Understanding the Relationship between GHG Emissions from Consumption and Household Characteristics

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NZAE Conference

Auckland, July 2014

Motivation

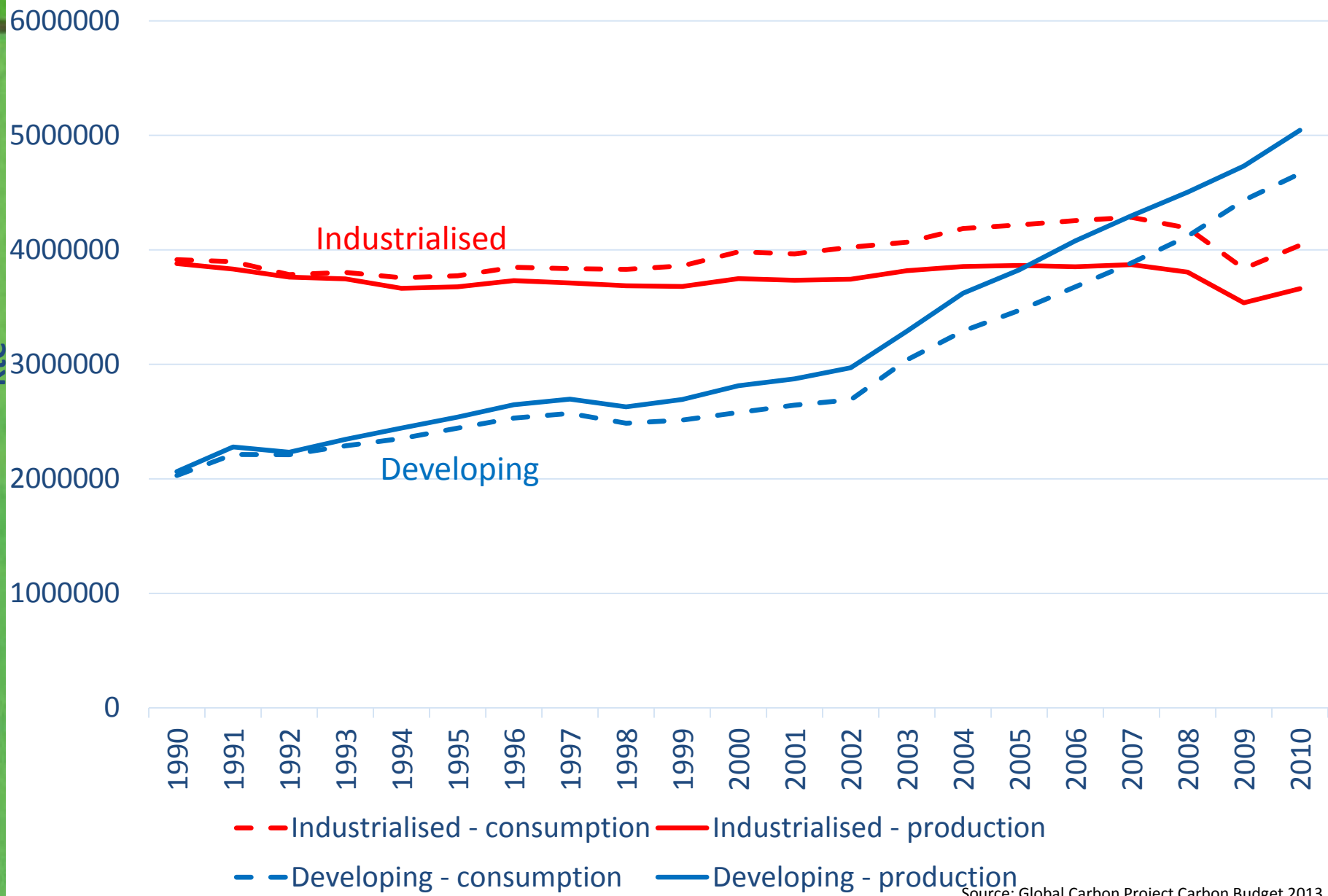
Current emissions reporting regimes focus on production

- Per capita
- Per industry

Consumers control what they earn and buy, which drives demand for emissions, but not what or how goods are produced

Production emissions are only one imperfect indicator of effort to reduce emissions – consumption emissions complements it

Production vs. Consumption of CO_2 Emissions - Industrialised vs. Developing Countries



Source: Global Carbon Project Carbon Budget 2013

Research questions

How do household GHG emissions vary with household characteristics?

How much variability in emissions is observed across households with a given set of characteristics?

Calculating household emissions

(Romanos and Kerr, 2014)

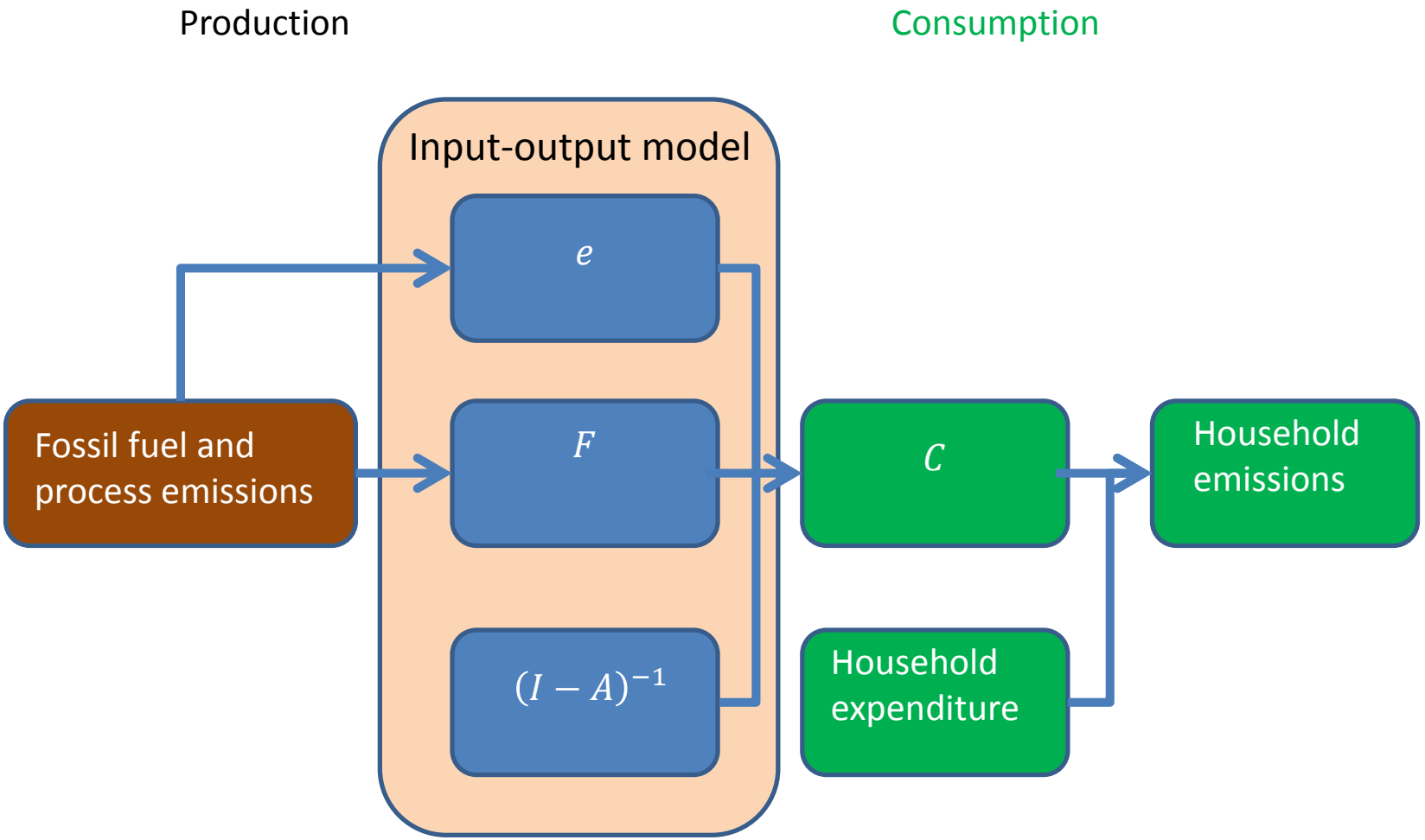
Relate industry production emissions to product emissions

- Carbon intensity vector c (t-CO_2/$ gross output) across industries
- Derive c by using an input-output (IO) model
  - Tracks CO_2 emissions from fossil fuel combustion
  - Tracks non-energy process emissions (e.g. agriculture and industry) in CO_2eq
  - Intermediate and final products are accounted for

Link product emissions to household expenditure data

Assign industries from the c vector to categories of household expenditure

Methodology flowchart



Limitations

Single region I-O model treats imports the same as domestic goods in the same industry

- imports are assumed to have the same emissions intensity as domestically produced goods
- No consideration of international transport

Homogeneous goods assumption

- expenditure patterns within groups can vary significantly – and emissions intensity

Subsidised consumption

- government spending on goods and services consumed by households not accounted for

Access to the data used in this presentation was provided by Statistics New Zealand under conditions designed to give effect to the security and confidentiality provisions of the Statistics Act 1975. The results presented are the work of the author, not Statistics New Zealand.

We acknowledge Statistics New Zealand, the Ministry of Business, Innovation and Employment, and the Ministry for the Environment for access to the data used in calculating consumption emissions.

Data

Emissions (all 2007)

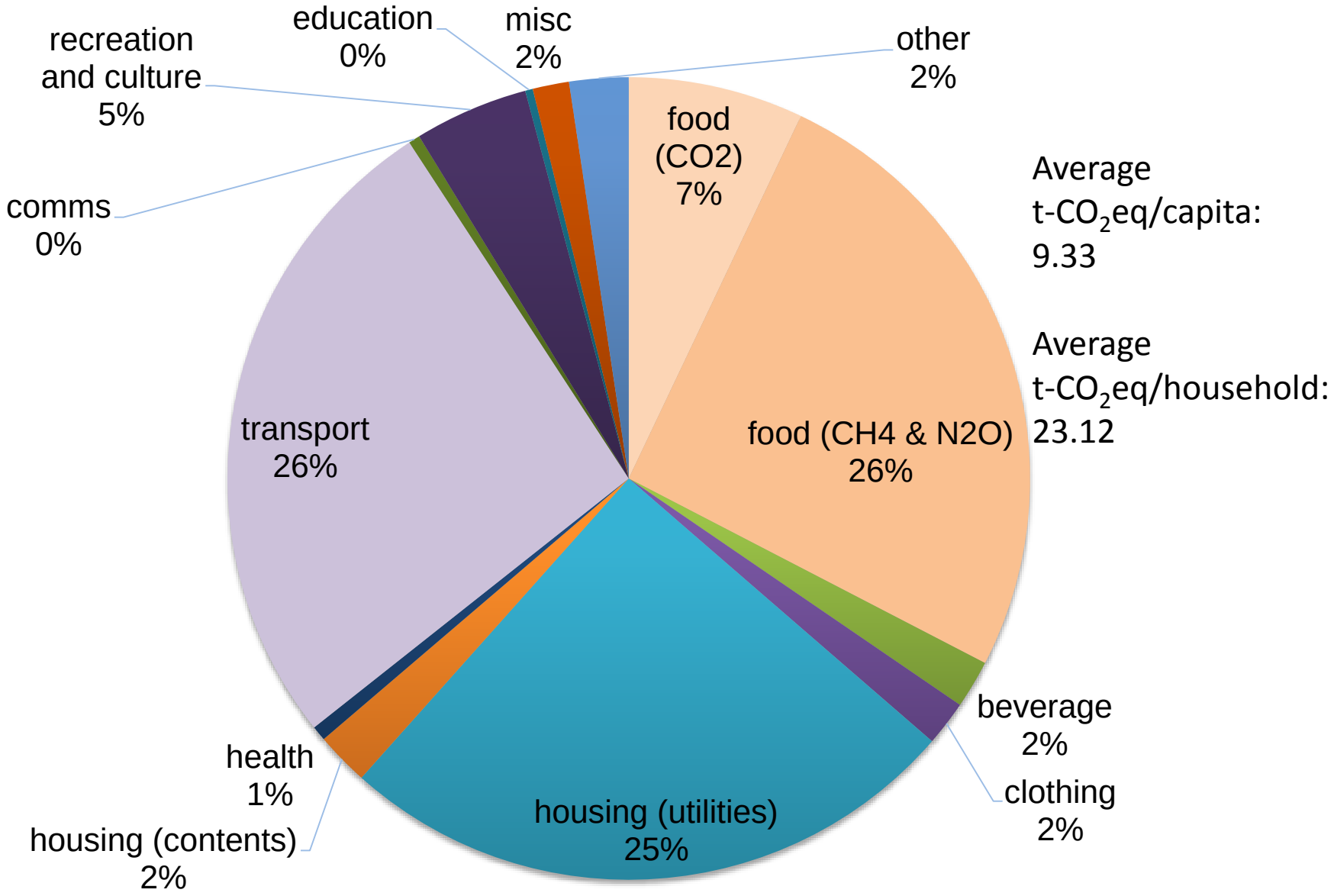
- Energy GHG Emissions web tables (MBIE) (e)
- GHG Inventory (MfE) (e)
- Energy Data File (MBIE) (F)
- National Accounts input-output tables (Stats NZ) $((I - A)^{-1})$

Household expenditure and household characteristics

- Household Economic Survey 2012/13 unit record data

Major sources of household emissions

Composition of NZ per capita consumption emissions 2012



HES Expenditure Category	Without process emissions (Kg CO2/dollar)	With process emissions (Kg CO2-e/dollar)
Food	0.176	0.739
Transport	0.700	0.726
Housing (Utilities)	0.376	0.425
Clothing	0.145	0.247
Rec/Culture	0.143	0.184
Housing(Contents)	0.153	0.197
Beverage	0.161	0.308
Other	0.079	0.092
Misc.	0.057	0.071
Health	0.078	0.104
Comm	0.047	0.058

FOOD	tons CO2-e	%	kg CO2-e /$
Fruit and vegetables	1.2	19%	1.3
Meat, poultry, and fish	2.1	34%	1.7
Grocery food			
Milk, cheese, and eggs	1.0	17%	1.7
Other grocery food	1.3	21%	0.40
Non-alcoholic beverages	0.1	2.2%	0.31
Restaurant meals and ready-to-eat food	0.5	7.1%	0.23
Total	**6.28**	**100%**	

TRANSPORT	tons CO2-e	%	kg CO2-e /$
Purchase of vehicles	0.36	6.8%	0.14
Private transport supplies and services			
Petrol	3.7	69%	1.8
Other private transport	0.28	5.3%	0.17
Passenger transport services	1.0	19%	0.91
Total	**5.31**	**100%**	

HOUSING UTILITIES	tons CO2-e	%	kg CO2-e /$
Actual rentals for housing	0.47	9.9%	0.14
Home ownership	0.64	14%	0.23
Property maintenance	0.21	4.5%	0.25
Property rates & related services	0.19	4.1%	0.15
Household energy			
Electricity	3.0	64%	1.86
Other household energy	0.15	3.2%	0.58
Other housing expenses	0.05	1.0%	0.057
Total	**4.72**	**100%**	

Emissions, expenditure, and household size

	$\log\left(\begin{matrix}Total\\emissions\end{matrix}\right)$
$\log(Expenditure)$	0.725***
	(0.010)
$Number\ of\ adults$	0.134***
	(0.008)
$Number\ of\ children$	0.052***
	(0.009)
Age controls	Y
Region controls	Y
R^2	0.801
N	2830

Notes: The above table contains marginal effects calculated at the mean of the variables. The number of adults and number of children enter the regressions quadratically, with an interaction term between them. *** denotes statistical significance at the 1% level. The number of observations has been rounded to preserve anonymity.

Emissions, expenditure, and household size

	$\log\left(\frac{Total}{emissions}\right)$	$\log\left(\frac{Food}{emissions}\right)$	$\log\left(\frac{Utilities}{emissions}\right)$	$\log\left(\frac{Transport}{emissions}\right)$
$\log(Expenditure)$	0.725*** (0.010)	0.631*** (0.026)	0.477*** (0.023)	1.102*** (0.044)
$Number\ of\ adults$	0.134*** (0.008)	0.235*** (0.020)	0.079*** (0.017)	0.174*** (0.035)
$Number\ of\ children$	0.052*** (0.009)	0.163*** (0.026)	0.072*** (0.020)	-0.051 (0.040)
Age controls	Y	Y	Y	Y
Region controls	Y	Y	Y	Y
R^2	0.801	0.407	0.286	0.33
N	2830	2830	2830	2830

Notes: The above table contains marginal effects calculated at the mean of the variables. The number of adults and number of children enter the regressions quadratically, with an interaction term between them. *** denotes statistical significance at the 1% level. The number of observations has been rounded to preserve anonymity.

Increase in material wellbeing vs. increase in household size

no household economies of scale

	Household 1	Household 2
Household Expenditure	$60,000	$90,000
# of adults	2	3
# of kids	0	0
Emissions (t-CO_2eq)	22.63	34.3
% difference from household 1	-	51.6%

Increase in material wellbeing vs. increase in household size

children are less emissions intensive – until they grow up!

	Household 1	Household 2	Household 3
Household Expenditure	$60,000	$90,000	$90,000
# of adults	2	3	2
# of kids	0	0	1
Emissions (t-CO_2eq)	22.63	34.3	32.02
% difference from household 1	-	51.6%	41.5%

Increase in material wellbeing vs. increase in household size

	Household 1	Household 2	Household 3	Household 4	Household 5	Household 6
Household Expenditure	$60,000	$90,000	$90,000	$60,000	$90,000	$60,000
# of adults	2	3	2	3	2	2
# of kids	0	0	1	0	0	1
Emissions (t-CO_2eq)	22.63	34.3	32.02	25.57	30.36	23.86
% difference from household 1	-	51.6%	41.5%	13%	34.2%	5.44%

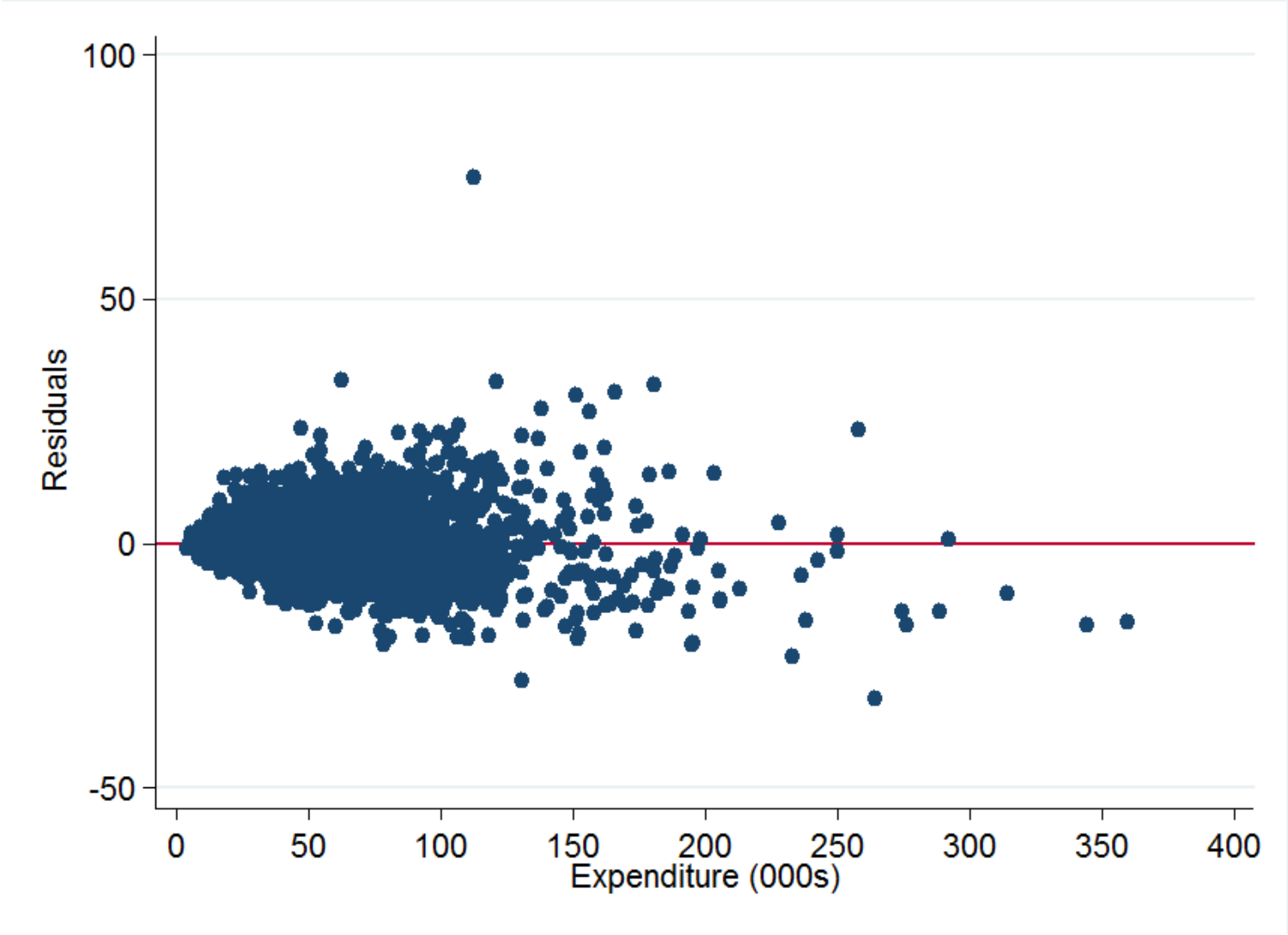
Increase in material wellbeing vs. increase in household size

	Household 1	Household 2	Household 3	Household 4	Household 5	Household 6
Household Expenditure	$60,000	$90,000	$90,000	$60,000	$90,000	$60,000
# of adults	2	3	2	3	2	2
# of kids	0	0	1	0	0	1
Emissions (t-CO_2eq)	22.63	34.3	32.02	25.57	30.36	23.86
% difference from household 1	-	51.6%	41.5%	13%	34.2%	5.44%

Variability of household emissions

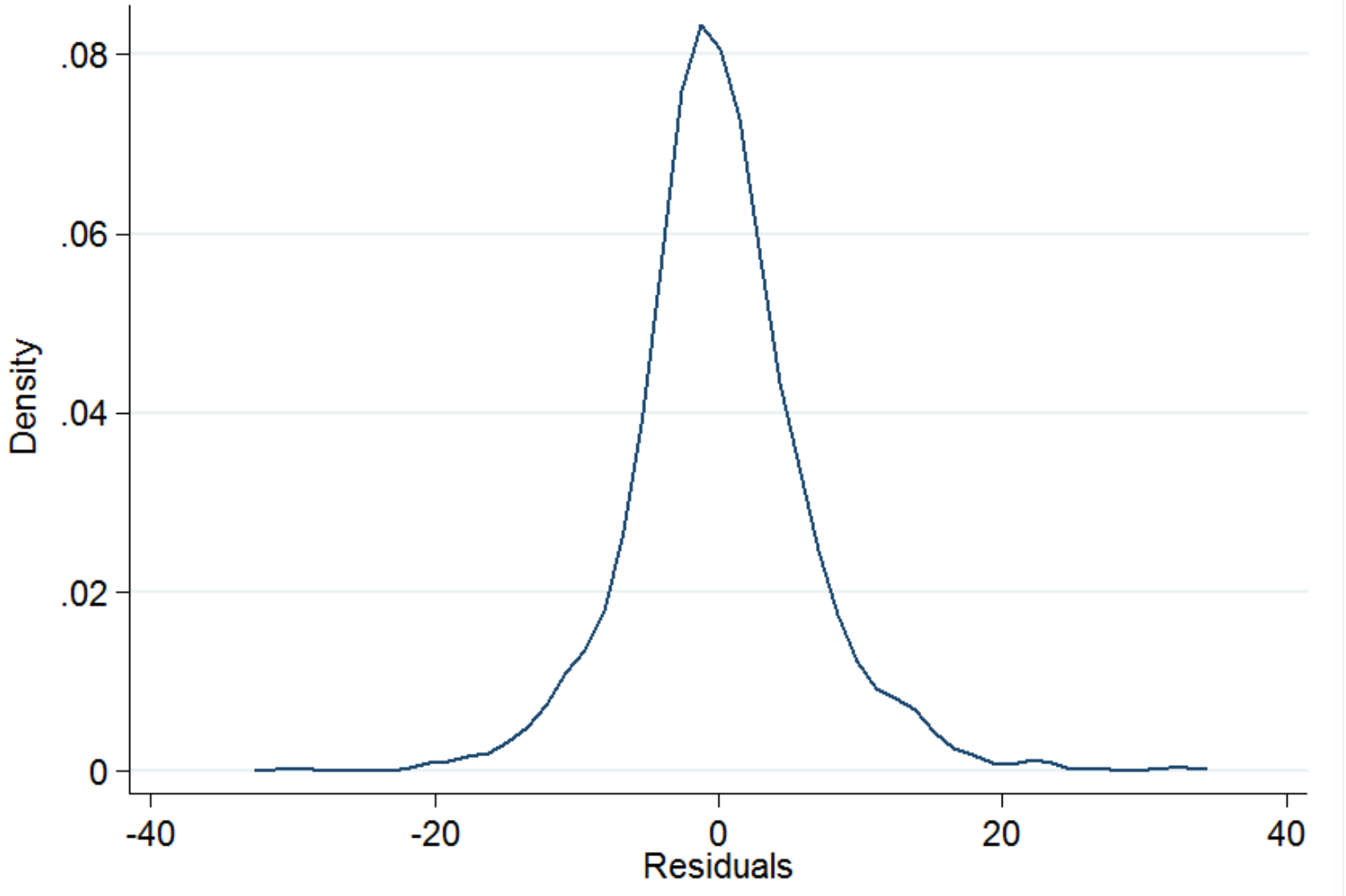
controlling for household composition, age and region

Household average: 23 t CO_2-e

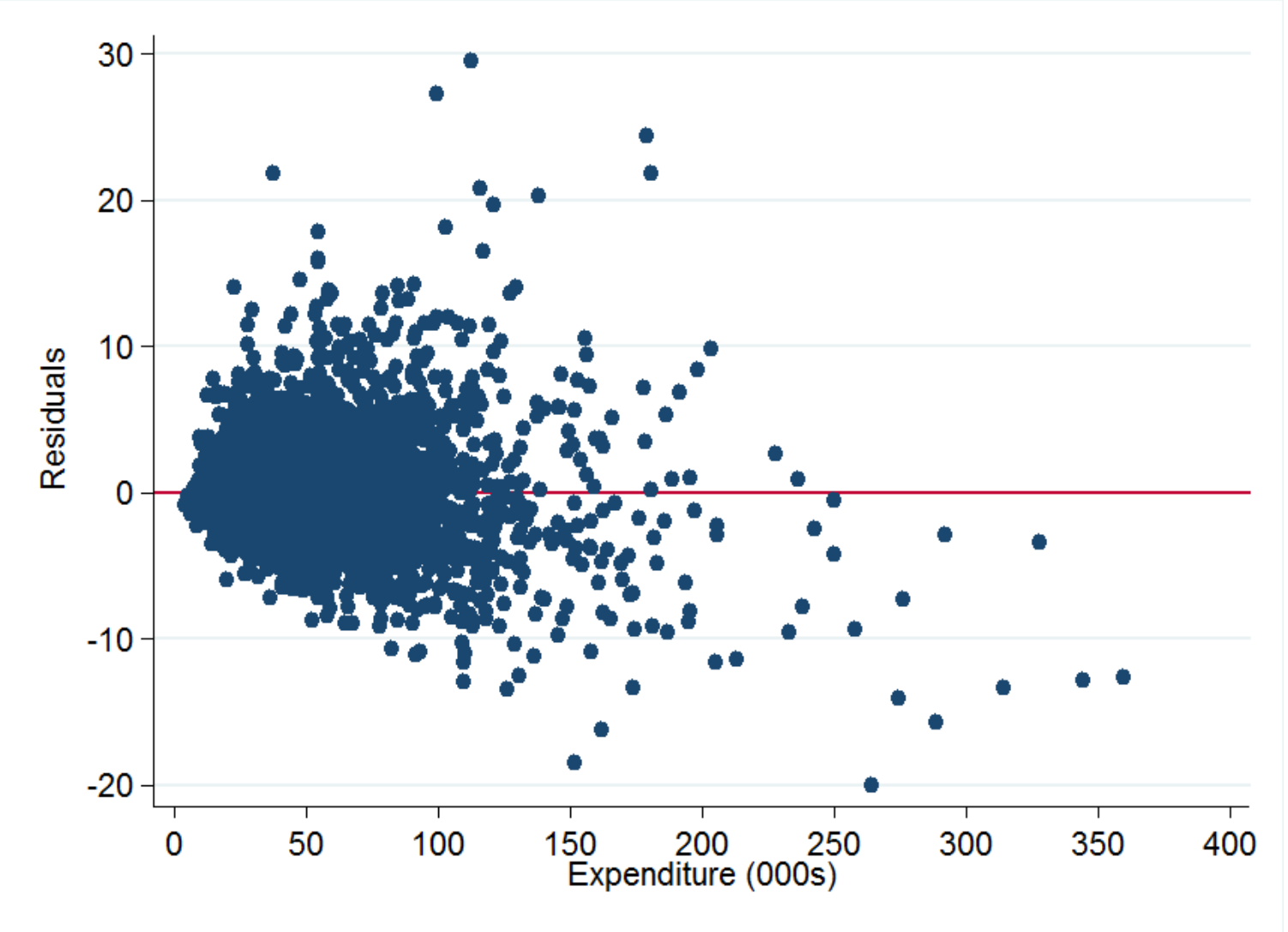


Distribution of residuals (t-CO_2eq)

household average 23



Food residuals vs. expenditure



Conclusions

Household consumption emissions dominated by food, transport and household utilities

- Focus areas for mitigation

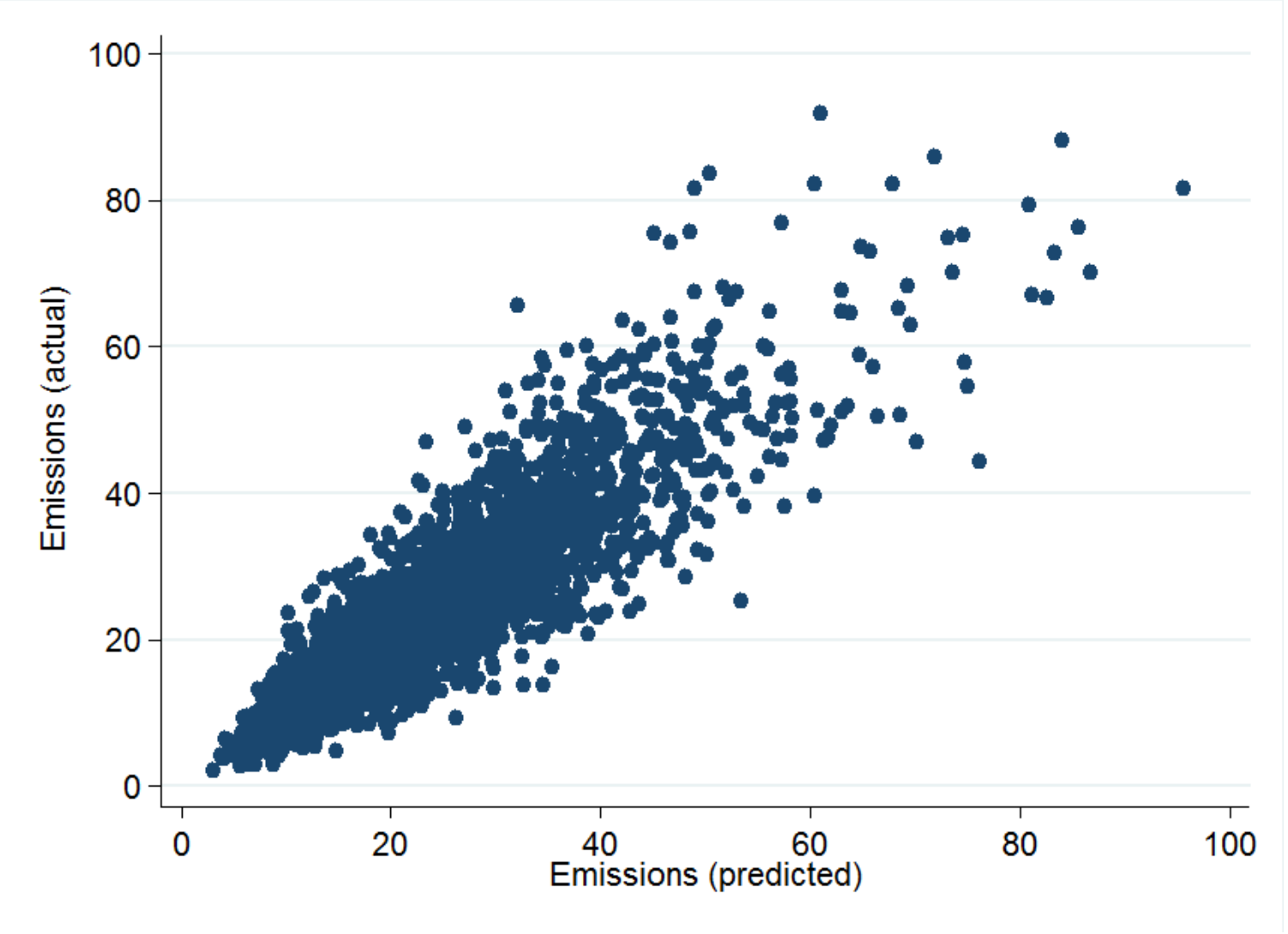
Total expenditure and household size are the major determinants of emissions –lifestyle and family size choices are important

Significant variability in emissions across households with same characteristics

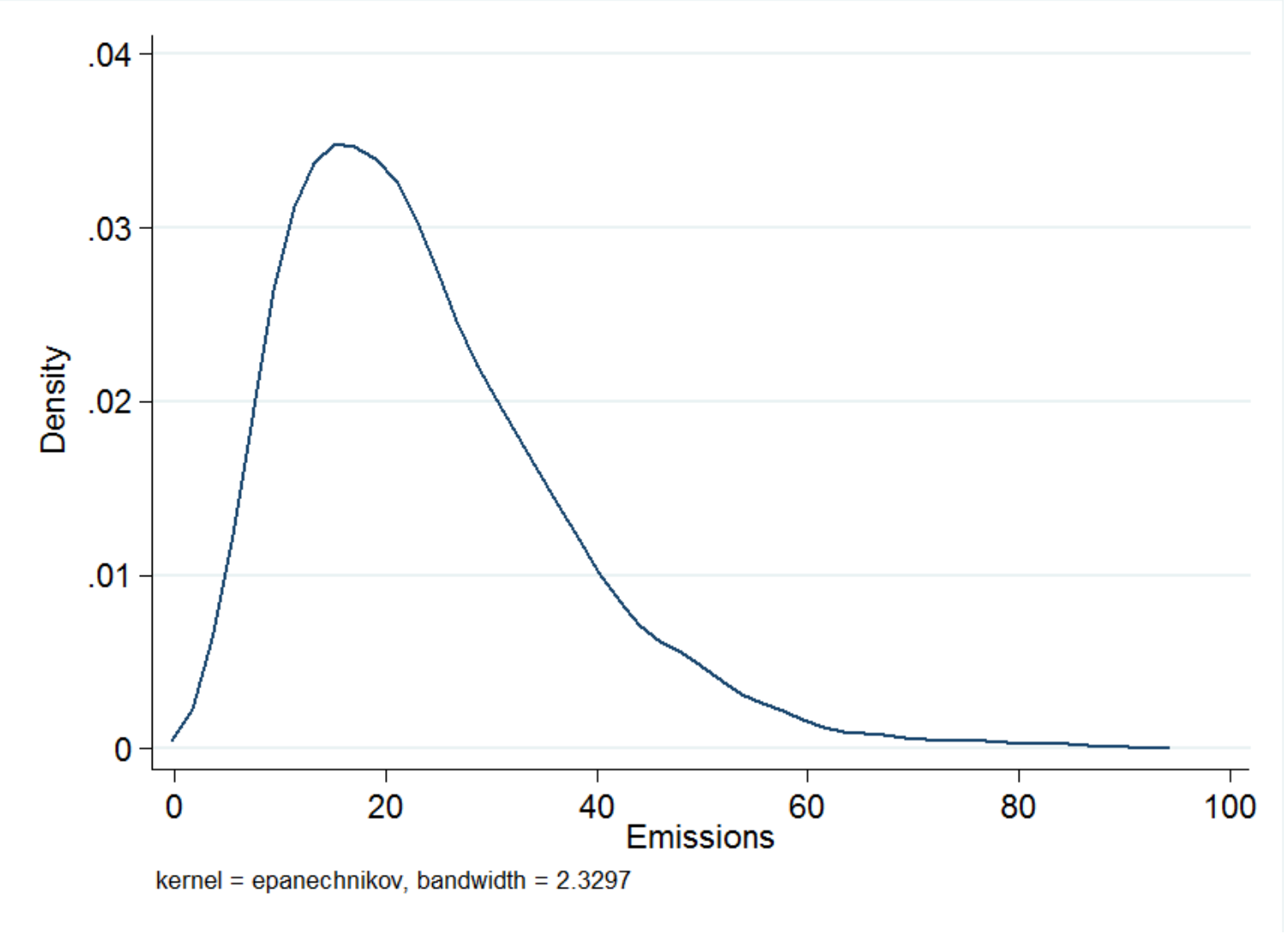
- Potential for mitigation through lifestyle choices

Emissions vs. Expenditure

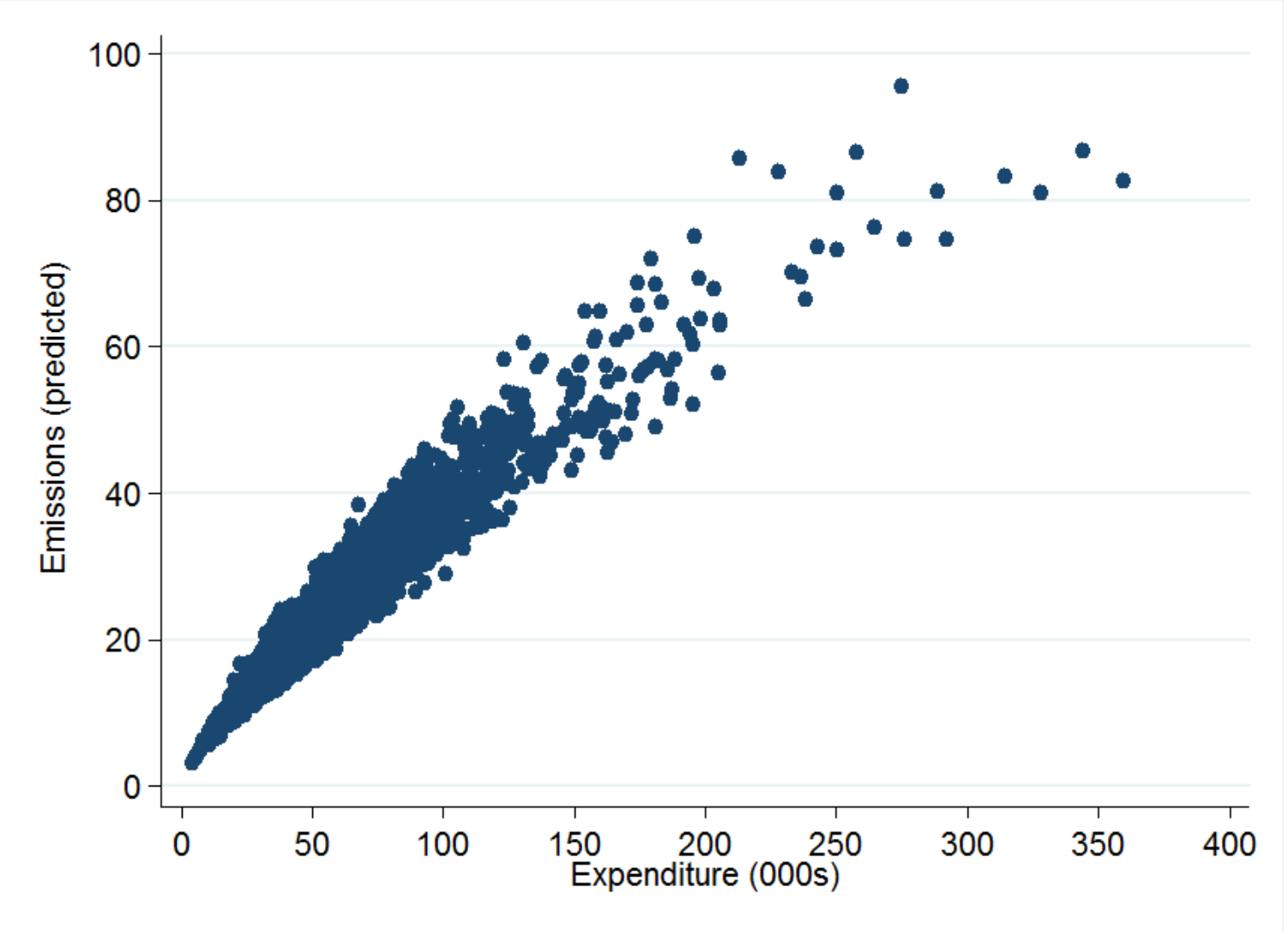
Actual vs. Predicted Emissions



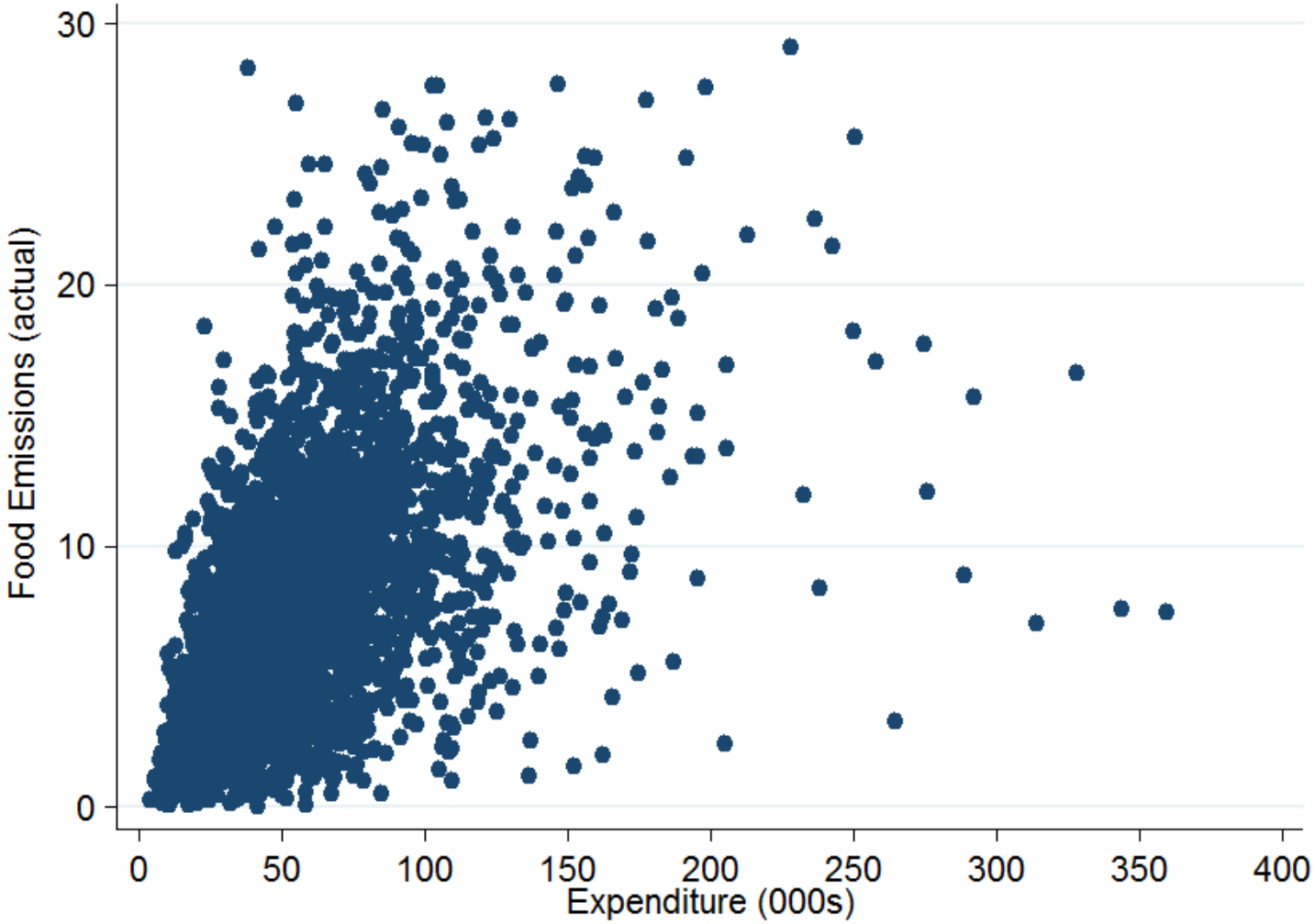
Distribution of Emissions



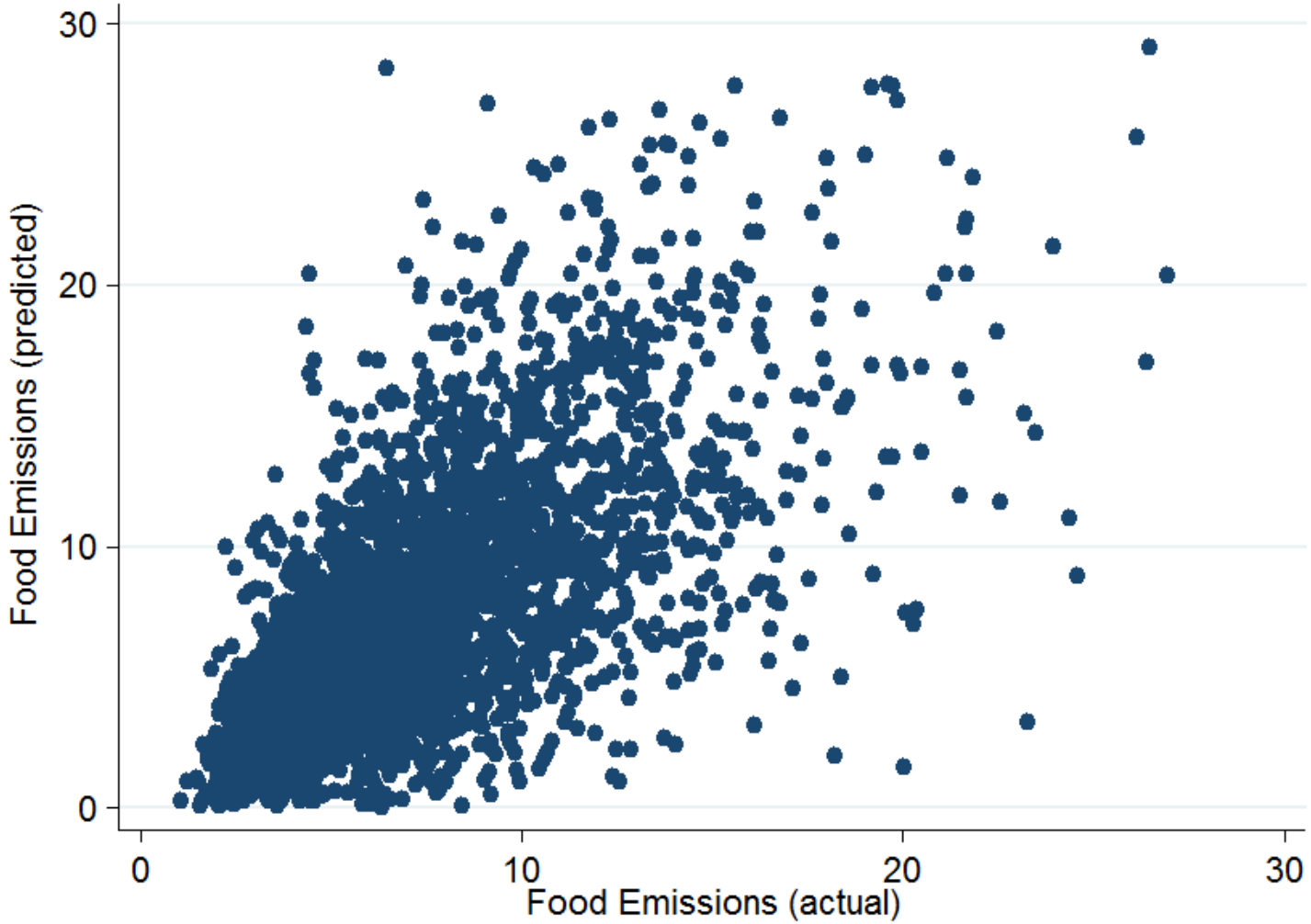
Predicted Emissions vs. Expenditure



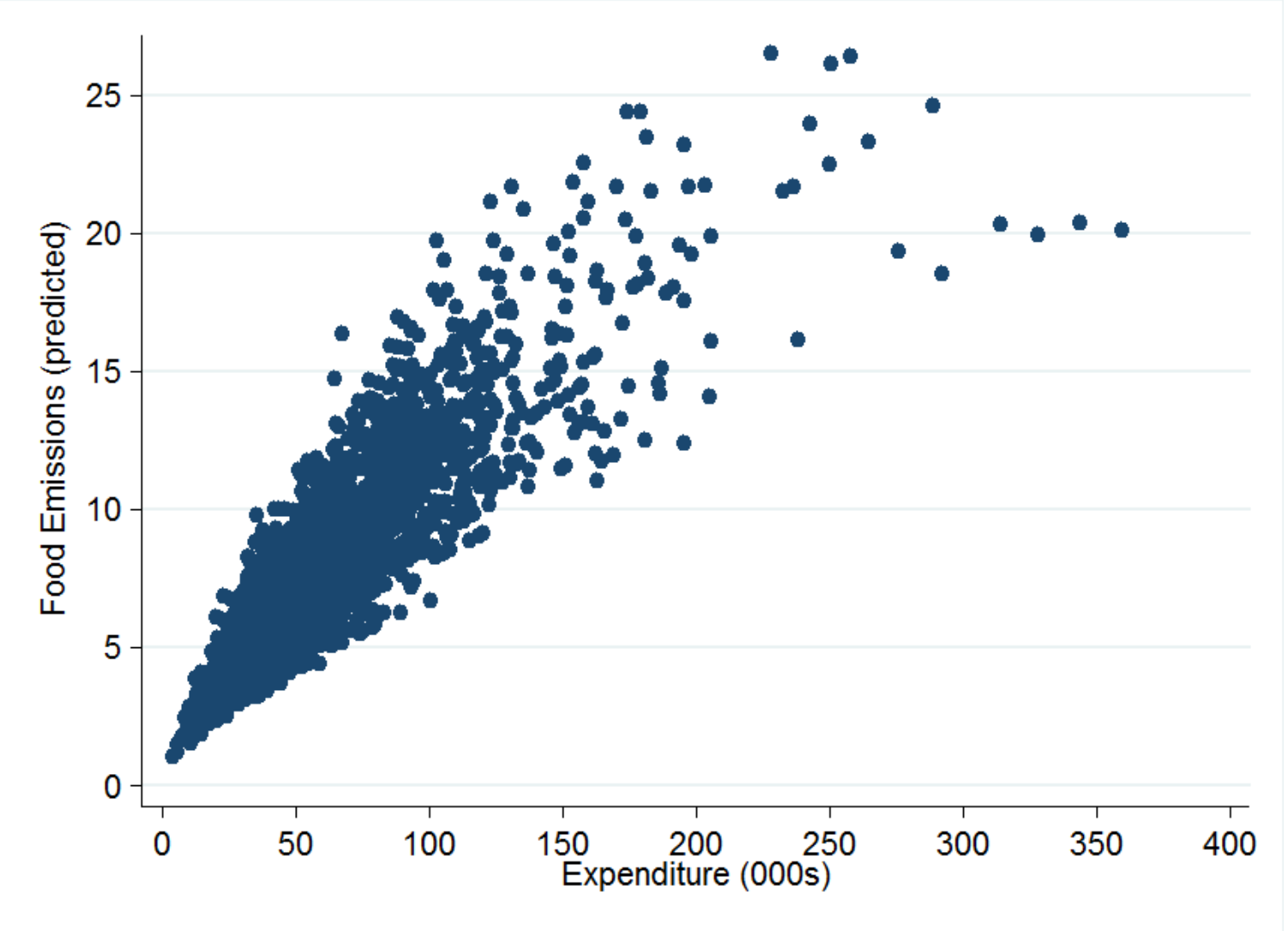
Food emissions vs. expenditure



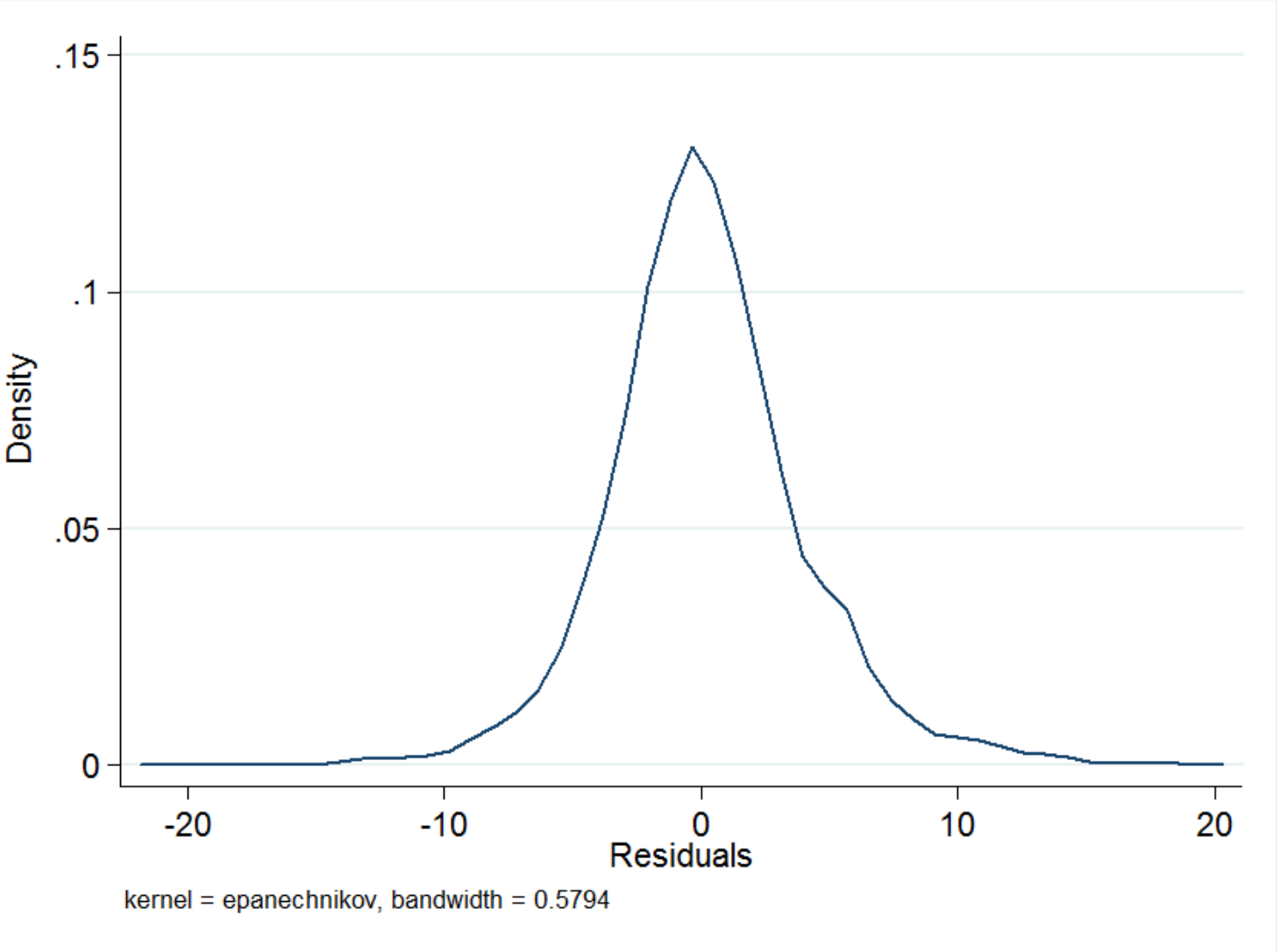
Food emissions: actual vs. predicted



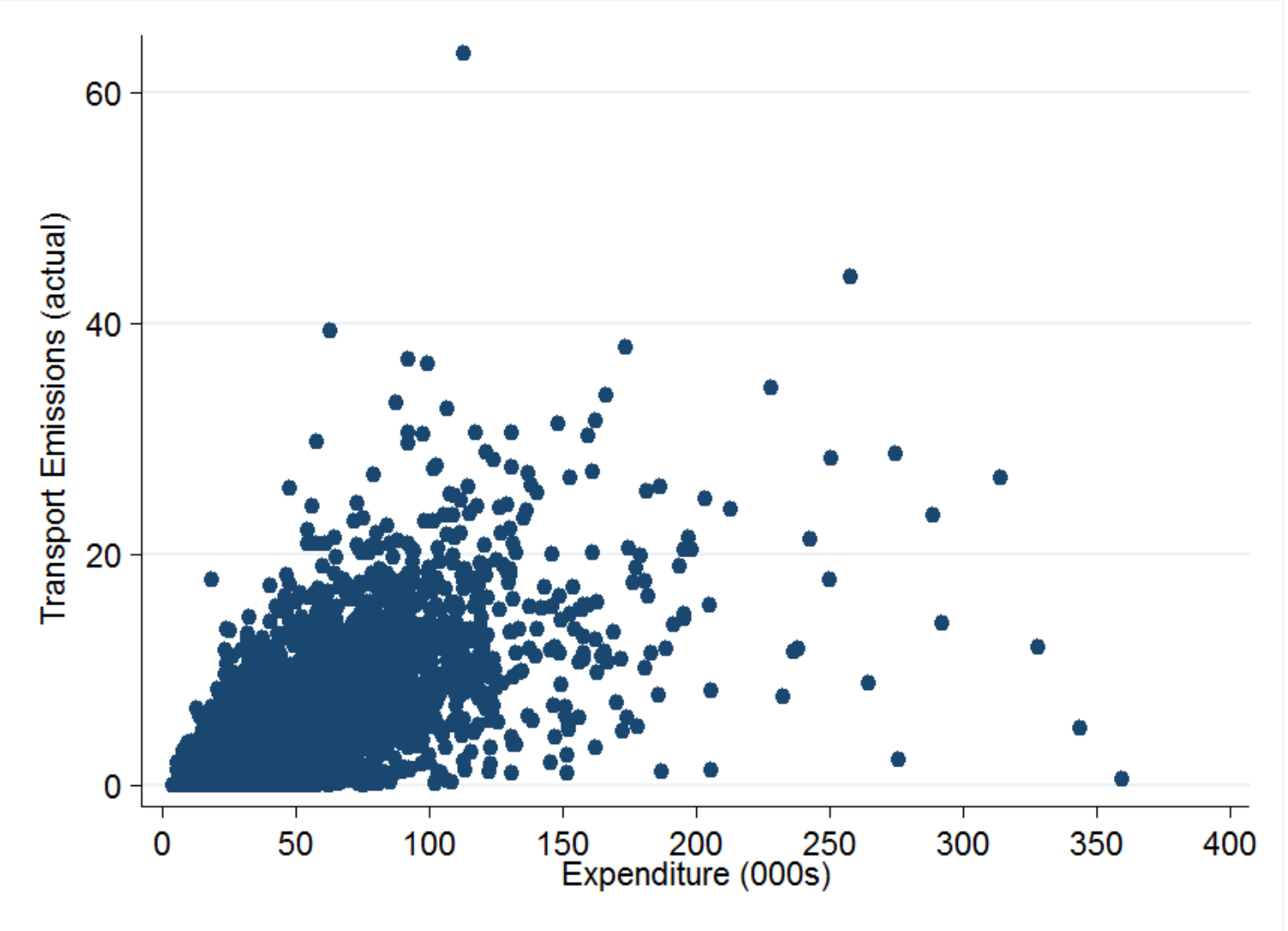
Predicted food emissions vs. expenditure



Food residuals density



Transport emissions vs. expenditure



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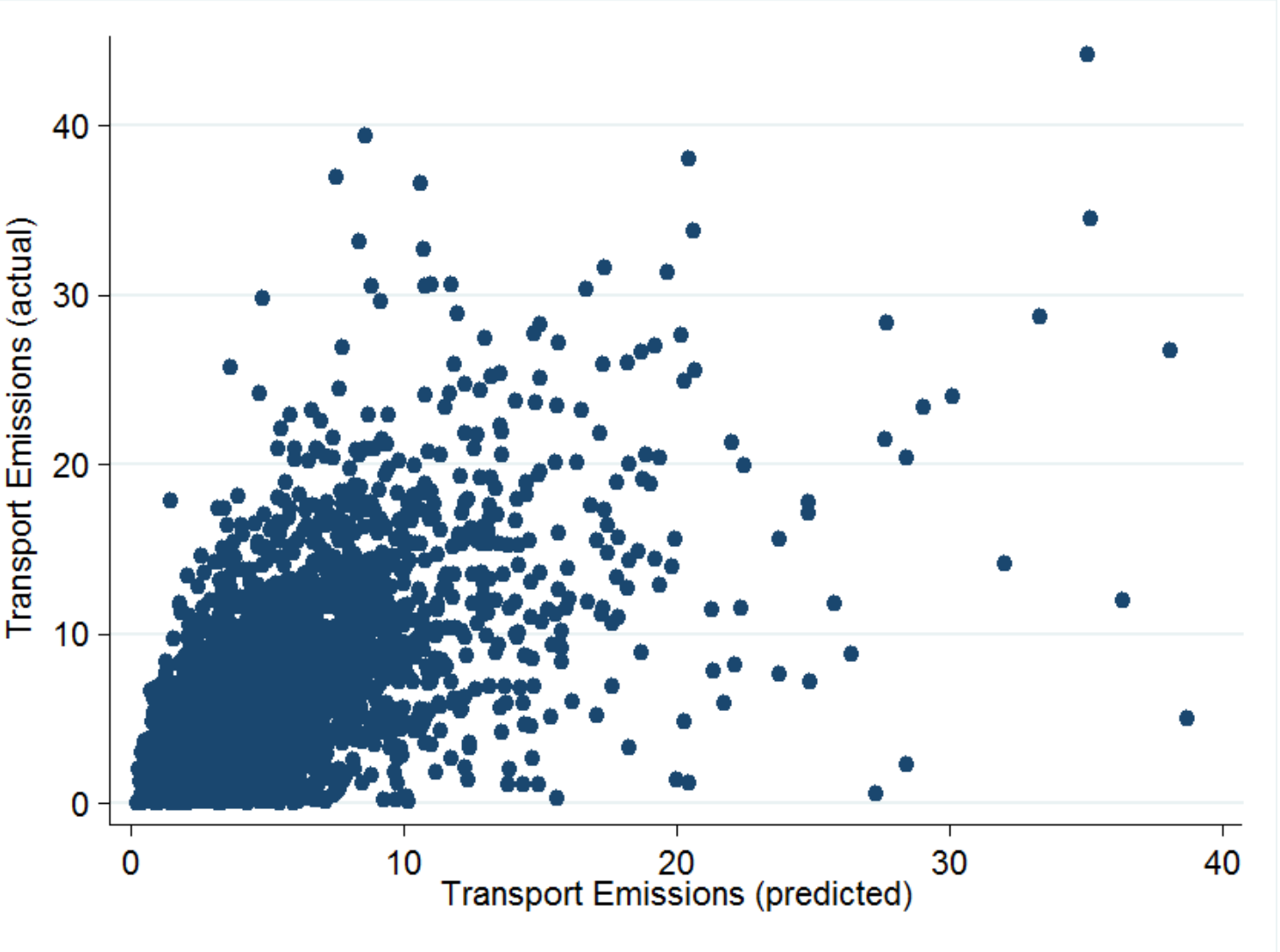
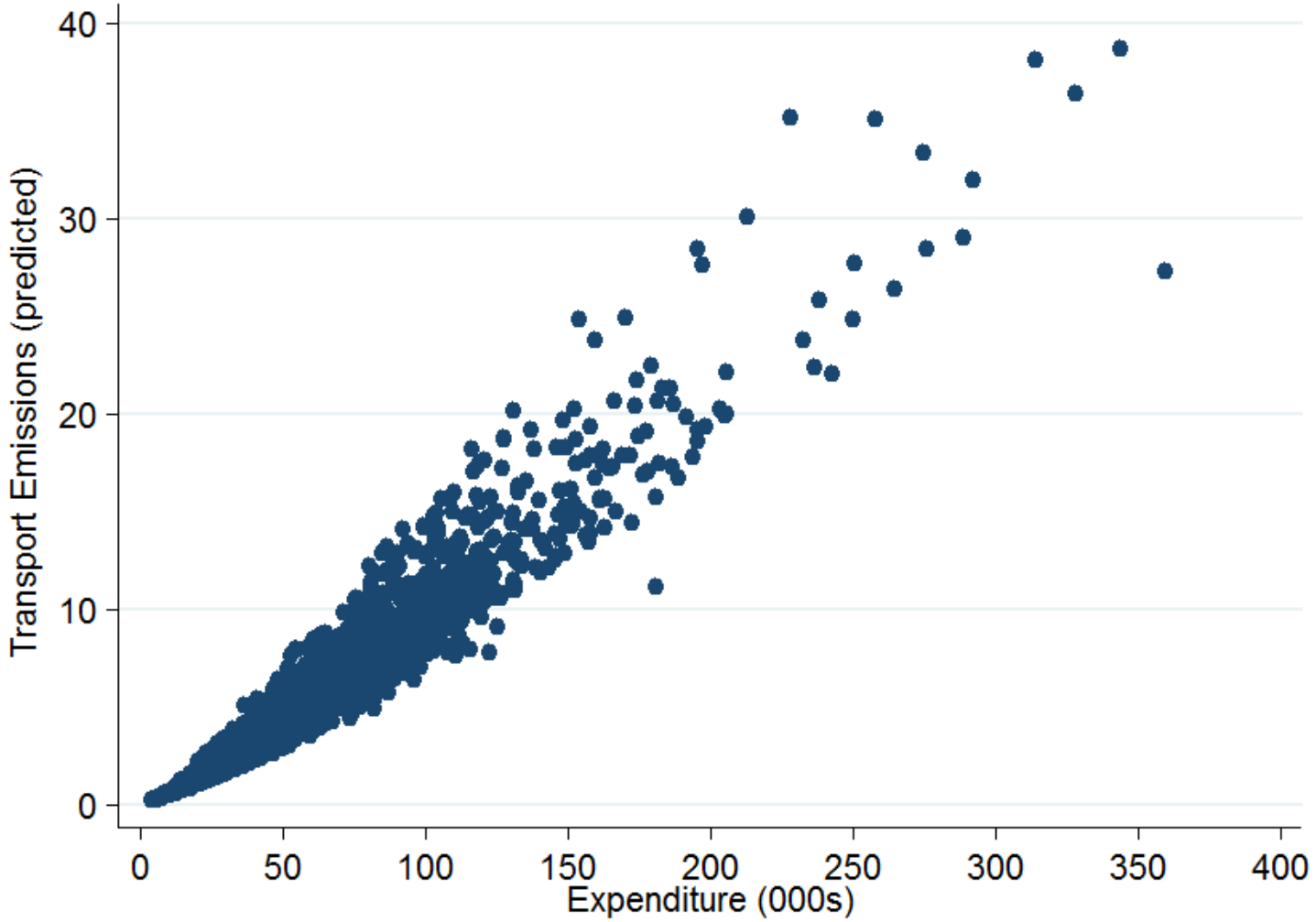


Predicted transport emissions vs. expenditure



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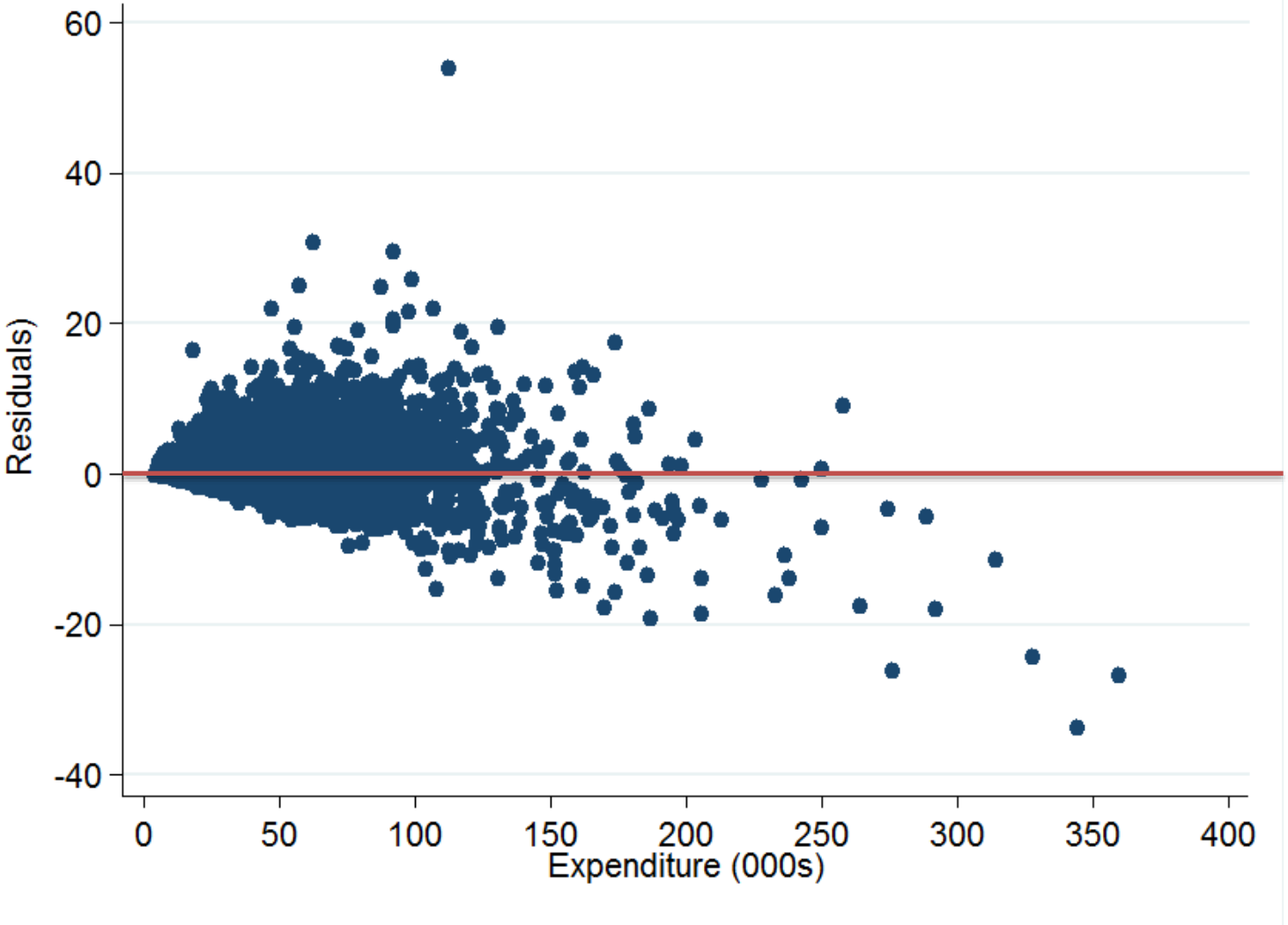

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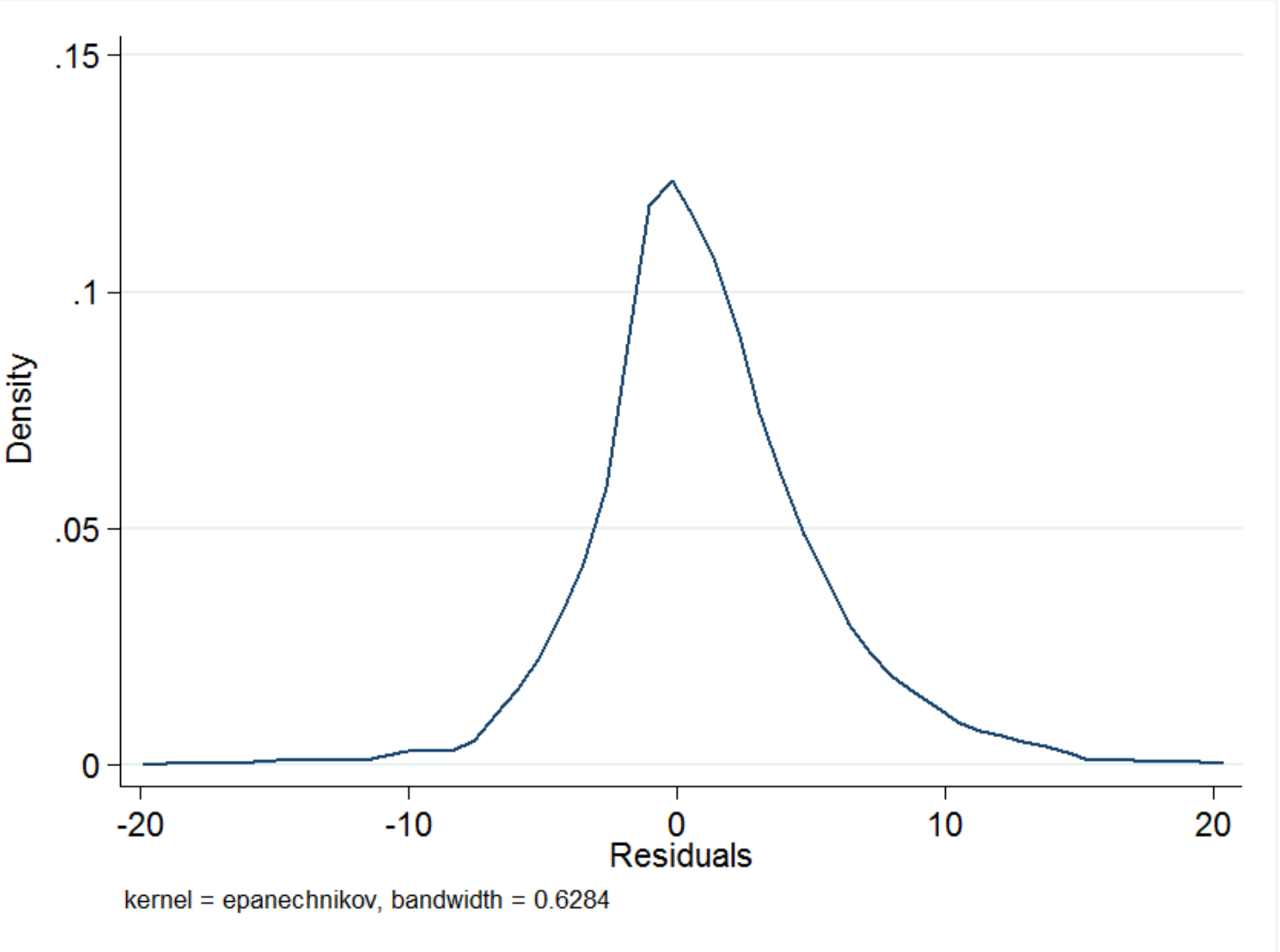
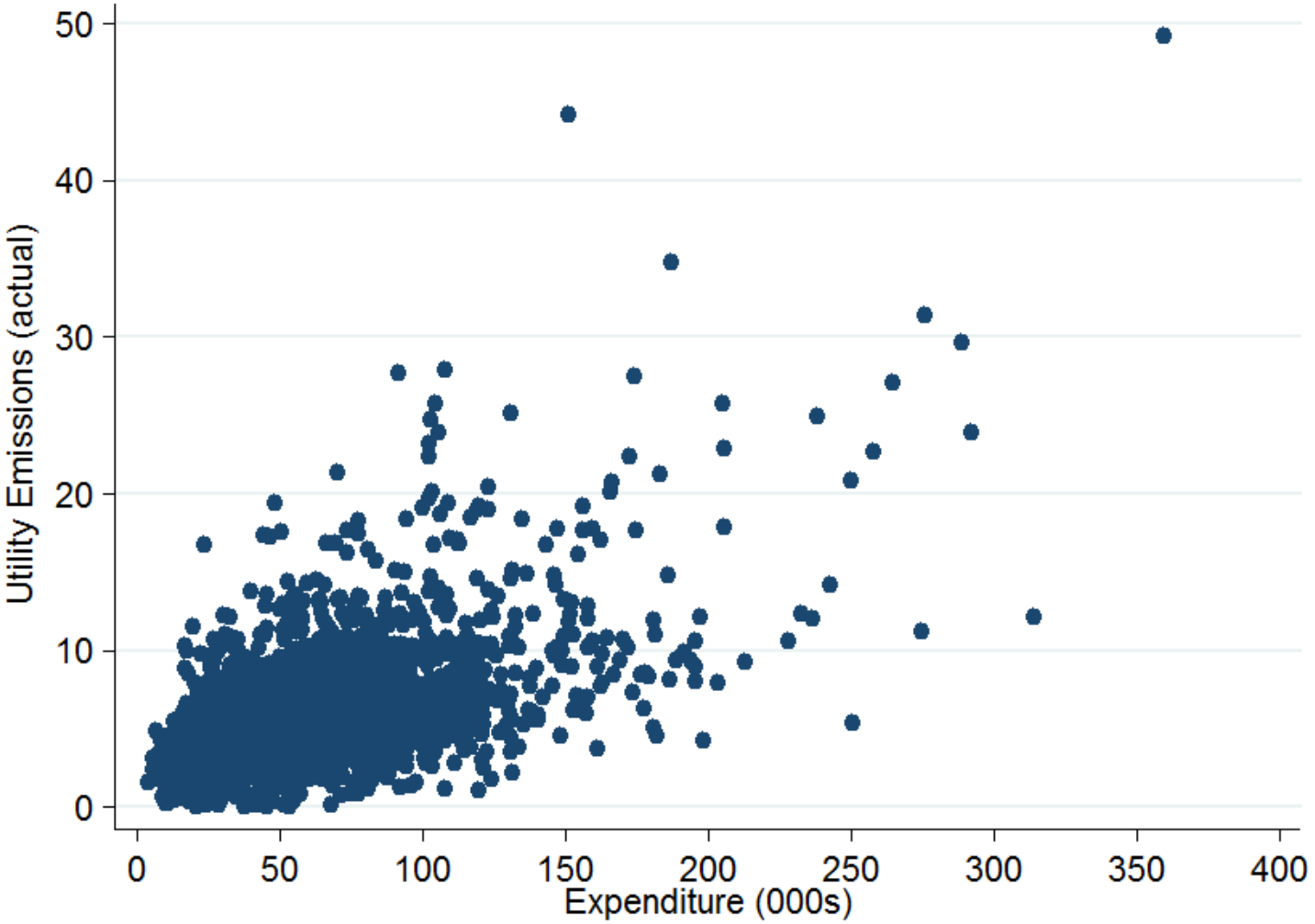
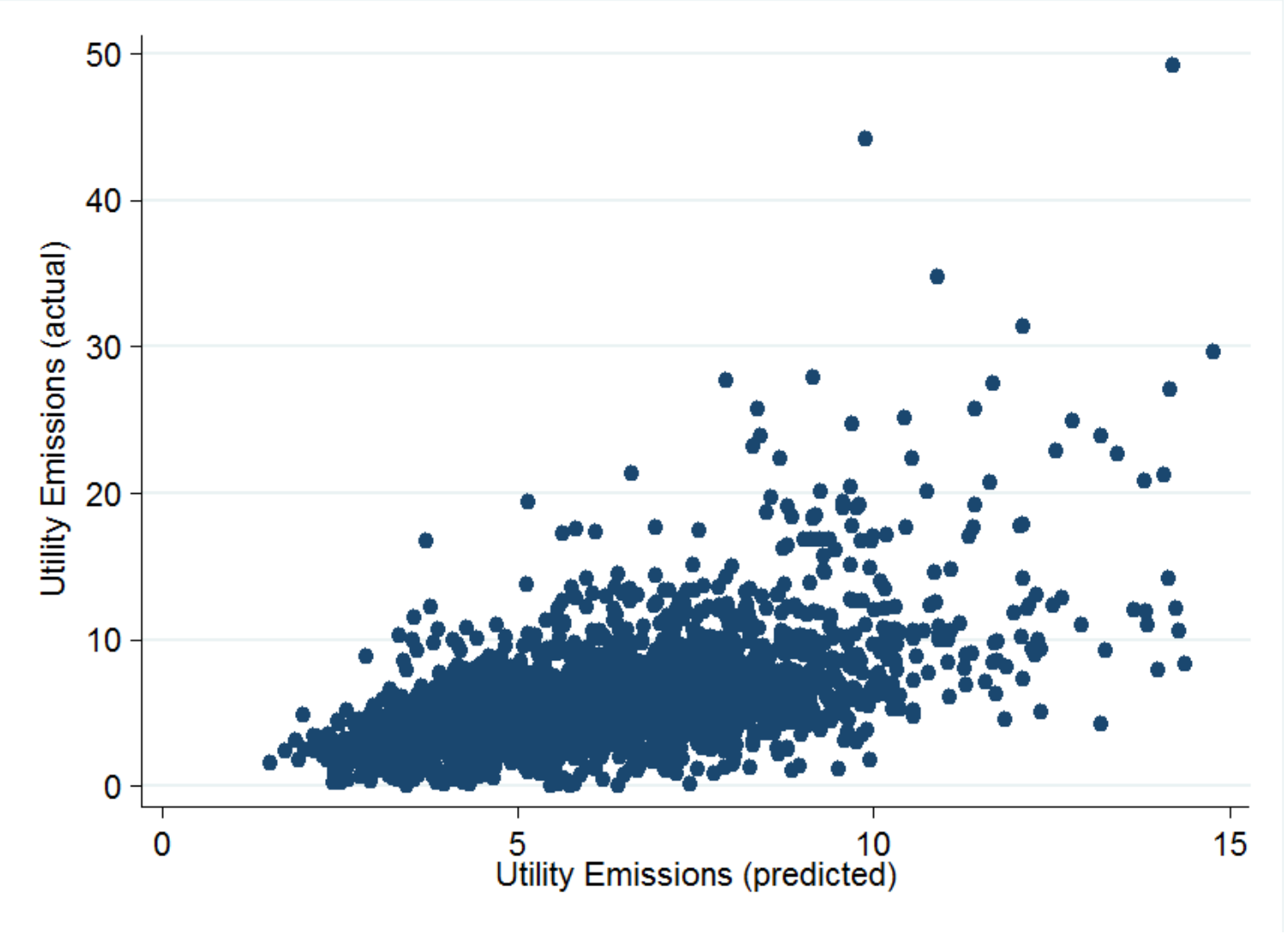


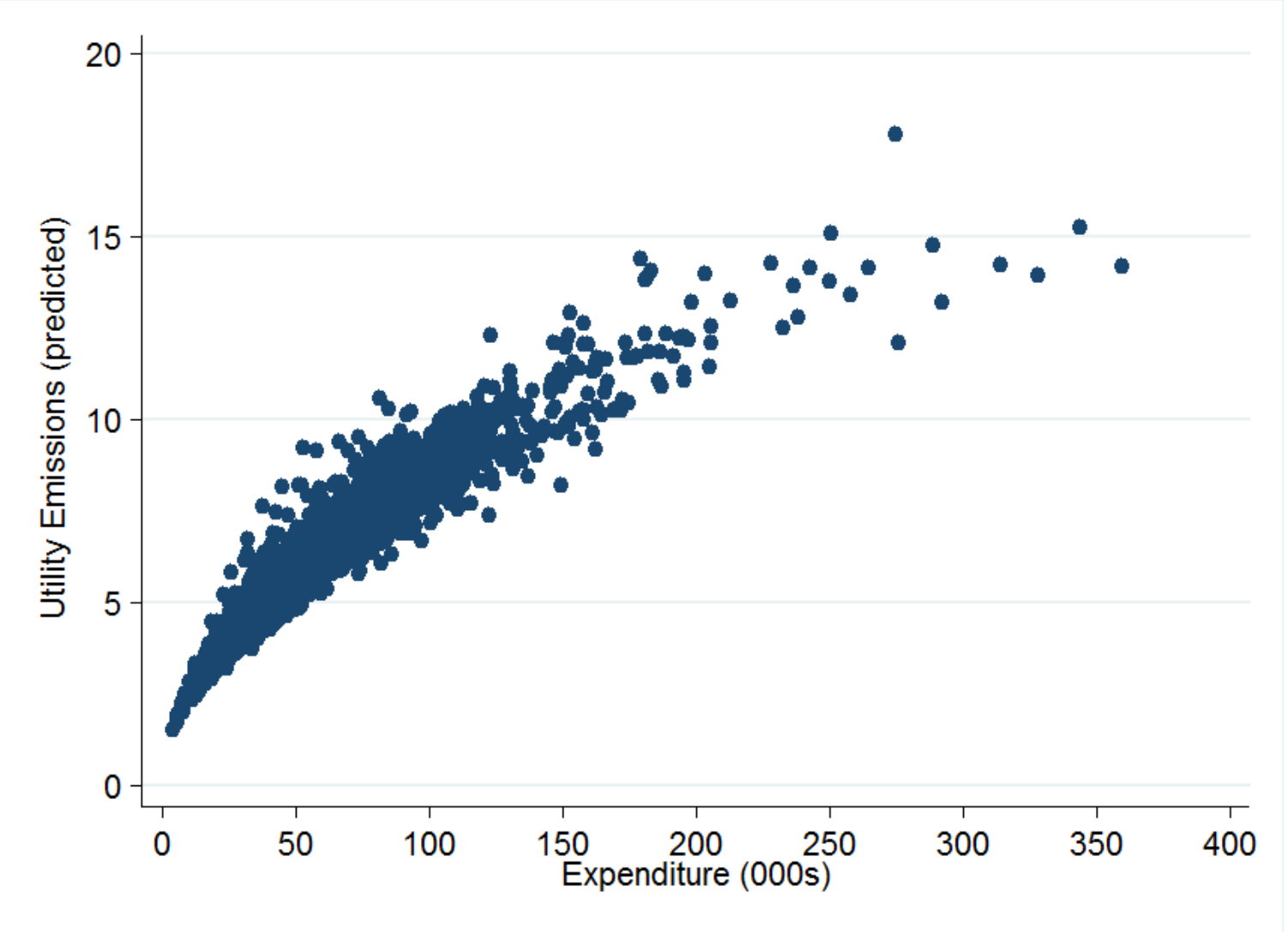
Utility emissions vs. expenditure



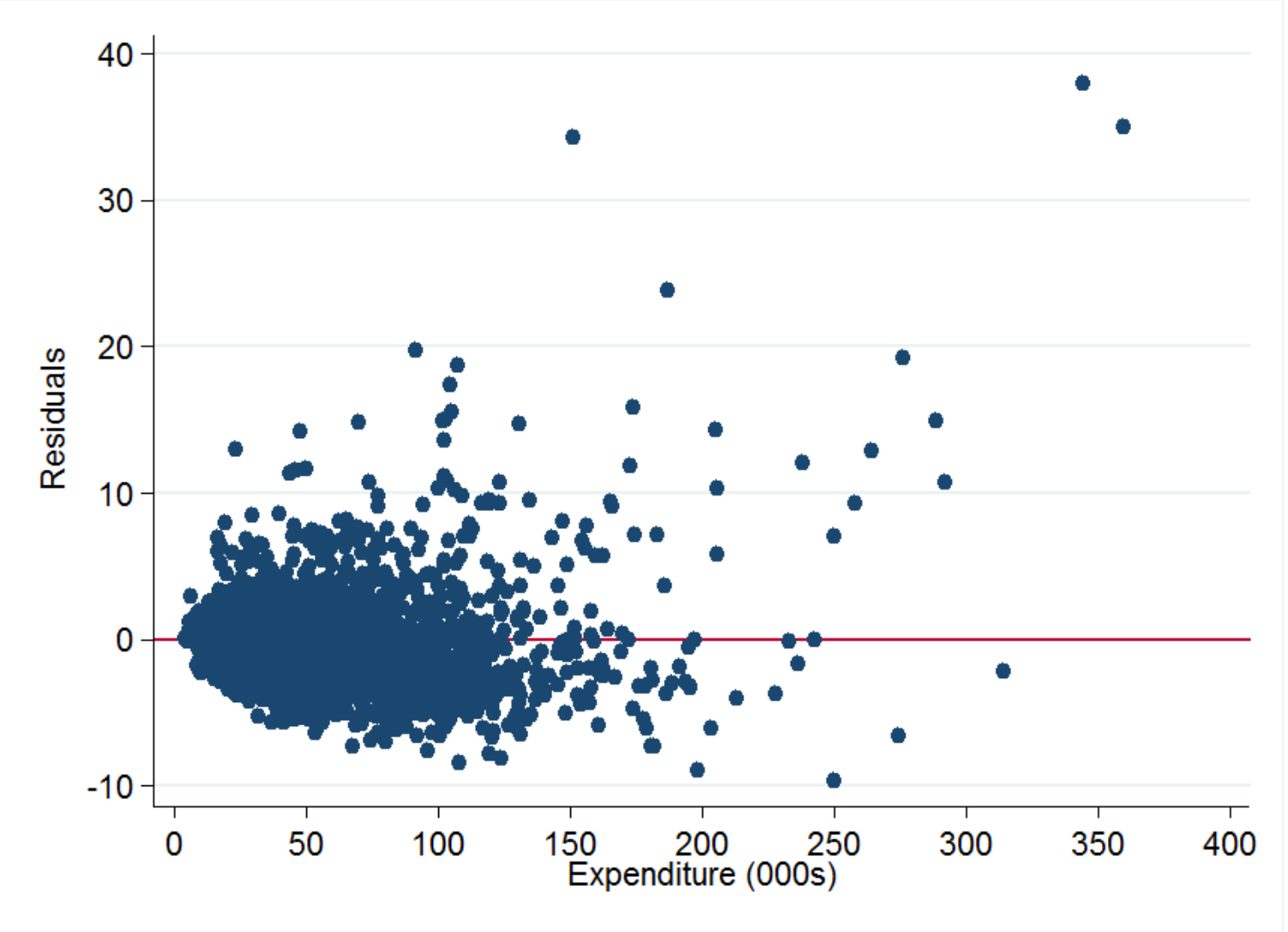
Actual utility emissions vs. predicted



Predicted utility emissions vs. expenditure



Utility residuals vs. expenditure



Utility residual density