford from June 29 to July 01, 2009.

1. Introduction

Atkinson (1999, p.186) states: 'A concept is effective if it causes people to think in a different way'. He refers it to Sen's concept of capability which opens the door for deontological considerations for the assessment of individual well-being.[1] It extends and encompasses the utilitarian (welfarist) and resourcist approaches of well-being evaluation[2].
This paper will develop freedoms' aspect of Sen's capability approach (CA) theoretically and empirically within the CA framework of thought[3]. According to Sen (2004, p.21), the idea of freedom is relevant to normative social choice theory, in general, and to the theory of justice, in particular, and provides normative foundations of human rights. Arrow (1999), Atkinson (1999), and Pressman and Summerfield (2000)[4] have separately discussed Sen's major contributions in the fields of social choice, welfare economics and its critique, measurement of economic inequality and poverty, development economics and the implementation of capabilities. This paper is related to the last of these four major contributions.

I will argue in this paper that individual freedom in Sen's perspective is an extremely significant factor in the evaluation of human welfare that its explicit theoretical and empirical modeling is not only necessary but also urgent since most of the human sufferings in the last decade have been related to this very concept; people are deprived off the kind of life they want to lead. Alkire (2005) emphasizes the need for measuring freedoms. She argues (p.10):

> With respect to the measurement of freedom as indicated above, I observe that the literature to date has focused upon the measurement of functionings, and left process freedoms – and indeed opportunity freedoms – largely unaddressed thus far.

Freedom in terms of range of choices and autonomy are the basic requirements for justice and measuring the standard of living. It has instrumental as well as intrinsic value and the evaluation on the basis of freedom provides an encompassing measure of well-being. 'According to Sen's capability approach, economic and social arrangements should be evaluated in terms of the freedoms enjoyed by those who live in them' (Akire, 2005). Sen (1990) discusses freedom as a *focal personal feature* for ethical judgment on the lives of persons and compares it to primary goods and liberties (Rawls), rights (Nozick), resources (Dworkin) among others. In this context, he distinguishes between *means* and what people can obtain from the *means*. He argues (p.115):

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[1] The fundamental theorems of welfare economics do not consider ethical or normative aspects unless modified in a certain way.
[2] According to Austrian school of thought, Sen's framework provides an alternative to neoclassical economics, which pays little attention to human development issues.
[3] It should be clear at the outset that Sen's capability concept is not a theory but a framework of thought. The strength of this framework is its generality. A theory can be developed within this framework, and this paper is an attempt in this direction. Nussbaum (2000) and Anderson (1999) advocate list of capabilities. I will not pursue their approach in this paper.
[4] Pressman and Summerfield (2000) have attached to their paper a bibliography of Sen's work which comprises of more than 20 books and nearly 300 published papers.

> 'Since the conversion of these primary goods and resources into freedom to select a particular life and to achieve may vary from person to person, equality in holdings of primary goods or resources can go hand in hand with serious inequalities in actual freedoms enjoyed by different persons'.

The notion of individual freedom has two aspects in Sen's capabilities approach: opportunity aspect and process aspect (Sen, 2002). The opportunity aspect is concerned with the advantage one has as compared to others (Sen, 1985). The first aspect is termed as 'Capability' while the second is called 'Agency' in Sen's writings. Sen (1985, p.5) states:

> " 'Well-being' is concerned with a person's achievement: how 'well' is his or her 'being'? 'Advantage' refers to the real opportunities that the person has, especially compared with others […]The freedom to achieve well-being is closer to the notion of advantage than well-being itself".

The concept of capability emphasizes the opportunity to achieve the best with the availability of multiple opportunities. Sen (2002, p.509) writes:

> "To conclude this section on concepts of freedom, we have to be concerned with at least two distinct aspects of freedom, viz. (i) the opportunity aspect, and (ii) the process aspect. The opportunity aspect must pay particular attention to the opportunity of achieving the best that can be achieved, but may extend that concern by taking some supplementary note of the range of opportunities offered. The process aspect, being concerned with the freedom of the person's decisions, must take note of both (iia) the scope for autonomy in individual choices, and (iib) immunity from interference by others".

Sen argues that it is the responsibility of the society to provide freedom to achieve functionings. Sen (1992, p.148) writes:

> "In dealing with responsible adults, it is more appropriate to see the claims of individuals on the society (or the demand of equity or justice) in terms of freedom to achieve rather than actual achievements. If the social arrangements are such that a responsible adult is given no less freedom (in terms of set comparisons) than others, it is possible to argue that no unjust inequality may be involved"

The possession of commodities does not correctly represent the opportunity-freedom. Sen (2002, p.519) says:

> "[…]opportunity-freedom cannot be sensibly judged merely in terms of possession of commodities, but must take note of the opportunity of doing things and achieving results one has reason to value."

Sen defines human agency as

> '[it is] people's ability to act on behalf of goals that matter to them'.

The above account clearly explained Sen's capability approach and its essentials. The main thrust of the approach is on the freedom to achieve functionings.
In the empirical capability literature, the three components of the CA- capabilities, functionings, and conversion efficiency- are measured separately and there is no explicit measurement of

freedom aspect of capability. This may be due to the fact that researchers are inclined to consider more than one functionings at a time and have to compromise with important dimensions of a particular functioning. This leads to measurement of functionings rather than capabilities. To resolve this issue, it is better to consider one important functioning in all its dimensions. This has not been done in the literature. Therefore, the main contribution of the paper is the simultaneous estimation of capability, functioning, and conversion efficiency with explicit modeling of freedom by latent variable modeling.

The paper suggests the following *Satisfaction Criteria* for empirical research within the CA framework:

a) Sen Satisfaction Criterion (SSC): empirical work should be in conformity with Sen's writings. The issues where Sen shows his reservations should not be used in empirical modeling. For example, Sen (1985) categorically mentions the inappropriateness of the use of production function for functioning achievement on the basis of analogy between firms and individuals. Studies using various frontier approaches have failed to satisfy this criterion. Similarly, the aggregation of human capabilities or functionings masks human diversity and hence inconsistent with the spirit of the CA.
b) Pre-requisite Satisfaction Criterion (PSC): the important assumptions underlying a statistical method should be checked before applying the method since most of the data used in the CA are discrete or ordinal in nature and most of the statistical methods are valid for continuous data and assume normality, and are confirmatory in nature and hence needs a strong a priori theory. Studies applying various confirmatory methods have failed to satisfy this criterion since the CA is a framework of thought and not a theory.

The paper is structured as follows. Section 1 introduced the concept and the context of Sen's capability approach. Section 2 reviews the empirical literature briefly. Section 3 develops an empirical model in two stages. Section 4 discusses the estimation results and limitations of the study, and the final section concludes the paper with policy implications and directions for future research.

2. Empirical capability literature: a brief review[5]

Operationalisation of Sen's capability approach is one of the most difficult, if not impossible, aspects of his approach. Operationalisation does not necessarily mean quantitative measurement. In a broad sense, measurement includes the following aspects according to Comim et al (2008): i) clarification of concepts; ii) specification of dimensions to be measured; iii) choice of scales for measurement; and iv) organization of results in a systematic way. Studies on measurement abound but I review some of the representative studies in this area (see Kuklys (2005) for a comprehensive survey of empirical capability literature). I use and follow Sen (1985) seminal multi-dimensional framework of capability approach as an organizing and unifying principle for the

[5] For survey of theoretical literature related to capability approach see Robeyns (2000, 2005). Surprisingly, there is no attempt to develop theoretical model within Sen's capability approach framework except the notable attempt by Kuklys (2005) for disabled individuals which I will discuss in this review. Alkire (2005) reviews the empirical issues in measuring freedoms.

literature review. According to his approach, capabilities are inherently unobservable and manifest themselves by indicators whereas functionings are unobserved and hence measured with error. Therefore, in most of the literature capabilities and functionings are represented by latent variables. In what follows, I discuss the theoretical framework proposed by Sen.

The capability set is defined by Sen as

$Q_i(X_i) = [b_i \mid b_i = f_i(c(x_i)), \text{for some } f_i(.) \in F_i \text{ and for some } x_i \in X_i]$

with the following functions:

$b_i = f_i(c(x_i))$ and

$u_i = h_i(b_i)$

where

$Q_i(X_i)$ = represents capabilities of person i or the freedom that person i has in terms of the choice of functionings, given his personal features F_i and his entitlements X_i (i.e., what real opportunities you have regarding the life you may lead (Sen, 1987)),

b_i = vector of achieved functionings; a set of valuable 'beings' and 'doings',

x_i = the vector of commodities possessed by person i,

X_i = entitlements or command over commodities for person i,

$c(.)$ = the function coverting a commodity vector into a vector of characteristics of those commodities,

$f_i(.)$ = a personal 'utilization function' of i reflecting one pattern of use of commodities that i can actually make i.e., conversion of characteristics into functionings,

F_i = the set of 'utilization functions' f_i, any one of which person i can in fact choose, and

$h_i(.)$ = the happiness function of person i related to the functionings achieved by i.

The three levels of capability approach have been the focus of measurement in the literature: achieved functionings (b_i), capability or achievable functionings ($Q_i(X_i)$), and conversion efficiency of utilization function ($f_i(.)$). I review the literature in the same order.

2.1 Measurement of achieved functionings (b_i):

Kuklys (2005) measured functionings by various indicators using structural equation model (SEM). She critically reviewed other methods used in the literature for measuring functionings like scaling, fuzzy sets theory, factor and principal component analysis, and time series clustering. Scaling, factor and principal component analyses assume perfect substitutability of functionings while fuzzy sets theory assumes zero elasticity of

substitution between the functionings. She considered the following vector of achieved functionings of individual i

$b_i = f_i(c(x_i) \mid z_i, z_s, z_e) \quad \forall \quad f_i \in F_i$ and $\forall \quad x_i \in \mathrm{X_i}$

The statistical representation of the above conversion function is

$b_i^* = f(y_h, z_i, z_s, z_e) + \varepsilon_i$

where

x_i = is a vector of market and non - market goods and services chosen by the individual i,

$c(x_i)$ = is a function that maps goods into the space of characteristics,

z_i, z_s, z_e = are vectors of personal characteristics, societal and environmental circumstances respectively,

f_i = is a conversion function that maps characteristics of goods into states of being or activities b_i, conditional on z_i, z_s, z_e,

$\mathrm{X_i}$ = is the resource constraint, and

F_i = is the set of all possible conversion functions,

y_h = household income

ε = is an error term

She discussed the following problems in the measurement of functionings:

1) Absence of an established measurement unit or scale for functionings.
2) Absence of natural aggregator to summarize different functionings in a composite welfare indicator.
3) Possible presence of measurement error since no single variable may represent a functioning appropriately.
4) Variables indicating a functioning often measured on ordinal scales. This feature leads to the following issues:
    a) Most standard measurement and aggregation techniques are not applicable to variables measured on ordinal scales since these are designed for continuous variables.
    b) Means, variances, covariance or correlation matrices for ordinal variables have no real meaning because of the absence of a unit of measurement or origin. It creates problem for running regressions since regression depends heavily on covariance matrices.
    c) Anchoring problem: different understanding of scales by individuals.

Kuklys measured two functionings-"being-healthy" and "being well-sheltered", each in turn measured by a range of indicators. The independent variables are corresponding to resources, such as income or education, and conversion factors, such as age, marital status, or region of living. She used MIMIC (Multiple-Indicators Multiple-Causes)

models (a special case of SEM) to analyze these two functionings. These two functionings are treated as latent endogenous variables. She estimated the model parameters in the following three steps for the British Household Panel Survey (BHPS) using individual as a unit of analysis:

1- Estimation of threshold values for ordinal variables assuming that a latent continuous variable underlies each ordinal variable.
2- Estimation of latent correlations (polychoric/polyserial) given the estimated thresholds.
3- Estimation of model parameters conditional upon steps1 and 2.

She established that resources such as income and education had little impact on functionings achievement.

2.2 Measurement of capability or achievable functionings ($Q_i(X_i)$):

Anand and Hees (2006) demonstrate that it is possible to design a questionnaire to distinguish between capabilities and functionings. Using this survey instrument they developed the data required by capability approach and tried to measure satisfaction or happiness with capabilities ($u_i = h_i(b_i)$). They examined capability approach in the following seven dimensions: happiness, sense of achievement, health, intellectual stimulation, social relation, environment, and personal projects. They used ordinal logistic regression models, ordered logit models, and Spearman rank correlations for the analysis of survey results. One of their notable findings is that higher income levels are associated with lower capability satisfactions. This may indicate a trade-off between objective improvement and subjective dissatisfaction. Another important finding is that people use their own capabilities to make judgments about the distribution of opportunities within society, except in the areas of heath and the environment.

Anand *et al*. (2005) developed a new survey instrument to elicit information about capabilities at individual level. The paper finds that many capability indicators are highly correlated with happiness after controlling for socio-demographic and personal variables.

Krishnakumar (2007) proposes a theoretical framework that encompasses all important features of capability approach. The proposed framework provides a basis for econometric analysis using real data. The theoretical framework suggests the following econometric model:

$Ay^* + Bz + Cx + u = 0$

$g(y) = h(y^*, w) + v$

where

y^* = a vector of latent capabilities,

y = a vector of observed indicators representing the functionings associated with the capability vector,

z = a vector of observed variables that influence the capabilities but are also influenced by them,

x = a vector of exogenous causes of y^* and z, and

w = a vector of exogenous factors entering the measurement equations,

u, v = error vectors for structural equation and meaurement equation respectively.

He considered the following three capabilities and used UNDP and World Bank databases besides others for their measurement; 'knowledge', 'health', and 'political freedom'. The indicators used for each capability are: adult literacy rate and gross enrollment ratio for 'knowledge', life expectancy at birth, infant mortality rate, and under-five mortality rate for 'health', and political rights, civil liberties, and voice and accountability for 'political freedom'. Along with these indicators he used a broad range of possible observed exogenous variables for structural and measurement parts of the model. He used robust maximum likelihood method for the estimation of model parameters.

He found highly significant coefficients for most of the indicators of capabilities and hence concluded that the selected indicators reflect their latent dimension satisfactorily. The political exogenous factors considered are turn out to be insignificant in the measurement model but some of them are significant in the structural model. The interactions among the latent variables in the structural model show a positive and significant impact of health on education which in turn has a positive effect on political rights. He also concluded from the results that greater political freedom leads to better health status.

Based on the estimation of the model, he computed an aggregate capability index (ACI, my abbreviation) as a weighted average of the factors scores using the inverse of their variance as weights. He then compared his ranking of countries on the basis of ACI with that of HDI. He found a strong correlation between the two indices but ranking for some countries are quite different. It may be due to the weak correlation between HDI and the third component of ACI, the political freedom. According to these rankings, China is 25th on the basis of HDI but 38th on the basis of ACI. He also compared this ranking with that of GDP but found a weaker correlation as compared to HDI. He has made a significant step towards developing an aggregate capability index.

Kuklys (2005) developed a method for the estimation of capability sets which takes into account differential needs of individuals especially in the context of disabled individuals.

On the basis of following assumptions she developed a theoretical model for capability. First, she assumes that the effect of conversion factors (non-monetary constraints) on the functioning can be expressed as an effect on the capability set. Second, she assumes that the same goods provide the same characteristics to each individual, so that the characteristics space can be neglected, i.e., c(x) = x. Third, she assumes that all goods affecting welfare are marketable especially in the context of a developed country like the U.K. Fourth, she assumes that more income leads to more capability[6].

On the basis of above assumptions, she proposed following definition of capability set,

$$Q_i(Y_i) = h(Y_i \mid z_i, z_s, z_e),$$

where Y is the disposable income of individual i given the conversion factors for some function h which is assumed to be monotonic. She inverts the above function and writes,

$$Y_i \mid z_i, z_s, z_e = h^{-1}(Q_i)$$

She argues that if the left hand side of above equation is identified empirically then a monotone transform of the capability set Q is also identified.
To derive a theoretical model, she further assumes that overall household utility is additively separable in utility derived from consumption of goods and utility derived from other sources. Focusing on the utility derived from consumption of goods, she estimated equivalent household income defined as the income that would allow household *h* to achieve the same level of income satisfaction as the reference household *r*. She estimated the following equivalent scale equation:

$$\frac{y^h}{y^r} = \exp\{\frac{1}{\hat{\beta}_1} * \hat{\beta}_2 (z^r - z^h)\}$$

where

y = household's income

z = disability indicator

The estimation results show that a disabled individuals needs 1.56 times the income of a healthy individual to achieve the same level of income satisfaction, i.e., his consumption set is only 1/1.56 the consumption set of a healthy individual. Therefore, the capability set of this individual is only 64% of the capability set of non-disabled. In this way, she showed that how a welfare measure adjusted for disability reflects a correct picture of social welfare.

2.3 Measurement of conversion efficiency of the utilization function ($f_i(.)$):

Some of the studies attempt to measure efficiency with which individuals convert their resources (x) into achieved functioning (b).
Binder and Broekel (2008) have used non-convex order-m frontier estimation in a two-stage method to assess the conversion efficiency of the basket of "basic functionings" namely: 'being happy', being educated', and 'being healthy' for the British Household

[6] This assumption is valid for an advanced country like the U.K. where markets are developed but it is not suitable for a developing country like Pakistan. As she mentions, this still does not allow us to correctly measure an individual's welfare level when a job with a lower income is chosen.

Panel Survey (BHPS) wave 2006 dataset. Their finding is striking in that 76.64 percent of the individuals in the sample are not able to transform their resources into functioning achievement as efficiently as the best 23 percent. Their results also show that the average inefficient individual achieves about 33 percent less functioning achievement than an efficient individual with the same resources. These results clearly show that resource-based welfare measures do not give correct level of human welfare. They argue that a measure of conversion efficiency reflects diverse welfare-reducing institutional constraints on individuals.

3. An Empirical Model:

3.1. Selection of Functioning:

I consider one functioning; *being-educated.* There are several reasons for taking single functioning and selecting 'being-educated' as a functioning:

1) Since the extent or nature of freedoms (opportunity and process) is different for different functionings, taking more than one functionings at a time would be problematic since it would be very difficult to isolate freedoms associated with each functioning. That's why Alkire (2005, p.15) argues:

> 'Thus I argue that autonomy or process freedoms must be evaluated with respect to *each* basic functioning. The reason for this is that the autonomies required for a woman to decide to seek paid employment, to be nourished, to plan her family, to vote, to attend literacy courses may be present in varying degrees and it is precisely these variations that may identify the 'freedom' associated with a particular functioning or a particular deprivation'.

2) It satisfies Sen's criteria of basic functionings. According to Sen (2004), a basic functioning must satisfy the following two criteria[7]:

a) They must be valued as being of *special importance* at time *t* to a significant proportion of the relevant population to which person i belongs.

b) They must be *socially influenceable***.** That is, they must be functionings that social and economic policies have the possibility to influence directly.

3) Because of the complexity of measurement of capabilities, it is better to analyze one functioning at a time in all its important capability dimensions. Kuklys (2005) highlighted the following four methodological problems:
i) Selection of relevant functionings, ii) measurement of functionings at the individual level, iii) aggregation of functionings into a composite measure of individual welfare, and iv) aggregation of a functioning across individuals.
By selecting one basic functioning, we can avoid first three problems altogether.

4) It satisfies at least two of the three 'basic needs' mentioned by Ryan and Deci (2000) in their Self-Determination Theory (SDT). These three innate psychological needs are: competence, autonomy, and relatedness. They argue that when these are satisfied yield enhanced self-motivation and mental health and when thwarted lead to diminished motivation and well-being.

[7] See Sabina Alkire (2005) for detail of these criteria.

5) According to Martha Naussbaum (2006, p.322) "education is a key to all human capabilities".
Furthermore, the functioning- being educated - varies more from person to person, particularly in developing countries and has instrumental as well as intrinsic values with positive externalities. It is a great source of autonomy, empowerment, and enlightment.

3.2 The Data

I will use PSES (2002) dataset because some of the questions in this survey are more relevant to the objective of this paper. The details of the sample design are given in Arif et al. (2001) and Siddiqui and Hamid (2003).
The PSES (2002) is based on round II of Pakistan Socio-Economic Survey (PSES). The round II is based on the sample design of round I conducted in 1998. Therefore, detail of the sample design of the round I is given below:
The 1998-99 PSES consists of all urban and rural areas of the four provinces of Pakistan (Punjab, Sind, Baluchistan, and NWFP) defined as such by 1981 population census excluding FATA, military restricted areas, districts of Kohistan, Chitral, Malakand, and protected areas of NWFP. The population of the excluded areas constitutes about 4 percent of the total population**.** See further details in the aforementioned references.

Two stage stratified sample design was adopted for the 1998-99 PSES. Enumeration blocks in urban areas and Mouzas/Dehs/villages in rural areas were taken as primary sampling units (PSUs). Households within the sampled PSUs were taken as secondary sampling units (SSUs). Within a PSU, a sample of 8 households from urban areas and 12 housholds from rural areas was selected. Households covered during the round I of the PSES was revisited during the round II in 2000-01. After some adjustment due to attrition, the total sample for round II of the PSES turned out to be 4021 households (2577 rural and 1444 urban). I have taken the data for 2850 individuals who have directly responded to the subjective questionnaire. This information is important since the unit of analysis is individual and capability is measured subjectively in the present paper.

3.3 Empirical Modeling Methodology

Since the present work involves latent variables, it is pertinent to ascertain the definition of a latent variable that will be used in the study.

3.3.1 Latent Variable Definitions

There are many definitions-formal and informal- being used in the literature. Bollen (2002) reviews some of these definitions. I summarize below only four common formal definitions of latent variables:
1) *Local independence definition*: It states that there are one or more latent variables that create the association between observed variables, and when the latent variables are held constant, the observed variables are independent. Formally,

$$P[Y_1, Y_2, ..., Y_K] = P[Y_1 \mid \eta]P[Y_2 \mid \eta]....P[Y_K \mid \eta]$$

where $Y_1, Y_2, ..., Y_K$ are random observed variables, η is a vector of latent variables,

$P[Y_1, Y_2, ..., Y_K]$ is the joint probability of the observed variables, and

$P[Y_1 \mid \eta]P[Y_2 \mid \eta]....P[Y_K \mid \eta]$ are the conditional probabilities.

This definition assumes that (a) errors of measurement are independent or uncorrelated, (b) observed variables or indicators have no direct or indirect effects on each other, (c) there are at least two observed variables, (d) each latent variable must have direct effects on one or more observed variables, and (e) the observed variables (indicators) do not directly affect the latent variable.
Bollen illustrates that these properties lead to counterintuitive elimination of some variables as latent variables.
2) *Expected value definition*: The underlying variable (the true score, T_i) is equal to the expected value, E(.) of the observed variable, Y_i for the ith individual. i.e.,

$$T_i \equiv E(Y_i)$$

The true score is obtained by the mean of repeated experiments for the ith individual. The equation for the observed random variable with measurement error, E_i is given by

$$Y_i = T_i + E_i$$

The definition assumes that (a) scale is defined by $E(Y_i)$, (b) the error of measurement, E_i has a mean of zero and is uncorrelated with T, (c) the E is uncorrelated for two different observed variables, (d) the T has direct effects on its corresponding observed variable, (e) the observed variables (indicators) do not directly affect the latent variable, and (f) two different observed variables have no direct or indirect effect on each other.
Bollen argues that this definition can lead to counterintuitive classifications of variables as latent or not.
3) *Nondeterministic function of observed variables definition*: It defines a latent variable, due to Bentler (1982), as ' A variable in a linear structural equation system is a latent variable if the equations cannot be manipulated so as to express the variable as a function of manifest variables only'. Bollen illustrates that this definition leads to disturbances being classified as latent variables in one model but not in another, whereas intuitively a consistent classification is expected.
4) *Sample realization definition*: Bollen (2002) provides his own definition due to the problems involved in the previous definitions. He defines a latent variable as follows: "A latent random (or nonrandom) variable is a random (or nonrandom) variable for which there is no sample realization for at least some observations in a given sample". He argues, according to this definition, that "…all variables are latent until sample values of them are available".
I take the last definition of latent variable for the present study due to its simplicity and clarity. Moreover, Bollen shows that this is the most inclusive of the four definitions in that it helps make connections between underlying variables in a variety of models and applications.

3.3.2 Latent Variable Modeling

According to Kementa (1991), unobservable variables in econometrics are represented in one of the following three ways: i) variables with measurement errors; ii) proxy variables; and iii) intrinsically latent variables. The last type of unobservable variables is characterized by a number of indicators (manifest or observed variables) or a number of observable causes. Because of the nature of the CA, I will use the last representation of unobservable variables in the subsequent modeling.

Latent variable modeling has potential for application in measuring functionings or capabilities due to inherent nature of capability approach. The structural equation

modeling (SEM) is being applied in this context successfully in social sciences. There are two common and widely used techniques for the SEM; The Linear Structural Relations (LISREL) method due to Karl G. Joreskog (1973) and the Partial Least Square (PLS) method (also called projection to latent structures) due to Herman Wold (1960).

The LISREL is a merger of simultaneous equations models developed in econometrics and factor analysis models developed in psychometrics. It is an interpretative (explanatory) and confirmatory covariance-based technique and hence it usually requires a strong theoretical foundation in order to model causal relationships and it is based on the assumption that manifest variables are multivariate normal. The estimators may be seriously biased if the underlying distribution is far from the multivariate normal. Generally a small departure leads to inflate the chi-square value but in some circumstances it may deflate it. The main cause of violation of this assumption is the use of dichotomous or ordinal variables. The most commonly used estimation method is MLE. But it is not robust in the presence of ordinal or non-normal data. The idiosyncratic error term needs to be i.i.d. normal. Huber, Ronchetti, and Victoria-Feser (2004) suggest the use of the Laplace approximated MLE (LAMLE) in this situation.

The PLS, on the other hand, is a predictive and exploratory variance-based technique and hence it does not require a strong theoretical basis and it is distribution free. It is useful when sample is small, there are missing values, and there is high multicollinearity problem. Ringle et al. (2009) have shown in a simulation study that LISREL is a better method when its prerequisites are met. Otherwise, the PLS provides a viable approximation of model parameters. As I pointed out earlier, the CA is a framework of thought and not a theory (see Robeyns, 2005). Therefore, it is not advisable to use methods of confirmatory analysis in the initial stage. Once a theory is formulated then it is strongly recommended to apply confirmatory methods. Since most of the theories in social sciences are conjectures, it is better to perform exploratory analysis before applying confirmatory methods. Freedman (2005, p.193) clarifies this point and writes:

> "There is no way to infer the 'right' model from the data unless there is strong prior theory to limit the universe of possible model. (More technically, diagnostics and specification tests usually have good power only against restricted classes of alternatives). That kind of strong theory is rarely available in the social sciences."

Given these circumstances, I apply a two-stage procedure. In the first stage, exploratory method is applied to figure out the causal mechanism and generate scores for the latent variables. Before going to second stage, I check the prerequisites for the application of confirmatory method. In the second stage, a confirmatory method is used to test the stage-1 model and estimate the population parameters.

The following section provides a succinct description of the LISREL model (for details, see, for example, Skrondal and Rabe-Hesketh (2007), Wansbeek and Meijer (2000), Diamantopoulos and Siguaw (2000)).

The LISREL model:

It consists of three parts:

a) *Structural model*: it is a simultaneous equation model with latent endogenous and exogenous variables. This model is linked to observed variables through the factor analysis models.

b) *Factor analysis model* for endogenous observed variables, and
c) *Factor analysis model* for exogenous observed variables.
The last two parts of the model are jointly called the *measurement model*.
The statistical equations for the model in the standard LISREL notations are given below:

$$\eta = \mathrm{B}\eta + \Gamma\xi + \varsigma$$
$$y = \Lambda_y \eta + \varepsilon$$
$$x = \Lambda_x \xi + \delta$$

The vectors η and ξ contain the latent endogenous and exogenous variables respectively.
The vectors y and x contain the corresponding observed variables.
The vector ς contains the residuals in the regression equations, and the vectors ε and δ contain the measurement errors.
The matrices B and Γ contain regression coefficients and the matrices Λ_y and Λ_x contain factor loadings.
The following assumptions are made in a standard LISREL model:
The random vectors $\xi, \varsigma, \varepsilon$, and δ are assumed to be mutually uncorrelated with means zero and covariance matrices are $\Phi \equiv \mathrm{E}(\xi\xi'), \Psi \equiv \mathrm{E}(\varsigma\varsigma'), \Theta_\varepsilon \equiv E(\varepsilon\varepsilon'), \Theta_\delta \equiv E(\delta\delta')$ respectively.
The model is estimated by fitting the theoretical covariance structure Σ to the sample covariance matrix S. The objective of this estimation is to find the estimates of parameter values such that the computed theoretical covariance matrix (also known as implied covariance matrix) is as close as possible to the observed sample covariance matrix, i.e., the parameters are chosen in such a manner that Σ maximally resembles S. This discrepancy between the implied covariance matrix and the empirical covariance matrix is estimated by many methods like ML, GLS, ULS (see, Ringle et al. (2009), for comparison of these and other techniques).
The reduced form equation for y is obtained by substituting equation 2 in equation 1 whereas reduced form for x is the same as equation 3.
The reduced form equation for y assuming (I - B) is a full rank (non - singular) is

$$y = \Lambda_y (\mathrm{I} - \mathrm{B})^{-1} (\Gamma\xi + \varsigma) + \varepsilon$$

The covariance matrix of observables is

$$\Sigma \equiv \begin{bmatrix} \Sigma_{yy} & \Sigma_{yx} \\ \Sigma_{xy} & \Sigma_{xx} \end{bmatrix}$$

With the following covariance and variance elements:

$$\Sigma_{yy} \equiv \Lambda_y (\mathrm{I} - \mathrm{B})^{-1} (\Gamma\Phi\Gamma' + \Psi)[(\mathrm{I} - \mathrm{B})^{-1}]'\Lambda_y' + \Theta_\varepsilon$$
$$\Sigma_{yx} \equiv \Lambda_y (\mathrm{I} - \mathrm{B})^{-1} \Gamma\Phi\Lambda_x'$$
$$\Sigma_x \equiv \Lambda_x \Phi\Lambda_x' + \Theta_\delta$$

There are two important limitations of the LISREL approach are that all latent variables are continuous and that multilevel data can be used only in the balanced case (where each cluster has the same number of units with the same number of covariate values).

Partial Least Squares Method

Bro and Elden (2009) describes the PLS as follows:

The problem in PLS is to determine an approximate solution to the regression model:

$$\min \| y - Xb \| \qquad (1)$$

Here y is the vector of the dependent variable, X, a matrix for the independent variables and b a vector of regression coefficients. The traditional PLS algorithms are based on using loading weights, W, as well as loadings, P. The components are calculated in a sequential manner. Given the pre-processed data, X_0, the first score vector is determined as

$$t_1 = \frac{X_0 w}{\| X_0 w \|} \qquad (2)$$

Normalization of the scores is used for convenience. Subsequently, the X_0 data are deflated using

$$X_1 = X_0 - t_1 p_1^T \qquad (3)$$

The next component is determined from X_1, etc. The loading vector p_1 is determined in a least squares sense in terms of approximating the data X_0 given t_1:

$$p_1 = X_0^T t_1 \qquad (4)$$

A several-component PLS model does not work on the overall data, but on deflated versions.

The crucial part of a PLS model is the prediction of the dependent variable, but the model also includes an approximation of X which is useful for diagnostic and exploratory purposes as well as for outlier detection. This model is given as

$$\hat{X} = T_k P_k^T \qquad (5)$$

Residuals can be found as

$$E = X_k = X - T_k P_k^T \qquad (6)$$

where k is the number of components used in the model. The PLS algorithm is given in the appendix.

Pirouz (2006) mentions the following key advantages of partial least squares:

1) Able to model multiple dependent as well as multiple independence variables
2) Can handle multicollinearity
3) Robust despite data noise and missing data
4) Creates independent latent variables directly on the basis of cross products involving response variable(s). It gives stronger predictions.
5) Allows for reflective and formative latents
6) Applied to small sample
7) Distributional free
8) Handle range of variables: nominal, ordinal, continuous

Some of the disadvantages of partial least squares are as follows:
1) Difficulty in interpreting loadings of independent latent variables (based on cross product relations with response variables not, as in conventional factor analysis, on correlations among manifest independents)
2) Distributional properties of estimates not known
3) Can't get significance unless run bootstrap
4) Lack of model test statistics

Table : Comparison of PLS and LISREL

Criterion	*PLS*	*LISREL*
Objective	Prediction oriented	Parameter oriented
Approach	Variance based	Covariance based
Assumptions	Predictor specification (non parametric)	Typically multivariate normal distribution and independent observations (parametric)
Parameter estimates	Consistent as indicators and sample size increase	Consistent
Latent variable scores	Explicitly estimated	Indeterminate
Epistemic relationship between a latent variable and its measures	Can be modeled in either formative or reflective mode	Typically only with reflective indicators (however procedures to consider formative indicators exist)
Implications	Optimal for prediction accuracy	Optimal for parameter accuracy
Model complexity	Large complexity (e.g. 100 constructs and 1000 indicators)	Small to moderate complexity (e.g. less than 100 indicators)
Sample size	Power analysis based on the portion of the model with the largest number of predictors. Minimal recommendations range from 30 to 100 cases.	Ideally based on power analysis of specific model – minimal recommendations range from 100 to 800.

Source: Andreas Hammer (2006).

Empirical modeling strategy:

A two-stage exploratory-confirmatory method is for empirical modeling. The first-stage involves the following steps:
Step-I propose a theoretical model.
Step-II formulate the proposed model in the PLS framework for exploratory analysis.
Step-III construct latent variable scores.

Joreskog (2000) describes the following uses of the latent variable scores:

1) Select subgroups of individuals on the basis of the latent variable scores. These subgroups can be made on the basis of, for example, gender, region, age, resources, etc.
2) Rank individuals on the basis of the scores of one latent variable.
3) Correlate latent variable scores with the observed variables.
4) Estimate linear/non-linear relationships among latent variables.
5) Regress the observed variables on the latent variable scores.

The Theoretical Model:

The following simultaneous structural model is proposed. Capability is assumed to be a function of achieved functioning with process and opportunity freedom.

Capability = f (functioning, freedom) ----------(1)

Functioning achievement is a function of conversion efficiency which is, in turn, a function of conversion factors (constraints) and resources.

Functioning = g(conversion efficiency) ----------(2)

Conversion efficiency = h(constraints, resources)----------(3)

The latent variable scores are constructed for every individual in the sample by the PLS algorithm (reported in the appendix). The indicators used in the construction of latent variable scores are reported in Table 1 while the causal variables for conversion efficiency are reported in Table 2. The LISREL method couldn't be applied since most of the variables do not satisfy multivariate normality test. More importantly, the formative indicators cannot be modeled according to the theoretical framework.

Table 1: Model variables and their indicators:

Latent variable (Type)	Indicator (Type)	Question Statement	Categories
Freedom (ξ^R) (exogenous)	Usefulness (x_1) (ordinal)	Have you recently felt that you are playing a useful part in things[8]?	1. More so than usual 2, 3… 4. Much less usual
	Decision (x_2) (ordinal)	Have you recently felt capable of making decisions about things[11]?	1. More so than usual 2, 3… 4. Much less capable
	Success (x_3) (ordinal)	How do you feel about the extent to which you have achieved success and are getting ahead[9]?	1. Very good 2… 3. Not so good
	Accomplishment (x_4) (ordinal)	Do you normally accomplish what you want to[12]?	1. Most of the time 2.. 3. Hardly ever
	Preference (x_5) (dichotomous)	School left due to preference or constraint.	0. Constraint 1. Preference
	Confidence (x_6) (ordinal)	Do you feel confident that in case of a crisis you will be able to cope with it?	1. Very much 2. To some extent 3. Not so much
Capability (η^C) (endogenous)	Life interesting (y_1) (ordinal)	Do you feel life is interesting?	1. Very much 2. To some extent 3. Not so much
	Happiness (y_2) (ordinal)	Have you been feeling reasonably happy, recently considering all difficulties?	1. More so than usual 2, 3… 4. Much less usual
	Enjoyment (y_3) (ordinal)	Have you recently been able to enjoy your normal day-to-day activities?	1. More so than usual 2, 3… 4. Much less usual
Functioning (η^F) (endogenous)	Standard (y_4) (ordinal)	Do you think you have achieved the standard of living and the social status that you had expected[10]?	1. Very much 2… 3. Not so much
	Education (y_5) (continuous)	Education years completed.	1 to 18 years
	Literacy (y_6) (dichotomous)	Can read or write?	0. No. 1. Yes.

Note: The composite reliability indices for capability and freedom indicators are 0.8 and 0.6 respectively whereas it is low (0.3) for functioning indicators.

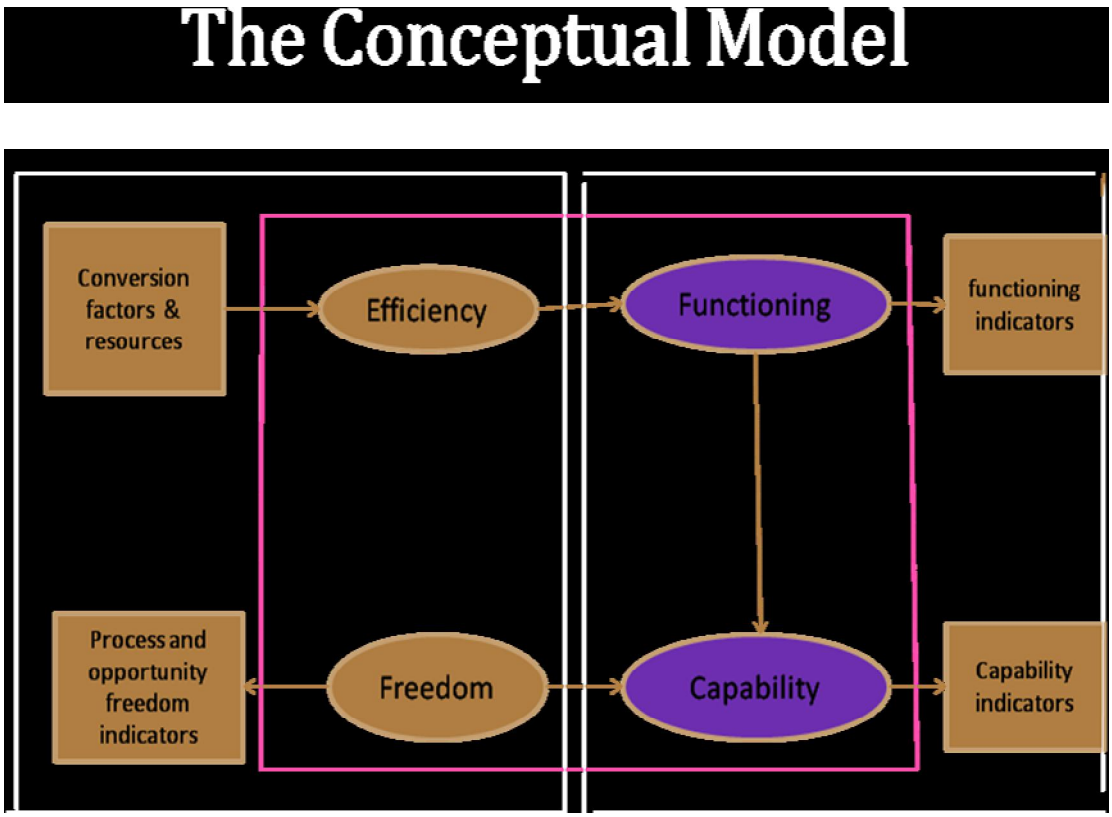
[8] 'The process aspect, being concerned with the freedom of the person's decisions, must take note of both (iia) the scope for autonomy in individual choices, and (iib) immunity from interference by others.' (Sen, 2002).

[9] '[…..]opportunity-freedom cannot be sensibly judged merely in terms of possession of commodities, but must take note of the opportunity of doing things and achieving results one has reason to value.' (Sen, 2002).

[10] 'Functionings are, in a sense, more directly related to living conditions, since they are different aspects of living condtions'. (Sen, 1987)

Table:2 Causal Variables: Formative Indicators for conversion efficiency (ξ^E)

No.	Variable	Type	Categories
1	Gender (x_7)	Categorical	1. Male 2. Female
2	Age (x_8)	Metric	>30
3	Province (x_9)	Spatial	1. Punjab 2. Sind 3. Baluchistan 4. NWFP
4	Urban (x_{10})	Spatial	1. Urban 2. Rural
5	Income (x_{11})	Metric	>0
6	Marital status (x_{12})	Categorical	1. Never married 2. Currently married 3. Widow/Widower 4. Divorced 5. Separated



Note: The blue ellipses show exogenous variables and the green ellipses show endogenous variables in the inner or structural model. The outer or measurement model consists of reflexive and formative indicators.

Estimation of the model

The above model is estimated by Three-Stage Least Squares (3SLS) system estimation method. It is not only asymptotically efficient but also not very sensitive to normality. Therefore, it is preferable to FIML method. Although the Quasi-Maximum Likelihood

(QML) method is applicable in the situation of non-normality yet it is not asymptotically efficient. The problems of identification and heteroscedasticity are checked before applying the 3SLS method.

Main Findings

The results show that income is associated with lower capability level which is consistent with the Anand and Hees (2006) finding. Moreover, conversion efficiency is positively related to functioning achievement. This result is in conformity with the Binder and Borekel (2008) result. Although it shows inefficient proportion of individuals yet it does not discriminate between voluntary and involuntary inefficient individuals. I have extended the concept of inefficiency into voluntary and involuntary inefficiency. According to mid efficiency criterion, there are 35% inefficient individuals. Out of these 35%, 36% are voluntary inefficient which are 22% of the total individuals in the sample. The capability is positively and significantly explained by the functioning achievement and the freedom which is consistent with Sen's capability approach. The sign and size of coefficients are robust to various model specifications. The freedom and functioning have almost equal impact on the capability. The resources have greater but negative impact on functioning than relative efficiency (see Table 3).

Table 3

Three-stage least-squares regression

Equation	Obs	Parms	RMSE	"R-sq"	chi2	P
RC	2850	2	.1085804	0.4425	1940.43	0.0000
RFN	2850	2	.0724248	0.0914	286.86	0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
RC						
RFR	.5056907	.0341961	14.79	0.000	.4386676	.5727139
RFN	.5781426	.1280443	4.52	0.000	.3271803	.8291048
_cons	.139549	.0194497	7.17	0.000	.1014283	.1776698
RFN						
RE	.0356986	.0132374	2.70	0.007	.0097537	.0616434
RR	-.3049891	.0195698	-15.58	0.000	-.3433451	-.266633
_cons	.4669921	.0180865	25.82	0.000	.4315433	.5024409

Endogenous variables: RC RFN
Exogenous variables: RFR RE RR

Table 4 shows inequality ratio of top decile average to bottom decile average for relative capability (RC), relative efficiency (RE), relative freedom (RFR), relative functioning (RFN), and relative resource (RR) ratios. The largest inequality is in the functioning achievement followed by capability and freedom. It is understandable since about 50% of the individuals in the sample are illiterate. The lowest inequality is in the resource distribution where top decile is getting 44% more resources than the bottom decile. There are no significant differences between provinces or urban and rural areas for these ratios.

Table 4

Inequality ratio				
RC	**RE**	**RFR**	**RFN**	**RR**
2.71	1.56	2.68	3.01	1.44

Conclusions and Policy Implications

The paper measures freedom aspect of capability by developing indicators from the survey data. The correctness of freedom measure depends on the quality of indicators and the robustness of statistical method. The paper also suggests criteria for the evaluation of empirical research within the capability approach framework.

The results show that capability is inversely related to resources and positively related to freedom and functioning. The computed relative capability and freedom inequality ratios are very high whereas relative functioning and efficiency inequality ratios are at a moderate level. The conventional income inequality ratio is lower as compared to the capability dimensions ratios and close to the Gini-coefficient. The paper recommends the use of inequality measures instead of averaging measures particularly in developing countries where inequality levels are very high. The state-dependence due to human diversity calls for taking individual as a unit of analysis. The paper also recommends development of specific survey instruments in order to create better indicators for capability dimensions and use of latent variable modeling for constructing latent variable scores, and their subsequent use in estimation. These findings suggest a capabilities-oriented public and education policies for the enhancement of knowledge dimension of capabilities in particular and human welfare in general. The focus of education policy should be extended from investment-oriented (human capital approach) to value-oriented (human capability approach).

The present study may be extended into several directions like cross-country comparison of capability inequality ratios, intertemporal comparisons using panel data, development of aggregate index of capabilities, simulation studies for public policy options for the expansion of capabilities, implications for poverty and income inequality measures, randomized controlled experiments for various capability interventions, etc.

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Appendix 1

Table 1

Highest education	Freq.	Percent	Cum.
< Class 1	28	0.35	0.35
Class 1	87	1.08	1.43
Class 2	285	3.53	4.96
Class 3	336	4.16	9.12
Class 4	432	5.35	14.47
Class 5	**1,671**	**20.71**	35.18
Class 6	344	4.26	39.44
Class 7	365	4.52	43.97
Class 8	**1,012**	**12.54**	56.51
Class 9	394	4.88	61.39
Class 10	**1,638**	**20.3**	81.69
Class 11	69	0.86	82.54
Class 12	613	7.6	90.14
Class 13	17	0.21	90.35
BA/BSc	394	4.88	95.23
Class 15	1	0.01	95.24
Post graduate MA, M.Sc, MEd.	187	2.32	97.56
Polytechnic Diploma	10	0.12	97.68
Degree in Engineering	28	0.35	98.03
Degree in Medicine	27	0.33	98.36
Degree in Agriculture	1	0.01	98.38
Degree in Law	14	0.17	98.55
Matric + PTC	43	0.53	99.08
FA + CT	25	0.31	99.39
BA + B.Ed	27	0.33	99.73
Others (specify)	22	0.27	100
Total	8,070	100	

Table 2

School Leaving Reason	Freq.	Percent	Cum.
1- Expensive	**2,034**	**25.81**	25.81
2- Too far away	320	4.06	29.87
3- No discipline in school	57	0.72	30.59
4- Had to help home	**955**	**12.12**	42.7
5- Had to help business	84	1.07	43.77
6- Parents/elders do not approve	508	6.45	50.22
7- Marriage	553	7.02	57.23
8- Education not useful	115	1.46	58.69
9- No interest	**1,534**	**19.46**	78.15
10- Education completed	408	5.18	83.33
11- Started work	**1,163**	**14.76**	98.08
12- Other reasons (specify)	151	1.92	100
Total	7,882	100	

Table 3
Subjective indicators for constraints and preferences:

Reason for leaving school	Constraint (c) or Preference (p)
1- Expensive	C
2- Too far away	C
3- No discipline in school	C
4- Had to help home	C
5- Had to help business	C
6- Parents/elders do not approve	C
7- Marriage	C
8- Education not useful	P
9- No interest	P
10- Education completed	P
11- Started work	P

Table 4

School left due to	Freq.	Percent
constraint	1,015	52.73
preference	910	47.27
Total	1,925	100

Table 5

Literacy (can read or write?)	Freq.	Percent
Yes	2,036	54.05
No	1,731	45.95
Total	3,767	100

Table 6

Highest education	School Leaving Reason												
	1- Expens	2- Too far	3-No discip.	4- Help home	5- Help business	6- Not approve	7- Marriage	8- Edu not useful	9- No interest	10- Edu comp.	11- Started work	12- Other	Total
< Class 1	3	0	0	0	0	0	0	1	4	0	1	0	**9**
Class 1	8	0	0	4	0	1	0	0	5	0	1	0	**20**
Class 2	24	2	0	17	2	8	0	0	27	0	7	2	**90**
Class 3	45	2	0	12	1	13	3	0	21	0	10	1	**109**
Class 4	57	7	2	26	4	11	4	3	19	0	14	1	**150**
Class 5	171	45	4	90	9	66	28	12	72	5	75	9	**591**
Class 6	34	2	2	16	5	6	7	5	15	1	9	1	**104**
Class 7	28	2	0	24	2	9	3	3	18	0	14	1	**105**
Class 8	90	8	2	74	3	16	38	8	60	3	63	2	**370**
Class 9	18	0	0	21	2	3	5	2	32	0	16	1	**102**
Class 10	97	7	2	86	8	18	78	6	58	16	199	7	**589**
Class 11	4	0	0	3	0	0	2	0	2	0	5	0	**16**
Class 12	20	1	0	37	5	7	27	1	15	12	74	2	**203**
Class 13	0	0	0	0	0	0	1	0	0	0	3	1	**5**
BA/BSc	9	0	0	17	4	2	17	1	1	33	71	3	**158**
Post graduate MA, M.S	2	0	0	5	0	0	3	0	0	61	28	0	**100**
Polytechnic Diploma	0	0	0	0	0	0	0	0	0	0	5	0	**5**
Degree in Engineering	0	0	0	0	0	0	0	0	0	11	9	0	**20**
Degree in Medicine	0	0	0	0	0	0	0	0	0	12	5	0	**19**
Degree in Agriculture	0	0	0	0	0	0	0	0	0	0	1	0	**1**
Degree in Law	0	0	0	0	0	0	0	0	0	6	5	0	**11**
Matric + PTC	4	0	0	4	1	0	4	0	2	7	5	0	**27**
FA + CT	1	0	0	1	0	0	1	0	0	3	4	0	**10**
BA + B.Ed	1	0	0	2	0	0	1	0	0	4	3	0	**12**
Others (specify)	1	0	0	0	0	0	1	0	0	6	4	0	**12**
Total	**617**	**76**	**12**	**439**	**46**	**160**	**223**	**42**	**351**	**180**	**631**	**31**	**2,838**

Table 7: Individual correlation matrices

Polychoric correlation matrix for reflexive indicators of freedom

	s13Aq4	s13Aq5	s13Bq5	s13Bq6
s13Aq4	1			
s13Aq5	.63066972	1		
s13Bq5	.36165646	.3885846	1	
s13Bq6	.35731299	.33248036	.6521731	1

Polychoric correlation matrix for formative indicators of conversion efficiency

	s1q2	s1q3a	s1q6	prov	ur	lnincome
s1q2	1					
s1q3a	-.29735372	1				
s1q6	-.17683146	.6755722	1			
prov	-.01322384	-.04855938	-.09291133	1		
ur	-.17044364	-.0870671	.00282481	-.22736825	1	
lnincome	-.2188247	.09300714	.13609522	.13334903	-.30651577	1

Polychoric correlation matrix for reflexive indicators of functioning

	news2q3	s13Bq4	s13Aq4	s13Bq3
news2q3	1			
s13Bq4	-.2019069	1		
s13Aq4	-.15489569	.32239206	1	
s13Bq3	-.25200336	.57130337	.49267445	1

Table 8: Summary statistics

Univariate Summary Statistics for Continuous Variables

Variable	Mean	St. Dev.	T-Value	Skewness	Kurtosis	Minimum	Freq.	Maximum	Freq.
s1q3a	39.793	13.477	118.289	0.433	-0.178	10.000	1	87.000	2
news2q3	8.268	3.865	85.708	0.573	0.890	0.000	5	26.000	7
lnincome	10.455	1.000	418.741	-1.078	6.787	2.303	1	14.123	1

Test of Univariate Normality for Continuous Variables

	Skewness		Kurtosis		Skewness and Kurtosis	
Variable	Z-Score	P-Value	Z-Score	P-Value	Chi-Square	P-Value
s1q3a	6.810	0.000	-1.459	0.145	48.502	0.000
news2q3	8.780	0.000	7.285	0.000	130.163	0.000
lnincome	-14.655	0.000	55.591	0.000	3305.172	0.000

Table 9: Correlations and Test Statistics

(PE=Pearson Product Moment, PC=Polychoric, PS=Polyserial)

		Test of Model			Test of Close Fit
Variable vs. Variable	**Correlation**	**Chi-Squ.**	**D.F.**	**P-Value**	**RMSEA**
s13Aq5 vs. s13Aq4	0.631 (PC)	64.969	8	0	0.067
s13Aq12 vs. s13Aq4	0.464 (PC)	28.549	8	0	0.04
s13Aq12 vs. s13Aq5	0.471 (PC)	54.701	8	0	0.06
s13Bq3 vs. s13Aq4	0.492 (PC)	24.712	5	0	0.05
s13Bq3 vs. s13Aq5	0.409 (PC)	28.698	5	0	0.054
s13Bq3 vs. s13Aq12	0.523 (PC)	25.999	5	0	0.051
s13Bq4 vs. s13Aq4	0.323 (PC)	15.148	5	0.01	0.036
s13Bq4 vs. s13Aq5	0.277 (PC)	9.824	5	0.08	0.025
s13Bq4 vs. s13Aq12	0.392 (PC)	23.71	5	0	0.048
s13Bq4 vs. s13Bq3	0.572 (PC)	15.706	3	0.001	0.051
s13Bq5 vs. s13Aq4	0.361 (PC)	15.846	5	0.007	0.037
s13Bq5 vs. s13Aq5	0.389 (PC)	8.438	5	**0.134**	0.021
s13Bq5 vs. s13Aq12	0.447 (PC)	15.187	5	0.01	0.036
s13Bq5 vs. s13Bq3	0.583 (PC)	40.2	3	0	0.088
s13Bq5 vs. s13Bq4	0.669 (PC)	39.482	3	0	0.087
s13Bq6 vs. s13Aq4	0.357 (PC)	3.944	5	**0.557**	0
s13Bq6 vs. s13Aq5	0.333 (PC)	9.647	5	**0.086**	0.024
s13Bq6 vs. s13Aq12	0.397 (PC)	10.326	5	**0.067**	0.026
s13Bq6 vs. s13Bq3	0.474 (PC)	18.93	3	0	0.058
s13Bq6 vs. s13Bq4	0.558 (PC)	17.171	3	0.001	0.054
s13Bq6 vs. s13Bq5	0.652 (PC)	4.851	3	**0.183**	0.02
s1q2 vs. s13Aq4	-0.389 (PC)	0.271	2	**0.873**	0
s1q2 vs. s13Aq5	-0.261 (PC)	1.016	2	**0.602**	0
s1q2 vs. s13Aq12	-0.190 (PC)	1.62	2	**0.445**	0
s1q2 vs. s13Bq3	-0.094 (PC)	0.613	1	**0.434**	0
s1q2 vs. s13Bq4	-0.213 (PC)	2.169	1	**0.141**	0.027
s1q2 vs. s13Bq5	-0.151 (PC)	5.753	1	0.016	0.054
s1q2 vs. s13Bq6	-0.185 (PC)	0.001	1	**0.979**	0
s13Aq4 vs. s1q3a	0.029 (PS)	9.279	5	**0.098**	0.023
s13Aq5 vs. s1q3a	-0.008 (PS)	5.998	5	**0.306**	0.011
s13Aq12 vs. s1q3a	-0.010 (PS)	6.138	5	**0.293**	0.012
s13Bq3 vs. s1q3a	0.006 (PS)	1.623	3	**0.654**	0
s13Bq4 vs. s1q3a	-0.134 (PS)	9.255	3	0.026	0.036
s13Bq5 vs. s1q3a	-0.127 (PS)	8.649	3	0.034	0.034
s13Bq6 vs. s1q3a	-0.093 (PS)	11.742	3	0.008	0.043
s1q2 vs. s1q3a	-0.259 (PS)	1.198	1	**0.274**	0.011

s1q6 vs. s13Aq4	0.015 (PC)	13.96	11	**0.235**	0.013
s1q6 vs. s13Aq5	0.000 (PC)	28.423	11	0.003	0.031
s1q6 vs. s13Aq12	-0.004 (PC)	12.836	11	**0.304**	0.01
s1q6 vs. s13Bq3	0.017 (PC)	1.775	7	**0.971**	0
s1q6 vs. s13Bq4	-0.092 (PC)	5.845	7	**0.558**	0
s1q6 vs. s13Bq5	-0.082 (PC)	10.501	7	**0.162**	0.018
s1q6 vs. s13Bq6	-0.053 (PC)	11.742	7	**0.109**	0.021
s1q6 vs. s1q2	-0.176 (PC)	4.637	3	**0.2**	0.018
s1q6 vs. s1q3a	0.663 (PS)	187.616	7	0	0.127
prov vs. s13Aq4	-0.124 (PC)	26.891	8	0.001	0.038
prov vs. s13Aq5	-0.080 (PC)	49.708	8	0	0.057
prov vs. s13Aq12	-0.089 (PC)	34.532	8	0	0.046
prov vs. s13Bq3	-0.121 (PC)	10.318	5	**0.067**	0.026
prov vs. s13Bq4	0.025 (PC)	5.846	5	**0.322**	0.01
prov vs. s13Bq5	-0.017 (PC)	18.068	5	0.003	0.04
prov vs. s13Bq6	0.046 (PC)	32.946	5	0	0.059
prov vs. s1q2	-0.013 (PC)	2.339	2	**0.311**	0.01
prov vs. s1q3a	-0.052 (PS)	10.457	5	**0.063**	0.026
prov vs. s1q6	-0.093 (PC)	13.312	11	**0.273**	0.011
ur vs. s13Aq4	0.006 (PC)	0.334	2	**0.846**	0
ur vs. s13Aq5	0.045 (PC)	1.117	2	**0.572**	0
ur vs. s13Aq12	0.108 (PC)	1.206	2	**0.547**	0
ur vs. s13Bq3	0.027 (PC)	8.576	1	0.003	0.069
ur vs. s13Bq4	0.016 (PC)	15.341	1	0	0.095
ur vs. s13Bq5	0.080 (PC)	5.84	1	0.016	0.055
ur vs. s13Bq6	0.076 (PC)	1.05	1	**0.305**	0.006
ur vs. s1q2	-0.169 (PC)	0	0	**1**	0.006
ur vs. s1q3a	-0.090 (PS)	0.034	1	**0.854**	0
ur vs. s1q6	0.002 (PC)	2.39	3	**0.496**	0
ur vs. prov	-0.229 (PC)	4.197	2	**0.123**	0.026
s13Aq4 vs. news2q3	-0.155 (PS)	4.36	5	**0.499**	0
s13Aq5 vs. news2q3	-0.129 (PS)	2.869	5	**0.72**	0
s13Aq12 vs. news2q3	-0.149 (PS)	11.675	5	0.04	0.029
s13Bq3 vs. news2q3	-0.252 (PS)	13.438	3	0.004	0.047
s13Bq4 vs. news2q3	-0.203 (PS)	3.881	3	**0.275**	0.014
s13Bq5 vs. news2q3	-0.259 (PS)	13.303	3	0.004	0.046
s13Bq6 vs. news2q3	-0.202 (PS)	6.126	3	**0.106**	0.026
s1q2 vs. news2q3	0.059 (PS)	0.046	1	**0.831**	0
news2q3 vs. s1q3a	-0.025 (PE)				
s1q6 vs. news2q3	-0.067 (PS)	8.378	7	0.3	0.011
prov vs. news2q3	0.088 (PS)	28.342	5	0	0.054

ur vs. news2q3	-0.279 (PS)	24.327	1	0	0.121
s13Aq4 vs. lnincome	-0.230 (PS)	6.943	5	**0.225**	0.016
s13Aq5 vs. lnincome	-0.194 (PS)	19.02	5	0.002	0.042
s13Aq12 vs. lnincome	-0.196 (PS)	33.063	5	0	0.059
s13Bq3 vs. lnincome	-0.245 (PS)	14.509	3	0.002	0.049
s13Bq4 vs. lnincome	-0.233 (PS)	4.896	3	**0.18**	0.02
s13Bq5 vs. lnincome	-0.291 (PS)	1.188	3	**0.756**	0
s13Bq6 vs. lnincome	-0.255 (PS)	17.326	3	0.001	0.055
s1q2 vs. lnincome	-0.291 (PS)	5.158	1	0.023	0.051
lnincome vs. s1q3a	0.096 (PE)				
s1q6 vs. lnincome	0.139 (PS)	39.428	7	0	0.054
prov vs. lnincome	0.137 (PS)	55.861	5	0	0.08
ur vs. lnincome	-0.298 (PS)	2.946	1	**0.086**	0.035
lnincome vs. news2q3	0.316 (PE)				

Table 10: Correlation Matrix

	s13Aq4	**s13Aq5**	**s13Aq12**	**s13Bq3**	**s13Bq4**	**s13Bq5**
s13Aq4	1					
s13Aq5	0.631	1				
s13Aq12	0.464	0.471	1			
s13Bq3	0.492	0.409	0.523	1		
s13Bq4	0.323	0.277	0.392	0.572	1	
s13Bq5	0.361	0.389	0.447	0.583	0.669	1
s13Bq6	0.357	0.333	0.397	0.474	0.558	0.652
s1q2	-0.389	-0.261	-0.19	-0.094	-0.213	-0.151
s1q3a	0.029	-0.008	-0.01	0.006	-0.134	-0.127
s1q6	0.015	0	-0.004	0.017	-0.092	-0.082
prov	-0.124	-0.08	-0.089	-0.121	0.025	-0.017
ur	0.006	0.045	0.108	0.027	0.016	0.08
news2q3	-0.155	-0.129	-0.149	-0.252	-0.203	-0.259
lnincome	-0.23	-0.194	-0.196	-0.245	-0.233	-0.291
	s13Bq6	**s1q2**	**s1q3a**	**s1q6**	**prov**	**ur**
s13Bq6	1					
s1q2	-0.185	1				
s1q3a	-0.093	-0.259	1			
s1q6	-0.053	-0.176	0.663	1		
prov	0.046	-0.013	-0.052	-0.093	1	
ur	0.076	-0.169	-0.09	0.002	-0.229	1
news2q3	-0.202	0.059	-0.025	-0.067	0.088	-0.279
lnincome	-0.255	-0.291	0.096	0.139	0.137	-0.298

	news2q3	lnincome				
news2q3	1					
lnincome	0.316	1				

Appendix 2

PLS Algorithm (Bro and Elden, 2009)

1. $X_0 = X$
2. For $i = 1,2,...,k.$

(a) $w_i = \frac{x_{i-1}^T y}{\| x_{i-1}^T y \|}$

(b) $t_i = \frac{x_{i-1}^T w_i}{\| x_{i-1}^T w_i \|}$

(c) $p_i = X_{i-1}^T t_i$

(d) $X_i = X_{i-1} - t_i p_j^T$