International Conference on Applied Energy 2019
Aug 12-15, 2019, Västerås, Sweden
Paper ID: 0022

THE FOOD-ENEERGY-($WATER_{VIRTUAL}$)-NEXUS OF THE GERMAN HOUSEHOLDS – A BUDGET ANALYSIS

Holger Schlör[*1], Sandra Venghaus[2]

1 Forschungszentrum Jülich, IEK-STE (*Corresponding Author)

2 Forschungszentrum Jülich, IEK-STE, 52425 Jülich, Germany

1. ABSTRACT

This paper addresses the issue of social inequality by comparing German household data (gross income, Food-Energy-($Water_{virtual}$)-Nexus expenditures) from 2008 and 2013. The distribution of gross income and of the FE($W_{virtual}$)-Nexus related consumption expenditures based on this income is analysed using a three step approach: First, the real distribution is determined, secondly, the dispersion (based on Rawls' philosophical concept) is analysed, and finally, the normative distribution according to the Atkinson index is calculated to reveal a view on social inequality.

The six main household groups were selected for the cross section analysis comparing the social conditions of 2008 and 2013: self-employed households, public servant households, white-collar and blue-collar worker households, unemployed households and retiree households. The three-dimensional model delivers data about the real and normative distribution of the households' gross income and consumption expenditures for the time period from 2008 to 2013 considering the inequality perception of society.

Keywords: FE($W_{virtual}$)-Nexus, virtual water, inequality, Germany

2. INTRODUCTION

This paper addresses the challenge of social inequality in the distribution of gross income and of consumption patterns based on this income by comparing German household data from 2008 and 2013 [1, 2]. It touches the core of liberal democracies because their constitutions guarantee equality of all citizens, whereas the efficiency of liberal market forces has resulted in economic inequality [3]. **This trade-off as introduced by Gordon [3] between equality of citizenship and economic efficiency causing inequality may exert significant pressure on societies [4], because it affects the core of any society: the households [5, 6]. Per se,** household members are all politically equal as citizens, but they are confronted with increasing economic inequalities around the globe [7], and through their consumption patterns they create impact on the environmental systems. We will concentrate our analysis on the gross income and the consumption expenditures of the German households for the Food-Energy-$Water_{virtual}$-Nexus (FE($W_{virtual}$)-nexus) as key resources for sustainable development [8]. The presented model quantifies not only the direct food and energy expenditures of the German household, but also direct and indirect water consumption. The indirect virtual water concept reflects "the extent of water use in relation to consumption of people [9]." The idea of virtual water describes which amount of water is used in the production process of the consumption goods (industrial and agricultural goods). The concept was developed by Tony Allan in the 1990ies [10, 11].

3. DATABASE 2008/2013

The disaggregated consumption data sets used in this analysis are provided by the German household expenditure survey (EVS) of the German Federal Statistical Office [2] and offer information about economic life and consumer behaviour of private households [12] according to the Classification of individual consumption by purpose (COICOP)[1]. The EVS contains the expenditures of the German households on food, accommodation, clothing, health, leisure, education, communication, private and public transport, restaurants and hotels. The survey data delivers no data about the kind of buildings the

[1] https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Classification_of_individual_consumption_by_purpose_(COICOP)

Selection and peer-review under responsibility of the scientific committee of the 11th Int. Conf. on Applied Energy (ICAE2019).

households living in and they provide no information about the age, type and heating method used.

The six main economic household groups were selected for the cross section analysis comparing the social conditions of 2008 and 2013 [13, 14]: self-employed households, public servant households, white-collar and blue-collar worker households, unemployed households and retiree households. The 2013 survey was the eleventh survey and was published in 2015 [7], following surveys in 1962/63, 1969, 1973, 1978, 1983, 1988, 1993, 1998, 2003, 2008 [12, 13]. The EVS 2018 survey will be published in October 2020.

4. DISTRIBUTION THEORY

In our analysis we distinguish three modes of distribution: (a) real distribution, (b) Rawls dispersion [15], and (c) normative distribution measured by the Atkinson Index [16, 17].

The real distribution

In the first step we analysed the real distribution of gross income and the FE($W_{virtual}$)-Nexus related household expenditures without considering society's opinion on the meaning of social inequality [18] or philosophical approaches.

The Rawls dispersion

In the second step the 'Rawls dispersion' inspired by the philosophical concept of John Rawls and in this case defined as the distribution in the social group between the lowest and highest income group [19]) is analysed. It is based on Rawls' MaxiMin strategy published in its Theory of Justice [20].

The normative distribution Atkinson index

Thirdly, for the normative analysis the Atkinson index is chosen, as it enables the consideration of a society's perception of inequality using the epsilon parameter [16, 21]:

$$AI_{type} = 1 - \left[\sum_{i=1}^{n} \left(\frac{X_{i,type}}{X_{type}} \right)^{1-\varepsilon} f_{i,type} \right]^{\frac{1}{1-\varepsilon}}, \quad (1)$$

X = gross income and $\mathrm{FEW}_{virtual}$ expenditures, for $\varepsilon \neq 1$

The larger epsilon is, the more the Atkinson index considers inequalities [22]. In 1997, Mau [18] showed that the inequality perception in Germany varies, for example, between East and West Germany. The households in East Germany regard inequality as a very critical societal issue, whereas households in the western part accept a certain degree of inequality as part of the economic process [18]. This view is confirmed by a survey of the Institut für Demoskopie Allensbach in 2010 [23]. This difference is considered in our analysis. The Atkinson index $\left(AI_{type}\right)$ enables us to analyse the inequality of the different household types (type). We analyse the gross income and FE($W_{virtual}$) expenditures. For our analysis we defined three epsilons: 1.5 (West Germany), 2.0 (Germany), 2.5 (East Germany) representing the different perceptions of inequality. We analysed the Atkinson index for the years 2008 and 2013, and determine the distribution of the FE($W_{virtual}$) costs and of the gross income.

5. RESULTS AND DISCUSSION

We will start our distribution analysis with the real distribution and the Rawls dispersion of FE($W_{virtual}$)-Nexus expenditures and of the gross income.

5.1 Real distribution and Rawls dispersion

The analysis of the distribution of gross income (tables 1+2) shows that in 2008 the self-employed households had the highest monthly average gross income (5395€), followed by the public servants (5255€), and the white- and blue-collar workers (4876€, 4066€). The retirees (2303€) and the unemployed households (1214€) lag far behind.

Table 1: Monthly gross income 2008

Monthly gross income of private households in Germany 2008 according to their household type

Net income groups in €	Self-employed	Public servants	White-collar	Blue-collar	Unemployed	Retiree
All households	5395	5255	4876	4066	1214	2303
under 900	1512	*949*	950	961	*709*	774
900-1300	1396	1153	1495	1462	1091	1210
1300-1500	1705	*1965*	1967	1881	1406	1525
1500-2000	2133	2056	2531	2362	1730	1904
2000-2600	2677	2778	3268	3031	2280	2475
2600-3600	3796	3722	4302	4098	3061	3247
3600-5000	5385	5177	5975	5582	4499	4488
5000-18000	10236	8093	9733	8087	*6490*	7597
Gross income Rawls dispersion*	6.77	8.53	10.25	8.42	9.15	9.82

Source: Own calculation based on German Federal Statistical Office, 2011, * Income dispersion: Ratio of the gross income of the highest income group to the gross income of the average household of the social group. Red italic numbers own estimation. IEK-STE 2019

The Rawls dispersion is lowest for the self-employed households (6.77), the blue-collar workers (8.42) and the public servants (8.53). The Rawls dispersion increases for the unemployed (9.15) and retirees (9.82), and reaches its highest value for the white-collar workers (10.25).

For the year 2013, the real distribution of the gross income of private households changed in Germany. The highest average gross income was then earned by the public servants (6027€), followed by the self-employed and the white-collar workers, whereas the blue-collar workers lag behind. The gross incomes of the unemployed and retirees' households, in contrast, significantly lagged behind the household group of the employed. The income of the unemployed households

increased by about 80€, whereas the retirees received an increase of on average 135€.

During the same time, the average income of the self-employed increased significantly by on average 300€, and that of the public servants by about 800€. The gross incomes of white- and blue-collar workers increased by on average about 500 and 700€ respectively. This shift is also reflected in the Rawls dispersion: the Rawls dispersion of the self-employed rose sharply (6.8 to 10.7) and increased also for the public servants (8.5 to 9.5),

Table 2: Monthly gross income 2013

Monthly gross income of private households in Germany 2013 according to their household type

Net income groups in €	Self-employed	Public servant	White-collar	Blue-collar	Unemployed	Retiree
All households	5634	6027	5324	4338	1294	2438
under 900	985	*850*	1046	958	*745*	854
900-1300	1473	1325	1475	1437	1099	1217
1300-1500	1932	1712	1868	1854	1420	1543
1500-2000	2303	2232	2469	2341	1762	1922
2000-2600	3311	3033	3261	3023	2282	2506
2600-3600	4286	3995	4324	4095	3157	3312
3600-5000	5872	5574	5956	5624	4463	4618
5000-18000	10591	8659	10098	8152	*7756*	7866
Gross income dispersion*	10.75	10.19	9.65	8.51	10.41	9.21

Source: Own calculation based on German Federal Statistical Office, 2015, * Rawls dispersion: Ratio of the gross income of the highest income group to the gross income of the lowest household of the social group. Red italic numbers own estimation.

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whereas the Rawls dispersion of the white-collar workers decreased (10.2 to -9.6), whereas that of the blue-collar workers (8.5 to 8.4) remained roughly the same. The dispersion of the unemployed households (9.1 to 10.4) increased significantly, whereas the dispersion among the retirees only decreased slightly (9.8 to 9.2). Furthermore, the household groups were affected differently by the economic crises following the Lehman bankruptcy in 2008. In the following it will be analysed, how those incomes were attributed to the consumption of different resources.

The food, energy, water and virtual water expenditures of the households are summarised in the FE($W_{virtual}$)-Nexus expenditures. The virtual water consumption costs are assessed using the average German water price [24, 25] and data of the German Statistical Office on water consumption [25]. Table 3 shows that the self-employed households have the lowest Rawls dispersion (2.83), followed by the blue-collar workers (3.65) and the unemployed households (3.66) in 2008. The dispersion increased to 3.77 for the retirees and 3.96 for the white-collar workers. The civil servants have the highest dispersion (4.22).

Table 3: Monthly FE($W_{virtual}$) expenditures 2008

FE($W_{incl.virtualwater}$) expenditures of private households in Germany, 2008, in €

Income groups in €	Self employed	Civil servants	White-collar	Blue-collar	Unemployed	Retiree
All households	878	898	761	827	426	599
< 900	445	295	299	325	279	308
900-1300	405	342	364	389	412	387
1300-1500	452	415	419	473	506	452
1500-2000	537	460	490	573	633	547
2000-2600	646	533	603	730	735	681
2600-3600	824	686	775	890	884	799
3600-5000	979	954	950	1058	1121	969
5000-18000	1260	1246	1182	1186	*1023*	1164
Rawls FEW dispersion*	2.83	4.22	3.96	3.65	3.66	3.77

Source: Own calculation based on German Federal Statistical Office, 2012, 2015,2018 *Italic numbers: own estimation, limited data basis in this income group.*

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The average consumption expenditures for FE($W_{virtual}$) commodities do not differ so much, whereas the expenditures of those households that are not employed (unemployed, retiree) are significantly lower. The analysis of the FE($W_{virtual}$) expenditures for 2013 shows (table 4), that the Rawls dispersion of the civil servants increased to 5.99.

Table 4: Monthly FE($W_{virtual}$) expenditures 2013

FEW($_{incl.virtualwater}$) expenditures of private households in Germany, 2013, in €

Income groups in €	Self employed	Civil servants	White-collar	Blue-collar	Unemployed	Retiree
All households	920	968	810	856	443	614
< 900	381	216	334	286	293	312
900-1300	445	274	376	372	407	379
1300-1500	484	394	431	452	503	448
1500-2000	599	480	492	556	620	547
2000-2600	741	569	596	715	767	688
2600-3600	876	696	757	884	896	813
3600-5000	1029	949	967	1066	925	955
5000-18000	1331	1294	1213	1256	*1050*	1175
Rawls dispersion*	3.49	5.99	3.64	4.39	3.59	3.76

Source: Own calculation based on German Federal Statistical Office, 2012, 2015,2018 *Italic numbers: own estimation, limited data basis in this income group.*

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The dispersion of the civil servants and of the blue-collar workers also increased, as well as the FE($W_{virtual}$) consumption spread between the lowest and highest income groups. It decreased, in contrast, for the white-collar workers and stayed nearly the same for the unemployed and retiree households. This analysis shows that the increase of the expenditures did not equally affect all income groups, and the increase is not consistent for all income groups of the private households. Accordingly, the possibility to increase consumption is not equally distributed. Hence, we analyse this different distribution against the background of society's perception of inequality [15].

5.2 Normative Distribution – Atkinson index

The analysis shows that the gross income is more unevenly distributed than the FE($W_{virtual}$) expenditures, and that the Atkinson index increases with rising epsilon parameter values (table 5). The analysis further revealed the differences also between the household groups. In the group of the self-employed households, the gross income is most unevenly distributed both in 2008 and in 2013, followed by the white-collar workers and the retirees. For the civil servants, blue-collar workers, and the unemployed households the gross income is more evenly distributed between the income groups.

Table 5 further shows that with an increasing inequality perception, expressed in the epsilon parameter, the Atkinson index increases. Accordingly, from 2008 to 2013 the Atkinson index increased for the self-employed, blue-collar workers, the unemployed households and the retirees, and decreased for the civil servants and the white-collar workers. The distribution of the FE($W_{virtual}$)-nexus expenditures, in contrast, reveals a different picture.

Table 5:

Atkinson Index	2008			2013		
Epsilon parameter	*1.5 (West Germany)*	*2 (Germany)*	*2.5 (East Germany)*	*1.5 (West Germany)*	*2 (Germany)*	*2.5 (East Germany)*
Households	Atkinson - Gross income					
Self employed	0.284	0.358	0.418	0.313	0.405	0.482
Civil servants	0.173	0.238	0.302	0.162	0.225	0.289
White-collar	0.231	0.299	0.360	0.228	0.295	0.355
Blue-collar	0.164	0.221	0.277	0.173	0.232	0.288
Unemployed	0.163	0.195	0.221	0.168	0.200	0.227
Retiree	0.195	0.248	0.295	0.204	0.257	0.303
	Atkinson - $FEW_{virtual}$ expenditures					
Self employed	0.099	0.132	0.165	0.110	0.149	0.186
Civil servants	0.101	0.137	0.173	0.107	0.149	0.194
White-collar	0.107	0.142	0.175	0.100	0.133	0.165
Blue-collar	0.081	0.111	0.143	0.093	0.128	0.165
Unemployed	0.097	0.122	0.145	0.097	0.121	0.142
Retiree	0.090	0.118	0.145	0.099	0.130	0.158

Source: Own calculation 2018 IEK-STE 2018

The Atkinson Index increased independent of the chosen epsilon parameter from 2008 to 2013 for the self-employed, civil servants, blue-collar workers and the retirees. It decreased for the white-collar workers and remained unchanged for the unemployed households.

6. DISCUSSION

From this development we can conclude that the living conditions of the household types are relatively similar and thus cause a certain FE($W_{virtual}$)-expenditure behaviour based on the gross income. However, the analysis also shows that the consumption expenditures are more evenly distributed than the gross income. This reflects the fact that certain basic needs exist that must be fulfilled independent of the household gross income. The increase in the epsilon parameter from 1.5 to 2.5 reflects the different self-assessment of various regions in the German society with respect to their respective vulnerabilities. These differences should be considered by the analysis of the effectiveness of governmental measures.

7. CONCLUSION

Our model, firstly, delivers data for a direct assessment over time (2008-2013) and a normative assessment considering different attitudes of households towards inequality (Rawls dispersion, Atkinson index) on the example of Germany. Secondly, the analysis of real and normative income distribution and FE($W_{virtual}$)-Nexus related consumption expenditures reveals social inequality also in Germany in the view of different social inequality perceptions. These results can support German institutions in developing measures in line with the inequality aversion of the German society and implementing measures and institutions for a new social contract. A special challenge, however, will consist in that those attitudes differ regionally within a country or between countries. Our analysis thus supports decision makers' to solve the basic trade-off between equality and efficiency which is relevant for any society. Our method can be used in all countries which provide household data survey. In a second research step our research approach will be used for an analysis of the socio-economic-ecological development of Bangladesh based on Bangladesh Household Income & Expenditure survey [26].

8. REFERENCE

[1] Statistisches Bundesamt. Einkommens- und Verbrauchsstichprobe -Einnahmen und Ausgaben privater Haushalte 2003. Wiesbaden: Statistisches Bundesamt,; 2008.

[2] Statistisches Bundesamt. Wirtschaftsrechnungen Einkommens- und Verbrauchsstichprobe Aufgabe, Methode und Durchführung. *Fachserie Wirtschaftsrechnungen*. 2013;Fachserie 15.

[3] Gordon K. *Foreword*. In: Okun AM, editor. *Equality and Efficiency: The Big Tradeoff*. Washington D.C: The Brookings Institution; 1975.

[4] Deaton A. *The great escape, health, wealth, and the origins of inequality*. Princeton: Princeton University Press; 2013.

[5] Stiglitz J. *Price of Inequality*. London: Norton; 2012.

[6] Stiglitz JE. The 1 Percent's Problem. Vanity Fair. London: Vanity Fair; 2012.

[7] Alvaredo F, Chancel L, Piketty T, Saez E, Zucman G. World inequality report 2018. Paris: World inequality lab; 2017.

[8] van Leeuwen CJ, Frijns J, van Wezel A, van de Ven FHM. City Blueprints: 24 Indicators to Assess the Sustainability of the Urban Water Cycle. *Water Resources Management*. 2012;26:2177-97.

[9] Hoekstra AY, Chapagain AK. Water footprints of nations: Water use by people as a function of their consumption pattern. *Water Resources Management*. 2007;21:35-48.

[10] Allan T. Watersheds and Problemsheds: Explaining the Absence of Armed Conflict Over Water in the Middle East. *Middle East Review of International Affairs*. 1998;2.

[11] Allan T. *Virtual Water: Tackling the Threat to Our Planet's Most Precious Resource* London, New York: I B TAURIS; 2011.

[12] German Federal Statistical Office. The Income and Consumption Survey (EVS)- tasks, methods and implementation (in German:Einkommens- und Verbrauchsstichprobe - Aufgabe, Methode und Durchführung der EVS). *Special serie household budget surveys (in German: Fachserie Wirtschaftsrechnungen)*. 2005;15.

[13] Statistisches Bundesamt. Wirtschaftsrechnungen - Einkommens- und Verbrauchsstichprobe Einnahmen und Ausgaben privater Haushalte. Wiesbaden: Statistisches Bundesamt; 2015.

[14] Statistisches Bundesamt. Einkommens- und Verbrauchsstichprobe -Einnahmen und Ausgaben privater Haushalte 2008. Wiesbaden2011.

[15] Schlör H, Fischer W, Hake J-F. Analysing Gordon's trade-off by adapting Thurow's approach of pure public good

to the German energy sector. *Energy, Sustainability and Society*. 2016;6.
[16] Atkinson AB. On the measurement of inequality. *Journal of Economic Theory*. 1970;2:244-63.
[17] Schlör H, Fischer W, Hake J-F. Measuring social welfare, energy and inequality in Germany. *Applied Energy*. 2012;97:135-42.
[18] Mau S. Ungleichheits- und Gerechtigkeitsorientierungen in modernen Wohlfahrtsstaaten. Berlin: Wissenschaftszentrums Berlin für Sozialforschung; 1997. p. 110.
[19] Schlör H, Venghaus S, Fischer W, Märker C, Hake J-F. Deliberations about a perfect storm – The meaning of justice for food energy water-nexus (FEW-Nexus). *Journal of Environmental Management*. 2018;220:16-29.
[20] Rawls J. *A Theory of Justice*. Cambridge, MA: Harvard University Press; 1971.
[21] Atkinson AB. *The Economics of Inequality*. 2 ed. Oxford: Clarendon Press; 1983.
[22] Schlör H, Fischer W, Hake J-F. Sustainable development, justice and the Atkinson index: Measuring the distributional effects of the German energy transition. *Applied Energy*. 2013;112:1493-9.
[23] The Institut für Demoskopie Allensbach (IfD Allensbach). Einstellungen zur sozialen Marktwirtschaft in Deutschland am Jahresanfang 2010. Allensbach am Bodensee: IfD Allensbach; 2010.
[24] German Federal Statistical Office. Press release water costs (in German: Pressemitteilung Nr. 110 vom 21.03.2014: 1 000 Liter Trinkwasser kosteten 2013 im Durchschnitt 1,69 Euro). In: Office GFS, editor. Wiesbaden: German Federal Statistical Office; 2014.
[25] German Federal Statistical Office (Statistisches Bundesamt). The water footprint of food (in German: Zu Wasserfußabdruck von Ernährungsgütern. Umweltökonomische Gesamtrechnungen Materialfluss-, Energie- und Wasserrechnungen). Wiesbaden: Statistisches Bundesamt; 2012.
[26] Bangladesh Bureau of Statistics. Report of the Household Income & Expenditure Survey 2010. Dhaka-1207, Bangladesh.: Bangladesh Bureau of Statistics; 2011.