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Deciphering rural households' biomass consumption patterns: evidence from ethnic minority region in western China

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Contributed presentation at the 60th AARES Annual Conference,
Canberra, ACT, 2-5 February 2016

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Introduction

- Traditional biomass (e.g. fuelwood, straw, residues, manure) plays an important role in providing energy for cooking and heating, in particular to poor households in developing countries (IEA, 2012).
- Biomass-based energy is still today the largest source of renewable energy, accounting for roughly 10% of world total primary energy supply.
- In China, biomass was still used by about two-thirds of rural households and accounted for 60 to 71% of rural household's fuel consumption in late 1990s (Jiang and O'Neill, 2004), albeit its share gradually declined to just 47.2% by 2005 (Zhou et al., 2008).
- Whereas traditional biomass is generally considered inefficient and has a number of associated disadvantages such as time-consuming biomass harvesting, exacerbated deforestation and indoor pollutions.

Introduction (cont.)

- Although challenges of energy sustainability in rural China have been extensively documented in the existing literature, the empirical studies dealing with rural households' energy consumption features at individual household level is scant;
- Even less is known about the influences of sociocultural backgrounds on household's fuel consumption behaviours.
- Based on in-field rural households survey data in two western Chinese provinces of Gansu and Yunnan where ethnic minority families are widely spread, this paper attempts to examine the pattern of residential energy consumption for cooking and heating.

Household survey and data

- The survey areas



Table 1. Sample distribution

Province	County	Village	Household
Yunnan	Shuangbai	3	32
	Weishan	3	30
	Ninglang	3	30
	Shangri-La	2	20
	Ning'er	3	30
	Shizong	3	30
	Qiubei	3	30
Gansu	Lintan	6	60
	Zhouqu	3	30
	Diebu	3	30
Total		32	322

Table 2. Village characteristics

Village characteristics	Gansu	Yunnan	Total
The number of minorities	0.833 (0.389)	3.750 (2.291)	2.656 (2.309)
The proportion of minority population (%)	0.472 (0.480)	0.601 (0.339)	0.553 (0.395)
Village population (persons)	937 (562)	2934 (1166)	2185 (1382)
The distance from village to township (km)	11.083 (10.867)	11.233 (11.694)	11.177 (11.376)
The distance from village to county (km)	80.333 (26.609)	40.325 (34.358)	55.328 (36.906)
Obs.	12	20	32

Note: The standard deviations are in parentheses.

Table 3. Household socio-economic characteristics

Variables	Gansu	Yunnan	Total
Household size (persons)	5.525 (1.593)	4.941 (1.623)	5.158 (1.634)
If household belongs to minority (1=yes)	0.433 (0.498)	0.554 (0.498)	0.509 (0.501)
Household head education (years)	4.875 (3.282)	5.676 (3.383)	5.377 (3.363)
Average education of household members (years)	4.436 (2.418)	5.182 (2.271)	4.904 (2.351)
Household head age (years)	45.150 (9.444)	46.153 (8.979)	45.780 (9.153)
Average age of household members (years)	33.535 (9.059)	33.438 (8.903)	33.474 (8.947)
Total household income (10000 yuan)	3.881 (3.784)	8.075 (7.366)	6.512 (6.588)
Total household income per capita (10000 yuan)	0.754 (0.753)	1.743 (1.811)	1.375 (1.579)
Off-farm income ratio	0.480 (0.340)	0.333 (0.298)	0.388 (0.322)
Agricultural land areas (mu)	8.886 (7.045)	15.700 (16.181)	13.161 (13.901)
Obs.	120	202	322

Note: The standard deviations are in parentheses.

Table 4.1 Household Energy consumption

<i>Household energy</i>	Gansu	Yunnan	Total	Obs.
Fuelwood (kg)	1912.613 (2264.410)	2113.400 (2694.496)	2035.044 (2531.490)	205
Coal (kg)	1916.196 (3117.347)	1360.000 (1307.648)	1846.672 (2950.967)	64
Electricity (kwh)	808.808 (408.860)	1170.259 (937.984)	1035.137 (801.702)	321
If household use biogas (1=yes)	0.033	0.223	0.152	49
Coal price per kg	1.073 (0.122)	1.209 (0.229)	1.158 (0.206)	64
Electricity price per kwh	0.517 (0.017)	0.517 (0.101)	0.517 (0.081)	321
Obs.	120	202	322	

Note: 1.The standard deviations in parentheses.

2. The coal and electricity price is averaged at village level .

Table 4.2 Biomass use description in Yunnan and Gansu

Sample	Consumption(kg)	Expenditure(yuan)	Use (%)	Fuelwood consumption		Obs.	
				allocation			
				Cooking (%)	Heating (%)		
Biomass-consuming households	Gansu	1912.61 (2264.41)	183.38 (774.23)	---	86.25	37.50	80
	Yunnan	2113.40 (2694.50)	295.16 (1038.84)	---	99.20	4.80	125
	Total	2035.04 (2531.49)	251.54 (943.98)	---	94.15	17.56	205
Total households	Gansu	1349.73 (2047.70)	125.17 (636.81)	66.67	57.50	25.00	120
	Yunnan	1366.96 (2358.15)	183.64 (828.40)	61.88	61.39	2.97	202
	Total	1360.53 (2244.23)	161.85 (762.13)	63.66	59.94	11.18	322

Note : 1.The standard deviations in parentheses.

Conceptual framework

- Biomass resources in most rural areas in many developing countries have generally not been widely commercialised yet, and there is simply no market for biomass resources transaction in rural regions.
- Among the 205 fuelwood consuming households, only 28 households reported expenditures for purchasing fuelwood.
- None of households reported selling in the market.
- The data absence prevents any attempt to simultaneously estimate a structural model including both fuelwood supply and demand.

Empirical strategy

- We employ a *reduced form equation* to evaluate household energy demands in a framework of *non-separable household model* (Chen et al.,2006; Demurger and Fournier,2011; Zhang and Koji,2012).
- The economic model can be specified as follows:

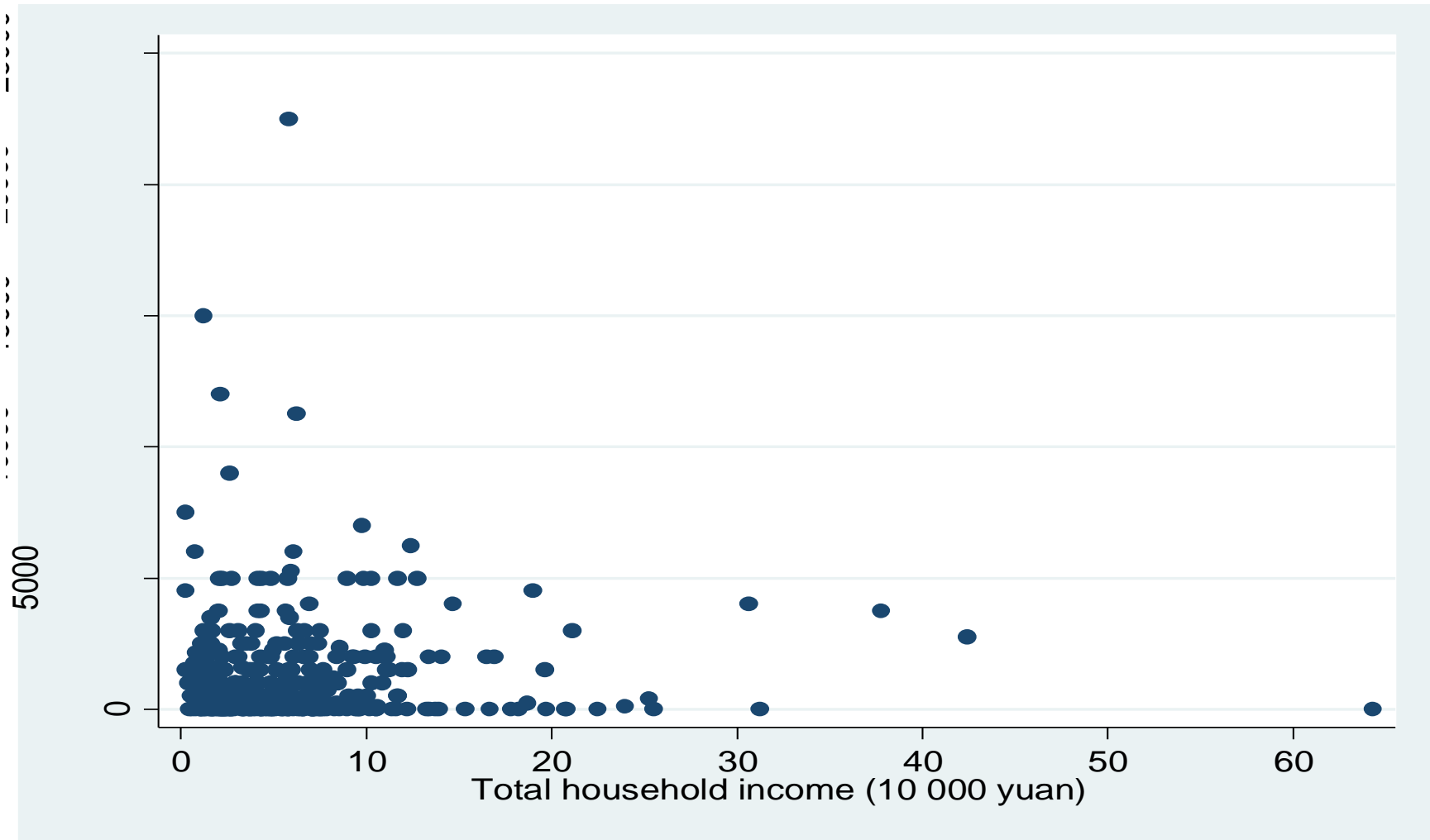
$$Q_{ij}^{fw} = f(p_j^c, p_j^e, d_{ij}^{bg}, R_{ij}, I_{ij}, H_{ij}) \quad (1)$$

- The reduced form of fuelwood demand equation can be specified as follows:

$$\begin{aligned} \text{Log}(Q_{ij}^{fw}) = & \alpha + \beta_1 \text{Log}(p_j^c) + \beta_2 \text{Log}(p_j^e) + \beta_3 d_{ij}^{bg} + \beta_4 R_{ij} + \gamma_1 I_{ij} + \\ & \gamma_2 I_{ij}^2 + \gamma_3 H_{ij} + \delta \text{Prov}_{ij} + \varepsilon_{ij} \end{aligned} \quad (2)$$

Table 5 Tobit regression results of household energy consumption

Variables	Model 1: Full sample	Model 2: Low income group	Model 3: High income group
Log of coal price	6.109* (3.291)	8.371** (3.352)	0.454 (3.005)
Log of electricity price	4.139 (2.675)	3.972 (3.025)	4.067* (2.245)
If household uses biogas (yes=1)	-2.798*** (0.521)	-2.298*** (0.751)	-3.750*** (0.623)
Off-farm income ratio	-1.873** (0.793)	-1.182 (1.304)	-3.410** (1.644)
<i>Household total income (yuan)</i>	0.0480 (0.0822)	0.161 (0.541)	0.159 (0.152)
<i>Square of household total income (yuan)</i>	-0.00136 (0.00162)	-0.00241 (0.0611)	-0.00343 (0.00283)
Agricultural land areas (mu)	0.0137 (0.0228)	0.0181 (0.0253)	-0.0139 (0.0303)
Household size (persons)	0.525 (0.609)	1.149 (0.865)	0.346 (1.099)
Square of household size (persons)	-0.0518 (0.0538)	-0.123 (0.0816)	-0.00627 (0.0806)
If household belongs to minority (1=yes)	1.181* (0.635)	1.039* (0.607)	1.482* (0.804)
Household head education (years)	0.00454 (0.0744)	0.0478 (0.0949)	0.0827 (0.120)
Household head age (years)	0.0272 (0.0217)	0.0682*** (0.0261)	-0.0519 (0.0421)
Province dummy (yunnan=1)	-1.084 (0.870)	-2.198** (1.089)	-0.110 (1.044)
Log pseudolikelihood	-707.992	-459.086	-235.891
Prob>F value	0.000	0.000	0.000
Observations	322	209	113



Conclusions

- Fuelwood turns out to be a basic energy resource for most rural households.
- Coal is a substitute for low income families, whereas electricity appeared to be a substitute only for higher income households.
- Biogas digesters significantly reduce household's demand for fuelwood.
- Larger share of off-farm income has significant negative impact on fuelwood demand.
- Ethnic minority households are more likely to rely on fuelwood for cooking and heating than their Han-ethnic counterparts.

Policy implication

- The high reliance on fuelwood poses a challenge to sustainable forest management and land use change.
- Integrated forest planning such as fast grown plantations will allow for efficient and sustainable production of biomass for residential energy use, create new employment and reduce environmental degradation.
- It proves the success of rural energy policy which promotes the generalization of energy efficient clean technology of biomass resources in rural China.
- The low-income group targeting poverty reduction schemes should take the role of off-farm ration into account along with sustainable energy implementation and peri-urbanisation programs in rural China.
- Achieving the double dividend target, i.e. poverty reduction and environmental quality in rural areas requires integrated rural development strategy to reconcile sustainable forestry management, clean bioenergy supply and rural development programs.

Thank you!