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Asset indexes and the measurement of poverty, inequality and welfare in Southeast Asia

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ABSTRACT

Using data on household consumer durables from the Asian Barometer Survey, this paper examines the evolution of inequality, poverty and welfare in six countries of South East Asia: Cambodia, Indonesia, Malaysia, the Philippines, Thailand and Vietnam. We start by deriving the most common order of acquisition of these durables, using first an algorithm proposed by Paroush (1965), and then Item Response Theory. We also compute the frequency distribution of the number of durables owned by households. We then use these results to compute inequality, poverty and achievement or welfare indices adapted to the case of ordinal variables.

Our empirical results confirm the existence of an order of acquisition. The results show that inequality was higher in Cambodia, Indonesia and the Philippines and lower in Vietnam, Thailand and Malaysia. A similar classification of countries was obtained when computing multidimensional poverty indices.

Finally, using the welfare or achievement index recently introduced by Apouey et al. (2019), we found that welfare was generally higher in Vietnam, Thailand and Malaysia and lower in Cambodia, Indonesia and the Philippines.

1. Introduction

Despite fast economic growth, income poverty remains a major challenge for Asia (ADB, 2014). Within Asia, China has made the most significant progress in eliminating abject poverty while South and South East Asia have lagged behind (Silber & Wan, 2016; Wan & Wang, 2020). On the other hand and closely related to income poverty, most citizens in Asia have suffered from rising income inequalities (ADB, 2012), which not only directly retard growth but also offset the benign effect of growth on poverty (Wan & Wang, 2020). Since the societal welfare of a country depends on the average living standard and its distribution or inequality, worsening income distribution is detrimental to the well-being of the majority of Asians.

However, most existing studies on poverty, inequality and welfare rely on household survey data collected by national statistical agencies and the resultant estimates are often flawed as they depend on whether income or expenditures data are used and on whether and how adjustments are made for household size. The problem become even more acute when it

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comes to cross-country comparisons, as the use of purchasing power parity data to estimate, for example, poverty, raises additional difficulties (Booth, 2019). Booth (2019) thus gives the following citation of a World Bank report: " . . . Five unique data sources are required for the World Bank's calculation of global poverty numbers and global poverty lines: household surveys, population censuses, national accounts, consumer price indexes, and purchasing power parities (PPPs) from the ICP. Each new round of the ICPs brings revisions of the PPPs, and these revisions, like revisions of the other data sources, can have large effects on global, regional and national poverty counts. The global poverty line itself is calculated as an average of the PPP equivalents of the poverty lines of the world's poorest economies. In general, therefore, the global line will also change with the new PPPs, even if the underlying national poverty lines remain unchanged (World Bank, 2014a:24)".

Whereas Booth (2019) considers that the ranking of countries in Southeast Asia according to per capita consumption expenditures in PPP dollars is plausible, she is much more critical as far as poverty estimates in this area are concerned. Regarding growth and inequality, Booth (2019) stresses the fact that between 2005 and 2015 most countries in Southeast Asia had a GDP growth rate between 5% and 7% per year and generally inequality in income or expenditure fell or only slightly increased, except in Indonesia where inequality increased considerably after 2004. Also, Booth notices that although in most countries, inequality measures were derived from household per capita expenditures, in Singapore inequality was derived from household income from work and in Malaysia from household income. Even for those countries where data on household expenditures were used, there were differences in the way these expenditures were computed. Additional discussions of international poverty comparisons may be found in Deaton (2010) and Lustig and Silber (2016) and in the articles of the special issue of the Journal of Economic Inequality which Lustig and Silber (2016) edited on Global Poverty Lines.

To supplement the income or expenditure-based estimates and more importantly to overcome the difficulties previously mentioned, the present paper attempts to measure inequality, poverty and welfare in South East Asia using data on household consumer durables from the Asian Barometer Survey. More precisely, we propose to use an asset approach to the measurement of standard of living, as originally suggested by Filmer and Pritchett (1999), Filmer & Pritchett (2001) and evaluated by Filmer and Scott (2012). However, rather than using principal components analysis to evaluate the standard of living of a household, we use Item Response Theory as well as an approach originally introduced by Paroush (1963, 1965, 1973), whose focus is on the order of acquisition of durable goods. Since count data are to be used, recently developed tools will be introduced to measure inequality, poverty and welfare when only ordinal variables are available.

The paper is organized as follows. Section 2 describes several techniques for detecting the order of importance of the various assets households may have and, as a consequence, deriving some measure of their standard of living. Given that the information on the assets that are available to households consists of dichotomous variables, Section 3 summarizes the counting approach to multidimensional poverty measurement. Section 4 presents various indices measuring inequality with ordinal variables. Section 5 then introduces the achievement or welfare measures recently proposed when only ordinal information is available. Section 6 briefly describes the dataset and presents the empirical results of our investigation. Concluding comments are given in Section 7.

2. The asset approaches to measuring standards of living

2.1. Traditional asset approaches

Consumption is generally considered as a better indicator of standard of living than income, supposedly because there are less missing values and less under- or over-reporting when working with consumption data. This is however a controversial issue. In fact in recent years there has been a tendency to use data on assets to measure standards of living, especially in developing countries. One approach uses a simple count variable, the unweighted sum of asset ownership (Case, Paxson, & Ableidinger, 2004; Montgomery, Gragnolati, Burke, & Paredes, 2000). It is however clear that this way of counting has drawbacks since having only a car and a refrigerator would be equivalent to having only a bicycle and a fan. Other studies regressed per-capita expenditures on asset indicators when the available datasets included both sets of variables (Stifel & Christiaensen, 2007). More sophisticated approaches have also been implemented such as item response theory (Das, Dercon, Habyarimana, & Krishnan, 2004), multiple-indicator multiple-cause (MIMIC) (Montgomery & Hewett, 2005) or correspondence analysis (Booysen, 2008; Bérenger, Deutsch, & Silber, 2013). Principal components analysis (PCA) is however the most common approach adopted to derive an asset index. And wealth is generally assumed to be represented by the first component.

2.2. The order of acquisition of durable goods approach

Suppose that consumers can buy three durables X, Y and Z. Table 1 gives all the possible ownership combinations of X, Y and Z. In Table 1, a number 1 indicates that the household has the corresponding good, a 0 that it does not have it. The various possible combinations of ownership will be labeled consumer profiles.

If the order of acquisition is X (most important), then Y (less important) and finally Z (least important), then the only possible combinations of ownership are the profiles 1–4. There will be no household with profiles 5, 6, 7 or 8. If this is really the case, there will be a "perfect scale" (see below the discussion related to Eq. (1)), because, if we rank the households

Table 1
Possible ownership profiles in the case of three goods.

Ownership Profile	The household has good		
	X	Y	Z
1	0	0	0
2	1	0	0
3	1	1	0
4	1	1	1
5	0	1	1
6	0	1	0
7	0	0	1
8	1	0	1

Source: Authors construction.

according to the goods they have, there will be a one-to-one correspondence between the profile and the rank of the households. In other words, it is possible to perfectly "reproduce" the profile of the households, given their rank.

But in the real world, there clearly will be some households that may deviate from the path of acquisition. We can nevertheless conclude that there is a path characterizing a dominant order of acquisition. Suppose a household *i* with profile 6 in Table 1. If the order of acquisition is X, Y, Z, then the closest profiles in the path of acquisition to the household's profile will be profiles 1 or 3, as will now be shown.

The four allowed profiles, if the order of acquisition is X, Y, Z, are profiles 1–4. Using the sum of the absolute values of the differences between the number appearing in the profile of individual *i* and those that correspond to profiles 1–4, we easily conclude that the deviations between the profile of individual *i* and profiles 1, 2, 3 and 4, are 1,2,1 and 2 respectively, and so the smallest deviation is 1, i.e., profiles 1 or 3

Call now S_j the smallest deviation for a household with profile *j* and N_j is the number of such households. Guttman et al. (1950) defined the reproducibility index *R* as

$$R = 1 - \frac{\sum_j N_j S_j}{K \sum_j N_j} \tag{1}$$

where *K* is the number of goods; S_j is the deviation value; and N_j is the number of individuals with deviation S_j. He proved that this index varies between 0.5 and 1. When there is a perfect scale $S_i = 0$ for all consumers and then $R = 1$.

The calculation of the index of reproducibility was based on a given order of acquisition. Paroush (1963, 1965, Paroush, 1973) suggested to compute the coefficient of reproducibility for all the possible orders of acquisition, concluding that the order of acquisition of the whole population would be the order of acquisition with the highest coefficient of reproducibility, provided that the latter is greater than 0.9.

The estimation of the order of acquisition of the population implies evidently a very high number of computations. Assume there are eight goods, as is the case in the empirical illustration of this paper. Then, for each household *j* in the sample, the determination of the minimum distance S_j from its profile to one of the possible profiles in the path of acquisition is based on nine comparisons.

In the case of the Philippines, for example, the number of observations was 1200. As was just mentioned, for each observation, there are 9 possible profiles. As a consequence, 10,800 (= 1200 times 9) comparisons are needed in order to determine the reproducibility index *R* for a given order of acquisition. But this procedure has to be repeated 40320 (= 8!) times. This is the total number of possible orders of acquisition, resulting from nine durable goods. Therefore the total number of iterations needed to find the order of acquisition with the highest index of reproducibility *R* is $10{,}800 \times 40320 = 435456000$ times.

The order of acquisition with the highest *R* is identified as the acquisition path. Household deprivation can then be estimated by examining if it owns the first durable, the first two durables, the first three durables, and so on. (Paroush, 1963, 1965 and 1973). The number of durables not owned by the household reflects the household level of deprivation. Hence for a given household, the larger is the number of (ordered) durables not owned, the higher is its deprivation level.

The idea of an order of acquisition of durable goods is evidently related to quite a longstanding hypothesis according to which there is a hierarchy in demand. In other words some types of expenditure are of a higher priority than others (Lancaster, 1971; Ironmonger, 1972; Jackson, 1984; Bertola, Foellmi, & Zweimmuller, 2006). Low-income households will concentrate on high-priority goods, such as food and clothing. As income grows the households will begin to diversify their consumption and include goods of a lower priority.

2.3. Item response theory (IRT)

Item Response Theory (IRT) refers to mathematical models that try to explain the link between unobservable characteristics and observed outcomes. In psychometrics, for example, IRT models the answer given by an examinee of a given ability to each item in the test. In other words IRT assumes that the probability of a correct answer to a question is a

function of both the individual's as well as the item's (question) parameters. The individual's parameter is generally interpreted as his intelligence or ability. The parameters which characterize an item are as follows:

- the first parameter refers to the difficulty of the item, in which case the term "location" is used. This difficulty is usually determined at the point of median probability, that is, at the ability at which 50 % of the respondents gave a correct answer. Clearly the more difficult an item (question) is, the further to the right the curve will be.
- A second parameter indicates how quickly the probability of answering correctly increases with the individual's ability, hence the use of the term "discrimination", because the steeper the slope of the curve (or item response function), the better the question discriminates those who answer correctly and those who do not. There is sometimes a third parameter which we will ignore here.

IRT is based on the following main assumptions:

- monotonicity: the probability of giving a correct answer increases with the ability of the individual.
- uni-dimensionality: one dominant trait only (e.g. ability) is supposed to be main determinant of the answers given by the respondent.
- independence: the answers given to the different questions (items) are mutually independent, given the ability of the individual

Various functions may be used to obtain the curve linking the ability of an individual to the probability of giving a correct answer to a given item. One can, for example, use a two-parameters logistic model and write that

$$Pr(Y_{ij} = 1/\theta_i) = \frac{e^{\alpha_j(\theta_i - \beta_j)}}{1 + e^{\alpha_j(\theta_i - \beta_j)}}$$

where $Pr(Y_{ij} = 1/\theta_i)$ is the probability that individual i gives a correct answer to question j, given his/her ability θ_i, α_j is the discrimination coefficient for question (item) j and β_j is the location (difficulty) parameter.

During the past thirty years Item Response Theory has also been used to measure deprivation (see, Dickes, 1983, 1989; Gailly & Hausman, 1984; Pérez-Mayo, 2004, 2005; Cappellari & Jenkins, 2007; Ayala & Navarro, 2007, 2008; Fusco & Dickes, 2008; Guio, Gordon, & Marlier, 2012; Szeles & Fusco, 2013), the idea being that poverty, like intelligence, is really a latent variable that is difficult to measure.

To measure poverty, we view the lack of an asset as a disadvantage. Assets are ranked according to the prevalence of ownership of the durables. If a household is deprived of an asset which is owned by most households, such a deprivation is considered to be more severe than otherwise. In the hypothetical case that only one household owns a particular durable but no one else has the ownership, this deprivation is much less important. In this way, a path of acquisition can be obtained.

A nice presentation of the application of IRT to the study of poverty is given in Fusco and Dickes (2008). It starts by stating the basic assumption of Dickes (1989) according to which poverty is a continuum. In fact this idea of a continuum of poverty appears in works taking a direct approach to poverty, such as those of Townsend (1979) and Mack and Lansley (1985). The main contribution of Dickes (1989) is his interesting discussion of the notion of a continuum of poverty where he argues that the same set of deprivation items belonging to different domains may measure a single or several latent characteristics. For Dickes (1989) poverty is to be viewed as unidimensional if only one continuum of poverty is measured and as multidimensional when more than one continuum is to be taken into account to reflect this phenomenon. We adopt what Dickes (1989) called the unidimensional and homogenous approach in which poverty is considered as a single phenomenon that manifests itself homogeneously in different domains of life. In other words deprivation may occur in different domains, but its manifestations are assumed to refer to the same latent trait.

There is in fact a clear parallelism between the approach to multidimensional poverty relying on Item Response Theory and that using the notion of order of acquisition of durable goods. This point has been stressed by Deutsch, Guio, Pomati, and Silber (2015) in their work on the order of curtailment of expenditures. The present paper emphasizes the standard of living rather than deprivation but the point made by Deutsch et al. (2015) amounts to saying that the link between the standard of living and a given item is a logistic function when using Item Response Theory while the order of acquisition approach assumes a step function.

2.4. The count approach

The idea here is simply to compute the percentage of households that have no asset, one asset, two assets, . . . , nine assets.

The three approaches that have been mentioned in this Section allow us to obtain the level of household or individual standard of living (or alternatively, deprivation) and the frequency distribution of households having (or lacking) a certain numbers of assets. These provide ingredients for estimating poverty, inequality and welfare in the following sections.

3. The counting approach to measuring poverty

Following Sen (1976) the traditional approach to unidimensional poverty measurement makes a distinction between an identification and aggregation stage. First one has to decide who is poor, then this information is aggregated to derive an overall measure of poverty.

A multidimensional approach to poverty measurement needs, however, to include three stages. First, for each variable, it is necessary to decide whether the individual or household is deprived with respect to this variable. Then, one has to determine the number of variables for which an individual or household has to be deprived, to be considered as "poor". Finally, in a third stage, we have to aggregate this latter information to derive an overall measure of the extent of multidimensional poverty.

3.1. The Alkire and Foster (2011) approach with dichotomous variables

Given the available data on the ownership of various assets, one may wonder how to aggregate such an information (individuals either own or do not own a given asset) to obtain an overall measure of poverty. There are in fact several ways of looking at this issue. First there is the so-called "union" approach. It assumes that the various assets are perfect complements, so that, as soon as one asset is missing, the individual or household will be considered as poor. The intersection approach, on the contrary, assumes that the assets are perfect substitutes, so that an individual or household will be considered as poor only if he does not own any asset. Alkire and Foster (2011) proposed an intermediate approach, where, given that N refers to the total number of assets, an individual (or household) will be considered as poor only if the number of assets he/she owns is smaller than or equal to l, with $1 \leq l \leq N$.

Let H refer to the proportion of individuals or households defined as "poor". Let T refer to the total number of individuals (households) and T_P to the number of poor. H is then computed as

$$H = \left(\frac{T_P}{T}\right) \tag{2}$$

Among those T_P individuals (households) considered as poor, let A refer to the proportion of assets that these poor individuals (households) do not have. Let $I(x_{ij})$ be equal to 1 if individual (household) i does not have asset j, to 0 otherwise. We may then write that

$$A = \frac{\left\{\sum_{i=1}^{T_P}\left[\sum_{j=1}^{N}\frac{I(x_{ij})}{N}\right]\right\}}{T_P} \tag{3}$$

Alkire and Foster (2011) combined these two indicators H and A to define a "dimension adjusted headcount ratio" M_0 where

$$M_0 = H \times A = \left(\frac{T_P}{T}\right)\left\{\left[\sum_{i=1}^{T_P}\left[\sum_{j=1}^{N}\frac{I(x_{ij})}{N}\right]\right]/T_P\right\} = \frac{\sum_{i=1}^{T_P}\left[\sum_{j=1}^{N} I(x_{ij})\right]}{T.N} \tag{4}$$

In other words, M_0 is equal to the ratio of the total number of assets that the individuals (households) classified as poor do not have, over the maximal number $(T.N)$ of assets that the total population may not have.

3.2. Alternative counting approaches

The Alkire and Foster (2011) approach is not the only one allowing to derive a measure of poverty when only binary or ordinal variables are available. Atkinson (2003) gave a nice introduction to the counting approach and stressed that it is an important topic because in many cases the data available on the various dimensions of poverty are binary variables.

Let $c_i$refer to the poverty counting function of individual (household) i where

$$c_i = \sum_{j=1}^{N} I(x_{ij})w_j \tag{5}$$

where w_j is the weight of asset j.

When analyzing multidimensional poverty, Dhongde et al. (2016) called c_i the "nominal deprivation" of individual i while they defined the "real deprivation" of individual i as

$$r_i = g(c_i) = g\left(\sum_{j=1}^{N} I(x_{ij})w_j\right) \tag{6}$$

The extent r of "real deprivation" in the population is then written as

$$r = \left(\frac{1}{T}\right)\sum_{i=1}^{T} g(c_i) = \left(\frac{1}{T}\right)\sum_{i=1}^{T} g\left(\sum_{j=1}^{N} I(x_{ij})w_j\right) \tag{7}$$

Table 2
On various counting measures of poverty.

Source	ψ_i	$r_i = g(c_i)$	$RD \equiv$
Alkire and Foster (2011)	= 1 if $c_i \geq l$ = 0 otherwise	c_i	$\frac{1}{T}\sum_{i=1}^{T}\psi_i c_i$
Bossert et al. (2013)	1	$[c_i]^r$	$\left[\frac{1}{T}\sum_{i=1}^{T}[c_i]^r\right]^{\frac{1}{r}}$
Chakravarty and D'Ambrosio (2006)	1	$g(c_i) = h(c_i)$ with $h(0) = 0;\ h' > 0;\ h'' \geq 0.$	$\frac{1}{T}\sum_{i=1}^{T}h(c_i)$
Rippin (2012)	1	$[c_i]^\gamma c_i$	$\frac{1}{T}\sum_{i=1}^{T}c_i^{\gamma+1}$

Source: Adapted from Yalonetzky (2012).

Yalonetzky (2012), and Silber and Yalonetzky (2013) extended expressions (6) and (7) to obtain, as special case, the approach of Alkire and Foster (2011). Let RD_i refer to the "real deprivation" of individual (household) i with

$$RD_i = \psi_i r_i = \psi_i g(c_i) = \psi_i g\left(\sum_{j=1}^{N} I(x_{ij})w_j\right) \tag{8}$$

In (8) ψ_i refers to some poverty identification function for individual i. One possibility, as implicitly suggested by Alkire and Foster (2011), is to assume that $\psi_i = 1$ if c_i, the extent of "nominal deprivation" (that is, the weighted number of assets that individual or household i does not have), is higher than or equal to l, the threshold defined previously, and that $\psi_i$will be equal to 0 otherwise.

In Table 2 (columns 2 and 3) we indicate different possible functions ψ_i and r_i that have been suggested in various studies. Real deprivation RD in the whole population is then given in column 4 of Table 2, which we borrowed from Silber and Yalonetzky (2013).

Note that the measures proposed by Bossert, Chakravarty, and D'Ambrosio (2013), Chakravarty and D'Ambrosio (2006) and Rippin (2012), take into account the degree of inequality, between the individuals (households) classified as poor, in the number of assets they do not have, while the measure introduced by Alkire and Foster (2011) ignores such an inequality.

4. Ordinal variables and the measurement of inequality

Several studies (Allison & Foster, 2004; Lazar & Silber, 2013; Zheng, 2011) recently stressed that popular income inequality indices such as the Gini, the Theil or the Atkinson index cannot be used to analyze the degree of dispersion of ordinal variables, the reason being that small variations in the scale used often leads to a reversal of the ordering of the frequency distributions compared.

4.1. Measuring inequality with ordinal variables

Following the work of Allison and Foster (2004) several inequality indices were introduced by Abul Naga and Yalcin (2008), that can be used with ordinal variables. Let us take as illustration the case of self-assessed health and let f_k be the proportion of individuals having health status k. Assume that the K health status categories are ordered by increasing health status and define as $F_k = (f_1 + \ldots + f_k)$, the sum of the proportions f_k. Abul Naga and Yalcin (2008) proposed several ordinal inequality indices among which an index I_{AY} is defined as:

$$I_{AY} = 1 - \left[\frac{2\sum_{k=1}^{K-1}|F_k - 1| - 1}{(K-1)}\right] \tag{9}$$

It is easy to check that the value of this index will not change if we vary the numerical scale. Note also that inequality will be at a minimum and equal to 0, when every individual has the same health status. And inequality will be at a maximum and equal to 1, when half the population has the lowest and the other half the highest health status. Lazar and Silber (2013) proposed an extension of the family of ordinal inequality indices introduced by Abul Naga and Yalcin (2008).

Other ordinal inequality indices have been suggested. Reardon (2009), for example, proposed, in the context of ordinal segregation measurement, several indices, among which the index $I_{REARDON}$ defined as

$$I_{REARDON} = \frac{1}{(K-1)}\sum_{k=1}^{K-1} 4F_k(1 - F_k) \tag{10}$$

Lv, Wang and Xu (2015) took a different approach to the measurement of ordinal inequality. Taking again the case of self-assessed health, they proceeded in two steps. First, they measured the inequality between any two different health outcomes. Then they aggregated these inequalities, using a weighted sum, the idea being that the further apart two health outcomes, the greater the weight that should be given to the inequality between these two health outcomes. Lv, Wang, and

Xu (2015) derived then axiomatically the two following indices:

$$I_{LWX1} = \sum_{k=1}^{K} \sum_{h \neq k} \left(\frac{2}{(K-1)} \right) |h-k| f_h f_k \tag{11}$$

where K, f_h and f_k were defined previously, and

$$I_{LWX2} = \sum_{k=1}^{K} \sum_{h \neq k} \alpha^{K-1-|h-k|} f_h f_k \tag{12}$$

with $\alpha = 0.9$, 0.6, 0.3 or 0.1.

When applying these indices to the inequality of asset ownership, K indicates the total number of assets under consideration, and f_k denotes the proportion of individuals or households owning k out of K assets.

5. Inequality-sensitive and additive achievement measures based on ordinal data

In an important paper Atkinson (1970) defined the concept of "equally distributed equivalent income"[1], which is the level of income that, if received by every individual, would put society at a level of welfare identical to the actual level of welfare. In a recent paper Silber and Xu (2018) attempted to obtain a somewhat similar result for the case where only ordinal variables are available. They derived axiomatically new classes of measures of the level of achievement in a population when the achievement variable is ordinal. The welfare index they proposed is written as

$$h(s) = \frac{1}{T} \sum_{k=1}^{K} p_k(s) \frac{1-\alpha^{K-k}}{1-\alpha^{K-1}} \tag{13}$$

with $0 < \alpha < 1$ and where s refers to the achievements, ranked by decreasing levels, K to the number of achievement categories, $p_k(s)$ to the number of individuals with achievement level k and T to the total number of individuals[2] .

When the parameter α tends towards 1, the social achievement index will be expressed as

$$h(s) = \frac{1}{T} \sum_{k=1}^{K} p_k(s) \frac{K-k}{K-1} \tag{14}$$

In such a case it can be shown that

$$h(s) = \frac{1}{(K-1)} \sum_{k=1}^{K-1} F_k(s) \tag{15}$$

where $F_k(s) = \sum_{j=1}^{k} p_j(s)$, that is, $F_{\ k}(s)$ is the cumulative relative frequency of the various achievement categories.

6. The database and the empirical results

Observations on asset ownership are obtained from the database of the Asian Barometer Survey (ABS) for the years 2014 and 2016 and for six countries in Southeast Asia: Cambodia, Indonesia, Malaysia, the Philippines, Thailand and Vietnam.

The ABS gathers public opinion data on issues such as political values, democracy, governance, human security, and economic conditions through face-to-face interviews across Asia. The interviews are based on stratified random sampling of eligible voters and are conducted by standardized research protocols and survey instruments, which generates a region-wide base of scientifically reliable and comparable data.

A standard questionnaire includes a core questionnaire while additional questions are more specific to the country under study. Field teams receive an intensive training program and face-to-face interviews are conducted in the language of the respondents. Supervisors make then random back-checks to make sure the sampling and interviews were conducted correctly. A typical Asian Barometer survey has about 1200 respondents.

We focus our attention on the economic conditions of families, namely household ownership of durables.

6.1. Computing the order of acquisition of assets in South East Asia

We limit our discussion to the durable goods on which we have data for both years. We use data on eight assets: (1) Car, jeep or van; (2) Color or black and white television; (3) mobile phone; (4) Electric fan or cooler; (5) Scooter, motorcycle or bicycle; (6) Radio transistor; (7) Pumping Set; and (8) Refrigerator.

Table 3 presents the results obtained on the basis of the two approaches previously mentioned: the order of acquisition algorithm of Paroush (1963), 1965, 1973) and Item Response Theory. Several studies have used previously the algorithm

[1] Most of the results presented in Atkinson (1970) appear in fact in Kolm (1969), but Atkinson was not aware of this. Kolm did not use the expression "equally distributed equivalent income". He labeled this concept the "equal equivalent income".

[2] See Silber and Xu (2018) for the list of desirable properties of such an index and for its axiomatic derivation.

Table 3
Order of Acquisition and Reproducibility Index.

Approach	Country	1	2	3	4	5	6	7	8	Reproducibility Index	Number of observations
Paroush	Philippines	TV	Fan/cooler	Transistor	Mobile phone	Refrigerator	Motorcycle	Pumping	Car	0.9068	1200
	Thailand	Fan/cooler	TV	Mobile phone	Motorcycle	Refrigerator	Transistor	Car	Pumping	0.9594	1435
	Indonesia	TV	Motorcycle	Mobile phone	Fan/cooler	Pumping	Refrigerator	Transistor	Car	0.9094	1550
	Vietnam	Motorcycle	TV	Fan/cooler	Mobile phone	Pumping	Refrigerator	Transistor	Car	0.9415	793
	Cambodia	Motorcycle	TV	Mobile phone	Transistor	Fan/cooler	Pumping	Car	Refrigerator	0.9001	1200
	Malaysia	Mobile phone	TV	Fan/cooler	Refrigerator	Motorcycle	Car	Transistor	Pumping	0.944	1210
IRT	Philippines	TV	Fan/cooler	Transistor	Mobile phone	Refrigerator	Motorcycle	Car	Pumping		1200
	Thailand	TV	Fan/cooler	Motorcycle	Mobile phone	Refrigerator	Transistor	Car	Pumping		1435
	Indonesia	TV	Motorcycle	Mobile phone	Fan/cooler	Pumping	Transistor	Refrigerator	Car		1550
	Vietnam	Motorcycle	Fan/cooler	TV	Mobile phone	Pumping	Refrigerator	Transistor	Car		793
	Cambodia	Motorcycle	TV	Transistor	Mobile phone	Fan/cooler	Pumping	Car	Refrigerator		1200
	Malaysia	Fan/cooler	Mobile phone	TV	Refrigerator	Motorcycle	Car	Transistor	Pumping		1210

Note: For the Philippines, for example, based on the Paroush approach and Item Response Theory, color TV was the first in the path of acquisition, fan or cooler the second, and so on.Source: authors computation based on data from Asian Barometer Survey, wave 4, 2014–2016

Table 4
Rank correlations between countries (based on Table 3).

Approach	Country	Philippines	Thailand	Indonesia	Vietnam	Cambodia	Malaysia
Paroush	**Philippines**	1.0000	0.7857	0.5000	0.4286	0.4286	0.5952
	Thailand	0.7857	1.0000	0.6905	0.6905	0.5000	0.8571
	Indonesia	0.5000	0.6905	1.0000	0.9524	0.7857	0.6190
	Vietnam	0.4286	0.6905	0.9524	1.0000	0.7619	0.5000
	Cambodia	0.4286	0.5000	0.7857	0.7619	1.0000	0.3571
	Malaysia	0.5952	0.8571	0.6190	0.5000	0.3571	1.0000
IRT	**Philippines**	1.0000	0.7857	0.4762	0.3333	0.4286	0.6667
	Thailand	0.7857	1.0000	0.7619	0.7619	0.5714	0.8095
	Indonesia	0.4762	0.7619	1.0000	0.8571	0.8095	0.4524
	Vietnam	0.3333	0.7619	0.8571	1.0000	0.6190	0.5476
	Cambodia	0.4286	0.5714	0.8095	0.6190	1.0000	0.1190
	Malaysia	0.6667	0.8095	0.4524	0.5476	0.1190	1.0000

Source: authors computation based on data from the Asian Barometer Survey, wave 4, 2014–2016.

proposed by Paroush (Bérenger et al., 2013; Deutsch & Silber, 2008; Deutsch et al., 2015) or compared the results based on this algorithm with those derived from Item Response Theory (Deutsch et al., 2015).

The dominant order of acquisition identified by the Paroush approach is acceptable since all the reproducibility indices have a value greater than 0.9 and the orders of acquisition identified by the two methods are quite similar. Nevertheless, there are marked differences in the order of acquisition across countries, which is not surprising since these six countries have different socioeconomic systems, ethnicity composition, cultures, religions and level of economic development.

Table 3 can be interpreted as follows. For the Philippines, for example, based on the Paroush approach and Item Response Theory, color TV was the first in the dominant path of acquisition, fan or cooler the second, and so on. In fact, the orders for the first six durables are the same but the 7th and 8th durables swapped positions under the two approaches.

In Table 4, using the results of Table 3, we computed the rank correlations between the countries. When using the Paroush approach, out of 15 correlations, 12 were higher than or equal to 0.5, and 8 higher than 0.6. When using Item Response Theory, 10 out of 15 correlations were higher than 0.5 and 8 higher than 0.6. The highest correlation is between Vietnam and Indonesia. Thailand and Malaysia also have exhibit similar order of acquisition.

However, under either approach, the correlation between the rankings of Cambodia and Malaysia was low (0.36 and 0.12). The order reflects preferences for different durables and preferences depends on cultures, geographical conditions, level of development, and so on. For example, in poor countries, bicycles may rank high in the purchase list while cars would rank higher in more developed countries. As another example, air-conditioner may rank high in the acquisition path in Malaysia, but most Cambodians cannot afford it (thus rank low). In other words, the low correlation in this case is most likely to be caused by gaps in the level of economic development: the per capita GDP in Malaysia is over 7 times that in Cambodia (See Table 9). The ownership inequality can also help explain the low correlation. Very few Cambodian households own a car or a refrigerator. Those owning these durable belong to the richest wealth or income quintile. In addition, the low correlation may reflect differences in the provision of public services. For example, motorcycle is the major means of travel in Cambodia, while in Malaysia, most residents rely on public transport facilities.

Next, we present in Fig. 1, for each country, the frequency distribution of the numbers of assets in the path of acquisition, using the approach of Paroush, Item response Theory, and the number of assets owned. We first observe that, whatever the approach we use, there is almost nobody in Malaysia, Thailand and Vietnam who does not have any asset, whereas in the other three countries (Cambodia, Indonesia and the Philippines) there are between 11 % and 17 % of the households that do not have any asset. Thus Cambodia, Indonesia and the Philippines appear to be poorer than the other three, based on the proportions of asset-less households.

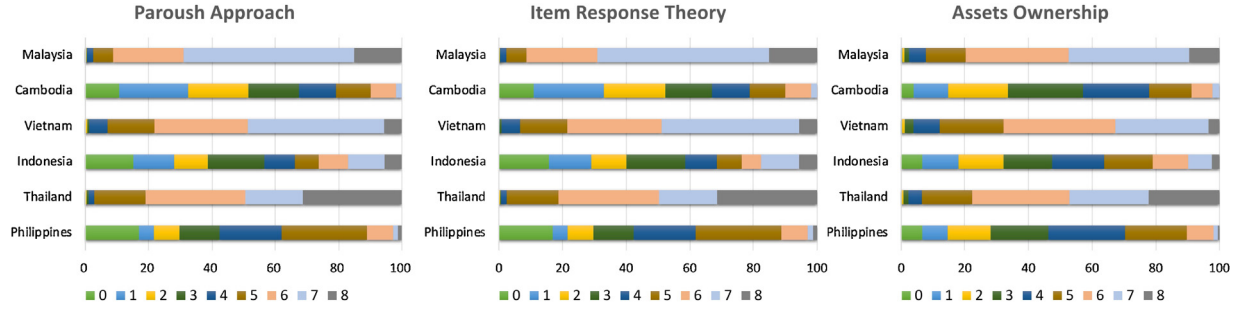

Fig. 1. Frequency distribution (in %) of the number of assets in the path of acquisition (Paroush approach, Item Response Theory and assets ownership). Source: Authors computations.

Table 5
Poverty Index of Alkire and Foster (P_{AF}), assuming equal weights, (Paroush approach, Item Response Theory and Percentage of ownership).

Country	P_{AF} with $l = 0.1$			P_{AF} with $l = 0.3$			P_{AF} with $l = 0.5$			P_{AF} with $l = 0.7$			P_{AF} with $l = 0.9$		
	Paroush	IRT	Ownership	Paroush	IRT	Ownership	Paroush	IRT	Ownership	Paroush	IRT	Ownership	Paroush	IRT	Ownership
Philippines	0.506	0.506	0.617	0.501	0.500	0.613	0.335	0.334	0.484	0.213	0.212	0.334	0.047	0.047	0.079
Thailand	0.302	0.300	0.327	0.217	0.215	0.237	0.018	0.015	0.044	0.007	0.004	0.017	0.000	0.000	0.001
Indonesia	0.524	0.529	0.594	0.488	0.492	0.572	0.416	0.430	0.454	0.356	0.368	0.352	0.129	0.133	0.114
Vietnam	0.346	0.344	0.392	0.231	0.229	0.314	0.047	0.043	0.082	0.010	0.007	0.031	0.002	0.002	0.003
Cambodia	0.666	0.665	0.676	0.662	0.660	0.671	0.577	0.574	0.580	0.504	0.500	0.450	0.217	0.221	0.108
Malaysia	0.284	0.283	0.343	0.131	0.130	0.236	0.016	0.014	0.053	0.003	0.002	0.019	0.001	0.000	0.003

Source: authors computation based on data from Asian Barometer Survey, wave 4, 2014–2016.

Table 6
Poverty Indices of Chakravarty et D'Ambrosio (P_{CD}), Rippin (P_R), Bossert et al. (P_{BCD}) (Paroush approach, Item Response Theory and Percentage of ownership).

Country	P_{CD} with $h(c_i) = c_i$			P_{CD} with $h(c_i) = c_i^2$			P_R with $\gamma = 1.5$			P_{BCD} with $r = 2$		
	Paroush	IRT	Ownership	Paroush	IRT	Ownership	Paroush	IRT	Ownership	Paroush	IRT	Ownership
Philippines	0.506	0.571	0.567	0.393	0.392	0.367	0.342	0.342	0.307	0.627	0.626	0.606
Thailand	0.300	0.177	0.204	0.056	0.054	0.067	0.033	0.032	0.041	0.235	0.233	0.258
Indonesia	0.529	0.581	0.544	0.422	0.435	0.363	0.378	0.390	0.310	0.650	0.660	0.603
Vietnam	0.344	0.219	0.267	0.067	0.065	0.093	0.040	0.038	0.059	0.259	0.255	0.305
Cambodia	0.665	0.663	0.596	0.493	0.495	0.395	0.438	0.440	0.332	0.702	0.704	0.629
Malaysia	0.283	0.160	0.219	0.040	0.039	0.069	0.022	0.021	0.043	0.199	0.197	0.263

Note: P_{CD} refers to the Chakravarty and D'Ambrosio index mentioned in Table 3. P_R refers to the Rippin index and P_{BCD} to the Bossert et al. index.Source: Authors computation based on data from the Asian Barometer Survey, wave 4, 2014–2016.

It is important to point out that the frequency distributions, as illustrated in Fig. 1, represent the basic ingredients for estimating poverty, inequality and welfare in the following sections.

6.2. Poverty in Southeast Asia

Here we present the values of the multidimensional poverty or real deprivation indices defined previously (see Table 2). According to the three approaches (Paroush approach, IRT and count approach), we obtained the number of poor households (H) and the proportion of assets that these poor households do not have (A). We can then obtain the poverty counting function of household $c_i$using Eq. (5), and further estimate poverty or RD_i using Eq. (8).

Table 5 tabulates the poverty estimates or the Alkire and Foster index, for the three approaches, assuming various values of the threshold l (0.1, 0.3, 0.5, 0.7 and 0.9). As expected, the poverty estimates become smaller as l increases. Cambodia is the poorest, followed by Indonesia and then the Philippines. The better-off countries are Malaysia, Vietnam and Thailand. The poverty ranking correlates well with the development status of these economies.

In Table 6, we present, again for the three approaches, the values of the alternative multidimensional poverty indices, those that have been proposed by Chakravarty and D'Ambrosio (2006), Rippin (2010)and Bossert et al. (2013). Although the estimates differ under different approaches, for a given approach the poverty ranking is negatively correlated with the per capita GDP presented in Table 9. This is similar to Table 5.

The results reported in Tables 5 and 6 are quite striking because, whatever approach we use and whatever the multidimensional poverty index we use, poverty is higher in Cambodia, Indonesia and the Philippines and much lower in Thailand, Malaysia and Vietnam, confirming the previous finding that was simply based on the proportion of asset-less households.

6.3. Ordinal inequality in the six Southeast Asian countries

Here we attempt to present results on wealth inequality. We need however first to issue a caveat. Until now the literature on ordinal inequality measurement focused on the case of a single variable. In our empirical illustration there are eight assets and we will therefore consider them as a single asset, assuming the following outcomes are possible. When a household does not own any of the eight assets, there will be eight zeros; when only one asset is present, there will be seven zeros; with one zero, it will means that seven of the eight assets are present, while with no zero, it will imply that the household owns all the assets. Using the three approaches (Paroush approach, IRT and count approach), we have obtained the frequency distribution of the number of assets in the path of acquisition (See Fig. 1), which provides values of f_k that are needed for estimating inequality using Eqs. (10)–(12).

In Table 7, using the data derived from the Paroush approach, we give the value of three ordinal inequality indices: the Reardon index, which was defined in Eq. (10) and turns out to be identical (see, Lv et al., 2015) to the index I_{LWX1} defined in Eq. (11) and the index I_{LWX2}. defined in Eq. (12), with two values for the parameter α, 0.9 and 0.5. The same indices are derived from the results that were obtained when applying Item Response Theory. Finally, we compute again these ordinal inequality indices, using this time the results that were obtained when computing the percentage distribution of the number of assets owned.

Several findings are discernable from Table 7. First, the estimates in the last three columns are small, because the parameter α is small. It seems thus better to use a value for α that is larger than 0.5 when studying asset inequality in Asia. Second, pair-wise comparisons of estimates under the Paroush and IRT approaches (they are presented in adjacent columns) are almost identical. Thus, future research on asset inequality in Asia may use the IRT rather than Paroush approach which is quite demanding in terms of computing cost. Finally, pair-wise comparisons of estimates under the IRT and Ownership approaches (they are also presented in adjacent columns) shows no systematic pattern. However, if we rank the countries in terms of asset inequality estimates, they give identical ranking.

Table 7
Ordinal Inequality Indices in Asset Ownership (Paroush approach, Item Response Theory, and Percentage of ownership).

Country	Reardon Index = Index I_{LWX1}			Index I_{LWX2} with $\alpha = 0.9$			Index I_{LWX2} with $\alpha = 0.5$		
	Paroush	IRT	Ownership	Paroush	IRT	Ownership	Paroush	IRT	Ownership
Philippines	0.569	0.57	0.481	0.483	0.484	0.463	0.0447	0.045	0.0277
Thailand	0.333	0.328	0.345	0.388	0.386	0.402	0.0142	0.0138	0.0151
Indonesia	0.712	0.708	0.593	0.543	0.541	0.507	0.0866	0.0877	0.0475
Vietnam	0.28	0.273	0.314	0.358	0.355	0.384	0.0108	0.0101	0.0126
Cambodia	0.528	0.532	0.452	0.48	0.481	0.453	0.0336	0.0342	0.0234
Malaysia	0.23	0.227	0.303	0.319	0.318	0.374	0.00963	0.00902	0.0131

Source: authors computation based on data from Asian Barometer Survey, wave 4, 2014–2016.

Table 8
Apouey et al. (2019) Welfare Index I_{SX} (Paroush approach, Item Response Theory and Percentage of Ownership).

Country	I_{SX} with $\alpha \to 1$			I_{SX} with $\alpha = 0.9$			I_{SX} with $\alpha = 0.5$			I_{SX} with $\alpha = 0.1$		
	Paroush	IRT	Ownership	Paroush	IRT	Ownership	Paroush	IRT	Ownership	Paroush	IRT	Ownership
Philippines	0.429	0.429	0.434	0.502	0.503	0.517	0.752	0.752	0.818	0.825	0.825	0.924
Thailand	0.822	0.824	0.797	0.870	0.871	0.850	0.987	0.987	0.984	0.998	0.998	0.998
Indonesia	0.431	0.419	0.457	0.492	0.480	0.532	0.727	0.717	0.808	0.834	0.828	0.921
Vietnam	0.780	0.782	0.734	0.839	0.841	0.802	0.985	0.986	0.977	1	1	1
Cambodia	0.338	0.338	0.405	0.41	0.409	0.489	0.707	0.704	0.815	0.869	0.867	0.948
Malaysia	0.840	0.841	0.782	0.886	0.887	0.840	0.990	0.991	0.983	0.999	0.999	0.999

Source: authors computation based on data from Asian Barometer Survey, wave 4, 2014–2016.

As a matter of fact, the results are similar to what was observed for poverty. Whatever approach we used and whatever the index selected, ordinal inequality is higher in Cambodia, Indonesia and the Philippines and much lower in Vietnam, Thailand and Malaysia. This classification of the countries is somewhat different from the ranking of the Gini index, as published by the World Bank. These data show that Malaysia has the highest Gini index (0.46 in 2009), the Philippines and Indonesia the second highest (0.40 both, in 2015 for the Philippines and 2013 for Indonesia). Lower Gini indices are observed in Thailand and Cambodia (0.38 in both countries, in 2012 for Cambodia and 2013 for Thailand) and Vietnam (0.38 in 2014).

Note that the correlation between the ranking of the countries by the value of the ordinal inequality measure (Reardon index) and that given by the Gini index (see Table 9, below) is low and equal to only 0.086. The low correlation implies that income gaps in South East Asia do not necessarily mean consumption gaps as far as durable consumption is concerned. The disconnection between income and durable ownership inequality estimates could be caused by the use of PPP or data recording or reporting errors when income or expenditure data are used for economic analysis.

6.4. Welfare levels in Southeast Asia

In Table 8, we present results based on the recent paper of Apouey, Silber, and Xu (2019). Here also we will consider the eight assets as a single good with the following possible outcomes, ranked from the lowest to the highest. When there are eight zeros, it means that none of the eight assets is available; with seven zeros: only one of the eight assets is present; . . . .; with one zero: seven of the eight assets are present; when there is no zero: all the eight assets are present. The three approaches to measure welfare (Paroush approach, IRT and account approach) provide information on the level of household or individual deprivation, or from the opposite side, the achievement level, which is denoted by k in Eq. (14). And the social welfare level is defined as the cumulative relative frequency of the various achievements. Eq. (15) can be used to compute the welfare indices corresponding to the three approaches. The empirical results are shown in Table 8.

Note that when the parameter $\alpha \to 1$, the welfare index I_{SX} introduced by Apouey et al. (2019) is a welfare index that ignores inequality between individuals. Table 8, based on the Paroush approach, shows that welfare is highest in Malaysia, Thailand and Vietnam and much lower in the Philippines, Indonesia and Cambodia. Similar results are obtained when Item Response Theory is used or when they are derived from data on the percentage of assets owned (see Table 8).

Note that the correlation between the ranking of the countries by their per capita GDP (see, Table 9 below) and that obtained when using the Apouey et al. (2019) welfare index with the parameter α equal to 0.999 (the case where this welfare measures ignores inequality) is high and equal to 0.77. As is known, per capita GDP ignores income inequality and such a high correlation is thus understandable.

Note that the Paroush and IRT approaches produce almost identical estimates when rounding to two decimal points. This again suggests that future studies on the welfare of South East Asians may choose to use IRT only which is easier to implement empirically.

Clearly, consistent classification of countries has been obtained irrespective of which index is examined: poverty, inequality or welfare. Malaysia, Thailand and Vietnam perform better than Cambodia, Indonesia and Philippines. In

Table 9
World Bank data on per capita GDP and the Gini index of income.

Country	Per capita GDP (in international $) in 2017	Gini index of income or household expenditures, adjusted for household size and year
Philippines	8200	0.40 (2013)
Thailand	17,800	0.38 (2013)
Indonesia	12,400	0.40 (2013)
Vietnam	6900	0.35 (2014)
Cambodia	4000	0.38 (2012)
Malaysia	28,900 _	0.46 (2009)

Source: Authors compilation based on data from the World Bank.

particular, Vietnam had a lower poverty and a higher welfare than Indonesia and Philippines, despite its lower level of economic development. This may be attributable to two major differences between Vietnam and the other Southeast Asian countries. The first is that inequality in Vietnam is lower. No matter what method is used, the ordinal inequality index in Vietnam is markedly lower than that in the Philippines, Indonesia, Thailand and Cambodia. The second is that the government of Vietnam prioritizes expenditure on social services, including health and education (NHDR, 2001). Social expenditures accounted for over 6% of GDP in 2000, which is more than a third of total governmental expenditures (IMF, 2000). Such a high spending on social services largely benefits the relatively poor and enables households to purchase more durables. It also helps keep inequality under control and improves the overall welfare.

7. Concluding comments

Asia has been rising as a major geo-political power, largely due to its fast GDP growth since the end of the World War II. The rise has been attracting more and more attention, including attention from economists (Wan & Wang, 2020). In particular, one wonders, after the prolonged growth, about the state of poverty, inequality and social welfare in Asia in general and in South East Asia in particular. Note that South East Asia succeeded to some extent in regional integration while other parts of Asia are less integrated.

Relying on asset ownership data from the Asia Barometer Survey, this paper focuses on poverty, inequality and social welfare in six member economies of ASEAN: Cambodia, Indonesia, Malaysia, the Philippines, Thailand and Vietnam. Data on the other four economies of ASEAN are not available. Due to the discrete data nature, ordinal approaches to measuring poverty, inequality and welfare are introduced and then applied to our data. A key step with the ordinal approaches lies in the identification of a dominant order of acquisition of assets. More specifically, we assume that households behave as if they were implicitly assigning an order of importance to the various assets that they acquire.

While the Paroush approach requires considerable computing cost, Item Response Theory is quite easy to use for identifying the order of acquisition or acquisition path. Interestingly, we found that for at least two thirds of the between countries correlations (the rank correlation coefficients between the orders of acquisition of different countries) were higher than 0.5. If orders of poverty or inequality are considered, the between country correlations are almost perfect. These findings suggest that using the relatively less demanding IRT is sufficient for using asset data to analyze poverty, inequality and social welfare in South East Asia.

More specifically, as far as multi-dimensional poverty is concerned, it appears that poverty is high in Cambodia, Indonesia and the Philippines and much lower in Thailand, Malaysia and Vietnam. The same conclusion holds for inequality, since the estimates of ordinal inequality that we obtained in this paper show that, whatever the approach and whatever the index selected, ordinal inequality is high in Cambodia, Indonesia and the Philippines and much lower in Vietnam, Thailand and Malaysia. These asset inequality estimates do not corroborate with income or expenditure-based estimates, possibly implying data recording and reporting errors when income are expenditure are considered. However, as far as welfare estimates (ignoring inequality) are concerned, country rankings are similar to those based on per capita GDP: relatively high in Malaysia, Thailand and Vietnam and relatively low in the Philippines, Indonesia and Cambodia.

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