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INEQUALITY OF OPPORTUNITY, INCOME INEQUALITY, AND ENVIRONMENTAL QUALITY: A MACHINE LEARNING APPROACH

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Abstract

The main objective of this paper is to fill the gap noted on the mediating role that inequality of opportunity can play in the link between economic inequalities and the quality of the environment in China. We start with data from the CFPS[2] survey (2012, 2014 and 2016), and we first calculate the share of inequalities explained by factors that households do not control, and which have an impact on their annual electricity consumption. We then estimate via a fixed-effect model, the link between household electricity consumption, income inequality, and inequality of opportunity.

The results obtained show that the factors not controlled by households and mainly: Hukou status, Hukou status at the age of 3, father's level of education, membership of the Chinese Communist Party, membership in an ethnic minority or even the region of birth, contribute almost 10% to inequalities in terms of electricity consumption at the provincial level. Our results also show that inequality of opportunity has a negative and significant effect on the electricity consumption of Chinese households. The heterogeneity analysis shows that the effect of the inequality of opportunity on electricity consumption id significant from the 50th percentile.

Keywords: China, inequality of opportunity, income inequalities, random forest, Python.

[1] https://gretha.cnrs.fr/

[2] China Family Panel Survey

1. CONTEXT

Chinese development model: dilemmas and contradictions

Despite the high economic growth rates that have enabled China to reduce rates of massive poverty significantly, economic inequality has recently reached high levels compared to the pre-reform period. According to official statistics from the Chinese government, the value of the Gini coefficient has increased at the national level from 0.37 in 1997 to more than 0.46 in 2014 (Song & Zhou, 2019). The direct impact of income inequality on Chinese economic growth has not left the Chinese authorities indifferent. Furthermore, the level of inequality of opportunity recorded in China currently exceeds that of the OECD member countries; this level is thus comparable to that recorded in some Latin American countries where the levels of income inequality are much higher than in China (Zhang & Eriksson, 2010; Song, 2017).

The environmental issue is also part of the dilemmas that characterize the Chinese development model. In addition to the economic and social inequalities currently facing the Chinese government to maintain social stability and the sustainability of its development model, environmental degradation is a significant challenge. This degradation affects both water resources, forests, waste management, energy consumption, and air pollution.

Regarding air pollution, the carbon consumption of Chinese households is considered currently as one of the primary sources of these emissions. The improvement in the income level of households and the increase in their purchasing power, the internal migration from rural areas to cities as well as the intense urbanization, mean that the impact of household behavior in terms of indirect CO_2 emissions on the quality of the environment is considerable.

Strong economic growth has also accompanied by a sharp increase in energy consumption in China. In 2009, China replaced the United States as the world's leading energy consumer. In 2014, China consumed nearly 4,250 million tons of coal equivalent (Salim et al., 2017), this consumption reached nearly 4,358 million tons of coal equivalent in 2018 according to the Chinese National Bureau of Statistics.

The share of domestic energy consumption remains significant in this sense. In 2018, it represented almost 542 million tonnes of coal equivalent, which represents almost 12% of total energy consumption (BNS, China).

Another aspect that characterizes China is the gap in terms of economic development between rural and urban areas; the dual structure of the Chinese economy, as well as fiscal policy, are among the main factors that widen the gap in per capita income between the two areas (Dong & Hao, 2018).

This paper investigates the evolution of household residential energy consumption, depending on income distribution and on the inequality of opportunity. Based on the Environmental Kuznets Curve hypothesis, we seek to identify the links between household energy consumption, income level, and income inequality.

The originality of our paper is to introduce the inequality of opportunity to try to understand the role that this component can play in the different transmission channels that we find in the literature, between income inequality and environmental quality.

The rest of the paper proceeds as follows: A literature revue is offered in section 2, followed by a brief discussion in section 3 of the conceptual framework data and variables. Sections 4 and 5 describe the empirical model and description of results. The final section offers some concluding thoughts and political implications of our results.

2. LITERATURE REVIEW

2.1. On the environmental consequences of income inequalities: production versus consumption approach

In this section, we explore the empirical and theoretical literature that explains the impact of income inequality on production-based and consumption-based carbon dioxide emissions.

In recent decades, many studies have investigated the possibility of simultaneous reduction of income inequality and pollution related to climate change. The authors of selected papers, published between 2001 and 2020, found a diverse impact of income inequality on carbon dioxide (CO_2) emissions. It could depend on different trajectories of Kuznets Curves. Furthermore, the majority of authors have provided theoretical analysis (even including human behavior) of the influence of income inequality on CO_2 emissions, considering only the production-based side.

We start from the literature on the link between income inequality and co2 emissions according to the level of development, and we analyze in a second step the different channels of transmission of these links.

Empirical studies on inequality and environmental impact offer different results (Borghesi 2006, Berthe and Elie 2015; Jorgenson et al., .2017; Grunewald et al. .2017; Chancel et al. 2018).

Grunewald et al. (2017) have stated that different links between inequality and environmental impact vary with the level of income and inequality; they show that for low and middle-income economies, higher income inequality is associated with lower carbon emissions while in upper-middle-income and high-income economies, higher income inequality increases per capita emissions. Chow and Li (2014), together with Ibrahim and Law (2014), have argued that income inequality level moderates the links between economic development and pollution.

Moreover, the change in the relationship between these variables is moderated by the level of economic development (Jorgenson et al. 2016; McGee and Greiner 2018). Therefore, in this paper, referring to Kuznets Curve theory, which was applied to both inequality (Kuznets 1955) and environmental impact (Grossman and Krueger 1995), particular attention was paid to revealing three possible alternatives: (**i**) the countries trace the same Kuznets Curve trajectory (Jun et al. 2011; Zhang and Zhao 2014; Baloch et al. 2018); (**ii**) the turn points are different, and in the case of inequality reduction, the environmental pollution increases (or vice versa) and (**iii**) Kuznets trajectories are different; for income inequality, a U-shape is observed, although, for environmental impact, it has an inverted U-shape (or vice versa).

Theoretical links of the relationship between environmental degradation (as air pollution level, residential energy consumption) and the inequality level still required for a complete understanding of the reasons (Chacel et al. 2018). Authors analyzing the inequality impact on CO_2 emissions frequently used three approaches (1) political economy explanation, (2) marginal propensity to emit (MPE) carbon dioxide, and (3) individual economic behavior (Liu et al. 2019a).

However, these approaches are not suitable to explore the inequality impact on national CO_2 emissions, which is production-based by definition. The argument that different consumer behavior (particularly consumption level) influences national emissions (which are production-based) (Hao et al. 2016; Jorgenson et al. 2015, 2016; Liu et al., 2019a) might be a misconception considering that the significant share of goods which people consume is imported or exported and thus related to the environmental impact of foreign countries. Analyzing approaches to the relationship between inequality and pollution have to consider the type of emissions (consumption or production-based).

Table 1 below shows the main theories analyzing the relationship between income inequality and environmental impact, and table 2 presents a collection of the various possible links between inequalities and the quality of the environment depending on the development level of the country.

Table 1: The main theories analyzing the relationship between inequality and environmental impact

Theories	References
Political economy explanation	Boyce (2007); Gassebner et al. (2008); Baek and Gweisah (2013); Prell et al. (2015); Downey (2015); Berthe and Elie (2015); Hao et al. (2016); Grunewald et al. (2017); Jorgenson et al. (2017); Kasuga and Takaya (2017); Wolde-Rufael and Idowu (2017); Knight et al. (2017); Mader (2018); Chancel et al. (2018); McGee and Greiner (2018); Liu et al. (2019, 2019a) and Jorgenson et al. (2019).
Economic behaviors of households	Borghesi (2006); Golley and Meng (2012); Grunewald et al. (2012); Zhang and Zhao (2014); Berthe and Elie (2015); Hao et al. (2016); Jorgenson et al. (2017); Hübler (2017); Charfeddine and Mrabet (2017); Knight et al. (2017); Kasuga and Takaya (2017); Wolde-Rufael and Idowu (2017); Jorgenson et al. (2017); Grunewald et al. (2017); Rao and Min (2018); Mader (2018); Baloch et al. (2018); Jorgenson et al. (2019); Liu et al. (2019a); Liu et al. (2019).
Inequality determined changes in working time	Knight et al. (2013); Fitzgerald et al. (2015, 2018); Grunewald et al. (2017); Wolde-Rufael and Idowu (2017); Chancel et al. (2018); Jorgenson et al. (2017, 2019).

In this study, we have chosen to explore this link between income inequality and environmental quality by using residential electricity consumption as an environmental proxy. To our knowledge, no other empirical study has already explored this question in the Chinese context. We also introduce inequality of opportunity as an explanation for this link in the light of the previous literature.

Table 2: possible links between inequalities and the quality of the environment depending on the level of development of the country

	Low income (developing) countries	Middle-income (transition) countries	High-income (developed) countries	Wide range of countries
Positive relationship	Zhang and Zhao 2014; Jorgenson et al., 2015; Hao et al. 2016; Hubacek et al., 2017; Wolde-Rufael and Idowu 2017; Zoundi 2017; Rao and Min 2018; Baloch et al. 2018; Liu et al. 2019		Baek and Gweisah 2013; Jorgenson et al. 2015, 2016; Knight et al. 2017; Grunewald et al. 2017	
Negative relationship	Jun et al. 2011; Golley and Meng 2012; Ali et al. 2016; Grunewald et al. 2017; Khan et al. 2018	Grunewald et al. 2017	Ravallion et al. 2000; Heerink et al., 2001; Gangadharan and Valenzuela 2001; Kasuga and Takaya, 2017, Liu et al. 2019	Gangadharan and Valenzuela 2001; Bimonte 2002; Hübler, 2017
Neutral (insignificant)	Wolde-Rufael and Idowu 2017; Khan et al. 2018	Policardo 2016	Jorgenson et al., 2017; Mader 2018	Borghesi 2006

The empirical literature lists several studies that are interested in the question of energy consumption in China; some studies have focused on the determinants of energy consumption.

Other studies have focused on the impact of energy consumption on economic growth and the level of emissions (Ahmed et al., 2016; Liu et al ., 2015; Ren et al., 2015; Wang & Yang, 2014; Yuan et al., 2014; Zhang et al., 2017) and the link between income inequality and energy consumption (Golley & Meng, 2012).

Residential energy consumption has also been the subject of a large number of empirical investigations (Cao et al., 2016; Du et al., 2015a; Fan et al., 2017; Herrerias et al., 2017; Zheng and al., 2014), depending on the type of energy: as (Auffhammer & Wolfram, 2014) for electrical energy, (Bloch et al., 2015; Chen et al., 2016,2017) for fossil fuels, as well as (Bhattacharya et al., 2016; Inglesi-Lotz, 2016; Li et al., 2015) for renewable energies.

Several authors have studied the fairness or even equality aspect of residential energy consumption in China; Clarke-Sather et al. (2011) show that the trend in terms of inequality in electricity consumption is similar to that of income inequality in China in rural areas. Zhang et al. (2010), on the other hand, present the spatial variation of energy consumption in urban China.

Two main shortcomings characterize studies on energy consumption in China: first, most of the studies that have looked at inequalities in terms of energy consumption have taken as their field of investigation either rural areas (Niu et al., 2014; Xiaohua et al., 2017) or urban areas (Xu et al., 2016; Zhang et al., 2010) but without carrying out comparative analyzes between the two environments. Secondly, to our knowledge, few studies have been interested in the contribution of equal opportunity to inequalities in terms of energy consumption, an insufficiency that we are trying to provide with this research work.

2.2. On the link between inequality of opportunity and electricity consumption

The literature on the inequality of opportunity starts from the observation that the inequality observed is neither entirely good nor completely bad. Several methods are used to estimate the inequality of opportunity for different wealth measures, including the per capita income of households and their consumption expenditure (Bourguignon et al., 2007; Ferreira & Gignoux, 2011), individual income (Bjorklund et al., 2011; Checchi & Peragine, 2010); or the level of education (Golley & Kong, 2016) and health (Jusot et al., 2013).

We note that few studies have been interested in studying the inequality of opportunity in terms of energy consumption (electricity consumption in this case).

Gonzalez-Eguino (2015) argues that residential energy consumption reflects the global inequalities. According to Peragine (2004), and from the principles of ethically equal opportunities, the society has to compensate economic inequalities due to circumstances not controlled by individuals. Inequalities in terms of energy consumption, also due to factors beyond control, must be compensated by society, hence the importance of taking

into account the notion of inequality of opportunity in policies aimed at reducing energy poverty and inequalities in access to energy.

In the Chinese context, a recent study conducted by Shi.X (2019) examines the role played by the circumstances (in this case: *Gender, Hukou Status, Place of birth, Ethnicity, or Parents' education level*) in generating inequalities in terms of energy consumption in China. They note that the share of inequality of opportunity in inequalities in electricity consumption reached 10.02%. The vectors that contribute most to these inequalities are the Hukou status as well as the native region.

2.3. On the link between inequality of opportunity and income inequality

Most of the studies that have analyzed the link between inequality of opportunity and income inequality proceed by decomposition, to analyze to what extent income inequality is associated with the observed circumstances (parents' level of education, household size, ethnicity or other) Bourguignon, Ferreira & Menérez (2007), Bourguigon, Ferreira & Walton (2007). Drawing on data from Brazilian urban areas, Ferreira & Gignoux (2008) examine the inequality of opportunity in terms of income in six Latin American countries (Brazil, Colombia, Ecuador, Guatemala, Panama, and Peru). These countries have typical high levels of income inequality. The Gini coefficient in these countries varies between 0.79 (for Guatemala) and 0.57 recorded in Panama. The proportion of income inequality due to inequality of opportunity was 35% in Brazil at the highest level, compared to 20% in Colombia at the lowest level. The authors note that among the circumstances that contribute most to the inequality of opportunity in these countries, the level of education of parents comes first. The same technique has been applied to other countries in Latin America and Africa by Nunez & Tartakowsky (2007) and Cogneau et al. (2006), respectively.

Cogneau & Mesple-Somps (2008) examine the inequality of opportunity in five countries in sub-Saharan Africa (Cote d'Ivoire, Ghana, Guinea, Madagascar, and Uganda). The results thus obtained point to similarities in levels of income inequality, but record differences in terms of inequality of opportunity.

Lefranc et al. (2008) focus on developed countries. Based on data from nine OECD countries, note that inequality of opportunity is not firmly correlated to income inequality. A high rate of inequality of opportunity accompanies the low level of Belgian income inequality; in West Germany, this trend is reversed.

In the Chinese context, a recent study by Wu et al. (2016) analyzes the sources of income inequality in China, distinguishing between controlled factors "Efforts" and uncontrolled "circumstances." At the national level, the part of inequality of opportunity in income inequality rose from 32% in 2010 to 43% in 2012, thus registering higher levels than those recorded in certain Latin American countries. This increase in the share of inequality of opportunity in income inequality suggests a relatively considerable indirect effect of circumstances on income distribution.

3. CONCEPTUAL FRAMEWORK, DATA, AND VARIABLES

This section gives a detailed explanation of the concept of inequality of opportunity and the estimation procedure that we have adopted.

3.1. Inequality of Opportunity in China

Inequality of opportunity: estimation procedure

The concept of inequality of opportunity has received much attention in development economics over the last decade. In his seminal contribution, Roemer (1998) proposed to divide total inequality into inequality due to different effort levels, to luck, and to different opportunities. The idea is that not all types of inequalities are equally bad. Checchi & Peragine (2010) name the part of inequality that is due to different levels of effort the ethically nonoffensive inequality. Different efforts should lead to different outcomes; thus, inequality due to different levels of effort might be tolerable.

In contrast, the ethically offensive part of inequality is the part that due to circumstances beyond the control of individuals. These circumstances are factors that people cannot change through effort, and that affects their outcome. The typical examples of circumstances include gender, race, and family background. Hence, in a situation of perfect equality of opportunities, circumstances should not affect the outcome of individuals.

The literature distinguishes ex-ante and ex-post inequality of opportunity (Fleurbaey and Peragine 2013). Ex-ante equality of opportunity is achieved when circumstances do not matter for the outcome. The ex-post approach focuses more on effort and argues that there is equality of opportunity when all people making the same degree of effort achieve the same outcome independently of their circumstances. We note that the two approaches are equally valid, and it is challenging to choose one over the other. However, empirically, the ex-ante approach is more comfortable to implement than the ex-post

one. However, for both approaches, the main challenge is that both effort and luck are not observable; therefore, it is difficult to distinguish them empirically. We have to note that the majority of empirical applications focus mostly on ex-ante inequality of opportunity, given that estimating effort requires robust assumptions.

Researchers have proposed several methods to assess ex-ante inequality of opportunity over the years. The regression method became popular, and the main idea of this method is to relate the outcome to circumstances by parametric or nonparametric regression methods (Juarez and Sologa, 2014). Therefore, is that in a world of equal opportunities, the circumstances should not matter, the regression should have a low fit. If the circumstances affect the outcome, there is consequently inequality of opportunity. The principal weakness of this approach is that it provides only lower-bound estimates of inequality of opportunity (see Ramos & Van de gaer, (2012), Balcazar (2015), Niehues & Peichl (2014).

In recent literature offers a different measure of inequality of opportunity (Ramos and Van de Gaer, 2016; Arneson, 2018). In our paper, inequality of opportunity is estimated as the between-type (ex-ant) inequality component following the parametric procedure of Ferreira and Gignoux (2011), Marrero and Rodriguez (2012), and Song (2017), which allows for the inclusion of a more extensive set of circumstances in the database we use.

Another approach to estimating the inequality of opportunity is that proposed by Brunori et al., (2018), who use the random forest method. This machine learning approach allows exceeding the limits of the regression method by minimizing the risque than the arbitrary choice of the estimation model. It makes possible the choice between the lower and the upper bound of the value of estimated inequality of opportunity.

We opt for the regression estimation method because of the availability of data. Since effort measurement does not have the same robustness as circumstance measurement, the ex-ante measure for inequality of opportunity seems a better choice than the ex-post measure, which requires a full set of effort variables (Reomer and Trannoy, 2016). We devide the determinants of individual income (denotes by W) into two categories, including circumstances (denoted by C) and efforts (denoted by E). since

In this case, we divide the determinants of household income (denoted R) into two distinct categories; the first category includes circumstances, over which the household has no control (rated C) and a second category, which includes efforts (rated E). since circumstances are exogenous by definition -in the sense that they cannot be affected by

individual decisions- and given that efforts may be, and generally are, influenced by circumstances, we can note the following equation:

$$R = f[C, E(C, v), u] \quad (1)$$

u and v represent other stochastic factors affecting income, such as luck (Lefranc et al., 2009). To measure inequality of opportunity -rather than of estimating any causal relationship between circumstances, efforts, and income – we can simply estimate a log-linearized version of the reduced form by OLS, which φ stands for a set circumstances variables:

$$\ln W = C\ \varphi + \varepsilon \quad (2)$$

Three steps are necessary to build our inequality of opportunity measure (noted *ineqopp* in this following):

1st step: we estimate equation (2) and obtain the predicted income denoted as $\widehat{W}$. Notably, the circumstances variables include (Gender, Hukou Status, Hukou status at age 3, Place of birth, Ethnicity, Father's education, Father's income, Membership of the Chinese Communist Party (CCP). These variables are the same as in other literature, measuring inequality of opportunity (Zhang & Eriksson, 2010; Ferreira & Gignoux, 2011; Marrero & Rodriguez, 2013), except that we include the hukou status at three years old, which reflects china's unique institutional background. China has a unique household registration system called hukou in Chinese (Song, 2007). People inherit at birth the hukou status from their parents. The hukou is related to access to government-provided public services. For instance, children with different hukou status may have a differing chance of attending good primary or middle schools (Song, 2014). Consequently, the hukou status at three years old is beyond an individual's control and may also have a significant influence on future income.

2nd step*:* we calculate the Theil index (0) for the predicted income ($\widehat{W}$) named T ($\widehat{W}$). Theil's index is favored in this sense since it allows a decomposition of the index, thus making it possible to determine to what extent the inequality of opportunity contributes to total income inequalities (Shorrocks, 1984; Bourguignon et al., 2007; Ferreira & Gignoux, 2011).

Step 3*:* we calculate the Theil (0) (called also mean log deviation) index for the predicted income denoted T($\widehat{\mathbf{W}}$). the Theil index offers the advantage that it is additively decomposable, which can help estimate the extent to which the total income inequality

in attributed to inequality of opportunity (Shorrocks, 1984; Bourguignon et al., 2007; Ferreira and Gignoux, 2011).

The formula for the Theil(0) index is as follows:

$$Theil = \frac{1}{n}\sum_{i=1}^{n}\frac{y_i}{\bar{y}}\, ln\frac{y_i}{\bar{y}} \quad (2.1)$$

In which $\bar{y}$ and y_i represent average income and income for the person i, respectively, and n denotes the total population.

Step 3: we calculate the measure for inequality of opportunity (denoted by *Ineqopp*) as the ratio of the Theil index for predicted income to that for the actual income (equation 3).

$$Ineqopp = \frac{T(\widehat{W})}{T(W)} \quad (3)$$

Note that because of the limited number of observations at the county level, we measure inequality of opportunity by aggregation data at the provincial level. A Shapley decomposition of the inequality of opportunity is then performed to measure the contribution of the different circumstances to this inequality (see results section).

3.2. Source of data

We analyze the impact of economic inequalities on environmental quality in the Chinese provinces using microdata from the "China Family Panel Studies (CFPS)" survey. We explore the mediator effect of inequality of opportunity on household income and residential energy consumption. CFPS is a tracking survey conducted by the Institute of Social Science Survey at Peking University every two years. CFPS investigate a national representative sample of households in 2010 for the first time. In 2010, the survey covered 25 provinces in China, which account for 95% of the national population. The household samples contain 14,798 households on average, in 635 villages/communities of 162 counties. The household questionnaire asks a set of detailed questions about income and expenditures, which we can use to calculate comparable income and expenditures for different waves. It also contains information on each adult's parents, which allows constructing the measure for inequality of opportunity.

To analyze the link between income inequality, inequality of opportunity, and the impact of household consumption behavior on the environment, we use three waves, 2012, 2014, and 2016.

4. EMPIRICAL MODEL AND DESCRIPTION OF RESULTS

We choose the fixed-effect model to explore the possible links between annual household energy consumption, income inequality, and inequality of opportunity. Very few studies have analyzed the empirical link between these variables. We conducted several tests which allowed us to confirm the robustness of our results. We used the Hausman test to confirm the choice of the fixed-effect model. In the rest of our empirical study, ***Elecexp*** designates in RMB, the amount of household electricity consumption each year, the income inequality, and inequality of opportunity variables are captured at the provincial level (by insufficient observation at the county level). ***Ineqopp*** denotes inequality of opportunity (see dedicated section), and ***Theil_finc*** denotes income inequality measured by the Theil index.

We introduce other control variables from the Environmental Kuznets Curve model. $\boldsymbol{h_i}$ and $\boldsymbol{y_i}$ denote the household fixed effect and the time fixed effect, respectively.

$$Elecexp_{ijt} = z_0 + z_1 ineqopp_{jt} + \gamma X_{ijt} + h_i + y_t + \varepsilon_{ijt} \quad (3)$$

4.1. Descriptive results

We present in this section, the main descriptive results relating to the estimation of the inequality of opportunity in terms of electricity consumption; then, we present the descriptive statistics relating to our empirical model.

Tableau 3: **Descriptive statistics**

Variables	Observations	Average	S.D	Min	Max
Variables of interest					
Electirc consumption	36 590	1075.246	2528.038	0.000	1600
finc	36 590	46636.28	54022.06	0.000	8336
Ineqopp	36,590	0.089	0.032	0.008	0.177
Theil_finc	36,590	0.465	0.176	0.349	0.762
Households socio-economics characteristics					
Family_size	36,590	03.866	1.8090	1	26
House_size	36,590	54.002	37.662	15	3000

Tables 3 and 4 presents the summary statistics of the key variables used in this study for all three data waves. We first look at the indicator of residential electricity consumption in China provinces. On average, Chinese households spend approximately 1075.25 yuan on electric consumption. We also note that factors that households do not control account for almost 9% of total income inequalities in Chinese provinces.

Tableau 4: **Descriptive statistics** (further)

	Freq.	Percent	Cum
Hukou			
Urban	8,711	23.81	23.81
Rural	27,879	76.19	100.00
Hukou3			
Urban	6,682	18,26	18.26
Rural	29,908	81,74	100
Gender			
Male	21,992	60,10	60,10
Female	14,598	39,90	100.00
Father's education			
Illetrate	16,903	46.19	46.19
Primary school	8,928	24.40	70.59
Junior high school	4,049	11.07	81.66
Senior high school	1,905	05.20	86.86
Senior high school & above	4,805	13.14	100.00
Father's occupation			
Off-farm employed	11,886	32.48	32.48
On-farm employed	24,704	67.52	100.00
Birth region			
East	13,371	36.54	36.54
Center	13,904	38.00	74.54
West	9,315	25.46	100.00
Father_CCP =1 if membre			
Yes	4,424	12.09	12.09
No	32,166	87.91	100.00

4.2. Contribution of inequality of opportunity

In what follows, we present the results relating to the contribution of factors not controlled by households in the inequalities of residential electricity consumption. The first results obtained are consistent with those obtained by Shi (2019). We note, however, that the inequalities in terms of electricity consumption slightly decreased between 2012 and 2016, from 0,62 to 0,52.

Table 5 also show that the contribution of inequality of opportunity to total inequality in terms of electricity consumption increased from 9.02% in 2012 to almost 11% in 2016, which suggests that, compared to global inequalities[3], the impact of factors not controlled by Chinese households on their level of electricity consumption, did not follow the same upward trend.

These first results are relevant; they give a first knowledge of the possible links between inequality of opportunity, income inequality, and household electricity consumption. Thus, an improvement in household incomes can lead to a reduction in inequalities in terms of access to electricity, but this reduction is tapering under the pressure of factors not controlled by households (Hukou status, the level parent education as well as the type of job held by the father). These results suggest that a reduction in energy poverty requires compensation for the negative effect of circumstances on household electricity consumption.

Tableau 5: inequality of opportunity in term of residential electric consumption

	2012	**2014**	**2016**
Total inequalities			
Gini	0.62	0.51	0.52
Inequality of opportunity			
Absolute (IOA)	0.06	0.07	0.09
Relative (IOR, en %)	9.02	10.12	11.05
Shapley Decomposition (% of total inequality)			
Hukou	35.50	32.08	29.06
Gender	03.56	02.50	03.06
Father's education	13.48	15.46	16.20
Father's occupation	16.25	13.18	14.36
Region of birth	27.41	33.78	33.99
Ethnic minority	02.30	02.05	01.90
Appartenance au PCC	01.50	00.95	01.43

[3] Measured here by the Gini coefficient of household electricity consumption.

4.3. **Fixed effect estimation**

We opt for the fixed-effect model to estimate the link between inequality of opportunity, income inequality, and household electricity consumption.

Table 6: Impact of the inequality of opportunity on household electricity consumption.

	(1)	(2)	(3)
Variables	**Elecexp**	**Elecexp**	**Elecexp**
Theil	-127.291	-116.332	-210.642
finc	-	0.0062856***	0.0045559***
fincsqr	-	-8.94e^{-10}***	-6.336e^{-10}***
ineqopp	-	-	-1020.538*
house_size	-	-	0.65322154
Elec_for_cook	-	-	112.79611***
Year_dummy	Yes	Yes	Yes
Effet fixe ménage	Yes	Yes	Yes
N	**36,590**	**36,590**	**36,590**
	Legend : * p<0.05 ; ** p<0.01 ; *** p<0.001		

The results in table 6 confirm our first hypothesis, and the electricity expenditures increase with the increase of income up to a certain level, from which this expenditure decrease. This first result suggests that the transition of households to a higher income group induces an increase in their electrical expenditure.

Note that we control income inequality by including it as an explanatory variable. The main reason is that inequality of opportunity measures the proportion of income inequality that is attributed to factors that households do not control. Controlling income inequality makes it possible to better capture the effect of inequality of opportunity on electricity consumption.

The negative impact of the inequality of opportunity on the level of electricity consumption expenditure is the second significant result. Indeed, this result suggests that households with less advantageous circumstances in terms of Hukou status, access to an advanced level of education, or even access to non-agricultural employment may reduce the level of electricity expenditure.

The demographic variable has no significant effect on household electrical consumption, while the choice of electricity for cooking significantly increases household electrical consumption.

4.4. **Heterogeneity analysis**

This subsection analyzes the impact of inequality of opportunity at different levels of electricity consumption, taking into account the possible heterogeneity of our data. As suggested by Alsayed et al. (2019), we proceed by quantile regression on panel data (equation 5), to take into account the possible heterogeneity of our data between different levels of electrical consumption (percentile 0.05, 0.25, 0.50, 0.75 and 0.95).

$$y_{ijt} = \alpha + X'_{ijt}\beta_q + \varepsilon_{ijt} \quad (5)$$

Compared to the previous results, the results of the quantile regression show that the effect of the inequality of opportunity differs according to the level of electricity consumption. This effect becomes significant from the 0.50 percentile. For the households at the highest levels, the impact of the inequality of opportunity is more significant in magnitude.

Table 7: Quantile regression of the link between electricity consumption and inequality of opportunity

Variable	5th	25th	50th	75th	95th
finc	-0.004273*	0.002052**	**0.003719*** **	**0.00969*** **	**0.029276*** **
fincsqr	$2.887e^{-10}$	$-4.461e^{-10}$***	$-6.398e^{-10}$***	$1.334e^{-09}$***	$-3.608e^{-09}$***
ineqopp	730.940	-353.580	**-639.400** **	**-1663.33** **	**-5020.70** **
Theil	- 144.757	3.98308	43.1829	183.571	639.171
Family_size	11.8254	46.2388***	55.3083***	87.799***	194.333***
house_size	- 0.337758	0.207490	0.351187	0.865977	2.55391

Legend : p<0.05; ** p<0.01; *** p<0.001

5. CONCLUSIONS AND POLITICAL IMPLICATIONS

This research, although in progress, explores the relationship between the inequality of opportunity and residential electricity consumption at the level of the Chinese provinces, using data from the "CFPS" survey. Introducing the notion of inequality of opportunity in income inequality versus the environment degradation field is the main contribution of this paper. We have selected household electrical consumption as a proxy for this impact without formulating any hypothesis on the link between household electrical consumption and environmental quality.

The first merit of our work is to have introduced the inequality of opportunities in terms of electrical consumption, by calculating the weight of factors not controlled by households in the distribution of household electrical consumption. This proportion was

9.02%, 10.12%, and 11.05% respectively in 2012, 2014 and 2016. The main circumstances explaining these proportions are the Hukou status of the household, the father's education level, and occupation.

The fixed-effect model shows that inequality of opportunity has a negative and significant effect on the electricity consumption of Chinese households.

To tackle the possible heterogeneity in our data, we perform a quantile regression. The impact of inequality of opportunity is significant in magnitude as the level of residential electricity consumption is high.

From the empirical results obtained, we suggest that political actions can be taken to reduce the impact of circumstances to allow a more equitable distribution in terms of access to electrical energy. The empirical literature suggests that factors such as Hukou status and gender can negatively affect household income in the Chinese context (Song, 2016; Heshmati & Su, 2017; Song, 2017).

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