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Dynamic modelling of consumption patterns using LA-AIDS: a comparative study of developed versus developing countries

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Abstract
The traditional applied demand system estimation assumes that when consumer income and commodity prices change, the consumers instantaneously fully adjust to a new consumption equilibrium level and use a static demand system such as Static Linear Almost Ideal Demand System (Static LA-AIDS) for estimation. However, in real-life situations, such an assumption does not hold as consumers take time to settle to a new consumption equilibrium level. Hence, dynamic demand system estimations generate more nuanced insights into the short-run dynamics of consumer demand. This paper estimates two forms of dynamic versions of AIDS, Dynamic LA-AIDS and the error-corrected LA-AIDS, and compares the results with the Static LA-AIDS. The paper also models the consumption patterns of consumers in developed and developing countries and provides a comparative analysis of implied elasticities using recent data. The results show that the dynamic models support demand theory hypotheses—demand homogeneity and Slutsky symmetry—more than the static model. The estimated mean own-price elasticities reveal that the demand in the short-run and long-run is price inelastic across all countries. Long-run and short-run income elasticities

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demonstrated notable variation across various commodity groups and country groups. For example, the restaurant meal is a luxury in the short-run for all countries. In the long-run, it is a necessity in developed countries and a luxury in developing countries. Food and housing are necessities; durables, transport and recreation are luxuries in developed and developing countries in the long-run and short-run.

Keywords Dynamic demand · Error correction · Developing and developed countries · Demand elasticities

JEL Classification D12 · C32

1 Introduction

The interest in the analysis of consumer demand dates back to the last century and has continued to be of great interest (Barten 1964; Clements and Gao 2015; Deaton and Muellbauer 1980a; Engel 1895; Selvanathan and Selvanathan 1994; Theil 1965). With the rapidly changing consumer behaviour resulting from income growth, price changes followed by domestic and international shocks, global mass production and technological changes, the analysis of consumer demand and the decision making around production and government policy has become severely complicated. As such, obtaining reliable estimates of income and price elasticities that provide vital inputs for various policy decision making has become more crucial than ever before.

Much of the demand analysis research heavily depends on the standard static demand system models. Although widely utilised, the static demand system, such as the standard static linear Almost Ideal Demand System (Static LA-AIDS), has some drawbacks. In particular, Static LA-AIDS does not account for consumer adjustments to consumer income and commodity price changes that take place in the short-run. This is because static demand systems assume that when income and prices change, the consumers instantaneously fully adjust to a new consumption equilibrium level. It is well acknowledged that in real-life situations, such an assumption does not hold. The consumers take time to settle to a new equilibrium consumption level in each time period due to distinct short-run consumption behaviour driven by short-run adjustment costs, unexpected real price levels, false expectations and habit formation (Hassan et al. 1977; Rathnayaka et al. 2019). For example, when petrol price increases, although consumers may make some consumption adjustments to manage their budgets, in the short-run, most of the consumers will continue to pay higher prices and use their car. This is because there are various costs involved in fully adjusting the consumption for a price change. The lack of alternatives could also be another factor that consumer may not be able to completely switch their consumption in the short-run. However, when they realise that the situation is no-longer sustainable, in the long-run, consumers tend to adjust their consumption, such as switch to an electric car, or to a scooter or motorcycle or public transport. This is in particularly common for costly items, such as housing and durable goods as consumers make substantial financial commitments to acquire these goods. For example, while demand for housing is inelastic in the short- run, in the long-run it may become demand elastic when consumers move out

of expensive housing in the city to cheaper housing in outer city area and decide to incur higher transport expenses. For this reason, obtaining the short-run elasticity estimates and the speed with which these estimates reach their long-run values is a critical consideration in most business and government policy decision making processes (Eakins and Gallagher 2003). Considering this requirement, while not denying the importance of estimating the long-run elasticity estimates, the literature on consumer demand analysis highlights the need for obtaining the counterpart short-run elasticities (see, for example, Anderson and Blundell 1983; Edgerton et al. 1996). For example, government policy related to Goods and Services Tax (GST) on a commodity requires long-run elasticity estimates, while decision making related to the marketing of a commodity requires short-run elasticity estimates.

Although production and consumption decision making require short-run elasticity estimates, Static LA-AIDS will not best serve such a purpose. The use of dynamic demand systems for estimations, however, provides a resolution for this concern. This is because the dynamic demand systems allow for intertemporal rationality of consumer behaviour in the demand system estimation by explicitly incorporating the mechanism underlying the short-run adjustment process in the model specification.

With the globalisation of economic activities, it has become important to know the income and price elasticity estimates of consumer goods at the single-country level so that importers/exporters, producers and manufacturers can make informed production and marketing decisions when and where these elasticities may differ across countries. Therefore, obtaining short-run and long-run elasticity estimates at the individual country level has also become valuable information for informing decisions related to various trade-related economic activities. There is a considerable body of the literature on dynamic demand systems and elasticity estimations of single-country settings (see, for example, Alessie and Kapteyn 1991; Blanciforti et al. 1986; Karagiannis and Velentzas 1993; Molina 1994; Rathnayaka et al. 2019; Singh et al. 2011). Nevertheless, so far, no attention has been paid to estimating dynamic demand systems for a group of countries and comparing the performance among the dynamic and static demand systems.

In this paper, we address these important gaps and contribute to the consumer demand analysis literature in three ways. Firstly, to provide insights into short-run implied elasticities for a broad range of commodities, using the most recent data available, we estimate two forms of dynamic versions of Almost Ideal Demand System (AIDS), namely Dynamic Linear AIDS (Dynamic LA-AIDS) (Blanciforti and Green 1983; Edgerton et al. 1996; Kesavan et al. 1993) and the error-corrected linear approximated AIDS (EC-LA-AIDS) (Karagiannis et al. 2000; Nzuma and Sarker 2010). Secondly, to provide further insights into the long-run and short-run elasticity differences, we compare the performance of the Static LA-AIDS demand system estimation results with those of the dynamic demand systems. Thirdly, we estimate and compare cross-country static and dynamic demand systems for 40 developing and developed countries. Such comparative analysis of consumption patterns of major consumer goods between developed and developing countries will also facilitate understanding the differences in consumption behaviour based on the stage of development and assist with production and policy decisions in a globalised economic setting.

The organisation of the paper is as follows. In Sect. 2, we present a review of the literature on cross-country demand analysis and dynamic demand modelling. In Sect. 3, we present a preliminary analysis of the data at individual country level, group levels (developed and developing countries) and global levels. Section 4 introduces the dynamic demand systems for estimations: Dynamic LA-AIDS and EC-LA-AIDS. In Sect. 5, we select the preferred model for each country and present the income and price elasticities implied by the preferred demand systems. We provide concluding comments in the last section of the paper.

2 A review of the literature

2.1 Cross-country demand analysis studies

There is a large body of consumption economics literature on modelling consumer demand. The literature on cross-country consumption goes back to the pioneering work of Houthakker (1957), which represents the first study to compare the expenditure elasticities for different countries—developed and developing. The study estimated expenditure elasticities for food, clothing, housing and miscellaneous items based on double-log Engel curves using cross-sectional data from 30 countries. The results revealed that elasticities are similar across commodities but not equal. Since the study utilised cross-sectional data that does not capture price variation, the study eschews the estimation of price elasticities. Houthakker (1965) performed a similar study as Houthakker (1957) using time-series data for the period 1948–1959 for 13 OECD countries. The results suggested that while price elasticities show no uniformity across the commodities (food, clothing, rent, durables and miscellaneous), the expenditure elasticities are consistent.

Goldberger and Gamaletsos (1970) analysed the consumer expenditure patterns of 13 OECD countries for food, clothing, rent and durables over the period 1950–1961, employing the Linear Expenditure System (LES) introduced by Stone (1954) and the Constant Elasticity Demand System (CEDS) used by Houthakker (1965). Parks and Barten (1973) hypothesised that some of the differences in demand behaviour between countries could be explained by differences in the age composition of the population. The study estimated LES using time-series data of five commodities (food, clothing, housing, durables, others) for the years 1950–1967 for 14 OECD countries. The results revealed that population composition has a significant effect on the parameters of the demand model after correcting for the difference associated with the level of real income across the countries. The results also found that income elasticities are positive and own-price elasticities are negative in all countries.

Lluch and Powell (1975) estimated the LES for eight commodity groups using data from 19 countries. The cross-country analysis revealed some discernible patterns in the variation of price and expenditure elasticities as a function of GNP per head. Moreover, the study noted that the own-price and expenditure elasticity of food appeared to decline in absolute value as real income increases. Overall, the own-price elasticities and cross-price elasticities of food appear to account for most of the total price responsiveness (about 80%). Lluch et al. (1977) employed an extended LES where

total consumption expenditure was assumed to be endogenous across 17 developing countries between 1955 and 1969. The study considered eight commodities (food, clothing, housing, durables, personal care, transport, recreation and miscellaneous) and found food and housing to be necessities, clothing to be borderline and durables, personal care, transport, recreation and miscellaneous goods to be luxuries.

Another leading work on cross-country application was conducted by Theil (1987) using data compiled by Kravis et al. (1982). These data, which are part of the International Comparisons Programme (ICP) sponsored by the United Nations and the World Bank, covered 34 countries and provided comparable price and volume indices for more than 100 detailed categories of consumption. Selvanathan and Selvanathan (1993) analysed the consumption of ten commodities across 18 OECD countries from 1960 to 1981. The study revealed that OECD consumers spend about half of their income on food, housing and transport. The results also found that food, housing and medical care are necessities and clothing, durables, transport and recreation are luxuries in most OECD countries. The demand for all goods considered was found to be price inelastic.

Clements and Theil (1996) used cross-sectional data from Kravis et al. (1978) from 16 countries to estimate a common system of demand equations for all countries. Compared to the usual time-series application for a given country, countries here played the role of time periods. This idea was introduced by Theil and Suhm (1981), which suggested that tastes are to be the same across countries. Although a rather bold assumption, it is the one advocated by Stigler and Becker (1977), who hypothesised that tastes neither change capriciously nor differ importantly between people. In the international context, this hypothesis implies that consumers in different countries have similar tastes irrespective of differences in language, religion, culture and geography. Pollak and Wales (1987) tested this using the quadratic expenditure system with time series/cross-country data for Belgium, the UK and the USA. Based on likelihood ratios and nonparametric (revealed preference) tests, the study concluded that the data from these countries could not be pooled to estimate a common demand system. Hence, the study rejected the hypothesis of identical tastes. Selvanathan and Selvanathan (1993) also found that OECD consumption data do not support Stigler and Becker's (1977) hypothesis using consumption data for 18 OECD countries.

Chen and Clements (1996) analysed consumption patterns in 13 emerging/developing economies to identify key empirical regularities using a system-wide approach. Chen (2001) extended the work of Selvanathan and Selvanathan (1993) by adding 13 less-developed countries (giving a total of 31) during the same time period. Clements and Ye (2003) estimated a double-log model for 18 wealthy (OECD) countries and 13 developing countries. The study concluded that differences in income and relative prices explained a significant share of the variation in international consumption patterns. Selvanathan and Selvanathan (2003b) investigated the consumption patterns of the five strongest Asian economies (Hong Kong, Japan, Korea, Singapore and Taiwan). The results based on the Rotterdam model revealed that the consumption data of these five countries supported a number of empirical regularities, including the law of demand and Engel's law. Clements et al. (2006a, b) constructed a new database that built upon that of Selvanathan and Selvanathan (2003a) and estimated the CBS model to analyse the extent to which the consumption basket was diversified,

how this changed with income and whether a simple utility maximising model was capable of explaining the diversity of consumption patterns internationally. In a recent study, Rathnayaka et al. (2022) examined the similarities in consumption patterns in ten Asian countries, using the Rotterdam, CBS and AIDS models. The study noted a less diversified consumption basket for consumers in developing countries than those in relatively wealthy countries in Asia. The demand elasticity estimates suggested that food and housing are necessities, and clothing, durables and transport are luxuries for Asian consumers. The demand for all goods was found to be price inelastic.

Many advances in this important area of study have been achieved due to data made available through the International Comparison Program (ICP) since the early 1970s. Pioneering studies that applied a cross-country demand system to ICP data include Clements et al. (1979), Theil et al. (1980), Finke et al. (1983), Seale et al. (2003) and Seale and Regmi (2009).

2.2 Dynamic demand analysis

As noted above, all cross-country consumption studies discussed in the previous section are based on the static demand systems estimations. A summary of selected static cross-country consumption studies is found in Table 1. However, static demand systems used in these empirical studies assume that consumers immediately and fully adjust to a new equilibrium when either incomes or prices change. However, consumers are unlikely to have adjusted to equilibrium in each time period; hence, the assumption of instantaneous adjustments by consumers is potentially incorrect. Therefore, a number of studies, predominantly single-country studies, have recognised the importance of including dynamic adjustments in demand systems and have adopted a number of approaches.

For instance, several consumer demand studies have introduced dynamic nature into the well-known AIDS by including the lagged budget share $w_{i,t\text{-}1}$ on the right-hand side of the AIDS equation (see Blanciforti and Green 1983 and Blanciforti et al. 1986 for the USA; Karagiannis and Velentzas 1993 for Greece; and Molina 1994 for Spain). Furthermore, a few other studies have estimated a more general dynamic AIDS model by including its own past budget shares and also that of all other goods (for example, Alessie and Kapteyn 1991 for the Netherlands; Edgerton 1997 for Sweden; Kesavan et al. 1993 for the USA; and Klonaris and Hallam 2003 for Greece).

Relatedly, Anderson and Blundell (1983) for the UK, Balcombe and Davis (1996) for Bulgaria, Edgerton et al. (1996) for Sweden and Karagiannis and Velentzas (1997) for Greece have incorporated dynamic elements into AIDS by relying on the statistical properties of the data. This has led to the application of the error-corrected linear approximated AIDS (EC-LA-AIDS) in a number of recent studies on demand for non-durable goods, such as food sub-categories. For example, using EC-LA-AIDS, Karagiannis et al. (2000) analysed the demand for meat in Greece. Eakins and Gallagher (2003) analysed the dynamics of alcohol expenditure in Ireland, while Fanelli and Mozzocchi (2002) estimated the demand for meat in Italy, and Nzuma and Sarker (2010) estimated the demand for major cereals consumed in Kenya. Singh et al. (2011) employed EC-LA-AIDS to estimate demand for major crustaceans at a disaggregated

Table 1 Major cross-country consumption studies

Authors (1)	Countries (2)	Type of data (3)	Number of goods (4)	Model (5)	Main findings (6)
Chen and Clements (1996)	13 developing countries	Cross-country	9	DL	Demand elasticities for the broad aggregates are the same in both rich and poor countries, except that of transport
Clements et al. (2006)	45 developed and developing countries	Time-series	8	CBS	Consumption baskets have a distinct tendency to become more diversified as income rises, indicating a positive income elasticity of the demand for variety
Clements and Ye (2003)	18 OECD and 13 poor countries	Cross-country	8	DL	Transport is less income elastic in poor countries and is more price elastic in the rich countries
Clements and Theil (1996)	16 developed and developing countries	Cross-country	4	Working's model	Similarity of tastes is taken as a maintained hypothesis
Houthakker (1957)	30 developed and developing countries	Cross-sectional	4	DL	Expenditure elasticities are similar across the 30 countries but not equal
Houthakker (1965)	13 OECD countries	Time-series (1948–1959)	5	DL	Food is a necessity for all the countries. For most of countries durables is a luxury

Table 1 (continued)

Authors (1)	Countries (2)	Type of data (3)	Number of goods (4)	Model (5)	Main findings (6)
Lluch and Powell (1975)	19 developed and developing countries	Time-series (1946–1968)	8	LES	Food expenditure elasticity declines on average from 0.93—0.38 over time. Own-price elasticities for food display a wide range of variation, from -0.85 to -0.16 over time
Lluch et al. (1977)	17 countries developing countries	Time-series (1955–1969)	8	ELES	Food and housing are necessities while durables, personal care, transport and recreation are luxuries
Parks and Barten (1973)	14 OECD countries	Time-series (1950–1967)	5	LES	Income elasticities are positive, own-price elasticities are negative in all countries
Pollak and Wales (1987)	Belgium, UK and USA	Time-series	3	QES	Caution is required in pooling international consumption data
Rathnayaka et al. (2022)	10 Asian countries	Time series	8	CBS AIDS Rotterdam	Food and housing are necessities, and clothing, durables and transport are luxuries. The demand for all goods was found to be price inelastic

Table 1 (continued)

Authors (1)	Countries (2)	Type of data (3)	Number of goods (4)	Model (5)	Main findings (6)
Seale et al. (2003)	Cross-country	Cross-sectional	5	Florida Slutsky	Low-income countries are more responsive to changes in income and food prices
Seale and Regmi (2009)	114 countries	1996 ICP data	9	Florida model	Income elasticity of food varies from 0.85 to 0.71 in low-income countries, from 0.71 to 0.57 in middle-income countries and from 0.56 to 0.35 in high-income countries
Selvanathan and Selvanathan (1993)	18 OECD countries	Time-series (1960–1981)	10	Rotterdam under PI	In most countries, food, housing and medical care are necessities and clothing, durables, transport and recreation are luxuries
Selvanathan and Selvanathan (2003a)	23 OECD countries and 23 LD countries			CBS	OECD consumers allocate a lesser proportion of their income on food and higher proportion on housing, medical care, transport and recreation

Table 1 (continued)

Authors (1)	Countries (2)	Type of data (3)	Number of goods (4)	Model (5)	Main findings (6)
Selvanathan and Selvanathan (2003b)	5 Asian countries	Time-series (1970–1999)	8	Rotterdam model	In most countries, food, housing and medical care are necessities while clothing, durables and transport are luxuries
Theil and Suhm (1981)	15 countries	Cross-country	8	Working's model	Similarity of tastes is taken as a maintained hypothesis
Van et al. (1997)	USA and Netherlands	Time-series (1929–1988)	6	CBS	Income elasticity of food is 0.75, own-price elasticity of food is -0.45 in the USA. Income elasticity of food is 0.65 and own-price elasticity of food is -0.20 in Netherlands

CBS Demand model introduced by Dutch Central Bureau of Statistics; CEDS = Constant Elasticity Demand System; DL Double-Log model; ELES Extended LES; LES Linear expenditure system; QES = Quadratic Expenditure System; and PI = Preference Independence

level in the USA. More recently, Rathnayaka et al. (2019) modelled the dynamic behaviour of Sri Lankan consumers in consuming eight broad commodity groups employing EC-LA-AIDS. A few studies have also employed EC-LA-AIDS to model tourism demand (Durbarry and Sinclair 2003; Wu et al. 2012).

In addition to the above studies based on dynamic versions of AIDS, Bushehri (2003) introduced a generalised dynamic Rotterdam model. A few consumption studies have employed this approach (see, for example, Muhammad and Jones 2009; Muhammad et al. 2015, for the USA and Greear and Muhammad 2021, for Japan).

In summary, according to the major findings from previous studies reported in Table 1, in most countries, food and housing are necessities. Moreover, OECD consumers spend about half of their income on food, housing and transport, while consumers in low-income countries spend more than half of their budget on food. Consumers in developing countries have a less diversified consumption basket than those in relatively wealthy countries. Also, the demand for all goods considered was found to be price inelastic. However, the above cross-country consumption studies assume that consumers immediately and fully adjust to a new equilibrium when either income or prices change, and their elasticity estimations are based on static demand systems.

To the best of our knowledge, no other published comprehensive econometric studies analyse the cross-country consumption patterns of broad commodity groups using dynamic demand models with more recent data. The current study, therefore, adds to the literature by bridging this gap by estimating dynamic AIDS and EC-LA-AIDS for 40 developed and developing countries using the data up to 2019 (for most of the countries) and comparing the performance of the two dynamic AIDS models with that of the static AIDS model.

3 Data description

3.1 Data sources

The annual consumption expenditures (in current and constant prices) and the population for 40 countries, consisting of 27 developed and 13 developing countries (selected based on data availability), are compiled from the *National Accounts of OECD Countries* (OECD: Paris, various issues) and various individual country *Government Statistical Department* websites and publications.[1]

In this paper, we classify the consumer basket into nine commodity groups.[2] When compiling data, it was found that statistical agencies of some countries publish information about commodities in less than nine commodity groups. Relatedly, during

[1] The selection of the countries in this study is purely based on data availability to allow sufficient degrees of freedom, which is determined by the number of commodities (n) and the number of years (T) for model estimation. Therefore, some of the prominent emerging economies, such as China, Indonesia, Vietnam and developing countries in the African region have been excluded from this study due to the lack of sufficient data. All the analysis were performed at single country level and without pooling the data across countries.

[2] Food: food, alcohol and non-alcoholic beverages; Clothing: clothing and footwear; Housing: housing and utilities; Durables: furniture, furnishings and household equipment and operation; Medical: medical care and health; Transport: transport and communication; Recreation: entertainment and cultural activities and education; Restaurant: restaurants and hotels meals; and Miscellaneous: miscellaneous goods and services.

the estimation, it was found that the sample size (time periods) was too small for the dynamic model estimation for nine commodity groups as lagged variables were involved. To overcome these issues, we combined some commodities into a single group when performing the estimation.

3.2 Data summary

Table 2 provides details about the database. Figure 1 plots the food share (column 9) against log of per capita GDP (column 6). As can be seen, in general, the higher a country's per capita GDP, the lower the budget share on food, which gives support to the Engel's (1987) law. In particular, a slope coefficient of − 0.13 is not inconsistent with the "strong version" of Engel's law.

Let there be n commodities and p_{it} be the price, and q_{it} be the per capita quantity consumed of commodity i. We define price and quantity log-changes, for commodity i, as

$$Dp_{it} = \log p_{it} - \log p_{it-1},\ Dq_{it} = \log q_{it} - \log q_{it-1},\ t = 1, \ldots, T, i = 1, \ldots, n$$

respectively. When these price and quantity log-changes are multiplied by 100, they can be interpreted as percentage growth rates in price and quantity, respectively, from year t-1 to t. Here and elsewhere, log refers to the natural logarithm.

Let M_{t} be the total expenditure (income for short) on the n commodities during period t. Therefore, the total expenditure $M_{\mathrm{t}} = \sum_{i=1}^{n} p_{it}q_{it}$. The proportion of total expenditure devoted to commodity i, called the budget share of i, is $w_{it} = \frac{p_{it}q_{it}}{M_t}$ ($t = 1,\ldots,\mathrm{T}$, $i = 1, \ldots, n$), where T is the sample size.

To measure the overall growth in consumption and prices, we use the Divisia volume and price indices defined below. The Divisia volume index, DQ_{t}, and Divisia price index, DP_{t}, for period t are defined as $DQ_t = \sum_{i=1}^{n} \overline{w}_{it} Dq_{it}$, and $DP_t = \sum_{i=1}^{n} \overline{w}_{it} Dp_{it}$, respectively ($t = 1,\ldots,\mathrm{T}$), where $\overline{w}_{it} = {}^1\!/_2(w_{it} + w_{it-1})$ is the arithmetic average of the budget shares of commodity i in periods t and $t - 1$.

The Divisia volume index and Divisia price index averaged over the whole sample period for each country are calculated as

$$D\overline{Q} = \frac{1}{T}\sum_{t=1}^{T} DQ_t \text{ and } D\overline{P} = \frac{1}{T}\sum_{t=1}^{T} DP_t \tag{1}$$

The Divisia quantity index (DQ_{t}) and the Divisia price index (DP_{t}) are first-order moments. The second-order moments and the Divisia quantity and price variances are defined as

$$\mathrm{K}_t = \sum_{i=1}^{n} \overline{w}_{it}[Dq_{it} - DQ_t]^2,\ \Pi_t = \sum_{i=1}^{n} \overline{w}_{it}[Dp_{it} - DP_t]^2,\ t = 1, \ldots, \mathrm{T}$$

Table 2 Country characteristics, 45 countries

Country		Currency	Sample period	Number of observations	Number of commodities	Per capita GDP in 2021		Gini coefficient	Mean budget share on food, non-alcoholic and alcoholic beverages
						PPP (constant 2017 international $)	USA = 100		
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Developed countries									
1	Australia	Dollars (Aus)	1985–2019	35	9	49,774	78	0.34	14.60
2	Austria	European euro	1995–2019	25	6	54,121	85	0.30	13.75
3	Belgium	European euro	1995–2019	25	5	51,740	81	0.27	17.16
4	Canada	Dollars (Can)	1981–2019	39	9	47,893	75	0.33	14.65
5	Denmark	Danish krone	1995–2019	25	5	57,963	91	0.28	15.98
6	Finland	European euro	1975–2019	45	9	48,753	77	0.27	22.00
7	France	European euro	1959–2019	61	9	44,993	71	0.32	20.68
8	Germany	European euro	1995–2019	25	6	53,180	84	0.31	14.35
9	Hong Kong	Hong Kong dollar	1971–2016	46	8	59,978	94	0.46	18.40
10	Iceland	Icelandic krona	1995–2019	25	4	53,586	84	0.26	19.32
11	Ireland	European euro	1996–2019	24	4	102,496	161	0.30	17.18
12	Israel	Israeli new shekel	1995–2019	25	6	42,061	66	0.38	18.14
13	Italy	European euro	1995–2019	25	6	41,929	66	0.35	19.29
14	Japan	Japanese yen	1970–2015	46	8	40,784	64	0.29	19.81
15	Luxembourg	European euro	1995–2019	25	6	115,683	182	0.35	18.67

Table 2 (continued)

Country		Currency	Sample period	Number of observations	Number of commodities	Per capita GDP in 2021		Gini coefficient	Mean budget share on food, non-alcoholic and alcoholic beverages
						PPP (constant 2017 international $)	USA = 100		
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
16	Netherlands	European euro	1995–2019	25	5	56,617	89	0.28	14.32
17	New Zealand	New Zealand dollar	1987–2019	33	6	42,915	67	0.32	19.53
18	Norway	Norwegian krone	1970–2019	50	9	65,662	103	0.27	21.43
19	Singapore	Singapore dollar	1963–2016	54	8	106,032	167	0.39	16.02
20	Slovenia	European euro	1995–2019	25	6	40,036	63	0.24	21.15
21	South Korea	South Korean won	1970–2019	50	8	44,232	69	0.31	26.95
22	Spain	European euro	1995–2019	25	5	37,913	60	0.34	18.07
23	Sweden	Swedish krona	1993–2019	27	6	53,613	84	0.30	16.64
24	Switzerland	Swiss franc	1995–2019	25	6	71,033	112	0.33	13.47
25	Taiwan	New Taiwan dollar	1962–2016	55	8	62,696	98	0.33	24.05
26	UK	Pound sterling	1995–2019	25	6	44,979	71	0.35	12.94
27	USA	US dollar	1970–2019	50	9	63,670	100	0.41	11.75

Table 2 (continued)

Country		Currency	Sample period	Number of observations	Number of commodities	Per capita GDP in 2021		Gini coefficient	Mean budget share on food, non-alcoholic and alcoholic beverages
						PPP (constant 2017 international $)	USA = 100		
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Developing countries									
28	Czech	Czech koruna	1995–2019	25	5	40,741	64	0.25	24.30
29	Estonia	European euro	1995–2019	25	5	38,718	61	0.30	28.85
30	Greece	European euro	1995–2019	25	4	29,548	46	0.32	20.73
31	Hungary	Hungarian forint	1995–2019	25	5	33,593	53	0.29	25.67
32	India	Indian rupee	1970–2015	46	8	6592	10	0.34	50.60
33	Latvia	European euro	1995–2019	25	4	32,081	50	0.35	32.94
34	Lithuania	European euro	1995–2019	25	6	39,306	62	0.35	35.42
35	Poland	Polish zloty	1995–2019	25	6	13,387	21	0.30	29.18
36	Portugal	European euro	1995–2019	25	4	17,077	21	0.33	20.29
37	Slovakia	European euro	1995–2019	25	6	40,741	27	0.25	26.16
38	South Africa	South African rand	1975–2014	40	9	38,718	64	0.67	28.61
39	Sri Lanka	Sri Lankan rupee	1975–2016	42	8	29,548	61	0.45	53.56
40	Thailand	Thai baht	1967–2015	49	8	33,593	46	0.36	33.58

PPP Purchasing power parity. According to Engel's law, four countries: Ireland, Luxembourg, Norway and Singapore, appear to be outliers as their food budget shares are higher than that of the USA, while the per capita GDP is also higher than that of the USA

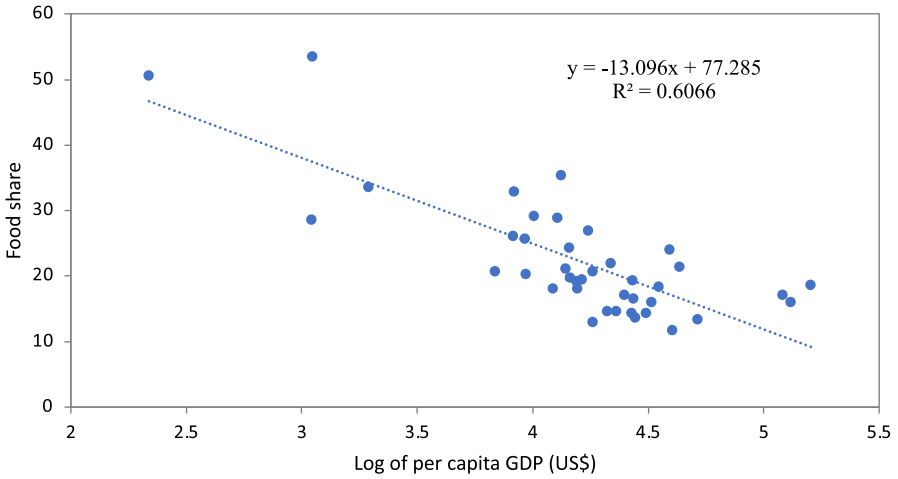

Fig. 1 Mean food share versus per capita GDP across 40 countries

These two variances measure the degree to which the quantities and prices of the individual commodities change disproportionately. When all quantities and prices change proportionately, these two variances will vanish.

To measure the co-movement of prices and quantities, the Divisia price-quantity correlation is defined as $\rho_t = \frac{\Gamma_t}{\sqrt{K_t \Pi_t}}$, where $\Gamma_t = \Sigma_{i=1}^{n} \overline{w}_{it}(Dp_{it} - DP_t)(Dq_{it} - DQ_t)$ is the Divisia price-quantity covariance between prices and quantities. Since relative prices and relative consumptions are expected to move in the opposite direction, we would expect Divisia price-quantity correlation to be negative. The corresponding sample period averages for each country are calculated as

$$\overline{K} = \frac{1}{T}\sum_{t=1}^{T} K_t,\ \overline{\Pi} = \frac{1}{T}\sum_{t=1}^{T} \prod_t \text{ and } \overline{\rho} = \frac{1}{T}\sum_{t=1}^{T} \rho_t. \tag{2}$$

Furthermore, if we regress the relative consumption $(Dq_{it} - DQ_t)$ against relative prices $(Dp_{it} - DP_t)$, under the assumption of *unitary income elasticity*, we can show that the weighted least squares estimate of the slope of the regression equation is the measure of *income flexibility* (for example see, Selvanathan and Selvanathan 2003b) given by

$$\hat{\phi}_t = \frac{\Gamma_t}{\Pi_t} = \rho_t \sqrt{\frac{K_t}{\prod_t}}. \tag{3}$$

Table 3 presents the collection of the above average values for each country, averaged over the respective time periods given in Eqs. (1)–(3).

As can be seen from column (2), the overall growth in consumption in the 40 countries vary between 0.3% (Italy) and 7.5% (Ireland) with an overall average of 2.5% per annum across all countries (see last row of the table). The average consumption

Table 3 Mean Divisia price and quantity indices and variances, price-quantity correlation and income flexibility, 40 countries

Country		Divisia Quantity Index $D\overline{Q}$	Divisia Price Index $D\overline{P}$	Divisia Quantity variance $\overline{K}$	Divisia Price variance $\overline{\Pi}$	Divisia price-quantity correlation $\overline{\rho}$	Income flexibility ϕ
(1)		(2)	(3)	(4)	(5)	(6)	(7)
Developed countries							
1	Australia	1.86	3.08	6.31	4.73	− 0.42	− 0.49
2	Austria	0.99	1.72	5.18	4.27	− 0.46	− 0.51
3	Belgium	0.75	1.78	5.65	5.20	− 0.21	− 0.22
4	Canada	1.54	2.54	4.91	3.34	− 0.32	− 0.39
5	Denmark	0.86	1.72	9.58	3.05	− 0.40	− 0.71
6	Finland	1.83	3.92	11.69	6.46	− 0.28	− 0.38
7	France	2.21	4.09	6.03	4.24	− 0.36	− 0.43
8	Germany	0.90	1.19	7.15	3.82	− 0.54	− 0.74
9	Hong Kong	3.86	4.85	31.43	10.21	− 0.06	− 0.11
10	Iceland	2.27	4.29	43.69	20.52	− 0.30	− 0.44
11	Ireland	7.48	− 3.60	123.04	38.20	− 0.88	− 1.58
12	Israel	1.62	3.04	11.57	8.28	− 0.22	− 0.26
13	Italy	0.26	2.23	5.32	4.17	− 0.44	− 0.50
14	Japan	2.12	2.31	8.14	4.17	− 0.28	− 0.39
15	Luxembourg	0.68	2.01	19.10	6.17	− 0.23	− 0.40
16	Netherlands	0.77	2.03	18.38	5.31	− 0.30	− 0.56
17	New Zealand	1.58	2.07	12.16	8.02	− 0.50	− 0.62
18	Norway	2.18	4.52	14.83	5.56	− 0.41	− 0.67

Table 3 (continued)

Country		Divisia Quantity Index $D\overline{Q}$	Divisia Price Index $D\overline{P}$	Divisia Quantity variance $\overline{K}$	Divisia Price variance $\overline{\Pi}$	Divisia price-quantity correlation $\overline{\rho}$	Income flexibility ϕ
(1)		(2)	(3)	(4)	(5)	(6)	(7)
19	Singapore	3.33	2.23	20.63	8.92	− 0.20	− 0.30
20	Slovenia	1.78	4.10	10.44	6.09	− 0.32	− 0.42
21	South Korea	4.33	7.68	24.35	13.19	− 0.32	− 0.43
22	Spain	0.77	2.50	8.06	4.03	− 0.21	− 0.30
23	Sweden	1.85	1.40	7.73	4.05	− 0.42	− 0.58
24	Switzerland	2.87	− 1.57	16.09	4.97	− 0.91	− 1.64
25	Taiwan	5.03	3.42	17.29	7.11	− 0.22	− 0.34
26	UK	1.73	1.70	8.84	7.37	− 0.65	− 0.71
27	USA	2.00	3.59	5.91	5.09	− 0.50	− 0.54
Mean							
(Developed countries)	2.13	2.55	17.17	7.65	− 0.38	− 0.54	
Developing countries							
28	Czech Republic	2.10	2.83	13.42	8.8	− 0.36	− 0.44
29	Estonia	4.67	5.29	34.72	17.42	− 0.40	− 0.56
30	Greece	0.89	2.51	36.26	7.57	− 0.26	− 0.57
31	Hungary	1.78	6.71	15.71	11.98	− 0.32	− 0.37
32	India	3.14	6.84	19.54	40.85	− 0.18	− 0.12

Table 3 (continued)

Country		Divisia Quantity Index $D\overline{Q}$	Divisia Price Index $D\overline{P}$	Divisia Quantity variance $\overline{K}$	Divisia Price variance $\overline{\Pi}$	Divisia price-quantity correlation $\overline{\rho}$	Income flexibility ϕ
(1)		(2)	(3)	(4)	(5)	(6)	(7)
33	Latvia	4.93	5.15	83.93	36.19	− 0.29	− 0.44
34	Lithuania	5.77	3.44	55.40	22.60	− 0.40	− 0.63
35	Poland	3.55	4.57	33.15	23.96	− 0.39	− 0.46
36	Portugal	1.98	1.59	29.38	26.88	− 0.55	− 0.58
37	Slovakia	3.49	3.48	27.97	16.00	− 0.43	− 0.57
38	South Africa	1.45	9.38	17.05	13.71	− 0.43	− 0.48
39	Sri Lanka	3.82	9.13	100.98	48.79	− 0.45	− 0.65
40	Thailand	3.65	4.45	47.20	12.89	− 0.16	− 0.31
Mean (Developing countries)		3.17	5.03	39.59	22.13	− 0.36	− 0.48
Mean (All countries)		2.47	3.36	24.46	12.35	− 0.37	− 0.52

Columns (2) − (3) are to be divided by 100, and columns (4) − (5) are to be divided by 10,000

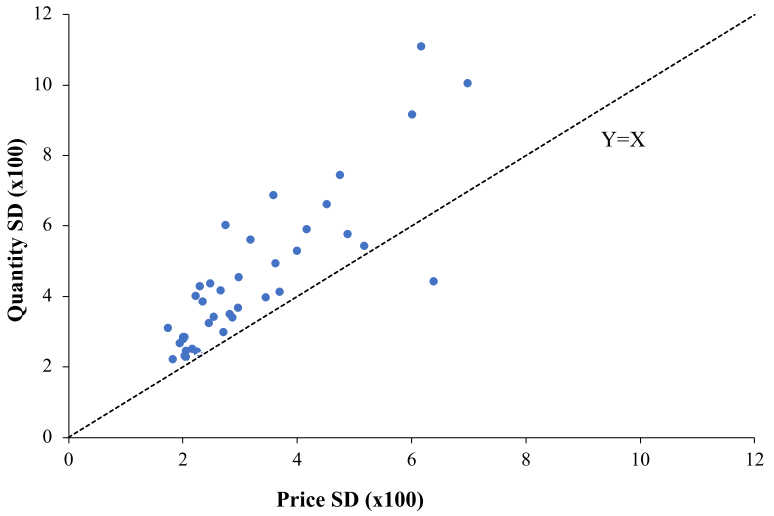

Fig. 2 Quantity standard deviation versus price standard deviation, all countries (at sample means)

growth across the developing countries (3.2%) is slightly higher than that of the developed countries (2.1%). The overall annual price growth in the 40 countries presented in column (3) of the table varies between − 3.6% (Ireland) and 9.4% (South Africa) with an overall cross-country average of 3.4% per annum. It is also observable that the overall cross-country average price growth in developing countries (5%) is twice that of the growth in the developed countries (2.6%). Columns (4) and (5) reveal that the Divisia quantity variances systematically exceed that of the corresponding Divisia price variances. To confirm this relationship, in Fig. 2, we plot $\sqrt{\overline{K}^c}$ against $\sqrt{\overline{\Pi}^c}$ for c = 1,…,40. As can be seen, most of the points lie above the 45° line indicating that, on average, the quantity variance systematically exceeds the price variance. This pattern agrees well with the results reported in Chen (2001), Clements et al. (2020), Meisner (1979), Rathnayaka et al. (2019), Selvanathan and Selvanathan (1993; 2003a; 2005) and Theil and Suhm (1981). This is mainly because prices are mostly sticky and take time to adjust, and it is the quantity consumed that adjusts to shocks mostly (for example, see Clements 2019).

As can be seen, all Divisia price-quantity correlations presented in Table 3 are negative with a cross-country average of − 0.4. The negative correlation values reflect the tendency of the consumer to move away from those commodities that have above average price increases. All the income flexibility ϕ estimates in column (7) are negative as they should be, and the cross-country average is close to − 0.5, which is well in agreement with previous studies (Clements et al. 2020; Rathnayaka et al. 2019; Selvanathan and Selvanathan 1993, 2003a, 2005 and Theil and Suhm 1981).

4 Dynamic demand systems

Below we consider three versions of Almost Ideal Demand System (AIDS) developed by Deaton and Muellbauer (1980b) to analyse the consumption pattern of 40 countries under consideration in this study, to obtain the income and price elasticities for each country in the short-run and the long-run.

4.1 Static LA-AIDS

The linear version of the standard static Almost Ideal Demand System (Static LA-AIDS) developed by Deaton and Muellbauer (1980b) is given by

$$w_i = \alpha_{\mathrm{i}} + \beta_{\mathrm{i}} \log \frac{M}{P} + \sum_{j=1}^{n} \gamma_{ij} \log\, p_{\mathrm{j}},\ i = 1, 2,\ \ldots, n \tag{4}$$

where $w_i = (p_i q_i / M)$ is the budget share of commodity i in the total consumer expenditure $M = \sum_{i=1}^{n} p_i q_i$, p_{i} is the price of commodity i and $\log P = \sum_{k=1}^{n} w_k \log p_k$ is the Stone price index and the variables α_i, β_i and γ_{ij} are constants satisfying the adding up conditions; $\sum_{i=1}^{n} \alpha_i = 1$; $\sum_{i=1}^{n} \beta_i = 0$; and $\sum_{i=1}^{n} \gamma_{ij} = 0$.[3] The Static LA-AIDS also satisfy the demand homogeneity, $\sum_{j=1}^{n} \gamma_{ij} = 0$, and symmetry conditions, $\gamma_{ij} = \gamma_{ji}$.

The income and uncompensated price elasticities implied by Static LA-AIDS are $\eta_i = 1 + \frac{\beta_i}{w_i}$, $\eta_{ij} = -\delta_{ij} + \frac{1}{w_i}\left[\gamma_{ij} - \beta_i \{w_j\}\right]$, $i, j = 1, 2, \ldots, n$.

4.2 Dynamic version of LA-AIDS

Blanciforti and Green (1983) incorporated habit effects along the line of Pollak and Wales (1969) and developed the following dynamic version of (4):

$$w_{it} = \phi_i + \sum_{j=1}^{n} \theta_{ij} w_{jt-1} + \beta_i \log \frac{M_t}{P_t} + \sum_{j=1}^{n} \gamma_{ij} \log p_{jt}, \quad i = 1, \ldots, n; t = 1, \ldots, T \tag{5}$$

where $\sum_{i=1}^{n} \phi_i = 1$, $\sum_{i=1}^{n} \theta_{ij} = 0$; $\sum_{i=1}^{n} \beta_i = 0$; and $\sum_{i=1}^{n} \gamma_{ij} = 0$.

[3] A major problem with the estimation of the standard AIDS is the nonlinearity nature of the model. For easy computation, the price index in the standard AIDS model is replaced or approximated with the Stone price index, making the model linear, and the resulting model is named as LA-AIDS. Several papers have discussed the relationship between AIDS and LA-AIDS (see, for example, Buse 1994; Green and Alston 1990; Pashardes 1993). One of the criticisms of such approximation is that in LA-AIDS estimation, the Stone price index is treated as exogenous, while it is defined in terms of budget shares which are the endogenous variables in the left-hand side of the model. However, Asche and Wessells (1997) showed that if the prices in the system are normalised to one, the AIDS and LA/AIDS representations are identical at the point of normalization and the expressions for price and expenditure elasticities from both AIDS and LA/AIDS systems are identical.

4.3 Error-corrected linear approximated AIDS (EC-LA-AIDS)

The error-corrected version of Eq. (4), EC-LA-AIDS, can be written as

$$\Delta w_{it} = \alpha_i + \theta_i \Delta w_{jt-1} + \beta_i \Delta \log \frac{M_t}{P_t} + \sum\nolimits_{j=1}^{n} \gamma_{ij} + \lambda_i EC_{it-1} \quad i = 1, 2, \ldots, n \qquad (6)$$

where Δ is the difference operator and $EC_{it\text{-}1}$ is the error correction term that measures the adjustment of the decision error made in the previous period, which is estimated using the residual term from the long-run Static LA-AIDS model given by Eq. (4). We have incorporated habit effects into Eq. (6) by including the lagged dependent variable on the right-hand side of (6).

5 Estimating the AIDS models

In this section, for each country, we estimate the three versions of AIDS model, Static LA-AIDS, Dynamic LA-AIDS and EC-LA-AIDS given by Eqs. (4), (5) and (6). Some of the previous research suggests that selecting a nonlinear form of AIDS models is crucial when there is a high-income inequality (Banks et al. 1997). Therefore, countries are listed in Table 2 with Gini coefficient higher than 0.4; namely, for Hong Kong, the USA, Sri Lanka and South Africa, we estimate the nonlinear AIDS model (QAIDS). We also test the demand theory hypotheses, demand homogeneity and Slutsky symmetry and select the preferred model based on the information inaccuracy measure. We then evaluate the implied income and price elasticities for each country based on its preferred model.

5.1 Testing for stationarity and co-integration

Before estimation, we first investigate whether the time-series variables w_{it}, $ln(M_t/P_t)$ and $ln(p_{it})$, $i = 1,2, \ldots, n$ are stationary, using the Lee and Strazicich (2003) unit root tests with multiple breaks. The results revealed that about 98% of the series are stationary.[4] Therefore, we consider that the estimation results are overall non-spurious.

5.2 Testing demand theory hypotheses

The traditional approach of testing demand theory hypotheses, demand homogeneity and Slutsky symmetry is based on the asymptotic tests such as Wald test, likelihood ratio test or Lagrange multiplier test. Using simulations, a number of previous research studies have showed that such asymptotic tests are bias towards rejecting the null hypothesis, especially when applied to large demand systems with fewer observations like ours (Balcombe and Davis 1996; Laitinen 1978; Meisner 1979; Selvanathan and Selvanathan 1993; Clements and Selvanathan 1995). Therefore, in this paper we use the sample-size corrected test developed by Court (1968) and Deaton (1974) to test

[4] The results are given in Table A1 of Appendix, under supplementary materials.

demand homogeneity and Slutsky symmetry. This test statistic has been used in many studies in the literature over time (for example see, Chambers 1990; Rathnayaka et al. 2019; Wu et al. 2012) and is given by

$$TS = \frac{tr\left(\Omega^R\right)^{-1}\left(\Omega^R - \Omega^U\right)/q}{tr\left(\Omega^R\right)^{-1}\Omega^U/(n-1)(T-k)} \tag{7}$$

where Ω^R and Ω^U are the unrestricted and restricted estimated residual covariance matrices, respectively; k is the number of parameters estimated in each equation; q is the number of restrictions imposed; n is the number of equations in the system; and T is the number of observations. The test statistic TS follows an F-distribution with q and $(n-1)(T-k)$ degrees of freedom.

Tables 4, 5, 6 present the hypotheses tests' results for demand homogeneity and Slutsky symmetry for the three versions of AIDS model, the Static LA-AIDS, Dynamic LA-AIDS and EC-LA-AIDS.[5] Table 7 gives the percentage acceptance of each hypothesis (which is calculated as 100 percentage rejections) calculated from Tables 4, 5, 6.[6] As can be seen, under Static LA-AIDS, homogeneity is acceptable for 67% of all countries, symmetry is acceptable for 47% of all countries and homogeneity and symmetry combined is acceptable only for 32% of all countries. Under Dynamic LA-AIDS, homogeneity is acceptable for 95% of all countries, symmetry is acceptable for 87% of all countries and homogeneity and symmetry combined is acceptable for 67% of all countries. Under EC-LA-AIDS, homogeneity is acceptable for 98% of all countries, symmetry is acceptable for 72% of all countries and homogeneity and symmetry combined is acceptable for 72% of all countries. The overall conclusion is that in terms of demand theory hypotheses, in general, the Dynamic LA-AIDS model outperforms the Static LA-AIDS and EC-LA-AIDS models.

Based on the hypothesis testing results presented in Tables 4, 5, 6, we can select the most appropriate restrictions we can impose for each country when estimating the respective demand systems. For example, for Australia, for Static LA-AIDS (Table 4) we estimate the unrestricted model because all three hypotheses were rejected by the data. For Dynamic LA-AIDS (Table 5), for Australia, all three hypotheses were accepted, and therefore, we use the model with homogeneity and symmetry restriction-imposed. However, for EC-LA-AIDS (Table 6), for Australia, we use only homogeneity restriction-imposed model as symmetry and homogeneity and symmetry restrictions were rejected by the data. Table 8 details which restrictions are acceptable for each country with respect to the three models. The results are presented in columns (3), (5) and (7) of Table 8, for each model, respectively.

[5] Figures A1–A3 of Appendix (under supplementary materials) depict the information on the p-values presented in Tables 4–6 in graphical form.

[6] The measurement errors associated with consumption data, especially in developing countries, may have resulted in higher acceptance rate of the hypotheses.

Table 4 Hypothesis testing results: Static LA-AIDS model

Country	n	T	Static LA-AIDS model								
			Homogeneity			Symmetry			Homogeneity and Symmetry		
			Test statistic	*p*-value	Decision	Test statistic	*p*-value	Decision	Test statistic	*p*-value	Decision
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Developed countries											
1. Australia	9	35	2.734	0.007	Reject	2.822	0.000	Reject	3.152	0.000	Reject
2. Austria	6	25	1.320	0.266	Accept	2.484	0.013	Accept	2.173	0.016	Accept
3. Belgium	5	25	3.159	0.021	Accept	2.237	0.053	Accept	3.295	0.002	Reject
4. Canada	9	39	2.561	0.011	Accept	3.057	0.000	Reject	3.831	0.000	Reject
5. Denmark	5	25	0.690	0.602	Accept	2.469	0.035	Accept	1.613	0.128	Accept
6. Finland	9	45	3.056	0.003	Reject	3.059	0.000	Reject	3.155	0.000	Reject
7. France	9	61	4.102	0.000	Reject	3.518	0.000	Reject	4.897	0.000	Reject
8. Germany	6	25	2.441	0.043	Accept	1.486	0.163	Accept	1.123	0.354	Accept
9. Hong Kong	8	46	3.623	0.001	Reject	4.868	0.000	Reject	4.233	0.000	Reject
10. Iceland	4	25	5.954	0.002	Reject	4.937	0.005	Reject	8.997	0.000	Reject
11. Ireland	4	24	2.808	0.053	Accept	2.771	0.055	Accept	3.766	0.005	Reject
12. Israel	6	25	2.225	0.062	Accept	3.230	0.002	Reject	3.475	0.000	Reject
13. Italy	6	25	1.483	0.207	Accept	2.845	0.005	Reject	2.547	0.005	Reject
14. Japan	8	46	4.523	0.000	Reject	4.526	0.000	Reject	4.177	0.000	Reject
15. Luxembourg	6	25	2.133	0.072	Accept	1.050	0.412	Accept	1.817	0.050	Accept
16. Netherlands	5	25	1.041	0.395	Accept	0.897	0.503	Accept	1.541	0.151	Accept
17. New Zealand	6	33	1.509	0.194	Accept	3.225	0.001	Reject	3.590	0.000	Reject

Table 4 (continued)

Country	n	T	Static LA-AIDS model								
			Homogeneity			Symmetry			Homogeneity and Symmetry		
			Test statistic	*p*-value	Decision	Test statistic	*p*-value	Decision	Test statistic	*p*-value	Decision
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
18. Norway	9	50	4.179	0.000	Reject	3.590	0.000	Reject	4.119	0.000	Reject
19. Singapore	8	54	2.659	0.011	Accept	3.224	0.000	Reject	3.637	0.000	Reject
20. Slovenia	6	25	2.335	0.051	Accept	2.195	0.028	Accept	2.469	0.006	Reject
21. South Korea	8	50	5.173	0.000	Reject	3.618	0.000	Reject	3.473	0.000	Reject
22. Spain	5	25	3.081	0.023	Accept	2.470	0.035	Accept	4.204	0.000	Reject
23. Sweden	6	27	2.944	0.018	Accept	2.302	0.020	Accept	2.684	0.003	Reject
24. Switzerland	6	25	1.276	0.285	Accept	1.615	0.121	Accept	1.881	0.041	Accept
25. Taiwan	8	55	2.924	0.006	Reject	3.157	0.000	Reject	3.651	0.000	Reject
26. UK	6	25	1.938	0.099	Accept	2.549	0.011	Accept	2.444	0.007	Reject
27. USA	9	50	2.716	0.007	Reject	4.338	0.000	Reject	4.551	0.000	Reject
% of rejection (developed countries)					*37%*			*56%*			*78%*
Developing countries											
28. Czech Republic	5	25	1.439	0.234	Accept	1.069	0.392	Accept	1.576	0.139	Accept
29. Estonia	5	25	3.626	0.011	Accept	3.349	0.007	Reject	2.596	0.012	Accept

Table 4 (continued)

Country	n	T	Static LA-AIDS model								
			Homogeneity			Symmetry			Homogeneity and Symmetry		
			Test statistic	*p*-value	Decision	Test statistic	*p*-value	Decision	Test statistic	*p*-value	Decision
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
30. Greece	4	25	2.127	0.113	Accept	0.139	0.936	Reject	3.070	0.015	Accept
31. Hungary	5	25	3.451	0.014	Accept	2.031	0.077	Accept	2.873	0.006	Reject
32. India	8	46	3.240	0.003	Reject	3.916	0.000	Reject	4.393	0.000	Reject
33. Latvia	4	25	4.128	0.013	Accept	1.781	0.167	Accept	2.861	0.021	Accept
34. Lithuania	6	25	1.629	0.164	Accept	1.299	0.249	Accept	1.907	0.038	Accept
35. Poland	6	25	1.095	0.371	Accept	1.567	0.134	Accept	1.648	0.084	Accept
36. Portugal	4	25	2.133	0.112	Accept	1.701	0.183	Accept	4.485	0.002	Reject
37. Slovakia	6	25	2.448	0.042	Accept	1.732	0.091	Accept	1.899	0.038	Accept
38. South Africa	9	40	3.077	0.003	Reject	2.216	0.001	Reject	2.5.77	0.000	Reject
39. Sri Lanka	8	42	2.610	0.014	Accept	2.754	0.000	Reject	2.683	0.000	Reject
40. Thailand	8	49	3.483	0.001	Reject	4.749	0.000	Reject	4.285	0.000	Reject
% of rejection (developing countries)					*23%*			*46%*			*46%*
% of rejection (all countries)					*33%*			*53%*			*68%*

Hypothesis testing results for Hong Kong, the USA, South Africa and Sri Lanka are based on nonlinear Static LA-AIDS model estimation results

Table 5 Hypothesis testing results: Dynamic LA-AIDS model

Country	n	T	Dynamic LA-AIDS model								
			Homogeneity			Symmetry			Homogeneity and Symmetry		
			Test statistic	p-value	Decision	Test statistic	p-value	Decision	Test statistic	p-value	Decision
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Developed countries											
1. Australia	9	35	1.283	0.260	Accept	1.156	0.293	Accept	1.348	0.123	Accept
2. Austria	6	25	0.969	0.447	Accept	1.323	0.248	Accept	1.286	0.251	Accept
3. Belgium	5	25	2.873	0.035	Accept	1.383	0.246	Accept	2.242	0.035	Accept
4. Canada	9	39	1.756	0.091	Accept	1.347	0.135	Accept	1.816	0.008	Reject
5. Denmark	5	25	0.652	0.629	Accept	0.792	0.582	Accept	1.232	0.302	Accept
6. Finland	9	45	2.251	0.026	Accept	1.579	0.041	Accept	1.783	0.008	Accept
7. France	9	61	1.654	0.109	Accept	2.0291	0.002	Reject	1.881	0.003	Reject
8. Germany	6	25	1.452	0.225	Accept	1.039	0.428	Accept	0.810	0.661	Accept
9. Hong Kong	8	46	2.252	0.033	Accept	2.084	0.006	Reject	1.955	0.005	Reject
10. Iceland	4	25	4.291	0.012	Accept	2.796	0.057	Accept	5.409	0.001	Reject
11. Ireland	4	24	2.564	0.075	Accept	2.732	0.063	Accept	3.615	0.009	Reject
12. Israel	6	25	1.279	0.290	Accept	1.347	0.236	Accept	1.345	0.218	Accept
13. Italy	6	25	1.492	0.212	Accept	1.254	0.285	Accept	1.748	0.076	Accept
14. Japan	8	46	2.870	0.007	Reject	2.360	0.001	Reject	3.363	0.000	Reject
15. Luxembourg	6	25	1.246	0.304	Accept	0.612	0.795	Accept	1.258	0.268	Accept

Table 5 (continued)

Country	n	T	Dynamic LA-AIDS model								
			Homogeneity			Symmetry			Homogeneity and Symmetry		
			Test statistic	p-value	Decision	Test statistic	p-value	Decision	Test statistic	p-value	Decision
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
16. Netherlands	5	25	0.298	0.878	Accept	0.904	0.502	Accept	0.684	0.732	Accept
17. New Zealand	6	33	1.485	0.205	Accept	0.911	0.528	Accept	1.559	0.106	Accept
18. Norway	9	50	1.935	0.056	Accept	1.496	0.060	Accept	1.867	0.004	Reject
19. Singapore	8	54	1.056	0.393	Accept	1.693	0.033	Accept	1.862	0.007	Reject
20. Slovenia	6	25	1.400	0.243	Accept	0.839	0.595	Accept	1.520	0.140	Accept
21. South Korea	8	50	3.698	0.001	Reject	2.592	0.000	Reject	2.486	0.000	Reject
22. Spain	5	25	1.882	0.133	Accept	1.066	0.399	Accept	1.722	0.110	Accept
23. Sweden	6	27	2.173	0.071	Accept	2.111	0.040	Accept	2.711	0.004	Reject
24. Switzerland	6	25	0.351	0.879	Accept	0.377	0.950	Accept	0.660	0.807	Accept
25. Taiwan	8	55	1.131	0.344	Accept	1.301	0.176	Accept	1.285	0.163	Accept
26. UK	6	25	1.539	0.198	Accept	1.499	0.172	Accept	1.576	0.121	Accept
27. USA	9	50	2.155	0.032	Accept	1.730	0.017	Accept	2.084	0.001	Reject
% of rejection (developed countries)					*7%*			*15%*			*41%*

Table 5 (continued)

Country	n	T	Dynamic LA-AIDS model								
			Homogeneity			Symmetry			Homogeneity and Symmetry		
			Test statistic	p-value	Decision	Test statistic	p-value	Decision	Test statistic	p-value	Decision
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Developing countries											
28. Czech Republic	5	25	0.182	0.947	Accept	0.645	0.693	Accept	0.573	0.826	Accept
29. Estonia	5	25	0.940	0.451	Accept	1.181	0.336	Accept	1.345	0.242	Accept
30. Greece	4	25	1.530	0.227	Accept	0.447	0.721	Accept	0.834	0.553	Accept
31. Hungary	5	25	2.298	0.076	Accept	0.898	0.505	Accept	1.639	0.132	Accept
32. India	8	46	2.086	0.048	Accept	1.577	0.059	Accept	1.911	0.007	Reject
33. Latvia	4	25	1.286	0.297	Accept	0.940	0.433	Accept	1.153	0.357	Accept
34. Lithuania	6	25	1.213	0.319	Accept	1.044	0.425	Accept	1.493	0.150	Accept
35. Poland	6	25	1.016	0.420	Accept	1.778	0.093	Accept	1.544	0.131	Accept
36. Portugal	4	25	1.282	0.298	Accept	2.766	0.059	Accept	2.890	0.024	Accept
37. Slovakia	6	25	1.082	0.384	Accept	0.582	0.820	Accept	0.771	0.701	Accept
38. South Africa	9	40	1.577	0.138	Accept	1.106	0.341	Accept	1.203	0.225	Accept
39. Sri Lanka	8	42	1.222	0.295	Accept	0.757	0.766	Accept	0.965	0.522	Accept

Table 5 (continued)

Country	n	T	Dynamic LA-AIDS model								
			Homogeneity			Symmetry			Homogeneity and Symmetry		
			Test statistic	p-value	Decision	Test statistic	p-value	Decision	Test statistic	p-value	Decision
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
40. Thailand	8	49	2.755	0.010	Accept	3.388	0.000	Reject	2.673	0.000	Reject
% of rejection (developing countries)					*0%*			*8%*			*15%*
% of rejection (all countries)					*5%*			*13%*			*33%*

Hypothesis testing results for Hong Kong, the USA, South Africa and Sri Lanka are based on nonlinear Dynamic LA-AIDS model estimation results

Table 6 Hypothesis testing results: EC-LA-AIDS model

Country	n	T	EC-LA-AIDS model								
			Homogeneity			Symmetry			Homogeneity and Symmetry		
			Test statistic	*p*-value	Decision	Test statistic	*p*-value	Decision	Test statistic	*p*- value	Decision
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Developed countries											
1. Australia	9	35	1.837	0.074	Accept	2.372	0.000	Reject	2.775	0.000	Reject
2. Austria	6	25	0.450	0.812	Accept	1.290	0.257	Accept	1.273	0.248	Accept
3. Belgium	5	25	2.439	0.060	Accept	1.099	0.377	Accept	2.205	0.033	Accept
4. Canada	9	39	0.929	0.494	Accept	2.471	0.000	Reject	1.478	0.051	Accept
5. Denmark	5	25	1.176	0.333	Accept	1.523	0.191	Accept	1.487	0.174	Accept
6. Finland	9	45	2.302	0.022	Accept	2.012	0.003	Reject	2.006	0.001	Reject
7. France	9	61	2.361	0.018	Accept	1.218	0.210	Accept	1.531	0.030	Accept
8. Germany	6	25	2.235	0.062	Accept	1.555	0.143	Accept	1.427	0.164	Accept
9. Hong Kong	8	46	2.543	0.016	Accept	1.984	0.008	Reject	2.144	0.001	Reject
10. Iceland	4	25	2.725	0.059	Accept	1.923	0.144	Accept	3.898	0.005	Reject
11. Ireland	4	24	2.512	0.076	Accept	3.528	0.026	Accept	2.148	0.075	Accept
12. Israel	6	25	1.817	0.123	Accept	2.237	0.027	Accept	2.277	0.013	Accept
13. Italy	6	25	1.533	0.193	Accept	2.063	0.042	Accept	2.354	0.010	Accept
14. Japan	8	46	2.519	0.017	Accept	2.775	0.000	Reject	3.197	0.000	Reject
15. Luxembourg	6	25	1.318	0.269	Accept	0.996	0.457	Accept	1.565	0.112	Accept
16. Netherlands	5	25	1.062	0.386	Accept	0.798	0.576	Accept	0.972	0.480	Accept
17. New Zealand	6	33	1.468	0.208	Accept	1.559	0.132	Accept	1.171	0.309	Accept

Table 6 (continued)

Country	n	T	EC-LA-AIDS model								
			Homogeneity			Symmetry			Homogeneity and Symmetry		
			Test statistic	*p*-value	Decision	Test statistic	*p*-value	Decision	Test statistic	*p*- value	Decision
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
18. Norway	9	50	3.018	0.003	Reject	1.879	0.006	Reject	2.186	0.000	Reject
19. Singapore	8	54	1.187	0.311	Accept	1.611	0.047	Accept	1.637	0.026	Accept
20. Slovenia	6	25	2.077	0.081	Accept	1.742	0.092	Accept	1.646	0.088	Accept
21. South Korea	8	50	2.489	0.018	Accept	3.006	0.000	Reject	2.837	0.000	Reject
22. Spain	5	25	1.860	0.133	Accept	1.780	0.123	Accept	2.266	0.029	Accept
23. Sweden	6	27	2.101	0.076	Accept	1.743	0.089	Accept	2.221	0.014	Accept
24. Switzerland	6	25	0.999	0.426	Accept	0.943	0.502	Accept	1.015	0.453	Accept
25. Taiwan	8	55	2.174	0.037	Accept	1.965	0.008	Reject	1.838	0.008	Reject
26. UK	6	25	0.767	0.577	Accept	2.062	0.042	Accept	1.980	0.032	Accept
27. USA	9	50	2.171	0.030	Accept	2.493	0.000	Reject	2.673	0.000	Reject
% of rejection (Developed countries)					*4%*			*33%*			*33%*

Table 6 (continued)

Country	n	T	EC-LA-AIDS model								
			Homogeneity			Symmetry			Homogeneity and Symmetry		
			Test statistic	*p*-value	Decision	Test statistic	*p*-value	Decision	Test statistic	*p*- value	Decision
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Developing countries											
28. Czech Republic	5	25	0.649	0.630	Accept	1.392	0.237	Accept	1.187	0.323	Accept
29. Estonia	5	25	2.473	0.057	Accept	2.443	0.038	Accept	1.885	0.071	Accept
30. Greece	4	25	0.782	0.512	Accept	0.485	0.695	Accept	0.707	0.646	Accept
31. Hungary	5	25	2.152	0.089	Accept	0.936	0.478	Accept	1.401	0.208	Accept
32. India	8	46	0.830	0.564	Accept	2.161	0.003	Reject	1.822	0.010	Accept
33. Latvia	4	25	2.122	0.116	Accept	1.123	0.353	Accept	1.379	0.251	Accept
34. Lithuania	6	25	0.510	0.768	Accept	1.948	0.056	Accept	1.494	0.137	Accept
35. Poland	6	25	0.940	0.462	Accept	1.029	0.431	Accept	1.224	0.280	Accept
36. Portugal	4	25	0.722	0.546	Accept	1.291	0.293	Accept	1.185	0.337	Accept
37. Slovakia	6	25	1.878	0.112	Accept	1.573	0.137	Accept	1.780	0.059	Accept
38. South Africa	9	40	2.409	0.017	Accept	1.633	0.030	Accept	1.513	0.006	Reject
39. Sri Lanka	8	42	1.343	0.233	Accept	1.576	0.060	Accept	1.796	0.013	Accept
40. Thailand	8	49	2.208	0.035	Accept	2.574	0.000	Reject	2.112	0.002	Reject
% of rejection (Developing countries)					*0%*			*15%*			*15%*
% of rejection (All countries)					*2%*			*28%*			*28%*

Hypothesis testing results for Hong Kong, the USA, South Africa and Sri Lanka are based on nonlinear Static LA-AIDS model estimation results

Table 7 Percentage of acceptance (100 – percentage rejections)

	Homogeneity			Symmetry			Homogeneity and Symmetry		
	Developed (%)	Developing (%)	All (%)	Developed (%)	Developing (%)	All (%)	Developed (%)	Developing (%)	All (%)
Static LA-AIDS	63	77	**67**	44	54	**47**	22	54	**32**
Dynamic LA-AIDS	93	100	**95**	85	92	**87**	59	85	**67**
EC LA-AIDS	96	100	**98**	67	85	**72**	67	85	**72**

Table 8 Information inaccuracies

Country	Static LA-AIDS	Restrictions	Dynamic LA-AIDS (DAIDS)	Restrictions	EC-LA-AIDS (EC-AIDS)	Restrictions	Preferred Model
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Developed countries							
1. Australia	728.9	UR	442.9	H&S	486.2	H	DAIDS-H&S
2. Austria	70.1	H&S	39.7	H&S	40.2	H&S	DAIDS-H&S
3. Belgium	75.4	H	68.6	H&S	61.9	H&S	EC-AIDS-H&S
4. Canada	94.0	H	26.6	H	98.6	H&S	DAIDS-H
5. Denmark	190.7	H&S	77.0	H&S	81.1	H&S	DAIDS-H&S
6. Finland	217.0	UR	130.0	H&S	163.2	H	DAIDS-H&S
7. France	122.7	UR	57.7	H	94.9	H&S	DAIDS-H
8. Germany	115.8	H&S	64.8	H&S	106.4	H&S	DAIDS-H&S
9. Hong Kong	683.6	UR	509	H	509.9	H	DAIDS-H
10. Iceland	123.8	UR	159.3	H	115.6	H	EC-AIDS-H
11. Ireland	251.2	H	158.6	H	184.8	H&S	DAIDS-H
12. Israel	98.5	H	83.9	H&S	94.1	H&S	DAIDS-H&S
13. Italy	37.0	H	33.3	H&S	50.0	H&S	DAIDS-H&S
14. Japan	234.0	UR	99.9	UR	135.3	H	DAIDS-UR
15. Luxembourg	278.6	H&S	175.8	H&S	199.2	H&S	DAIDS-H&S
16. Netherlands	744.6	H&S	222.3	H&S	270.6	H&S	DAIDS-H&S
17. New Zealand	176.2	H	97.0	H&S	112.9	H&S	DAIDS-H&S
18. Norway	278.9	UR	110.9	H	134.0	UR	DAIDS-H

Table 8 (continued)

Country	Static LA-AIDS	Restrictions	Dynamic LA-AIDS (DAIDS)	Restrictions	EC-LA-AIDS (EC-AIDS)	Restrictions	Preferred Model
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
19. Singapore	1295.5	H	452.6	H	670.8	H&S	DAIDS-H
20. Slovenia	84.9	H	78.8	H&S	114.7	H&S	DAIDS-H&S
21. South Korea	1097.7	UR	258.3	UR	410.1	H	DAIDS-UR
22. Spain	142.9	H	67.5	H&S	61.4	H&S	EC-AIDS-H&S
23. Sweden	84.8	H	33.5	H	84.7	H&S	DAIDS-H
24. Switzerland	319.8	H&S	58.9	H&S	51.2	H&S	EC-AIDS-H&S
25. Taiwan	1126.9	UR	438.7	H&S	448.8	H	DAIDS-H&S
26. UK	62.5	H	59.1	H&S	72.0	H&S	DAIDS-H&S
27. USA	66.3	UR	36.3	H	38.4	H	DAIDS-H
Developing countries							
28. Czech Republic	216.4	H&S	91.4	H&S	111.7	H&S	DAIDS-H&S
29. Estonia	528.7	H&S	136.9	H&S	218.4	H&S	DAIDS-H&S
30. Greece	629.2	H&S	256.1	H&S	268.2	H&S	DAIDS-H&S
31. Hungary	230.5	H	120.1	H&S	125.1	H&S	DAIDS-H&S
32. India	707.5	UR	432.8	H	696.7	H&S	DAIDS-H
33. Latvia	703.8	H&S	319.7	H&S	292.2	H&S	EC-AIDS-H&S
34. Lithuania	725.7	H&S	455.2	H&S	364.9	H&S	EC-AIDS-H&S
35. Poland	342.9	H&S	166.3	H&S	190.0	H&S	DAIDS-H&S

Table 8 (continued)

Country	Static LA-AIDS	Restrictions	Dynamic LA-AIDS (DAIDS)	Restrictions	EC-LA-AIDS (EC-AIDS)	Restrictions	Preferred Model
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
36. Portugal	74.4	H	98.8	H&S	65.6	H&S	EC-AIDS-H&S
37. Slovakia	728.9	H&S	442.9	H&S	486.2	H&S	DAIDS-H&S
38. South Africa	383.8	UR	303.3	H&S	360.9	H	DAIDS-H&S
39. Sri Lanka	2284	H	1671	H&S	2231.6	H&S	DAIDS-H&S
40. Thailand	2326.8	UR	785.4	H	1281.6	H	DAIDS-H

UR Unrestricted; *H* Homogeneity; *S* Symmetry; and *H&S* Homogeneity and symmetry. These models (UR or H or S or H&S) were selected based on the hypothesis testing results presented in Tables 5, 6, 7. Entries in columns 2, 4 and 6 are multiplied by 10^6

5.3 Selecting the preferred model using information inaccuracy

To select the preferred model among the three versions of AIDS, we use the budget shares predicted by the three models. To measure the quality of the predictions, we use the concept from information theory, called the *information inaccuracy*. This measure has been extensively used in the literature (see, for example, Jayasinghe et al. 2019; Selvanathan and Selvanathan 2005; Theil 1996) and is well suited to analyse the fit of allocation models such as ours. In general, if we have n goods with budget share predictions $\hat{w}_{1t},\ldots,\hat{w}_{nt}$, the information inaccuracy of these predictions is defined as

$$I_t = \sum_{i=1}^{n} w_{it} \log \frac{w_{it}}{\hat{w}_{it}} \tag{8}$$

where $\widehat{w}_{it} = w_{it} - e_{it}$.

When predictions are perfect (i.e. $\hat{w}_{it} = w_{it}$, $i = 1,\ldots,n$), $I_t = 0$; otherwise, $I_t > 0$. Therefore, the smaller the information inaccuracy, the better the predictions. Consequently, the preferred demand system would be the one with the lowest value of information inaccuracy. If we define $e_{it} = \log(w_{it}/\hat{w}_{it})$ as the relative error, then $I_t = \sum_{i=1}^{n} w_{it} e_{it}$ can be interpreted as the Divisia mean (i.e. the budget-share-weighted mean) of the relative errors. Thus, $I_t \times 100$ is approximately equal to the weighted average percentage error.

Table 8 presents the information inaccuracies for each model, calculated based on Eq. (8). The column (8) of Table 8 gives the preferred model among the three models with appropriate restrictions for each country. As can be seen, based on information inaccuracies, for 80% of the countries, the preferred model among the three versions of AIDS is the Dynamic LA-AIDS model and EC-LA-AIDS for the remaining 20% of the countries. Static LA-AIDS is not preferred by any country.

5.4 Implied income and price elasticities

Tables 9 and 10 present the short-run and long-run income elasticities, and Tables 11 and 12 present the short-run and long-run own-price elasticities for the individual countries based on the preferred models reported in the last column of Table 8.

Table 13 presents a summary for the short-run and long-run income elasticities, and Table 14 presents a summary for the short-run and long-run price elasticities. As can be seen, in the short-run as well as in the long-run, across all countries, food and housing are necessities (less than 1); durables, transport and recreation are luxuries (greater than 1). In the short-run, clothing is a luxury for developed countries and a necessity for developing countries, while in the long-run it is a necessity for all countries. Medical is a necessity in the short-run and a luxury in the long-run. Restaurant is a luxury in the short-run for all countries, and in the long-run, it is a luxury for developing countries but a necessity for the developed countries. In the short-run, there is no difference in the characteristics of the commodities (food, housing, medical are necessities, and durables, transport, recreation and restaurant meals are luxuries) in developing and developed countries, except clothing, which is a luxury for developed countries and a

Table 9 Short-run income elasticities

Country (1)	Food (2)	Clothing (3)	Housing (4)	Durables (5)	Medical (6)	Transport (7)	Recreation (8)	Restaurant (9)	Miscellaneous (10)
Developed Countries									
1. Australia	0.510	0.797	0.664	0.713	1.022	1.592	1.086	1.547	1.222
2. Austria	0.652	–	0.846	0.689	0.796	1.710	–	–	1.154
3. Belgium	0.545	–	0.715	–	1.864	1.522	–	–	1.241
4. Canada	0.458	1.057	0.367	1.556	0.833	1.836	0.881	1.217	1.413
5. Denmark	0.666	–	0.631	–	0.569	2.239	–	–	1.094
6. Finland	0.460	1.327	0.382	1.627	1.103	1.992	1.464	1.455	0.693
7. France	0.374	0.880	0.710	1.202	0.416	1.628	1.521	1.145	1.420
8. Germany	1.053		0.610	1.128	0.798	0.986	–	–	1.305
9. Hong Kong	0.847	3.433	0.429	2.359	1.217	1.135	0.758	–	1.279
10. Iceland	0.810	–	1.094	–	1.084	–	–	–	1.061
11. Ireland	0.838	–	1.052	–	0.384	–	–	–	1.069
12. Israel	0.617	–	0.586	1.696	1.244	1.755	–	–	1.012
13. Italy	0.776	–	0.106	1.527	1.596	1.364	–	–	1.555
14. Japan	0.563	1.311	0.564	1.910	1.018	1.355	1.696	–	0.942
15. Luxembourg	0.972	–	1.036	0.657	0.069	0.886	–	–	1.241
16. Netherlands	0.903	–	0.651	–	0.992	1.432	–	–	1.148
17. New Zealand	1.005	–	0.681	1.680	0.875	0.976	–	–	1.191
18. Norway	0.406	1.233	0.481	1.347	0.248	2.313	1.031	0.938	0.894
19. Singapore	0.557	0.857	0.368	0.711	0.768	1.194	1.449	–	1.390

Table 9 (continued)

Country	Food	Clothing	Housing	Durables	Medical	Transport	Recreation	Restaurant	Miscellaneous
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
20. Slovenia	0.754	–	–	0.704	1.100	0.615	1.195	–	1.369
21. South Korea	0.742	1.332	0.797	0.654	0.376	1.317	0.943	–	1.401
22. Spain	0.787	–	0.801	–	0.911	1.620	–	–	1.144
23. Sweden	0.860	–	0.566	2.879	– 0.509	1.646	–	–	0.998
24. Switzerland	1.236	–	1.222	1.201	0.755	0.998	–	–	0.819
25. Taiwan	0.698	1.119	0.830	1.333	1.183	1.260	1.040	–	1.242
26. UK	0.680	–	0.908	1.003	2.557	0.938	–	–	1.261
27. USA	0.305	0.861	0.488	1.615	0.456	2.182	1.355	0.740	1.435
Developing Countries									
28. Czech Republic	0.842	–	0.695	–	1.711	1.970	–	–	1.027
29. Estonia	0.987	–	0.731	–	0.948	1.190	–	–	1.186
30. Greece	0.754	–	0.649	–	1.992	–	–	–	1.333
31. Hungary	0.800	–	1.012	–	0.515	1.228	–	–	1.193
32. India	0.690	1.508	0.693	1.750	0.798	1.199	1.080	–	2.495
33. Latvia	0.718	–	0.630	–	1.445	–	–	–	1.494
34. Lithuania	0.924	–	0.653	1.163	0.676	0.883	–	–	1.529
35. Poland	0.966	–	0.845	1.246	1.123	1.144	–	–	1.024
36. Portugal	1.014	–	0.314	–	0.848	–	–	–	1.349
37. Slovakia	1.023	–	1.409	1.568	– 0.678	0.669	–	–	0.778

Table 9 (continued)

Country (1)	Food (2)	Clothing (3)	Housing (4)	Durables (5)	Medical (6)	Transport (7)	Recreation (8)	Restaurant (9)	Miscellaneous (10)
38. South Africa	0.808	0.972	0.968	1.472	0.711	1.901	0.944	1.103	0.416
39. Sri Lanka	0.288	0.880	0.448	1.615	0.488	2.206	1.356	–	1.436
40. Thailand	0.723	0.993	1.290	0.681	1.393	1.174	1.259	–	0.835

Table 10 Long–run income elasticities

Country	Food	Clothing	Housing	Durables	Medical	Transport	Recreation	Restaurant	Miscellaneous
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Developed Countries									
1. Australia	0.491	0.777	0.506	0.187	0.317	1.941	1.292	2.247	1.061
2. Austria	0.598	–	0.910	0.569	0.993	2.082	–	–	0.957
3. Belgium	0.593	–	0.764	–	1.662	1.508	–	–	1.196
4. Canada	0.337	0.734	0.257	1.492	1.276	1.686	1.724	1.184	1.350
5. Denmark	0.702	–	0.417	–	0.620	2.183	–	–	1.334
6. Finland	0.288	0.879	1.302	0.531	0.821	1.172	1.399	0.828	1.698
7. France	0.472	0.268	1.448	1.024	0.946	1.300	1.350	0.295	1.284
8. Germany	1.102	–	0.506	1.325	0.565	0.918	–	–	1.388
9. Hong Kong	0.827	0.837	0.603	3.349	1.183	1.048	0.865	–	0.755
10. Iceland	1.111	–	0.928	–	0.547	–	–	–	1.002
11. Ireland	0.821	–	1.066	–	0.873	–	–	–	1.032
12. Israel	0.448	–	0.621	1.208	1.176	1.544	–	–	1.438
13. Italy	0.870	–	0.315	1.493	1.238	1.683	–	–	1.130
14. Japan	0.036	0.315	1.301	0.431	1.339	1.535	1.518	–	1.260
15. Luxembourg	0.999	–	1.059	0.771	0.164	0.933	–	–	1.124
16. Netherlands	0.754	–	0.562	–	3.286	1.576	–	–	0.967
17. New Zealand	1.031	–	0.628	1.320	0.455	1.115	–	–	1.252
18. Norway	0.415	1.424	0.242	1.411	0.086	2.319	1.555	0.613	0.828
19. Singapore	0.269	0.626	0.896	0.660	1.307	1.311	1.373	–	1.223

Table 10 (continued)

Country (1)	Food (2)	Clothing (3)	Housing (4)	Durables (5)	Medical (6)	Transport (7)	Recreation (8)	Restaurant (9)	Miscellaneous (10)
20. Slovenia	0.670	–	0.654	1.004	0.918	1.284	–	–	1.412
21. South Korea	0.311	0.977	1.005	0.931	1.238	1.309	1.499	–	1.395
22. Spain	0.851	–	0.779	–	0.751	1.357	–	–	1.256
23. Sweden	0.917	–	0.476	3.175	0.304	0.914	–	–	1.351
24. Switzerland	1.406	–	1.457	0.411	1.421	0.546	–	–	0.562
25. Taiwan	0.493	1.066	0.792	1.310	1.027	1.989	1.169	–	0.877
26. UK	0.391	–	0.551	1.433	2.405	1.038	–	–	1.661
27. USA	0.556	0.852	0.511	1.276	0.713	1.678	1.135	1.272	1.473
Developing Countries									
28. Czech Republic	0.623	–	0.684	–	2.055	1.970	–	–	1.320
29. Estonia	0.805	–	1.006	–	1.153	1.047	–	–	1.245
30. Greece	0.857	–	0.233	–	2.575	–	–	–	1.428
31. Hungary	0.437	–	1.032	–	0.964	1.712	–	–	1.243
32. India	0.725	1.429	0.567	1.662	0.913	1.138	1.289	–	2.570
33. Latvia	0.361	–	1.093	–	2.197	–	–	–	1.474
34. Lithuania	0.587	–	0.431	1.658	0.957	1.477	–	–	1.644
35. Poland	0.632	–	0.734	1.804	1.917	1.286	–	–	1.215
36. Portugal	1.134	–	0.323	–	1.200	–	–	–	1.218
37. Slovakia	0.870	–	1.842	1.491	– 0.049	0.746	–	–	0.450

Table 10 (continued)

Country	Food	Clothing	Housing	Durables	Medical	Transport	Recreation	Restaurant	Miscellaneous
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
38. South Africa	0.295	0.849	0.953	1.439	0.717	1.466	0.811	1.232	1.469
39. Sri Lanka	0.308	1.080	1.466	0.622	1.040	1.229	0.911	–	0.788
40. Thailand	0.658	0.994	0.904	1.203	1.323	1.482	0.999	–	1.532

Table 11 Short-run price elasticities

Country (1)	Food (2)	Clothing (3)	Housing (4)	Durables (5)	Medical (6)	Transport (7)	Recreation (8)	Restaurant (9)	Miscellaneous (10)
Developed countries									
1. Australia	− 0.521	− 0.719	− 0.321	− 0.095	− 0.871	− 0.191	− 0.640	− 0.644	− 0.921
2. Austria	− 0.048	–	− 0.345	− 1.395	− 0.994	− 1.143	–	–	− 1.050
3. Belgium	− 0.196	–	− 0.258	–	− 0.509	− 0.513	–	–	− 0.347
4. Canada	− 0.529	− 1.075	− 0.471	− 1.152	− 1.652	− 0.555	− 0.193	− 0.858	− 0.226
5. Denmark	− 0.576	–	− 0.427	–	0.302	− 0.113	–	–	− 0.328
6. Finland	− 0.473	− 0.628	− 0.153	− 1.601	− 0.729	− 0.376	− 1.061	− 0.855	− 0.219
7. France	− 0.530	− 1.116	− 0.099	− 0.853	− 0.798	− 0.449	− 0.967	− 0.636	− 0.346
8. Germany	− 0.718	–	− 0.334	0.328	− 1.279	− 0.263	–	–	− 0.744
9. Hong Kong	− 0.772	− 1.289	− 0.724	− 1.052	− 1.035	− 1.010	− 0.926	–	− 0.779
10. Iceland	− 0.354	–	− 0.956	–	− 0.178	–	–	–	− 0.686
11. Ireland	− 1.219	–	− 1.024	–	− 0.408	–	–	–	− 1.308
12. Israel	− 0.277	–	− 0.131	− 0.300	0.976	0.343	–	–	− 0.148
13. Italy	− 0.644	–	− 0.080	− 0.220	− 0.360	− 0.876	–	–	− 0.667
14. Japan	− 0.477	− 0.402	− 0.198	− 0.910	− 0.645	− 0.874	− 0.737	–	–0.911
15. Luxembourg	− 0.644	–	− 1.037	− 0.346	− 1.574	0.356	–	–	− 0.258
16. Netherlands	− 0.634	–	− 0.162	–	− 0.550	− 0.498	–	–	− 0.276
17. New Zealand	− 0.669	–	− 0.602	− 0.283	− 0.996	− 0.859	–	–	− 0.390
18. Norway	− 0.599	− 0.928	− 0.701	− 1.389	− 0.805	− 0.899	− 0.865	− 0.797	− 0.554
19. Singapore	− 0.571	− 0.663	− 0.220	− 0.890	− 0.260	− 0.737	− 0.970	–	− 0.588

Table 11 (continued)

Country (1)	Food (2)	Clothing (3)	Housing (4)	Durables (5)	Medical (6)	Transport (7)	Recreation (8)	Restaurant (9)	Miscellaneous (10)
20. Slovenia	− 0.195	–	0.195	− 0.675	− 1.209	− 0.901	–	–	− 0.144
21. South Korea	− 0.521	− 0.019	− 0.199	− 0.535	− 1.172	− 0.734	− 0.992	–	− 2.068
22. Spain	− 0.941	–	− 0.073	–	− 0.763	− 0.700	–	–	− 1.134
23. Sweden	− 0.344	–	− 0.291	− 0.404	− 0.205	− 1.381	–	–	− 0.369
24. Switzerland	− 1.656	–	− 1.345	− 1.377	− 1.336	− 0.765	–	–	− 1.145
25. Taiwan	− 0.300	− 0.546	− 0.678	− 0.714	0.048	− 0.157	− 0.896	–	− 0.885
26. UK	− 0.748	–	− 0.515	− 1.734	− 1.471	− 0.653	–	–	− 0.843
27. USA	− 0.497	− 0.281	− 0.091	− 0.844	− 0.245	− 0.701	− 0.772	− 0.091	− 0.2555
Developing Countries									
28. Czech Republic	− 0.687	–	− 0.447	–	− 0.588	− 0.665	–	–	− 0.756
29. Estonia	− 0.578	–	− 0.605	–	0.324	− 0.370	–	–	− 0.408
30. Greece	− 0.242	–	0.311	–	− 0.744	–	–	–	0.473
31. Hungary	− 0.406	–	− 0.185	–	− 0.292	− 0.315	–	–	− 0.588
32. India	− 0.446	− 0.359	− 0.193	− 0.504	− 0.337	− 0.417	− 0.386	–	0.293
33. Latvia	− 0.444	–	− 0.512	–	− 0.132	–	–	–	− 0.657
34. Lithuania	− 0.607	–	− 0.480	− 0.052	− 0.319	− 0.636	–	–	− 0.393
35. Poland	− 0.372	–	0.053	0.404	− 1.344	− 0.758	–	–	− 0.831
36. Portugal	− 0.834	–	− 0.314	–	− 1.089	–	–	–	− 0.774
37. Slovakia	− 0.790	–	− 1.147	− 0.300	− 1.519	− 0.288	–	–	− 0.808

Table 11 (continued)

Country (1)	Food (2)	Clothing (3)	Housing (4)	Durables (5)	Medical (6)	Transport (7)	Recreation (8)	Restaurant (9)	Miscellaneous (10)
38. South Africa	− 0.498	− 1.012	− 0.969	− 0.992	− 0.916	− 1.044	− 0.946	− 0.991	− 0.905
39. Sri Lanka	− 0.549	− 998	− 1.025	− 0.976	− 0.994	− 1.010	− 0.984	–	− 0.999
40. Thailand	− 0.448	− 0.481	0.048	− 0.808	− 0.569	− 0.480	− 0.008	–	− 0.262

Table 12 Long-run price elasticities

Country	Food	Clothing	Housing	Durables	Medical	Transport	Recreation	Restaurant	Miscellaneous
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Developed Countries									
1. Australia	− 0.432	− 2.620	− 0.288	− 0.033	− 0.569	− 0.376	− 0.009	− 0.734	− 1.686
2. Austria	− 0.096	–	− 0.167	− 0.395	− 0.705	− 0.764	–	–	− 0.956
3. Belgium	− 0.404	–	− 0.004	–	− 0.314	0.165	–	–	− 0.534
4. Canada	− 0.570	− 1.408	− 0.542	0.419	− 0.320	− 0.525	− 1.046	− 0.645	− 0.045
5. Denmark	− 0.142	–	− 0.275	–	− 0.222	− 0.834	–	–	− 0.648
6. Finland	− 0.172	− 0.768	− 0.534	− 0.793	− 0.276	− 0.662	− 1.110	− 0.214	− 0.359
7. France	− 0.511	− 0.297	− 0.314	− 0.626	− 1.427	− 0.432	− 0.688	0.482	− 0.384
8. Germany	− 0.276	–	− 0.284	1.047	− 1.003	− 0.329	–	–	− 0.852
9. Hong Kong	− 0.762	− 0.292	− 0.214	− 0.684	− 0.580	− 0.184	− 0.778	–	− 0.203
10. Iceland	− 0.049	–	− 0.377	–	− 0.111	–	–	–	− 0.658
11. Ireland	− 1.216	–	− 0.879	–	− 0.613	–	–	–	− 1.021
12. Israel	− 0.076	–	− 0.190	− 0.136	0.422	0.042	–	–	− 0.295
13. Italy	− 0.319	–	0.080	− 0.252	− 0.156	− 1.124	–	–	− 0.740
14. Japan	− 0.531	− 0.084	− 0.117	− 0.862	− 0.171	− 0.590	− 1.515	–	− 1.119
15. Luxembourg	− 1.686	–	− 2.539	− 2.654	− 0.441	0.448	–	–	− 0.495
16. Netherlands	− 0.048	–	0.193	–	− 3.101	− 0.007	–	–	− 0.416
17. New Zealand	− 0.880	–	− 0.298	− 1.316	1.036	− 0.397	–	–	− 0.480
18. Norway	− 0.445	− 0.914	− 0.295	− 0.859	− 0.152	− 1.689	− 1.490	− 1.853	− 0.393
19. Singapore	− 0.429	− 0.515	− 0.021	− 0.748	− 0.026	− 0.583	− 0.582	–	− 1.041

Table 12 (continued)

Country (1)	Food (2)	Clothing (3)	Housing (4)	Durables (5)	Medical (6)	Transport (7)	Recreation (8)	Restaurant (9)	Miscellaneous (10)
20. Slovenia	− 0.610	–	− 0.039	− 0.241	− 1.525	− 0.773	–	–	− 0.459
21. South Korea	− 0.248	− 0.253	− 0.196	− 0.317	− 2.377	− 0.796	− 0.760	–	− 2.163
22. Spain	− 2.154	–	− 0.071	–	− 0.666	− 1.481	–	–	− 0.385
23. Sweden	− 0.092	–	− 0.208	− 0.259	0.168	− 2.209	–	–	− 0.829
24. Switzerland	− 1.522	–	− 1.311	− 1.259	− 0.849	− 0.778	–	–	− 0.930
25. Taiwan	0.112	− 0.366	− 0.515	− 0.587	0.133	− 1.017	− 0.525	–	− 1.580
26. UK	− 0.720	–	− 0.432	− 0.200	− 1.738	− 0.752	–	–	− 0.879
27. USA	− 0.782	− 0.941	− 0.669	− 1.001	− 0.607	− 1.025	− 0.995	0.915	− 1.045
Developing Countries									
28. Czech Republic	− 0.201	–	− 0.195	–	0.295	− 0.663	–	–	− 0.442
29. Estonia	− 0.257	–	− 1.273	–	0.689	− 0.508	–	–	− 0.150
30. Greece	− 0.366	–	0.974	–	− 0.699	–	–	–	0.165
31. Hungary	− 0.243	–	− 0.202	–	− 0.471	− 0.104	–	–	− 0.550
32. India	− 0.444	− 0.223	− 0.137	− 0.567	− 0.248	0.132	− 0.427	–	0.107
33. Latvia	− 0.383	–	− 0.798	–	− 0.906	–	–	–	− 0.570
34. Lithuania	− 0.372	–	− 0.465	− 0.034	− 0.397	− 0.526	–	–	− 0.625
35. Poland	− 0.283	–	0.109	0.089	− 0.542	− 0.779	–	–	− 0.978
36. Portugal	− 0.786	–	− 0.118	–	− 1.601	–	–	–	− 0.455
37. Slovakia	− 0.631	–	− 1.502	− 0.266	− 0.908	− 0.071	–	–	− 0.788

Table 12 (continued)

Country (1)	Food (2)	Clothing (3)	Housing (4)	Durables (5)	Medical (6)	Transport (7)	Recreation (8)	Restaurant (9)	Miscellaneous (10)
38. South Africa	− 0.487	− 0.280	− 0.445	− 0.890	− 0.475	− 0.081	− 0.767	− 0.054	− 0.238
39. Sri Lanka	− 0.515	− 0.744	− 0.656	− 0.879	− 0.666	− 0.338	− 0.962	–	− 0.304
40. Thailand	− 0.328	− 0.151	− 0.883	− 0.723	− 0.768	− 0.425	− 0.138	–	− 1.893

Table 13 Summary of short-run and long-run income elasticities

	Food	Clothing	Housing	Durables	Medical	Transport	Recreation	Restaurant	Miscellaneous
Short-run income elasticities									
Developed Countries									
Mean	0.706	1.292	0.676	1.342	0.879	1.460	1.202	1.174	1.185
SD	0.223	0.739	0.258	0.590	0.583	0.447	0.292	0.305	0.205
Median	0.698	1.119	0.658	1.333	0.875	1.432	1.141	1.181	1.222
Developing countries									
Mean	0.811	1.088	0.795	1.356	0.921	1.356	1.160	1.103	1.238
SD	0.196	0.284	0.309	0.362	0.667	0.499	0.184	0.000	0.495
Median	0.776	1.233	0.666	1.340	0.911	1.336	1.275	1.042	1.191
All Countries									
Mean	0.740	1.237	0.716	1.346	0.892	1.430	1.191	1.164	1.202
SD	0.218	0.645	0.278	0.536	0.604	0.457	0.264	0.280	0.322
Median	0.754	1.057	0.681	1.340	0.862	1.355	1.141	1.145	1.208
Long-run income elasticities									
Developed Countries									
Mean	0.658	0.796	0.761	1.205	1.023	1.439	1.353	1.073	1.195
SD	0.317	0.325	0.347	0.792	0.673	0.442	0.235	0.679	0.267
Median	0.598	0.837	0.654	1.208	0.946	1.357	1.373	1.006	1.252
Developing countries									
Mean	0.638	1.088	0.867	1.411	1.305	1.355	1.003	1.232	1.354
SD	0.247	0.247	0.451	0.398	0.708	0.347	0.206	0.000	0.485

Table 13 (continued)

	Food	Clothing	Housing	Durables	Medical	Transport	Recreation	Restaurant	Miscellaneous
Median	0.702	0.852	0.684	1.242	0.964	1.310	1.373	0.721	1.256
All countries									
Mean	0.651	0.874	0.796	1.257	1.115	1.415	1.259	1.096	1.247
SD	0.293	0.326	0.381	0.713	0.689	0.414	0.272	0.623	0.354
Median	0.628	0.852	0.749	1.293	1.010	1.357	1.292	1.184	1.254

Table 14 Summary of short-run and long-run price elasticities

	Food	Clothing	Housing	Durables	Medical	Transport	Recreation	Restaurant	Miscellaneous
Short-run price elasticities									
Developed Countries									
Mean	− 0.580	− 0.697	− 0.416	− 0.783	− 0.693	− 0.586	− 0.820	− 0.647	− 0.651
SD	0.322	0.384	0.363	0.540	0.601	0.417	0.242	0.290	0.444
Median	− 0.530	− 0.663	− 0.321	− 0.844	− 0.763	− 0.700	− 0.896	− 0.721	− 0.588
Developing countries									
Mean	− 0.531	− 249.963	− 0.420	− 0.461	− 0.655	− 0.598	− 0.581	− 0.991	− 0.509
SD	0.168	498.691	0.441	0.518	0.516	0.274	0.470	0.423	0.451
Median	− 0.576	− 0.628	− 0.291	− 0.779	− 0.645	− 0.683	− 0.926	− 0.717	− 0.588
All Countries									
Mean	− 0.564	− 67.168	− 0.418	− 0.702	− 0.681	− 0.589	− 0.756	− 0.696	− 0.605
SD	0.280	257.507	0.384	0.544	0.568	0.377	0.318	0.295	0.445
Median	− 0.530	− 0.663	− 0.328	− 0.761	− 0.737	− 0.653	− 0.896	− 0.797	− 0.623
Long-run price elasticities									
Developed Countries									
Mean	− 0.558	− 0.769	− 0.389	− 0.578	− 0.543	− 0.701	− 0.853	− 0.342	− 0.763
SD	0.543	0.728	0.528	0.736	0.825	0.632	0.399	0.980	0.480
Median	− 0.432	− 0.515	− 0.284	− 0.607	− 0.320	− 0.626	− 0.778	− 0.430	− 0.658
Developing countries									
Mean	− 0.407	− 0.350	− 0.430	− 0.467	− 0.515	− 0.336	− 0.574	− 0.054	− 0.517
SD	0.166	0.268	0.633	0.400	0.563	0.295	0.365	0.000	0.526

Table 14 (continued)

	Food	Clothing	Housing	Durables	Medical	Transport	Recreation	Restaurant	Miscellaneous
Median	− 0.366	− 0.366	− 0.275	− 0.684	− 0.276	− 0.662	− 0.778	0.134	− 0.550
All Countries									
Mean	− 0.509	− 0.657	− 0.402	− 0.549	− 0.534	− 0.594	− 0.787	− 0.300	− 0.683
SD	0.458	0.656	0.556	0.660	0.743	0.575	0.399	0.901	0.502
Median	− 0.417	− 0.366	− 0.286	− 0.587	− 0.473	− 0.526	− 0.767	− 0.214	− 0.560

necessity for developing countries. In the long-run, for both groups of countries, food, clothing and housing are necessities and durables, medical, transport and recreation are luxuries; restaurant meals is a necessity for the developed countries and is a luxury for the developing countries. Irrespective of short-run or long-run and developed or developing countries, the demand for all goods is price inelastic (less than one in absolute value). Overall, our results are in line with those of many previous studies (see, for example, Bustamante and Shimoga 2018; Clements et al. 2006a, b; Clements, et al. 2020).

We carried out a meta-analysis of the income and own-price elasticities for 40 countries presented in Tables 9, 10, 11 and 12 to investigate the cross-country heterogeneity in the estimates.[7] The results indicate substantial heterogeneity in income and own-price elasticities in food, housing and medical between countries both in developed and developing country groups. However, the test of group differences indicates that the group-specific overall effect sizes are not statistically significantly different. The results also reveal substantial variability in the elasticity estimates by development status and level of inequality of countries. The boxplots of long-run income and price elasticity also reveal substantial variability in the elasticity estimates by development status and level of inequality of countries under consideration of this study.[8]

The relationship between price and income elasticities was first considered by Pigou (1910) and is associated with preference independence. Under preference independence, the consumers tastes can be described by a utility function which is the sum of n sub-utility functions, one for each commodity. Deaton (1974) showed that under preference independence, the own-price elasticities are approximately proportional to the income elasticities,

$$\eta_{ii} = \phi \eta_i$$

where ϕ is the income flexibility we introduced in Sect. 3. Several studies such as Clements et al. (1984), Theil (1980) and Selvanathan (1993) found that support for the above relationship with ϕ, generally, lies between -0.5 and -0.6.

Scatter plots[9] of the own-price elasticities against income elasticities for each of the 9 commodities individually and pooled across commodities demonstrate that there is a negative linear relationship between income and price elasticities. The slopes of the scatter diagrams, which are also the income flexibility ϕ, for the 9 commodities and pooled data are presented in Table 15. As can be seen, our estimates are also giving an overall average of -0.5 and closer to the value reported for ϕ in the above studies.

6 Concluding comments

It is well known that different commodities exhibit different income and price elasticities and that implied elasticities provide valuable information on consumption patterns

[7] Detailed results and plots are given in Appendix to this paper under supplementary materials.

[8] The boxplots are presented in Figures A10–A13 of Appendix under supplementary materials.

[9] The scatter plots are presented in Figure A14 of Appendix under supplementary materials.

Table 15 Income flexibility estimates

Commodity	Estimate of ϕ
Food	− 0.744
Clothing	− 0.670
Housing	− 0.552
Durables	− 0.316
Medical	− 0.445
Transport	− 0.410
Recreation	− 0.623
Restaurant	− 0.232
Miscellaneous	− 0.490
Average	− 0.498
Pooled data	− 0.451

which in turn influences policy, pricing and production decisions. To this end, this paper modelled the dynamic patterns of consumption behaviour using the most recent available time-series data of 40 developed and developing countries. The empirical analysis of this study involved an investigation of the empirical validity of homogeneity and symmetry constraints and model selection process based on the demand theory hypothesis testing and information inaccuracy estimations to select the preferred demand model out of a static and two dynamic versions of AIDS, namely Static LA-AIDS, Dynamic LA-AIDS and EC-LA-AIDS. The nonlinearities in consumption in countries with high-income inequality using QAIDS were also incorporated into the model estimations in this study. By doing so, this study contributed to the limited body of the literature on cross-country comparison of consumer demand patterns based on a dynamic demand system modelling approach. In particular, the dynamic demand modelling techniques facilitate distinguishing long- and short-run effects of income and prices on demand for various commodity groups. This study represents one of the few studies that provide a comparison of both long-run and short-run income and price elasticities for developed and developing countries.

Overall, the Dynamic LA-AIDS model appeared to be the preferred model for most countries, followed by the EC-LA-AIDS model. The implied elasticities reveal that, in general, there are some differences between the long-run/short-run elasticities and developed/developing countries. Such differences in long-run and short-run elasticities across countries must be acknowledged in the design of long-run policy instruments. This is because long-run policy instruments that rely on short-run implied elasticities lead to market distortions.

Further reinforcing the findings of previous studies, the results of the current study revealed some similarities in consumption patterns of consumers in developed and developing countries, such as food, clothing and housing being determined as necessities and durables, medical, transport and recreation being determined as luxuries, and the demand for all goods is price inelastic. On the other hand, some differences based

on country classification were also observed; in the long-run, restaurant meals are a necessity for developed countries and a luxury for developing countries; and in the short-run, clothing is a luxury for developed countries and a necessity for developing countries.

Through a rigorous analysis to identify the appropriate dynamic structure to represent data from 40 different countries, the current study provides new insight into the consumption patterns of consumers in different countries. The findings of this paper can be used as inputs by policy analysts and researchers since the knowledge of price and income responses is undoubtedly an important element in the formulation of fiscal policy or any other type of economic control. This is primarily because consumption absorbs more than 60% of GDP in most economies and is the largest macroeconomic aggregate; it thus has great significance for the state of an economy as a whole.

The study also reveals more advanced and reliable information for industries and businesses on the possible impact of changes in income and prices on consumer demand for various goods. For instance, as income growth is usually larger for poorer countries than for rich countries, and it is expected that the demand for durables, medical, transport and recreation in the future will grow faster for the developing countries than for the developed ones on a per capita basis. This boom in consumption thus will create exciting opportunities for business and investors in developing countries.

Moreover, household consumption patterns are of greater interest to policymakers as these provide important signals for planning government budgetary allocations and tax policy design. For such planning, having up-to-date income and price elasticity estimates for consumer goods at the individual country level is important as they are the key inputs for a number of policy applications, such as public finance policies and economy-wide models (for example, CGE modelling) that are used in designing consumer welfare policies. An up-to-date understanding of household consumption behaviour is also important for manufacturing industries, import and export businesses and investors to understand consumer preferences, identify emerging market opportunities and invest in research and development. The scale and patterns of household consumption are important determinants of environmental impacts because households represent about two-thirds of the demand for raw materials and land as well as the waste flows mobilised by production activities, and their attendant environmental loads globally. The income elasticities estimated in the current study along with the environmental extended multiregional input–output (MRIO) models can be used to examine the impact of income changes on consumption, and how this will translate to changes in carbon footprints.

Though income induces changes in household spending patterns and thereby a country's consumption patterns, this is also likely to be influenced by the economy's level of openness, urbanisation and the demographic features of the population. Therefore, future research can be designed to explore the impact of the aforementioned factors on similarities and dissimilarities in consumption patterns of individual countries as well as of a regional group of countries around the globe.

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Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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