FLOOD RISK AND INCOME IN A HIGHLY DEVELOPED COUNTRY:

HOW FLOOD EXPOSURE, VULNERABILITY AND COPING CAPACITY RELATE TO HOUSEHOLD INCOME IN GERMANY

Rich homeowner gets cars salvaged due to flooding. 😩
@pmwhiphop

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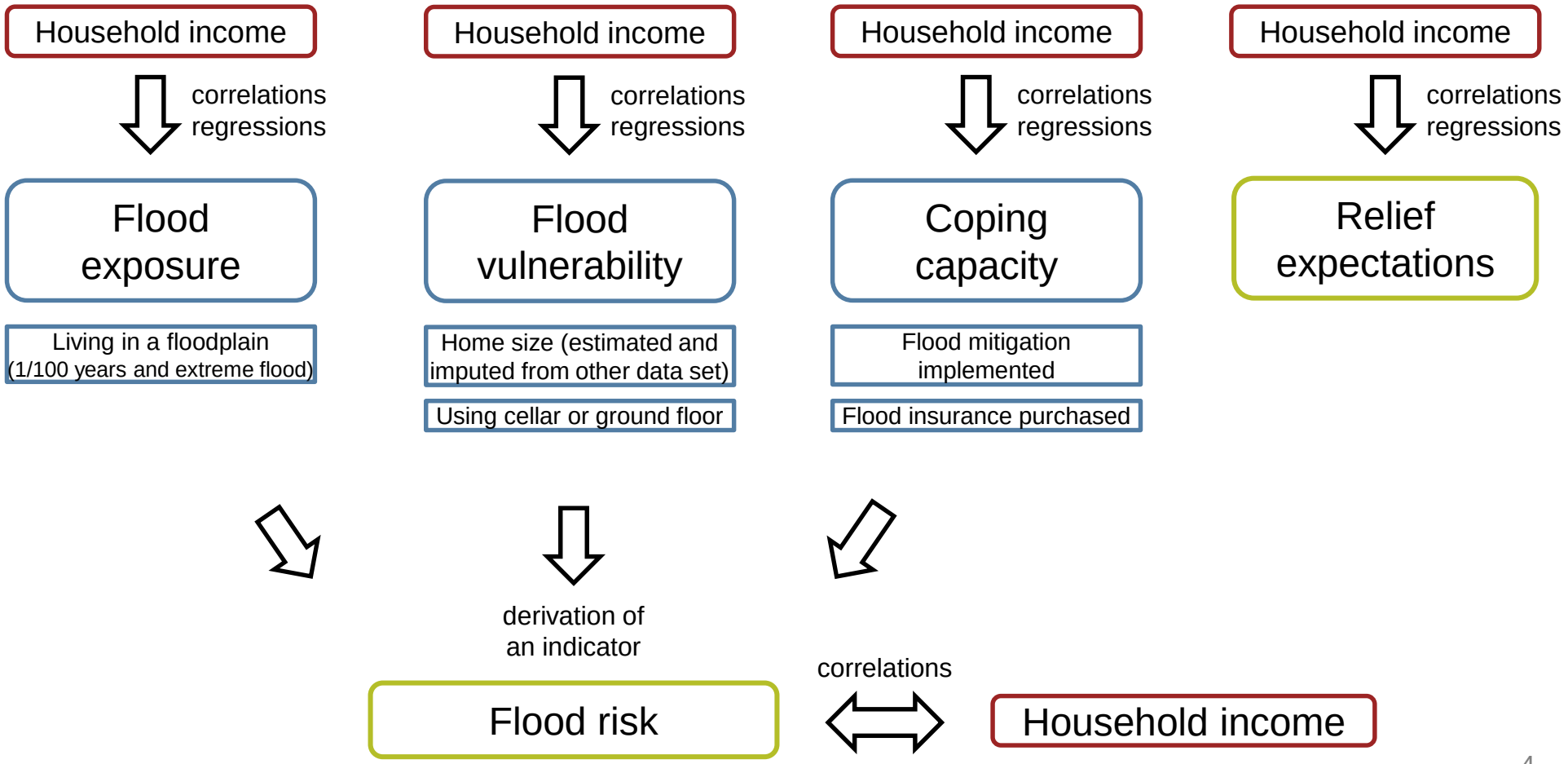
INTEGRATED FLOOD RISK MANAGEMENT AND HOUSEHOLD INCOME

- **Integrated flood risk management:**
  - Flood protection of households and other private actors needed
  - Limiting factor low-income households: Flood exposure? Vulnerability / Susceptibility? Coping capacity?
- **Related Literature**
  - Income and flood exposure in US and UK: ambigious findings
    Bin et al. 2017; Collins et al. 2018; Cutter & Emrich 2006; Kahn & Smith 2017; Maldonado et al. 2016; Martinich et al. 2013; Smith & Whitmore 2019
  - Hurricane Katrina: Different recovery across income levels
    Elliot & Pais 2006; Masozera et al. 2007
  - Different effects of public flood policy
    Bin et al. 2012; Grube et al. 2018; Munoz Tate 2016; Noona & Sadiq 2018; Penning-Rowsell & Pardoe 2012
  - ➢ Empirical studies at the household level: so far only case studies

OUTLINE

1. Methodological approach
2. Income and the components of flood risk
3. Income and overall flood risk
4. Income and relief expectations
5. Policy implications and conclusions

METHODOLOGICAL APPROACH



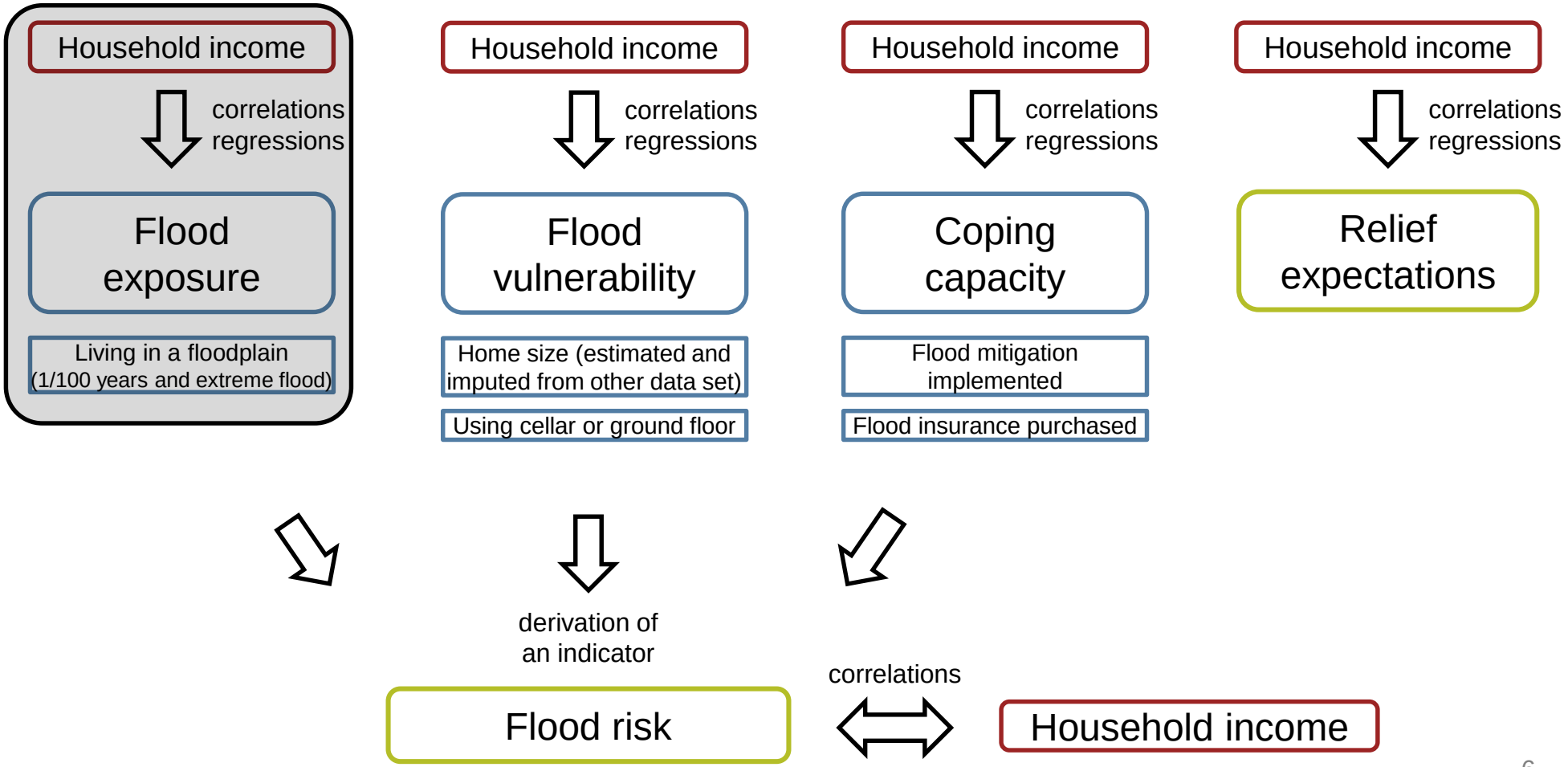
METHODOLOGICAL APPROACH: DATA

- **Eval-MAP: Household panel survey in Germany**
  - Nationwide online- and TV-based survey by market research agency forsa
  - Weighting factor provided by forsa, nationally representative in terms of federal state and household size
  - Two waves: Autumn 2012 and Summer 2014
  - >8,000 participating household heads
  - Topics of the questionnaire:
    - Housing characteristics
    - Flood adaptation measures, i.a. flood mitigation and insurance
    - …

EVAL MAP

Bundesministerium für Bildung und Forschung

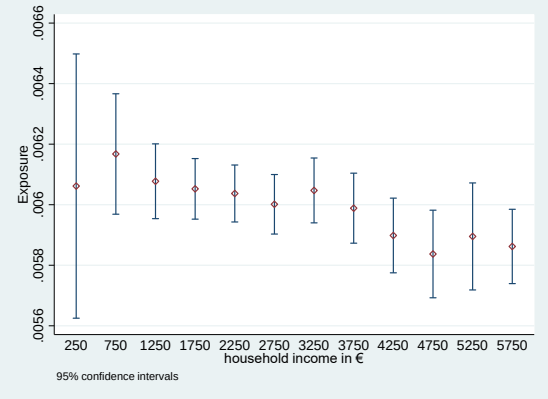
FLOOD RISK COMPONENT: EXPOSURE



FLOOD RISK COMPONENT: EXPOSURE

Ordinal variable of flood exposure:

Flood exposure (N=8,114)	%
Low (no riverine floodplain)	90.9
Medium (extreme riverine floodplain)	7.2
High (1/100 years riverine floodplain)	1.9



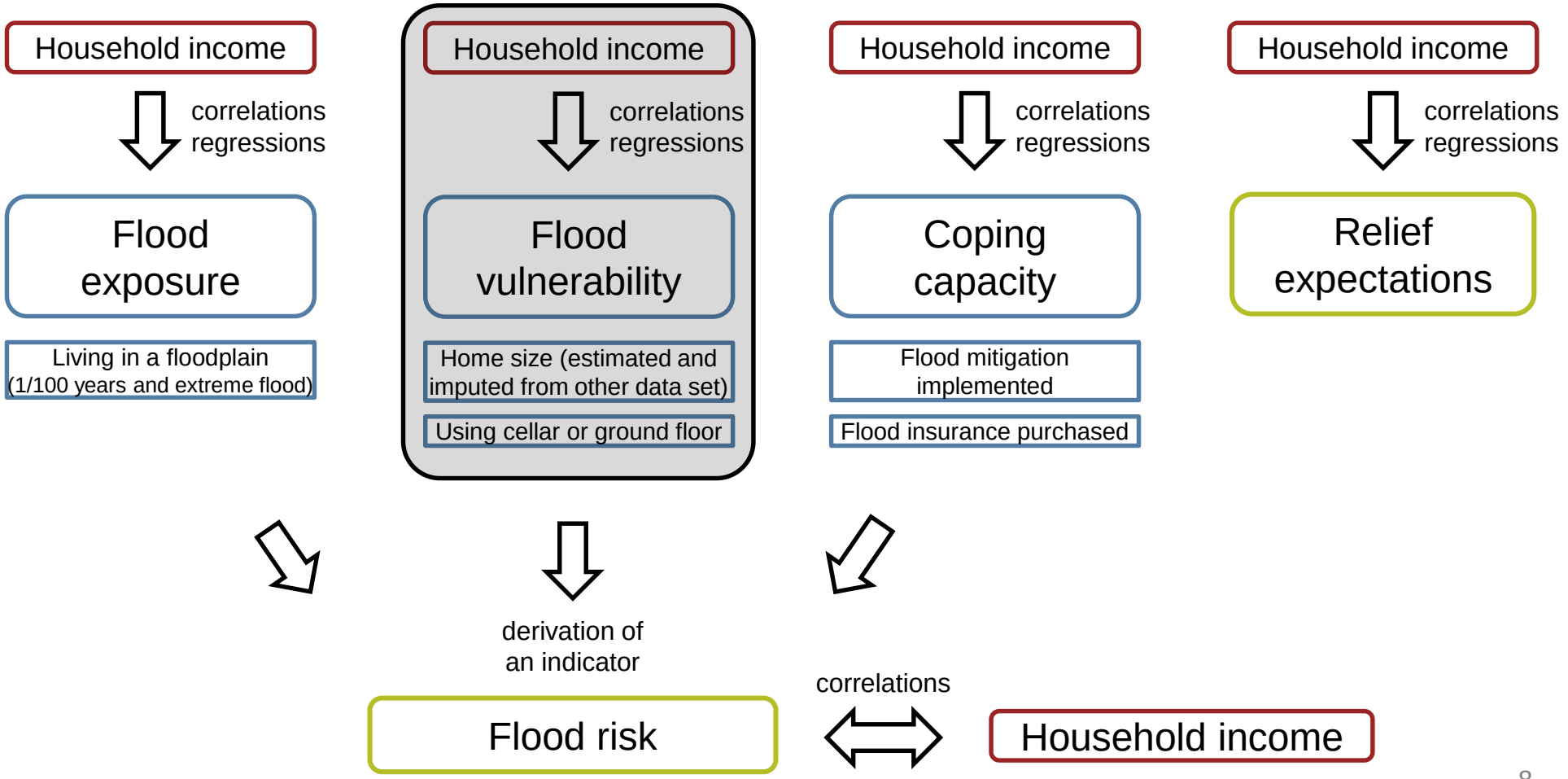
Correlation with income: -0.03***

- Relatively similar exposure levels across income classes
- Flood exposure is a non-issue for most households in Germany

Regression analysis:

Ordered probit, weighted	Exposure
Income	**-3.1e-5**
Female	0.05
Education	0.01
Household size	-0.00
Home type: Rented house	-0.11
Home type: Own flat	0.08
Home type: Own house	-0.07
Risk aversion	-0.01
Financial assets	0.07
Age, federal states and rural categories	included
N	6,163
Pseudo R2	0.10

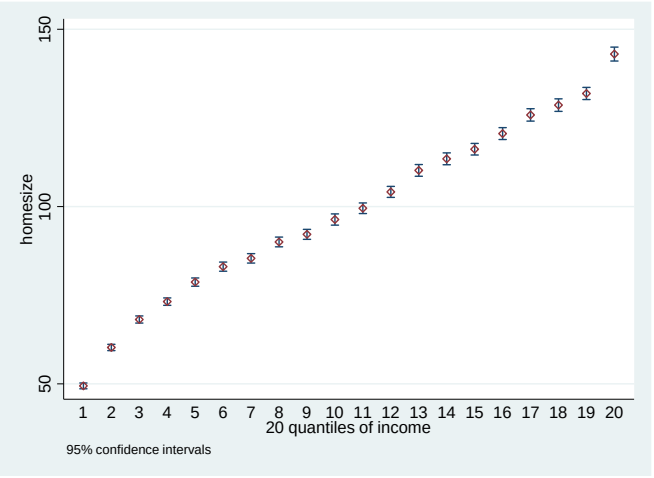
FLOOD RISK COMPONENT: VULNERABILITY



FLOOD RISK COMPONENT: VULNERABILITY

Home size

Home size (N=42,789)	m2	ln(home size)
Mean	98.5	4.5
Median	90.0	4.5
Minimum	14.0	2.6
Maximum	300.0	5.7



Correlation with income: 0.62***

Regression analysis:

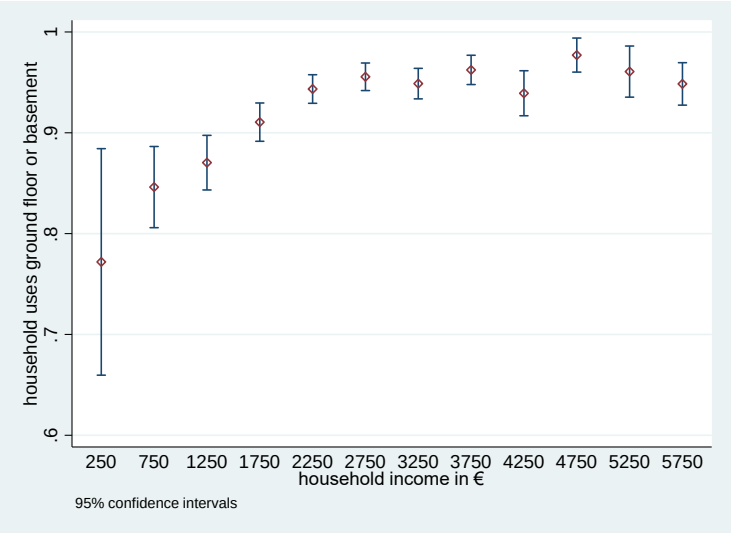
OLS (cross section of 2013)	ln(home size)
ln(Income)	**0.20*** **
Female	0.03***
Detached home	0.22***
Homeowner	0.17***
Household size, age	Included
Federal states and urban/rural categories	Included
N	42,789
Adjusted R2	0.65

- Vulnerability of low-income households considerably lower

FLOOD RISK COMPONENT: VULNERABILITY

Ground floor or basement usage

Ground (N=8,114)	%
No ground floor or basement usage	6.7
Groung floor or basement usage	93.3



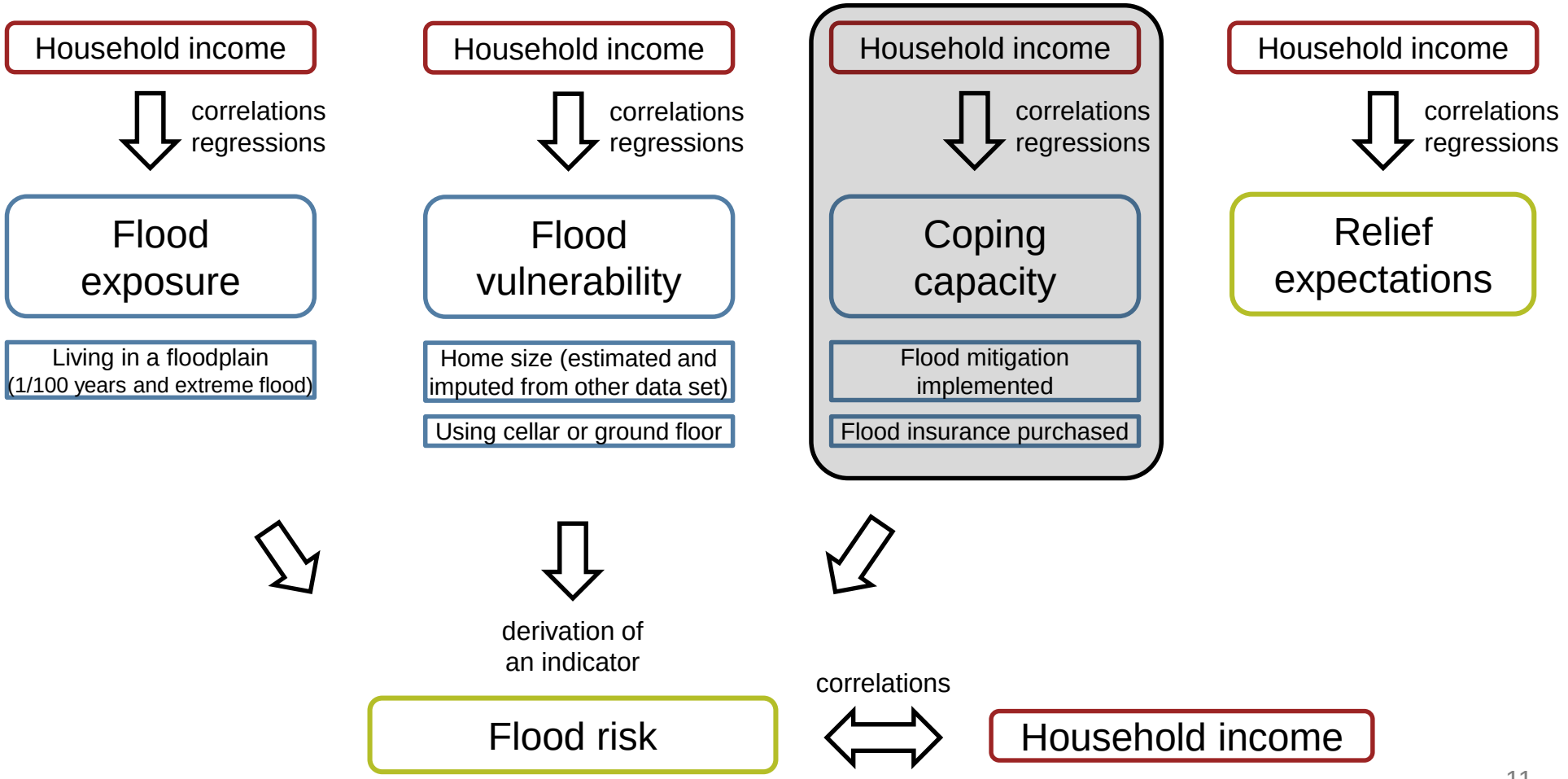
Correlation with income: 0.11***

Regression analysis:

Probit, weighted	Ground
Income	**8.4e-5****
Female	-0.02
Education	-0.14
Household size	0.19***
Risk aversion	-0.01
Financial assets	0.224***
Age, federal states and rural categories	included
N	6,367
Pseudo R2	0.08

- Vulnerability of low-income households considerably lower

FLOOD RISK COMPONENT: COPING CAPACITY



FLOOD RISK COMPONENT: COPING CAPACITY

Flood mitigation

Flood mitigation (N=10,832)	%
Implemented	30.6
Not implemented	69.4

Correlation with income: 0.18***

Flood insurance, home

Flood insurance reported, home (N=6,301)	%
Insured	68.2
Not insured	31.8

Correlation with income: 0.05***

Flood insurance, contents

Flood insurance reported, contents (N=10.058)	%
Insured	52.5
Not insured	47.6

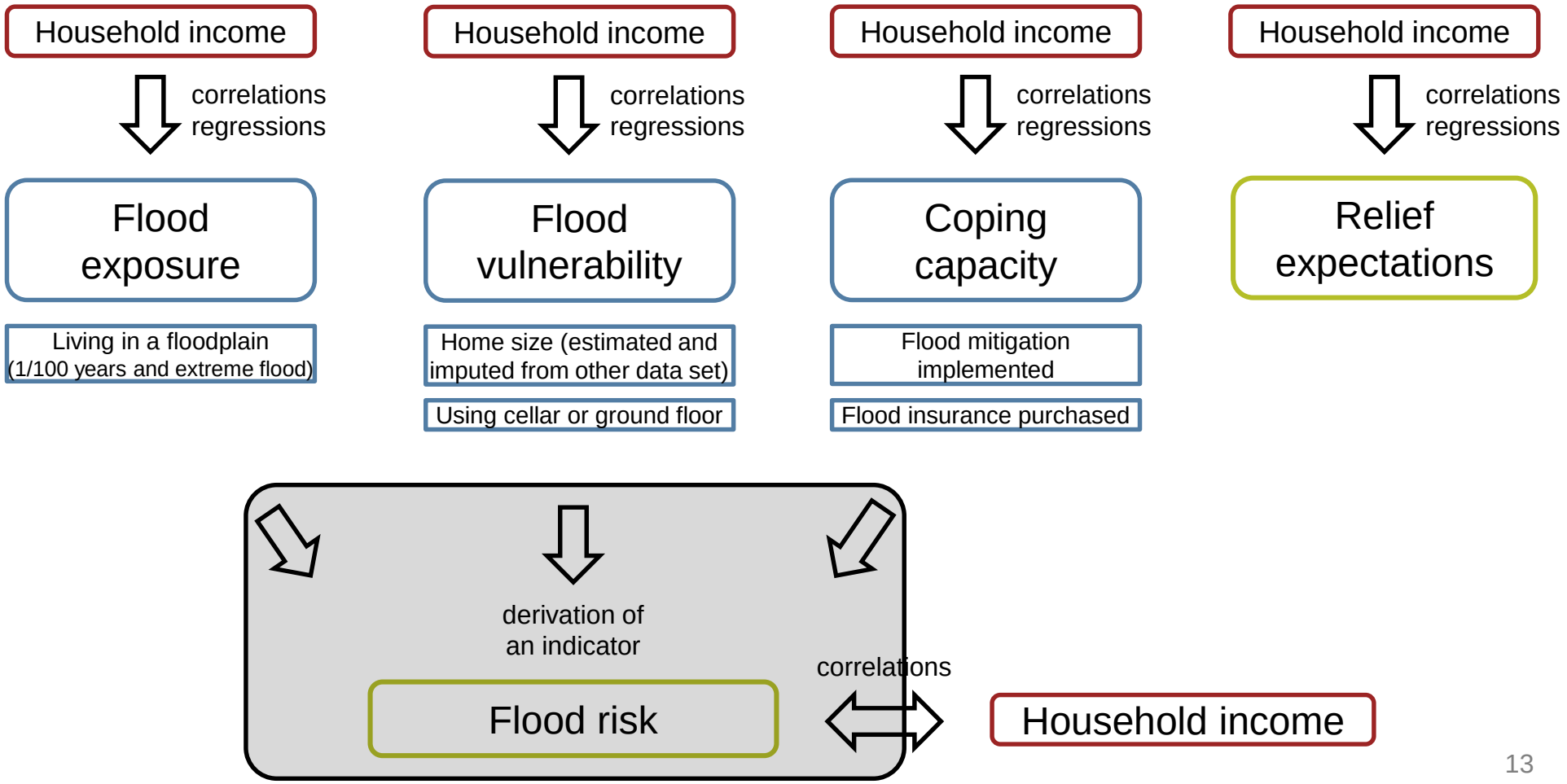
Correlation with income: 0.13***

- Coping capacity restricted by low income

Regression analyses:

Probit, weighted	Mitigation	InsHome	InsCont
Income	**4.0e-5****	**3.0e-5**	**8.6e-5*****
Female	0.02	0.07	0.07***
Education	0.01	-0.07	-0.20***
Household size	0.04**	0.04	0.05***
Home type: Rented house	0.22***	---	0.23*
Home type: Own flat	1.53***	-0.10	0.35***
Home type: Own house	1.49***	Reference	0.35***
Risk aversion	-0.02	-0.02**	-0.02**
Financial assets	0.10	-0.01	-0.04
Flood experience (self-rep.)	0.48***	0.07	0.23***
Objective risk level	Included	Included	Included
Subjective risk perception	Included	Included	Included
Age, federal states and urban/rural categories	Included	Included	Included
N	6,420	3,972	5,940
Pseudo-R2	0.24	0.06	0.06

FLOOD RISK: INDICATOR



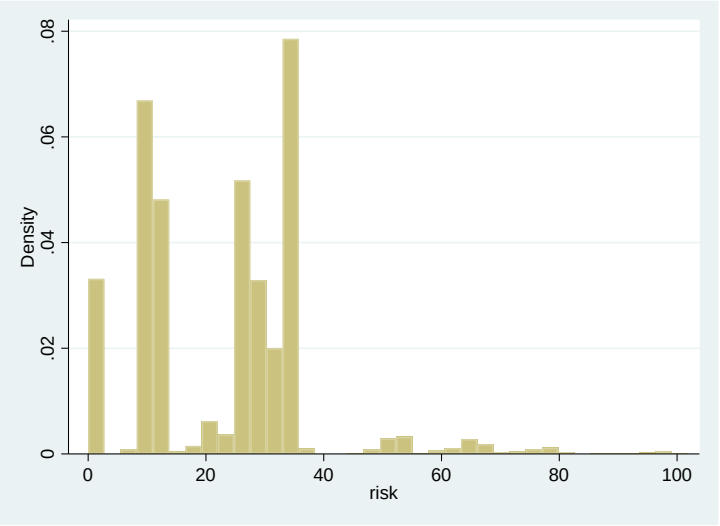
FLOOD RISK: INDICATOR

Derivation of risk indicator (without insurance):

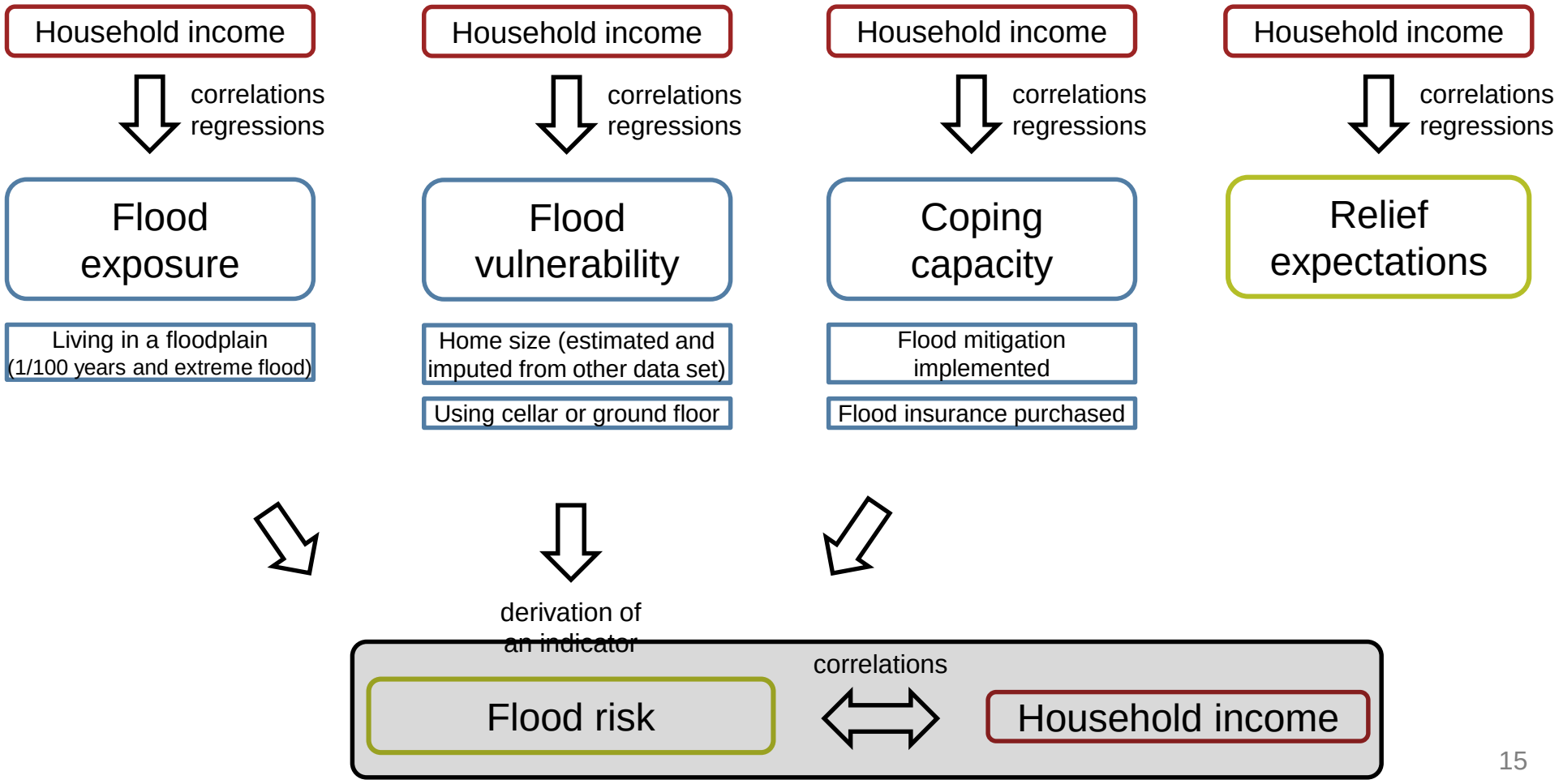
$$Risk = \underbrace{Exposure}_{\text{Probability that flood occurs}} * Ground * (1 - 0.5 * Mitigation) * \underbrace{(Dam^{cont}}_{\text{Probability that flood damage occurs}} + \underbrace{Homeowner * Dam^{home})}_{\text{Weighting by homesize and assets at risk}}$$

Descriptive statistics:

Indicator	Mean	Std. dev.	Min	Max	Median
Risk	22.92	14.93	0	101.85	26.74



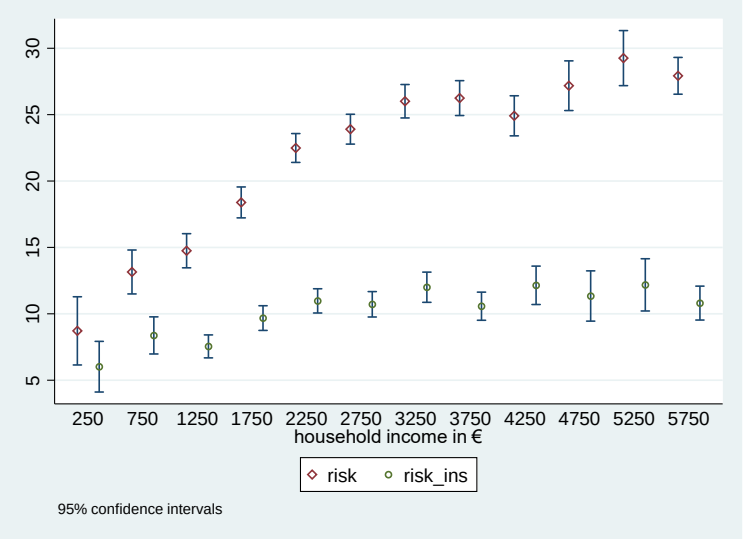
FLOOD RISK: INDICATOR



FLOOD RISK: INDICATOR

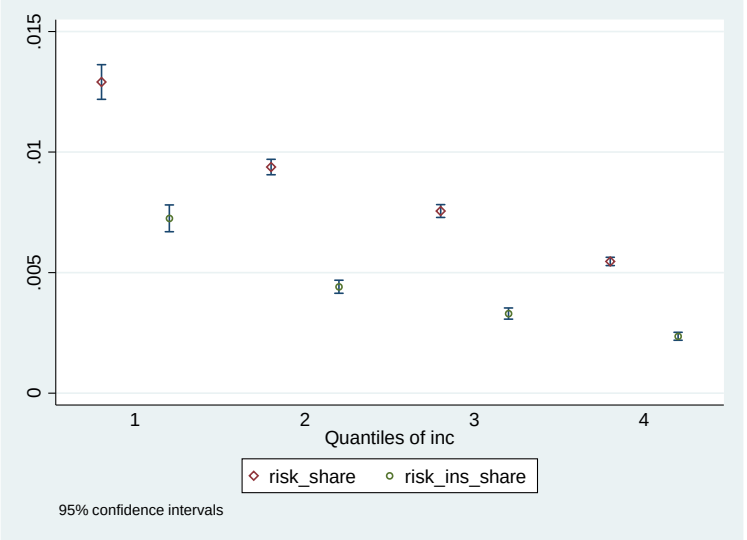
- **Risk indicators without and with insurance for different income classes**

… as expected annual monetary damage



Correlation with income: 0.42*** / 0.12***

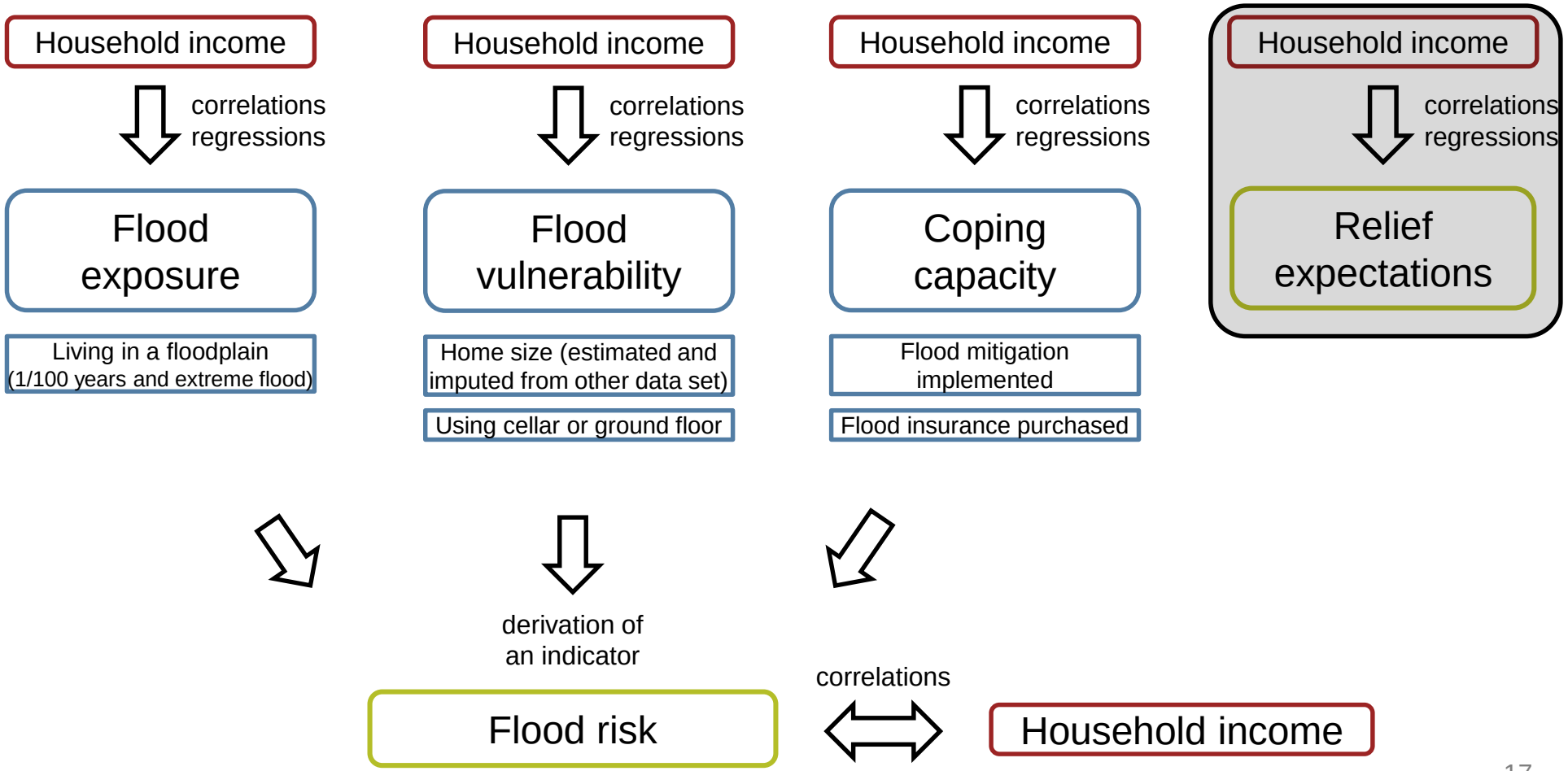
… as expected damage per income



Correlation with income: -0.35*** / -0.23***

- Risk in terms of absolute monetary damages increases with income
- Risk in terms of damage per income decreases with income

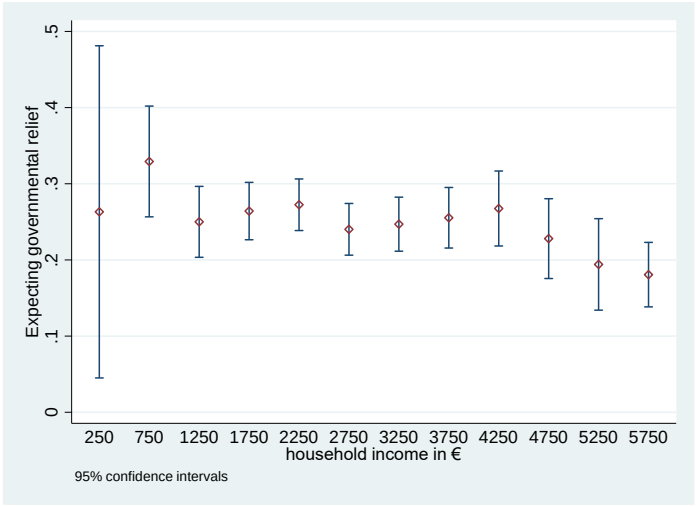
INCOME AND RELIEF EXPECTATIONS



INCOME AND RELIEF EXPECTATIONS

Expecting governmental relief

Relief expectation (N=5,104)	%
Expecting relief	24.8
Not expecting relief	75.2



Correlation with income: -0.05***

- Low-income households tend to expect governmental relief in case of a flood
- No regulated disaster relief in Germany!

Regression analysis:

Probit, weighted	Relief expectation
Income	**-6.2e-5****
Female	0.18***
Education	-0.06
Household size	0.06**
Home type: Rented house	-0.14
Home type: Own flat	0.09
Home type: Own house	0.05
Risk aversion	0.00
Financial assets	-0.17**
Flood experience (self-rep.)	0.07
Objective risk level	Included
Subjective risk perception	Included
Age, federal states and urban/rural categories	Included
N	3,715
Pseudo-R2	0.04

POLICY IMPLICATIONS AND CONCLUSIONS

- **Flood risk increases with income levels**
  - But relative effects are probably higher for low-income households
- **Mitigation and insurance of low-income households is limited**
  - Challenge for integrated flood risk management
  - Public financial support may be an option
- **Management of relief expectations**
  - Either communicate better about (non existence of) governmental relief…
  - … or meet the expectations and introduce regulated disaster relief scheme
  - BUT: relief schemes may have adverse effects on individual adaptation

THANK YOU!

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