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Predicting Expenditure Patterns across provinces in China based on AIDADS demand system

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Abstract:

There are so many studies analyzing expenditure behavior with international cross-section data. However, there are few literatures involving demand analysis using data across provinces in one single country. On one hand, China is a fast-growing developing country and its composition of consumer demand is changing rapidly. On the other hand, China is one of the world's largest countries, including more than 30 provinces, and there exists significant income inequality between different regions. Per capita income of urban households in richest province is more than ten times of that of rural households in poorest province. Therefore, it's particularly import to study demand patterns across provinces in China. In this study, an AIDADS demand system is constructed based on household survey data from different provinces. Then income elasticity and price elasticity are calculated for different provinces and the trendy of provincial expenditure pattern is predicted. All these results will be useful for analyzing regional effect of policies.

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Introduction and motivation

Over the last three decades, China has become one of countries with highest growth. China's Gross Domestic Product (GDP) has grown very rapidly (about 9.8% per year), since China began market reform in 1978. Although income and expenditure grow more slowly than GDP, there has been a nine-fold increase in China's household expenditure on consumption per capita, which is much higher than other developing countries.

With the high growth of expenditure/income, the structure of expenditure has changed dramatically. Figure 1 shows the consumption structure for urban and rural households since 1985. The proportion of total expenditure devoted to food declined by 15 percentage points in urban households and 14 percentage points in rural households. This transition conforms to "Engel's Law"[1]. Meanwhile, the share of clothing and household equipment consumption also experiences a decrease. In contrast, most of other expenses in the total consumption increase, especially expenditure on transport and communications. The ratio of "transport and communication" expenses to total expenditure increases by 11 percentage points for urban households and 8 percentage points for rural households.

According to latest International Comparison Project (ICP 2005) data, consumers in China spend 26 percent of their total budget on food, with is much higher than 8% in USA and 15% in Japan. On the contrary, China's households spend much less on service (including medical care, recreation etc.) than high-income countries. As a fast-growing developing country, China's composition of consumer demand will keep changing rapidly. On the other hand, China is one of the world's largest countries, including more than 30 provinces, and there exists significant income inequality between different regions. Per capita income of urban households in richest province is more than ten times of that of rural households in poorest province. Therefore, it's particularly important to study demand patterns across provinces in China, for purpose of planning and policy analysis.

[1] In 1857, Prussian economist Ernst Engel found that the proportion of total expenditure on food declines as income rises, using household data on 153 Belgian families. This hypothesis is known as "Engel's Law".

As for China's demand system study, most of domestic researches (e.g. ….) use time-series national aggregated expenditure data. However, the time-series household expenditure data for China is very limited. Due to the shortage of wild variation in per capita incomes, it's difficult to get well behaved demand system. Furthermore, most of the studies just focused on food demand. From an international point of view, there is a long and distinguished literature involving demand analysis using international cross section data (Monika, 2009), such as Rimmer and Powell (1992); Theil and Clements (1987); Hunter and Markusen (1988); Theil, Chung and Seale (1989); Cranfield et.al (2000, 2002, 2003); Regmi et.al (2001); and Reimer et.al (2004). However, it's very much debatable whether preferences across regions are uniform (Yu et.al. 2000). In this study, an AIDADS demand system is constructed based on household survey data from different provinces in China.

The first section of this paper introduces AIDADS demand system and the methodology of its estimation. The second section in this paper shows household survey data used for estimation. Finally this paper discusses the result of estimation and implication.

AIDADS demand system and its estimation

By now, researchers has developed many demand systems, such as Stone's (1954) Linear Expenditure System (LES) and following ELES; Deaton and Muellbauer's (1980) Almost Ideal Demand System (AIDS); Cooper and McLaren's (1987) MAIDS; Banks et al.'s Quadratic almost Ideal Demand System (QUAIDS); Rimmer and Powell's (1996) An Implicitly Directly Additive Demand System (AIDADS) and following MAIDADS. Yu et al. (2000) compared three different demand specifications (LES, CD and AIDADS) with GTAP model and found for regions with rapid income growth, LES over-predicts growth demand for food and under-predict that for non-food products. However, for high-income regions with smaller income growth, the result of AIDADS is similar with LES. Cranfield et al. (2003) assesses the ability of five structural demand systems to predict demand when estimated with cross

sectional data spanning countries with widely varying per capita expenditure levels and found AIDADS is the best when income exhibits wide variation. In view of high growth of income in China, this paper chooses AIDADS demand system.

To begin with same definition of implicit direct additivity in Hanoch (1975), Rimmer and Powell (1992) constructed AIDADS expenditure system. The definition is:

$$\sum_{i=1}^{n} U_i(x_i, u) = 1 \tag{1.1}$$

Based on MAIDS and LES, Rimmer and Powell assume the following function form for utility function:

$$U_i = \mu_i \ln\left(\frac{x_i - \gamma_i}{Ae^u}\right) \tag{1.2}$$

Where, x_i is consumption of i^{th} goods or service, i=1,2,…,n. γ_i is subsistence minimum and,

$$\mu_i = \frac{\alpha_i + \beta_i G(u)}{1 + G(u)} \tag{1.3}$$

with restrictions:

$$\begin{aligned} &\sum_{i=1}^{n} \alpha_i = \sum_{i=1}^{n} \beta_i = 1 \\ &0 \le \alpha_i, \beta_i \le 1 \end{aligned} \tag{1.4}$$

With the following nonlinear programming (minimizing the cost of obtaining a given level of utility),

$$\min \sum_{i}^{n} p_i x_i$$

$$s.t$$

$$\sum_{i=1}^{n}\left(\mu_i \ln\left(\frac{x_i - \gamma_i}{Ae^u}\right)\right) = 1$$

consumer demand[2] is deduced:

$$x_i = \gamma_i + \frac{\mu_i}{p_i}\left(y - \sum_{i=1}^{n} p_i \gamma_i\right) \tag{1.5}$$

[2] In special case that $\alpha_i = \beta_i$ for all goods, AIDADS collapses to the LES.

Where, y is aggregated expenditure. The budget share in AIDADS expenditure system is followed as

$$w_i = \frac{p_i \gamma_i}{y} + \frac{\mu}{y}\left(y - \sum_{i=1}^{n} p_i \gamma_i \right) \tag{1.6}$$

To calibrate AIDADS, this paper followed the Maximum Likelihood estimation used in Cranfield et al.(2002):

$$\min \sum_{i}^{n-1} r_{ii}^2 \tag{1.7}$$

s.t

$$T^{-1} \sum_{t=1}^{T} v_{it} v_{jt} = \sum_{k}^{n-1} r_{ki} r_{kj}, \quad \forall i \neq n, j \neq n, r_{kl} = 0 \; for \; all \; k > l \tag{1.8}$$

$$v_{it} = s_{it} - \hat{s}_{it} \tag{1.9}$$

$$\hat{s}_{it} = \frac{p_{it} \gamma_i}{y_t} + \frac{1}{y_t}\left(\frac{\alpha_i + \beta_i e^{u_t}}{1 + e^{u_t}} \right)\left(y_t - \sum_{i=1}^{n} p_{it} \gamma_i \right) \tag{1.10}$$

$$u_t = \sum_{i=1}^{n} \frac{\alpha_i + \beta_i e^{u_t}}{1 + e^{u_t}} \ln\left(x_{it} - \gamma_i \right) - 1 - \ln\left(A \right) \tag{1.11}$$

In Eq.(1.7)-(1.11), $\hat{s}_{it}$ is the fitted budget share for i^{th} good in the t^{th} observation, v is the residue between fitted and sample budget, T is total number of observations. r is the cholesky decomposition factor of covariance matrix. In general, the calibration algorithm with calculate the parameters α, β, γ and A in order to minimize eq. (1.7), subject to constraints and model equations ((1.4), (1.8)-(1.11)). Given that good starting values will helps reduce the computational burden of finding an optimal solution (Cranfield, 2002), it's import to choose starting values for this non-linear programming. Table 1 shows the lower, upper bounds and initial values for all unknown variables. Different from Cranfield (2002), as for α, β, γ, this paper constructed a LES demand system with mean value of all samples and use its subsistence minimum and marginal budget share are used. This non-linear programming is solved by software GAMS 22.9, using MINOS solver.

Household Survey Data

This study uses the urban household samples of data from the China Household Income Project (CHIP), a national cross-sectional study collectively designed by a team of Chinese and Western economists and conducted by the Institute of Economics at the Chinese Academy of Social Sciences. Samples of the CHIP study were drawn from larger NBS samples using a multistage stratified probability sampling method and the CHIP study is considered the best publicly available data source on household income and expenditures (Gao, 2006).

The data from CHIP study used in this paper includes 6835 sample urban households from 12 provinces, including 3 eastern, 3 central and 3 western provinces of China. The data include eight broad expenditure categories: expenditure on food, expenditure on clothes, expenditure on home equipment, facilities and services, Health and medical expenditure, expenditure on transportation and communication, expenditure on entertainment, education and culture services, expenditure on housing and the related and expenditure on miscellaneous goods and services. Table 2 shows the questionnaire for expenditure survey. Table 3 presents summary statistics for per capita expenditure and the budget shares. Because this data is collected at households, per capita expenditure is total household expenditure dividing by population in that household. The budget shares are calculated by dividing expenditure on each broad category by total expenditure. Apart from ICP data, this data doesn't price information. Reimer (2004) pointed out that in estimating AIDADS with and without any price variation, there are almost no qualitative or quantitative difference in the Engel responses. In this paper we just assume the same price across province and households.

Result of estimation of AIDADS

Table 4 shows the estimation of AIDADS based on urban household survey data.

According to the values of a and b, all categories can be divided into two groups. One is “food” and “clothes”. For these two categories, the value of α is larger than β, therefore marginal budget shares for these consumption categories will fall as aggregate expenditure increases, which is conforming to Engel’s law. Different from “clothes”, the value of β for “food” is zero, which indicates that the Engel elasticity should converge to zero with increasing expenditure. The other group includes all other consumption categories. As for these categories, the value of a is lower than β, then marginal budget shares will increase as aggregate expenditure rises. Especially for “entertainment, culture services and others”, the β is 0.258, much larger than α. In this case the marginal budget share should converge to the value of β. Powell et al. (2002) note that AIDADS has asymptotic Cobb-Douglas behavior as expenditure grows and the Engel elasticities should converge to one as expenditure increases (Reimer et, al. 2004). The result of estimation also shows that Engel elasticities for all consumption categories, except “food”, converge to one with increasing expenditure.

The fourth row in Table 4 gives the estimates of γ. For all categories, except “food” and “housing and the related”, the subsistence parameter, γ, are zero, while the γ for “food” and “housing and the related”, which indicate “food” and “housing and the related” are indeed subsistence goods/service.

The last row in Table 4 presents the correlation coefficients between the actual and fitted budget shares. The fitness for “food” and “entertainment, culture services and others” is much better than for other consumption categories. As for “Health and medical expenditure”, the correlation coefficient is the lowest. There are two reason for this: one is that the price disparity between poor regions and rich regions is very large; the other is that poor household will not go to hospital when they get ill because of low income.

To predict the consumption pattern for different region, this paper also calculates the

expenditure elasticities and marginal budget share for each province (see table 5 and 6). In those richer provinces, such as Shanghai, Beijing and Guangdong, the expenditure elasticities for “food” is lower than that in poor provinces, such as Heilongjiang, Guizhou and Shanxi. Meanwhile the expenditure elasticities for luxury (such as entertainment, culture services and others) in rich regions is also lower than in poor regions, while all are excess of one.

Marginal budget share of “food” in Heilongjiang is the biggest one, which is more than 10 percentage point higher than that in Shanghai. In the contrast, the marginal budget share of “entertainment, culture services and others” is the biggest one and it is about 5 percentage point higher than in Heilongjiang.

Conclusion

This paper estimate AIDADS demand system based on urban household survey data, following Cranfield et al.(2002). Result shows the marginal budget share for “food” and “clothes” will decrease as expenditure increases, conforming to Engel’s Law; while for other consumption categories, the marginal budget share will increase with increasing expenditure. This paper also calculates the expenditure elasticities and marginal budget share for each province based on estimated AIDADS model.

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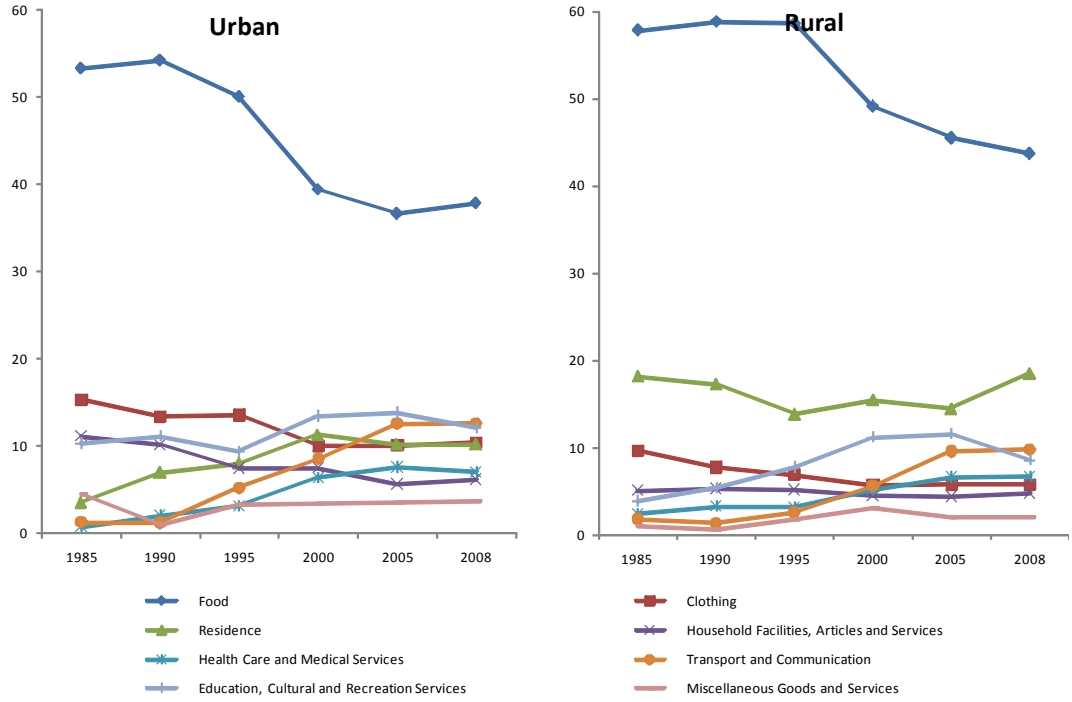
Fig 1 The change of expenditure structure in China



Data source: China Statistic Yearbook (2009)

Table 1 lower, upper bounds and initial values for all unknown variables

variables	Lower bounds	Upper bounds	Initial values
α	0	0.9	*Marginal budget share in LES*
β	*0*	*0.9*	*Marginal budget share in LES*
γ	0	$1.65\times\min\{x_t, x_t,>0\}$	$0.1\times\min\{x_t, x_t,>0\}$
A	0	∞	1
u	-10	10	Calculated by (1.11)
w	0.001	0.99	Calculated by (1.10)
v	-1	+1	Calculated by (1.9)

Table 2 Questionnaire of Household expenditure in 2002

Items	Code	Sum (Yuan)
A300 consumptive expenditure	E	
A301 food	E1	
1) Foodstuff and edible oil	E11	
Of which,（1）Foodstuff	E111	
2) Meat, birds, egg and aquatic product	E12	
3) Garden stuff	E13	
4) Condiment	E14	
5) Expenditure on candy, cigarettes, alcohol and beverage	E15	
Of which,（1）Expenditure on candy	E151	
（2）Expenditure on cigarettes	E152	
（3）Expenditure on alcohol	E153	
（4）Expenditure on beverage	E154	
6) Expenditure on eating out	E192	
A302 Expenditure on clothes	F2	
A303 Expenditure on home equipment, facilities and services	F3	
A304 Health and medical expenditure	F4	
Of which, (1) Expenditure on medicines	F43	
(2) Fee-for-service	F45	
A305 Expenditure on transportation and communication	F5	
Of which, (1) expenditure on transportation		
(2) expenditure on communication		
A306 Expenditure on entertainment, education and culture services	F6	
Of which, Expenditure on education	F63	
1. Expenditure on textbooks	F631	
2. Tuition on education	F632	
（1）Tuition and miscellaneous on non-compulsory education	F6321	
（2）Tuition and miscellaneous on compulsory education	F6322	
（3）Expenditure on nursery and kindergarten	F6323	
（4）Expenditure on adult education	F6324	
（5）Expenditure on family education	F6325	
（6）Expenditure on vocational education	F6326	
（7）Fee for abode in the school	F6327	
（8）Other expenditure on education	F6328	
A307 Expenditure on housing and the related	F7	
1) Expenditure on housing	F71	
Of which,（1）Rent on leasehold housing	F711	
（2）Estimated rent of owned housing	F712	
2) Water, electricity, fuel and others	F72	
（1） Water	F721	
（2） Electricity	F722	
（3） Fuel	F723	
3) Expenditure on housing service	F73	
A308 Expenditure on miscellaneous goods and services	F8	

Source: www.icpsr.umich.edu

Table 3 Means, standard deviations, maximum and minimum of urban household expenditure per capita in 2002

	consumptive expenditure (yuan)	food	clothes	home equipment, facilities and services	Health and medical expenditure	transportation and communication	education	housing and the related	entertainment, culture services and others
mean	6,279	0.425	0.102	0.056	0.067	0.092	0.133	0.095	0.030
st.dev	*4,479*	*0.139*	*0.068*	*0.065*	*0.089*	*0.068*	*0.122*	*0.085*	*0.034*
max	70,638	1.000	0.615	0.566	0.809	0.829	0.847	0.853	0.692
min	395	0.023	-	-	-	-	-	-	-

Table 4 AIDADS estimates based on China's Urban Household survey

	food	clothes	home equipment, facilities and services	Health and medical expenditure	transportation and communication	education	housing and the related	entertainment, culture services and others
α	0.635	0.117	0.006	0.041	0.047	0.065	0.089	0.000
β	0.000	0.071	0.156	0.121	0.182	0.105	0.108	0.258
γ	15.626	0.000	0.000	0.000	0.000	0.000	1.500	0.000
η	0.714	0.918	1.472	1.216	1.268	1.097	1.036	1.528
cor	0.565	0.198	0.308	0.033	0.158	0.104	0.173	0.418

Notes: η are expenditure elasticities evaluated at the means of the data. *cor* are correlation coefficients between the actual and fitted budget shares. Other estimates correspond to parameters in equation (1.10)

Fig 2 Fitted AIDADS budget share

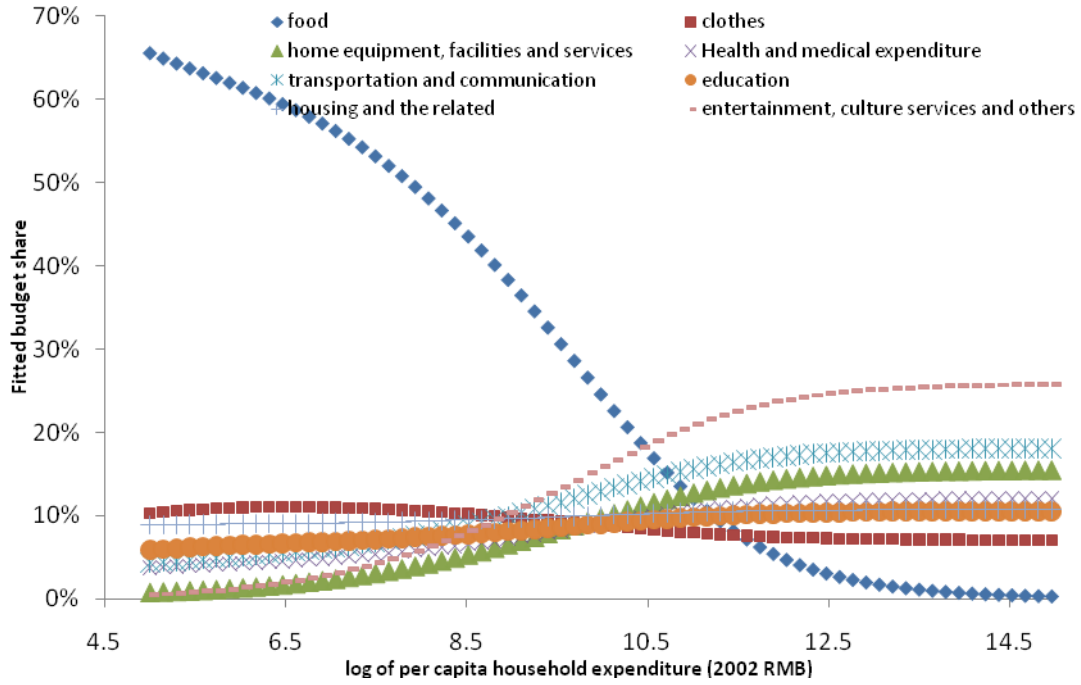


Fig 3 Observed and fitted budget share

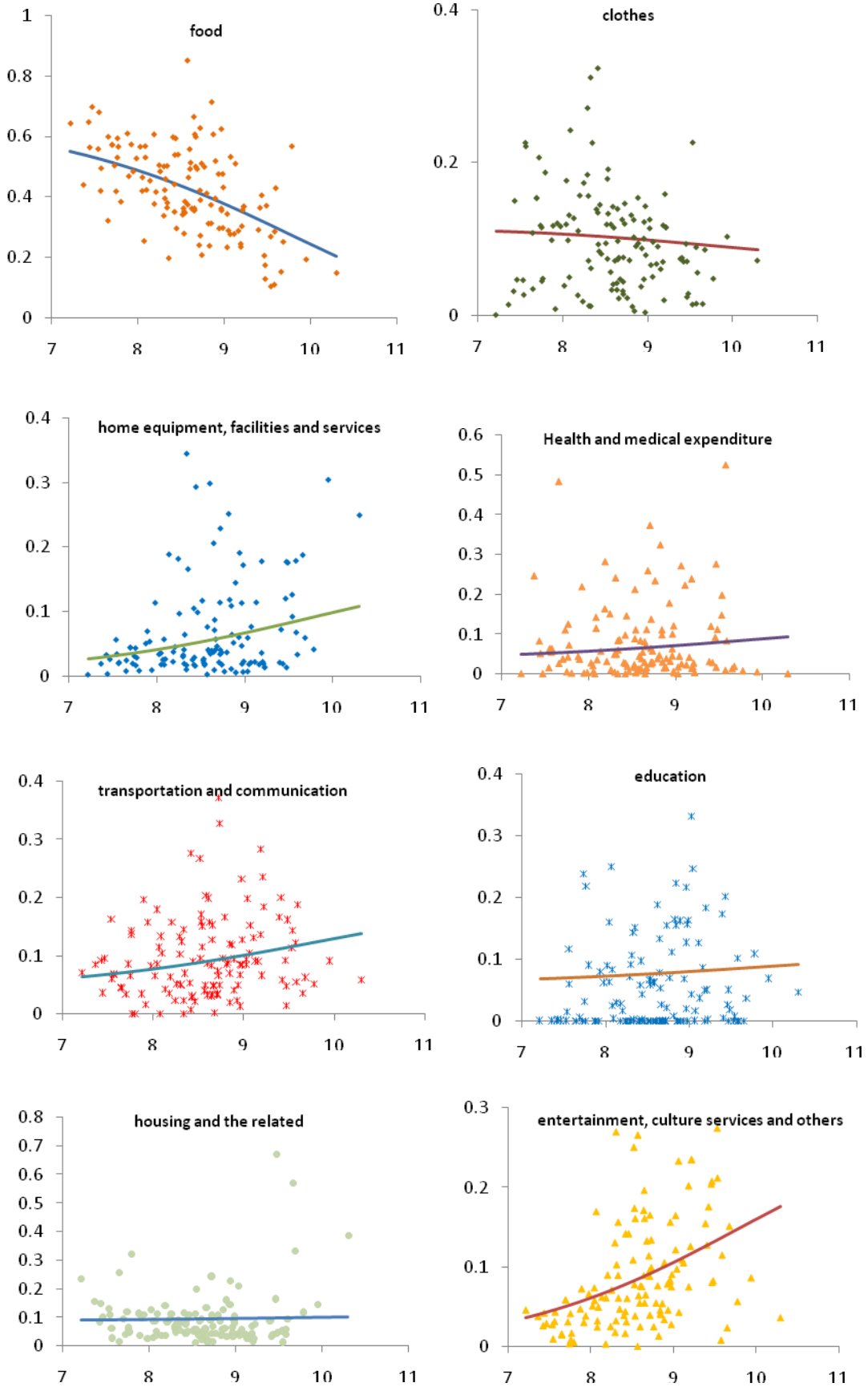


Table 5 Expenditure Elasticities Evaluated At provincial average expenditure level (2002)

	food	clothes	home equipment, facilities and services	Health and medical expenditure	transportation and communication	education	housing and the related	entertainment, culture services and others
National Average	0.714	0.918	1.472	1.216	1.268	1.097	1.036	1.528
Beijing	0.618	0.901	1.418	1.216	1.260	1.102	1.039	1.456
Tianjin	0.685	0.912	1.455	1.217	1.267	1.100	1.037	1.504
Hebei	0.740	0.924	1.488	1.214	1.267	1.095	1.034	1.551
Shanxi	0.751	0.926	1.495	1.213	1.266	1.094	1.033	1.561
Inner Mongolia	0.746	0.925	1.492	1.213	1.267	1.094	1.034	1.557
Liaoning	0.733	0.922	1.483	1.215	1.267	1.096	1.035	1.544
Jilin	0.743	0.924	1.490	1.214	1.267	1.094	1.034	1.554
Heilongjiang	0.758	0.928	1.499	1.212	1.265	1.093	1.033	1.569
Shanghai	0.615	0.901	1.416	1.215	1.260	1.103	1.039	1.453
Jiangsu	0.714	0.918	1.472	1.216	1.268	1.097	1.036	1.527
Zhejiang	0.651	0.906	1.435	1.217	1.264	1.101	1.038	1.478
Anhui	0.750	0.926	1.494	1.213	1.266	1.094	1.033	1.560
Fujian	0.699	0.915	1.463	1.217	1.267	1.099	1.036	1.515
Jiangxi	0.756	0.928	1.498	1.212	1.266	1.093	1.033	1.566
Shandong	0.726	0.920	1.479	1.215	1.267	1.096	1.035	1.538
Henan	0.757	0.928	1.498	1.212	1.266	1.093	1.033	1.567
Hubei	0.725	0.920	1.479	1.215	1.267	1.096	1.035	1.537
Hunan	0.726	0.921	1.479	1.215	1.267	1.096	1.035	1.538
Guangdong	0.645	0.905	1.432	1.217	1.263	1.102	1.039	1.474
Guangxi	0.731	0.922	1.482	1.215	1.267	1.096	1.035	1.542
Hainan	0.730	0.921	1.481	1.215	1.267	1.096	1.035	1.541
Chongqing	0.706	0.916	1.467	1.217	1.267	1.098	1.036	1.520
Sichuan	0.731	0.922	1.482	1.215	1.267	1.096	1.035	1.542
Guizhou	0.754	0.927	1.497	1.212	1.266	1.093	1.033	1.564
Yunnan	0.720	0.919	1.475	1.216	1.267	1.097	1.035	1.532
Tibet	0.691	0.913	1.458	1.217	1.267	1.099	1.037	1.508
Shaanxi	0.732	0.922	1.483	1.215	1.267	1.096	1.035	1.543
Gansu	0.741	0.924	1.488	1.214	1.267	1.095	1.034	1.551
Qinghai	0.741	0.924	1.489	1.214	1.267	1.095	1.034	1.552
Ningxia	0.739	0.924	1.487	1.214	1.267	1.095	1.034	1.550
Xinjiang	0.725	0.920	1.478	1.215	1.267	1.096	1.035	1.537

Table 6 Marginal budget share Evaluated At provincial average expenditure level (2002)

	food	clothes	home equipment, facilities and services	Health and medical expenditure	transportation and communication	education	housing and the related	entertainment, culture services and others
National Average	0.295	0.092	0.086	0.084	0.119	0.086	0.099	0.138
Beijing	0.214	0.086	0.105	0.094	0.136	0.091	0.101	0.171
Tianjin	0.269	0.090	0.092	0.087	0.125	0.088	0.100	0.149
Hebei	0.321	0.094	0.080	0.080	0.114	0.085	0.098	0.128
Shanxi	0.332	0.095	0.078	0.079	0.111	0.084	0.098	0.123
Inner Mongolia	0.327	0.095	0.079	0.080	0.112	0.084	0.098	0.125
Liaoning	0.313	0.094	0.082	0.081	0.115	0.085	0.098	0.131
Jilin	0.324	0.095	0.079	0.080	0.113	0.084	0.098	0.127
Heilongjiang	0.339	0.096	0.076	0.078	0.110	0.083	0.098	0.120
Shanghai	0.211	0.086	0.106	0.094	0.137	0.092	0.101	0.172
Jiangsu	0.295	0.092	0.086	0.084	0.119	0.086	0.099	0.138
Zhejiang	0.240	0.088	0.099	0.091	0.131	0.090	0.101	0.161
Anhui	0.331	0.095	0.078	0.079	0.112	0.084	0.098	0.124
Fujian	0.281	0.091	0.089	0.085	0.122	0.087	0.099	0.144
Jiangxi	0.337	0.095	0.076	0.078	0.110	0.084	0.098	0.121
Shandong	0.306	0.093	0.083	0.082	0.117	0.085	0.099	0.134
Henan	0.338	0.096	0.076	0.078	0.110	0.083	0.098	0.121
Hubei	0.306	0.093	0.084	0.082	0.117	0.086	0.099	0.134
Hunan	0.307	0.093	0.083	0.082	0.117	0.085	0.099	0.133
Guangdong	0.235	0.088	0.100	0.091	0.132	0.090	0.101	0.163
Guangxi	0.311	0.094	0.082	0.082	0.116	0.085	0.099	0.132
Hainan	0.310	0.094	0.083	0.082	0.116	0.085	0.099	0.132
Chongqing	0.287	0.092	0.088	0.085	0.121	0.087	0.099	0.141
Sichuan	0.311	0.094	0.082	0.082	0.116	0.085	0.099	0.132
Guizhou	0.335	0.095	0.077	0.079	0.111	0.084	0.098	0.122
Yunnan	0.300	0.093	0.085	0.083	0.118	0.086	0.099	0.136
Tibet	0.274	0.091	0.091	0.086	0.124	0.088	0.100	0.147
Shaanxi	0.312	0.094	0.082	0.081	0.115	0.085	0.099	0.131
Gansu	0.321	0.094	0.080	0.080	0.114	0.085	0.098	0.128
Qinghai	0.322	0.094	0.080	0.080	0.113	0.085	0.098	0.127
Ningxia	0.320	0.094	0.080	0.081	0.114	0.085	0.098	0.128
Xinjiang	0.305	0.093	0.084	0.082	0.117	0.086	0.099	0.134