Income distribution and willingness to pay for ecosystem services

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Motivation

Question:

How does the distribution of income among members of society, in particular mean income and income inequality, affect the average willingness to pay (WTP) for ecosystem services?

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  2. distributive justice (influences monetary valuation)

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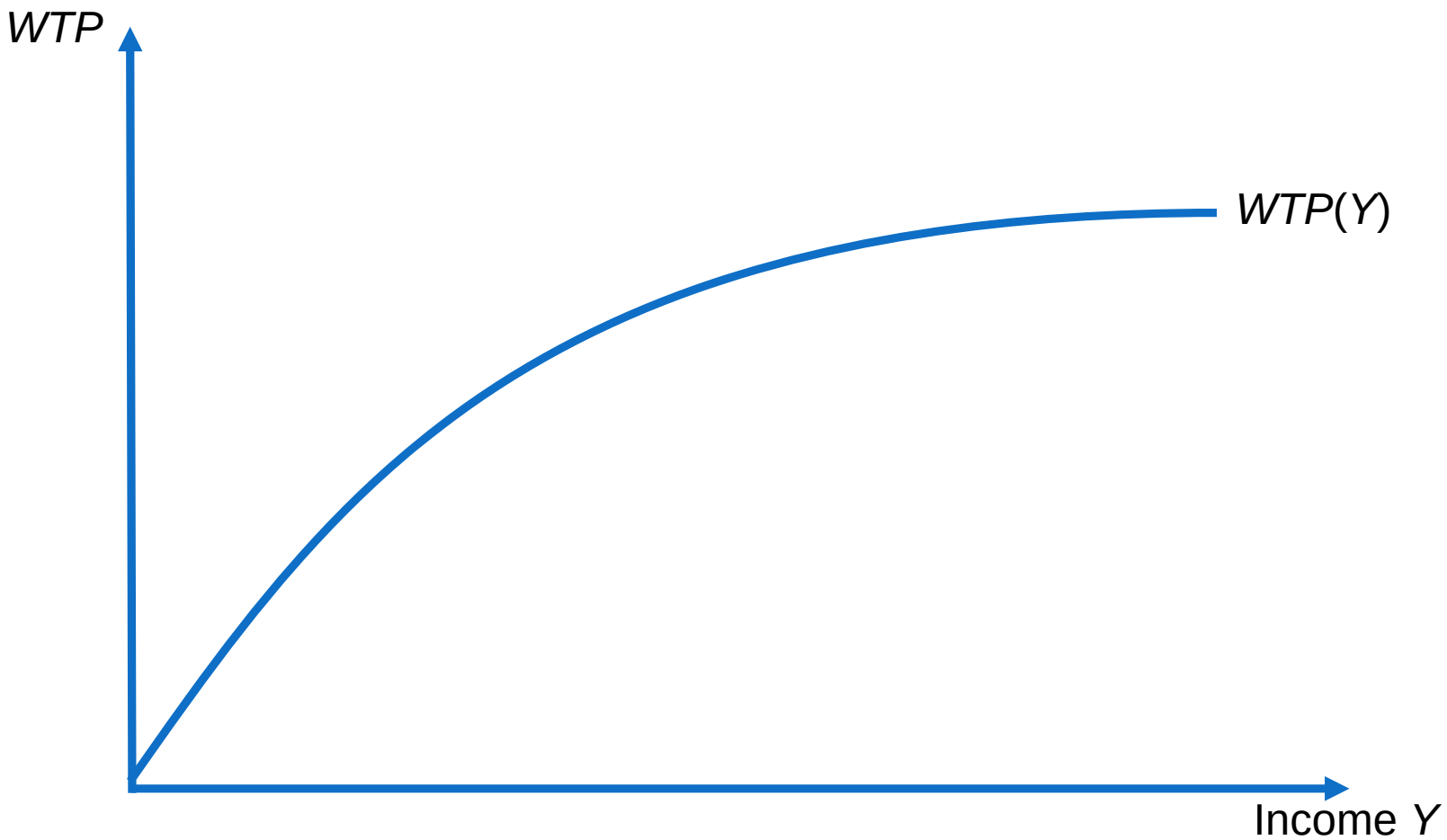

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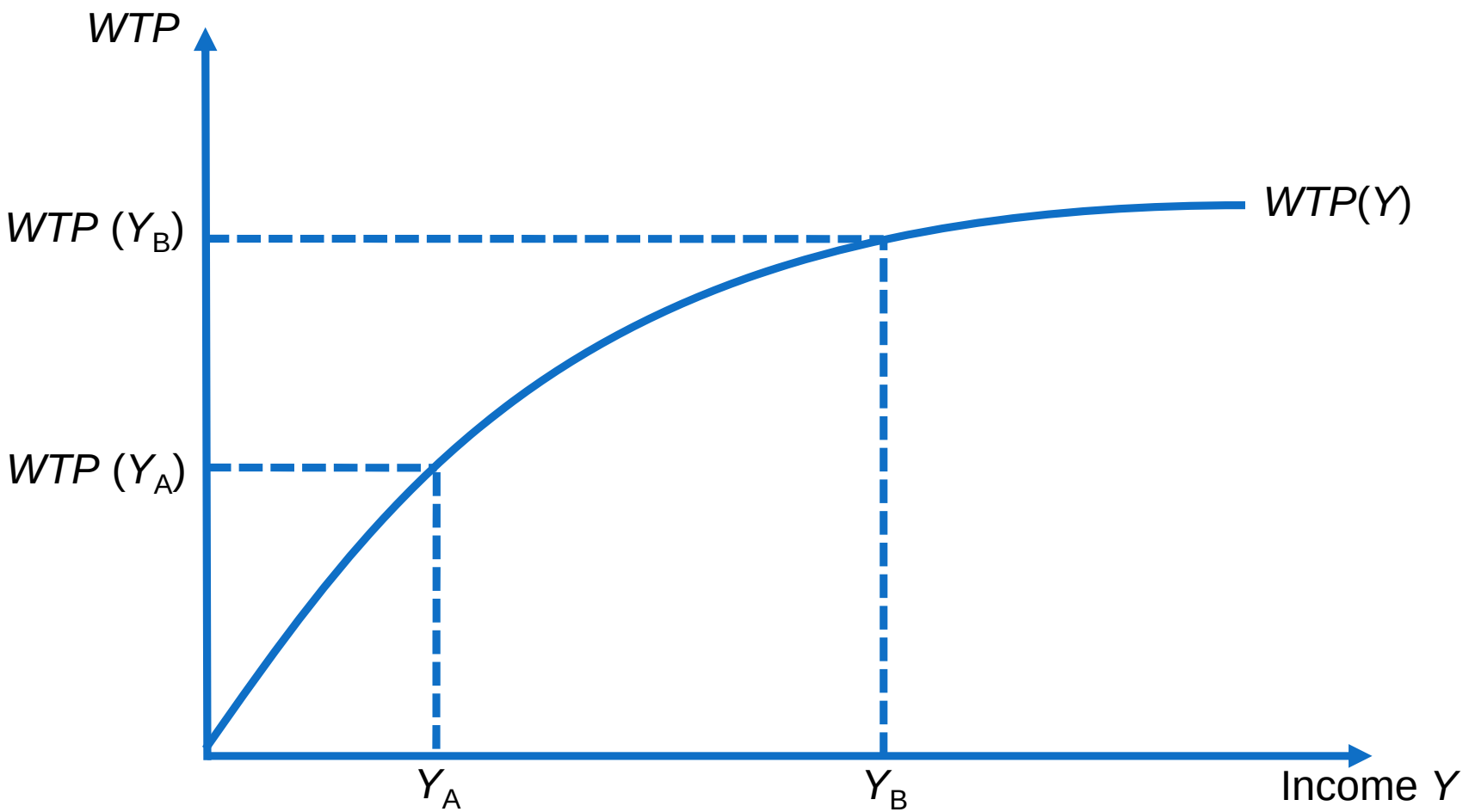

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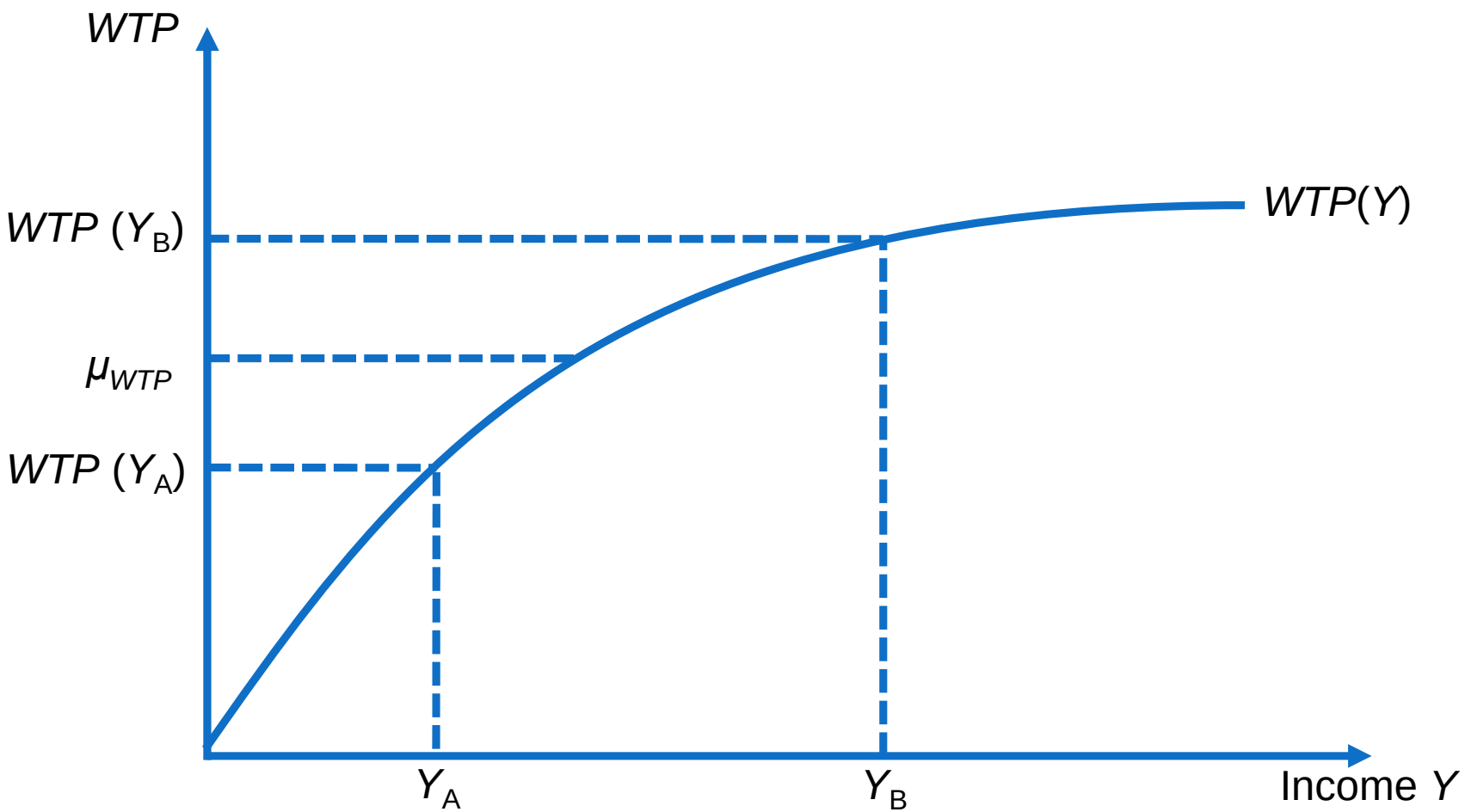

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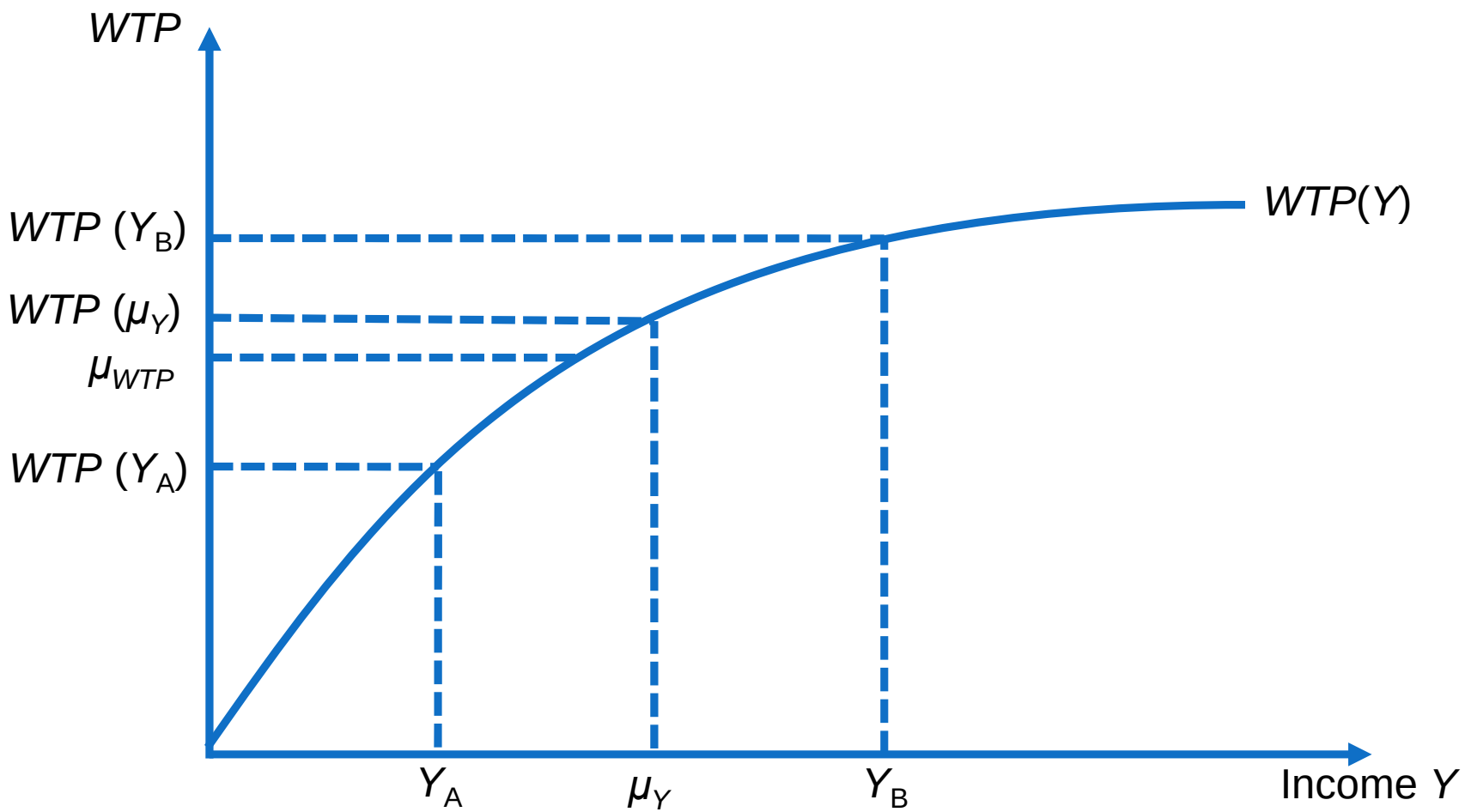

Outline

1. Model
2. Data
3. Results

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- exogenous income Y, continuously (unevenly) distributed over households
- consumption good is traded on a market at given price p,
  consumption of ecosystem service is fixed at level E

1. Model

Households' WTP for ecosystem service at level E depends on income Y as follows:
[Ebert, *Environmental and Resource Economics* 25: 435–459, 2003]

$$\text{WTP}(Y) = w\,Y^{\eta} \quad \text{with} \quad w = \frac{1-\alpha}{\alpha}(pE)^{1-\eta} = \text{const.}$$

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$$\eta = \frac{1}{\theta} \quad \left\{ \begin{array}{c} > \\ = \\ < \end{array} \right\} \; 1 \quad \text{iff} \quad \theta \left\{ \begin{array}{c} < \\ = \\ > \end{array} \right\} \; 1 \qquad \begin{array}{l} (X, E \text{ complements}) \\ (X, E \text{ substitutes}) \end{array}$$

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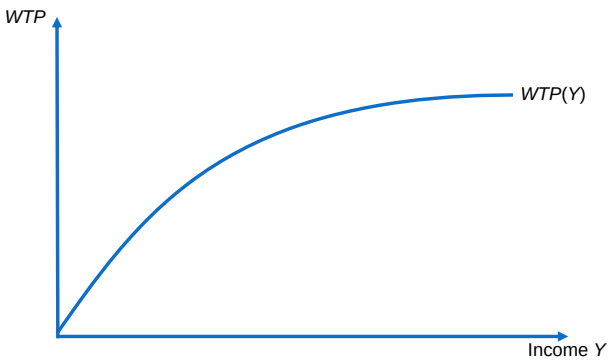
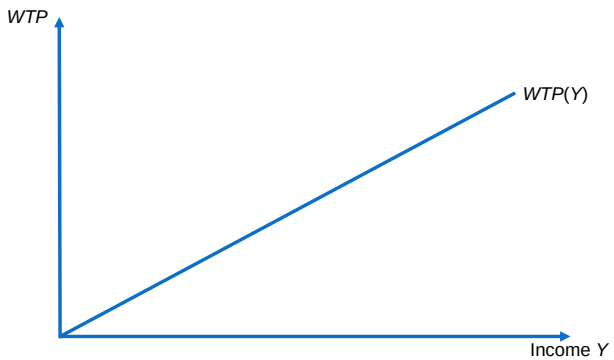
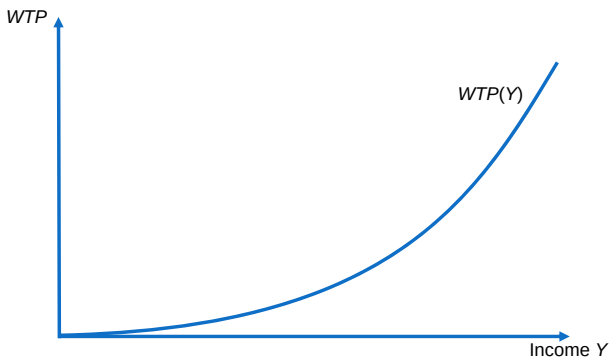


$\theta > 1$ (substitutes) $\Leftrightarrow \eta < 1$ (regressive)



$\theta = 1$ (Cobb-Douglas) $\Leftrightarrow \eta = 1$ (proportional)



$\theta < 1$ (complements) $\Leftrightarrow \eta > 1$ (progressive)

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- Distribution of income Y over households is log-normal with mean μ_Y and standard deviation σ_Y

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mean willingness to pay for ecosystem service at level E

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$$\mu_{\text{WTP}} = w\,\mu_Y^{\eta}\left(1+\frac{\sigma_Y^2}{\mu_Y^2}\right)^{\frac{\eta(\eta-1)}{2}}$$

- Hypothetical growth and redistribution of income: variation of μ_Y and σ_Y

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Global income distribution

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World Development Indicator Database (World Bank 2011):

- gross national income [2006-PPP-US$] per capita
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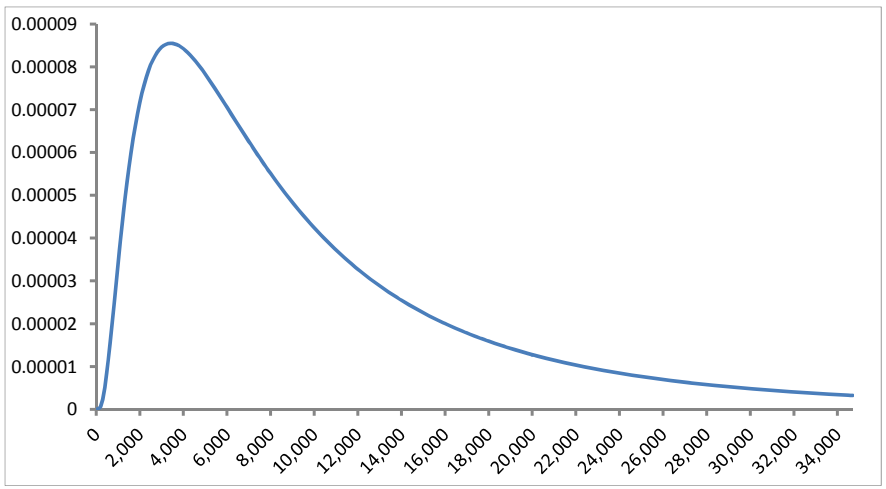
Global income distribution

- is log-normal (Kolmogorov-Smirnov test significant)
- $\mu_Y = 11{,}691$ US$
- $\sigma_Y = 13{,}157$ US$



2. Data

Income elasticity of marginal willingness to pay

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Meta-study by Jacobsen/Hanley (*Environmental and Resource Economics* 43: 137–160, 2009)

- 145 WTP-estimates from 46 contingent-valuation studies across 6 continents from 1979–2005, with focus on developed countries
- all kinds of biodiversity/ecosystem-services conservation, with focus on existence value
- dependent variable: willingness to pay (WTP) per year [2006-PPP-US$]
- explanatory variable (among others): annual household income (Y) [2006-PPP-US$]

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Income elasticity of marginal willingness to pay

Meta-study by Jacobsen/Hanley (*Environmental and Resource Economics* 43: 137–160, 2009)

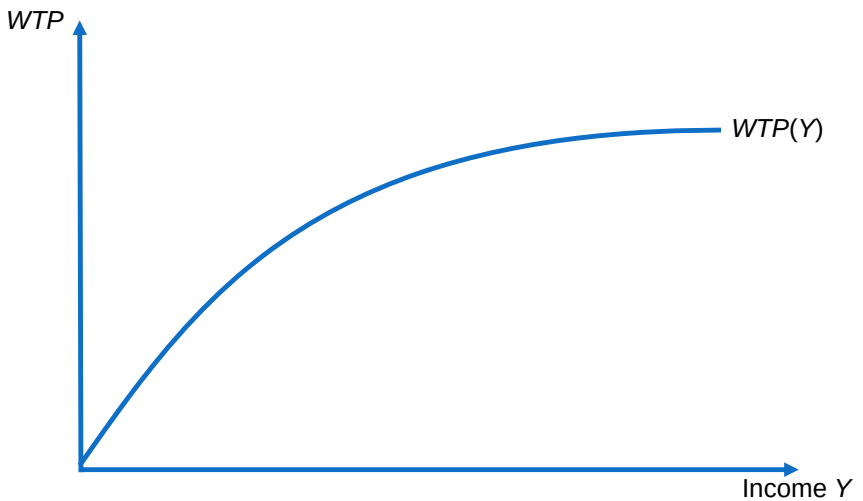
Result:

$$\text{WTP}(Y) = w\,Y^{\eta} \text{ with } \eta = 0.38 \pm 0.14$$

$$w = 0.92 \pm 16.50$$

i.e. $\theta = 2.63 \pm 0.97 > 1$,

X and E are substitutes



3. Results

Proposition 1:

Mean WTP for the ecosystem service

1. increases with mean household income, if the ecosystem service and the consumption good are substitutes or weak complements:

$$\frac{d\,\mu_{\text{WTP}}}{d\,\mu_Y} > 0 \qquad \text{if } \theta \geq 1/2\ ;$$

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2. decreases with mean household income below $\mu_Y^{\text{min}} = \sqrt{1/\theta - 2}\,\sigma_Y$ and increases with mean household income above μ_Y^{min}, if the ecosystem service and the consumption good are strong complements:

$$\frac{d\,\mu_{\text{WTP}}}{d\,\mu_Y} \begin{cases} < 0 & \text{for} \quad \mu_Y < \mu_Y^{\text{min}} \\ > 0 & \text{for} \quad \mu_Y > \mu_Y^{\text{min}} \end{cases} \qquad \text{if } \theta < 1/2\ .$$

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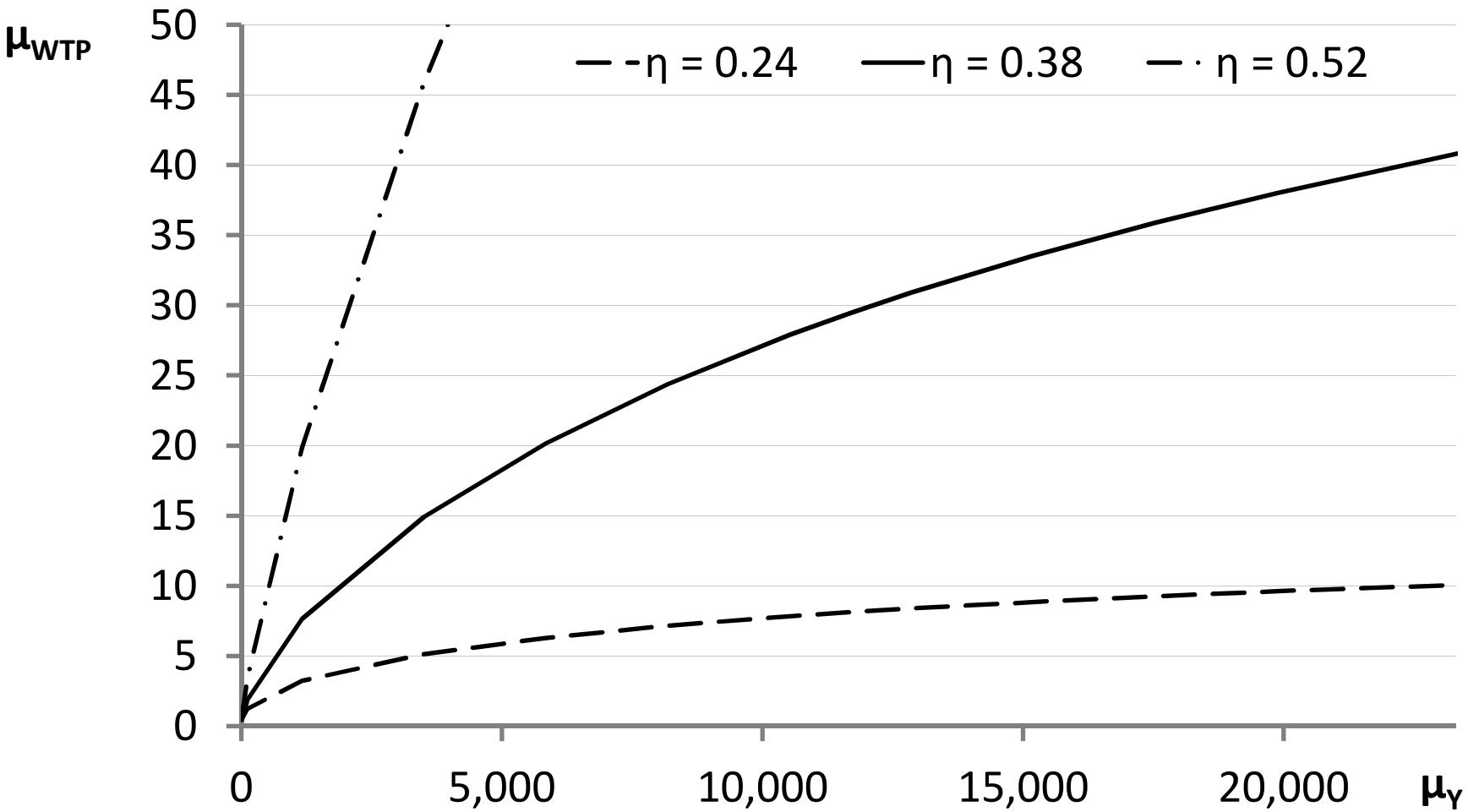
μ_{WTP}
50
45
40
35
30
25
20
15
10
5
0
η = 0.24
η = 0.38
η = 0.52
0
5,000
10,000
15,000
20,000
μ_Y

3. Results

Proposition 2:

1. Mean WTP for the ecosystem service decreases (increases) with income inequality, if the ecosystem service and the consumption good are substitutes (complements):

$$\frac{d\,\mu_{\text{WTP}}}{d\,\sigma_Y} \begin{cases} < 0 & \text{if} \quad \theta > 1 \\ = 0 & \text{if} \quad \theta = 1 \\ > 0 & \text{if} \quad \theta < 1 \end{cases} .$$

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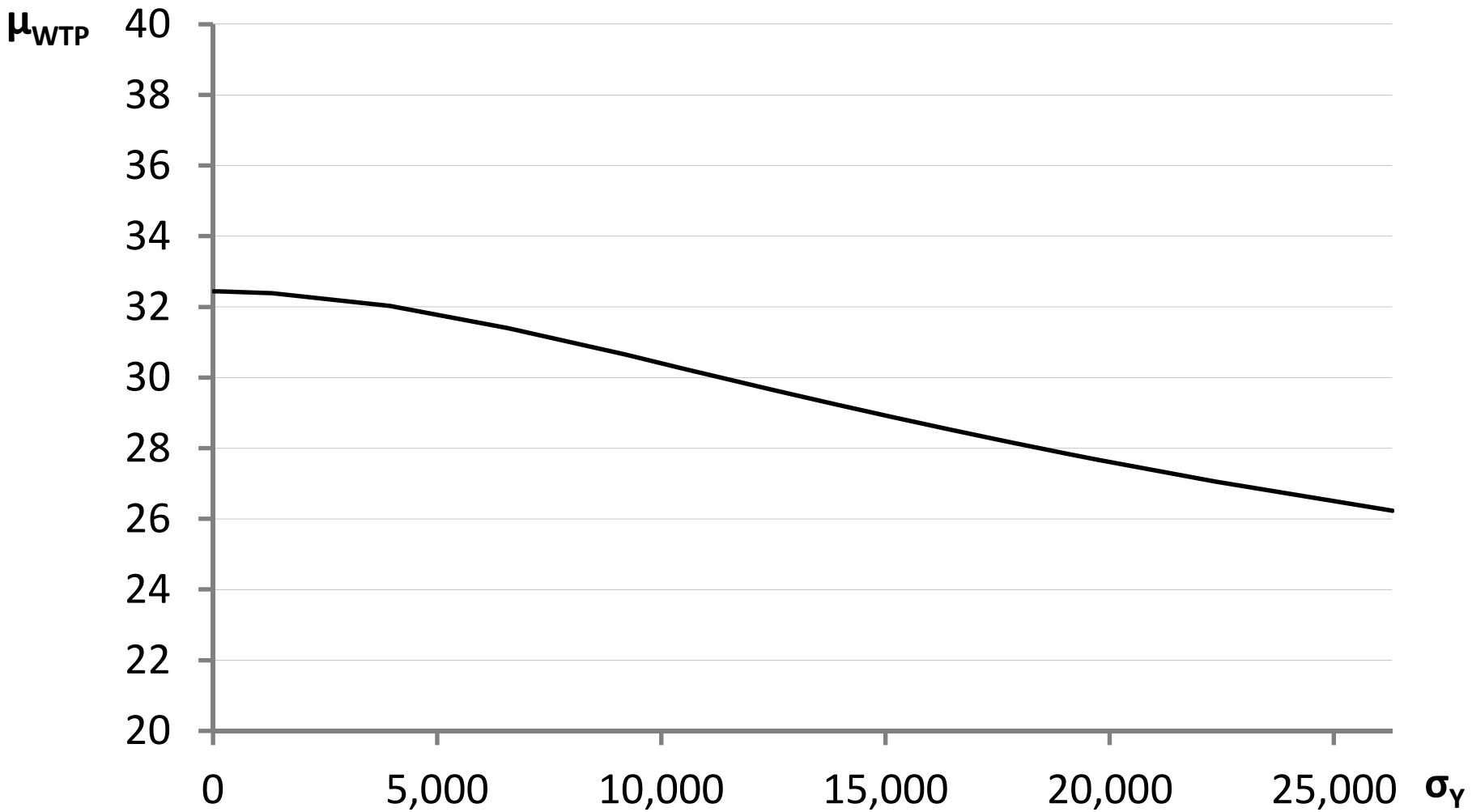
μ_{WTP}
40
38
36
34
32
30
28
26
24
22
20
0
5,000
10,000
15,000
20,000
25,000
σ_Y

3. Results

Proposition 2:

2. $d\mu_{\text{WTP}}/d\sigma_Y$ decreases with mean household income below $\tilde{\mu}_Y = \sqrt{1/\theta}\sigma_Y > \mu_Y^{\min}$ and increases with mean household income above $\tilde{\mu}_Y$, if the ecosystem service and the consumption good are substitutes or strong complements:

$$\frac{d\,\mu_{\text{WTP}}^2}{d\,\mu_Y d\,\sigma_Y} \begin{cases} < 0 & \text{for} \quad \mu_Y < \tilde{\mu}_Y \\ > 0 & \text{for} \quad \mu_Y > \tilde{\mu}_Y \end{cases} \qquad \text{if } \theta > 1 \text{ or } \theta < 1/2 \ .$$

$d\mu_{\text{WTP}}/d\sigma_Y$ increases with mean household income below $\tilde{\mu}_Y$ and decreases with mean household income above $\tilde{\mu}_Y$, if the ecosystem service and the consumption good are weak complements:

$$\frac{d\,\mu_{\text{WTP}}^2}{d\,\mu_Y d\,\sigma_Y} \begin{cases} < 0 & \text{for} \quad \mu_Y > \tilde{\mu}_Y \\ > 0 & \text{for} \quad \mu_Y < \tilde{\mu}_Y \end{cases} \qquad \text{if } 1/2 < \theta < 1 \ .$$

$d\mu_{\text{WTP}}/d\sigma_Y$ does not change with mean household income if $\theta = 1/2$ or $\theta = 1$.

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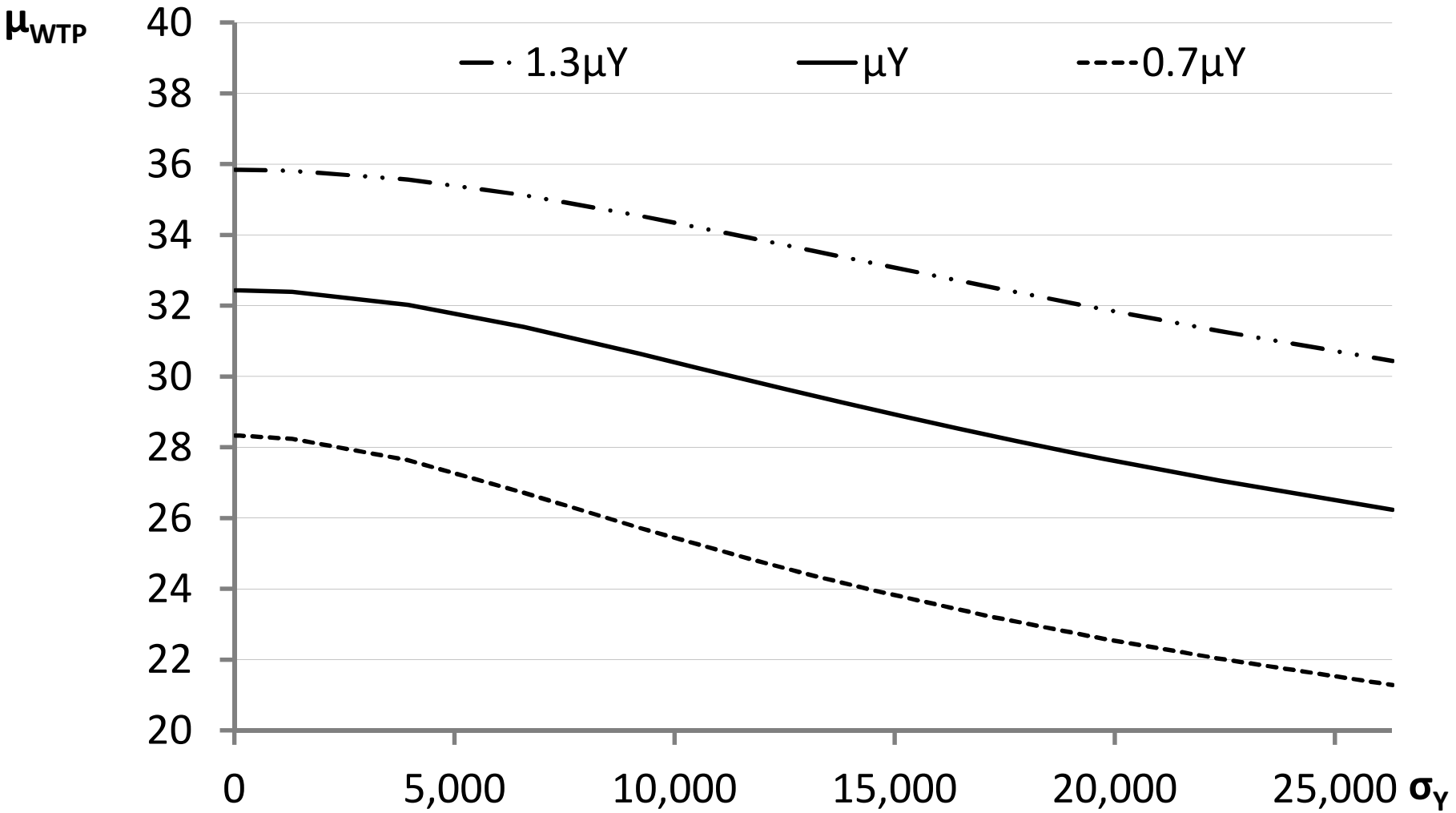
μ_{WTP}
40
38
36
34
32
30
28
26
24
22
20
1.3μY
μY
0.7μY
0
5,000
10,000
15,000
20,000
25,000
σ_Y

3. Results

Proposition 3:

Mean WTP for the ecosystem service changes more (less) elastically with mean household income than with income inequality, if the ecosystem service and the consumption good are substitutes (complements and mean household income is smaller than $\mu_Y^{\min} = \sqrt{1/\theta - 2}\,\sigma_Y$):

$$\left|\frac{d\,\mu_{\text{WTP}}}{d\,\mu_Y}\,\frac{\mu_Y}{\mu_{\text{WTP}}}\right| \left\{ \begin{array}{c} > \\ < \end{array} \right\} \left|\frac{d\,\mu_{\text{WTP}}}{d\,\sigma_Y}\,\frac{\sigma_Y}{\mu_{\text{WTP}}}\right| \quad \text{if} \quad \begin{cases} \theta > 1 \\ \theta < 1 \text{ and } \mu_Y < \mu_Y^{\min} \end{cases} .$$

Summary

If income is unevenly distributed among otherwise identical households, and consumption goods and ecosystem services are substitutes:

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   - increases with mean household income,
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If income is unevenly distributed among otherwise identical households, and consumption goods and ecosystem services are substitutes:

1. Mean WTP for ecosystem services
   - increases with mean household income,
   - decreases with income inequality.
2. The effect of income inequality on mean WTP for ecosystem services is the higher, the lower the mean household income.
3. Increasing mean household income has a larger relative effect on mean WTP for ecosystem services than reducing income inequality.

Conclusions

1. WTP-studies in poor countries:

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2. Benefit transfer:

   Correct WTP-estimates for differences in mean household income and income inequality

3. Policy recommendations aimed at both allocative efficiency and distributive justice:

   Correct WTP-estimates for grossly unjust income inequality, and use inequality-corrected WTP-estimates for efficiency(e.g. cost-benefit)-analysis