



Parameter screening: the use of a dummy parameter to identify non-influential parameters in a global sensitivity analysis

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Ann van Griensven and Willy Bauwens





Parameter screening requires a filter



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In theory...



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Non-influential parameters: $SI=0$



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Non-influential parameters: $SI=0$

...but due to numerical approximations



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A sample is still just a sample



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How to decide if parameter is non-influential?



Parameter screening requires a filter

In theory...

Non-influential parameters: $SI=0$

...but due to numerical approximations

Non-influential parameters: $SI \neq 0$

A sample is still just a sample

How to decide if parameter is non-influential?

Set a threshold!

A threshold for parameter screening is necessary to identify non-influential parameters



Parameter screening requires a filter

In theory...

Non-influential parameters: $SI=0$

...but due to numerical approximations

Non-influential parameters: $SI \neq 0$

A sample is still just a sample

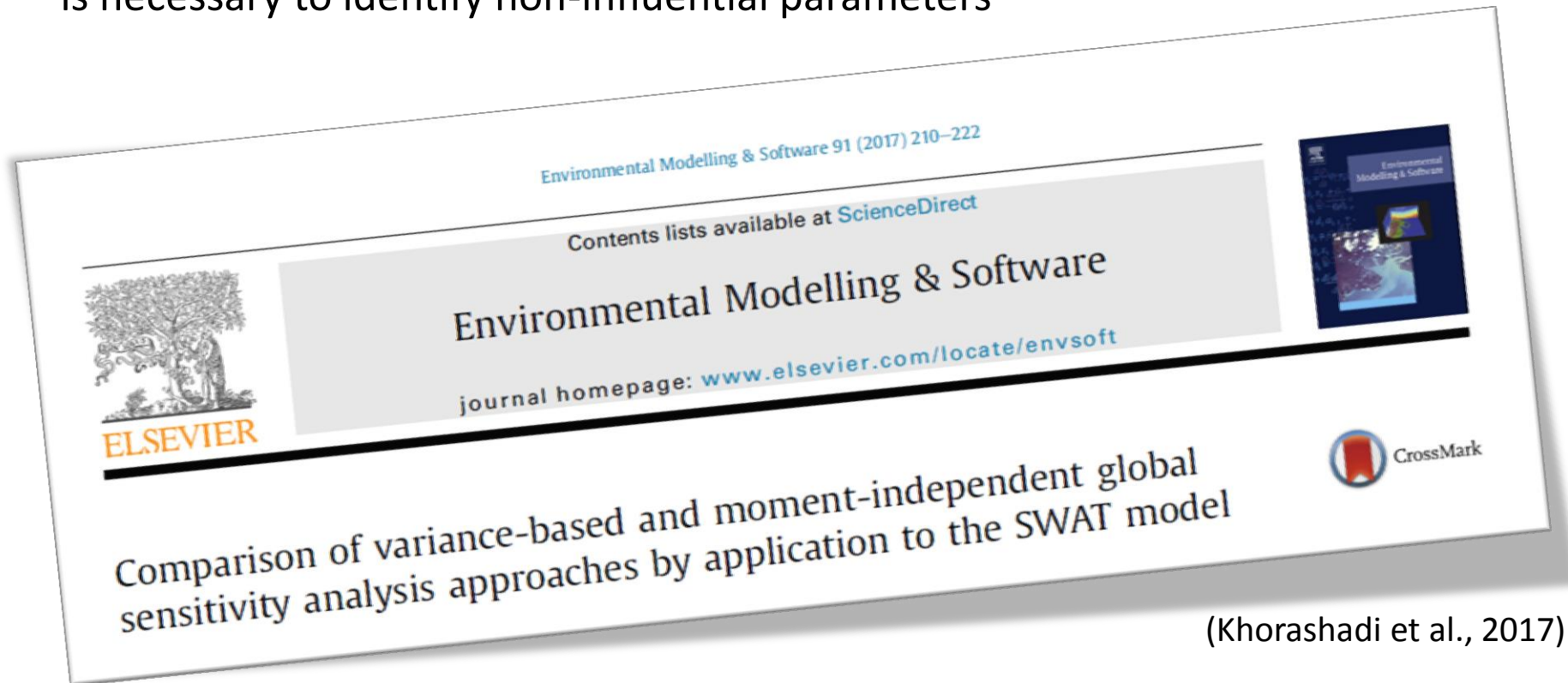
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Set a threshold!

A threshold for parameter screening
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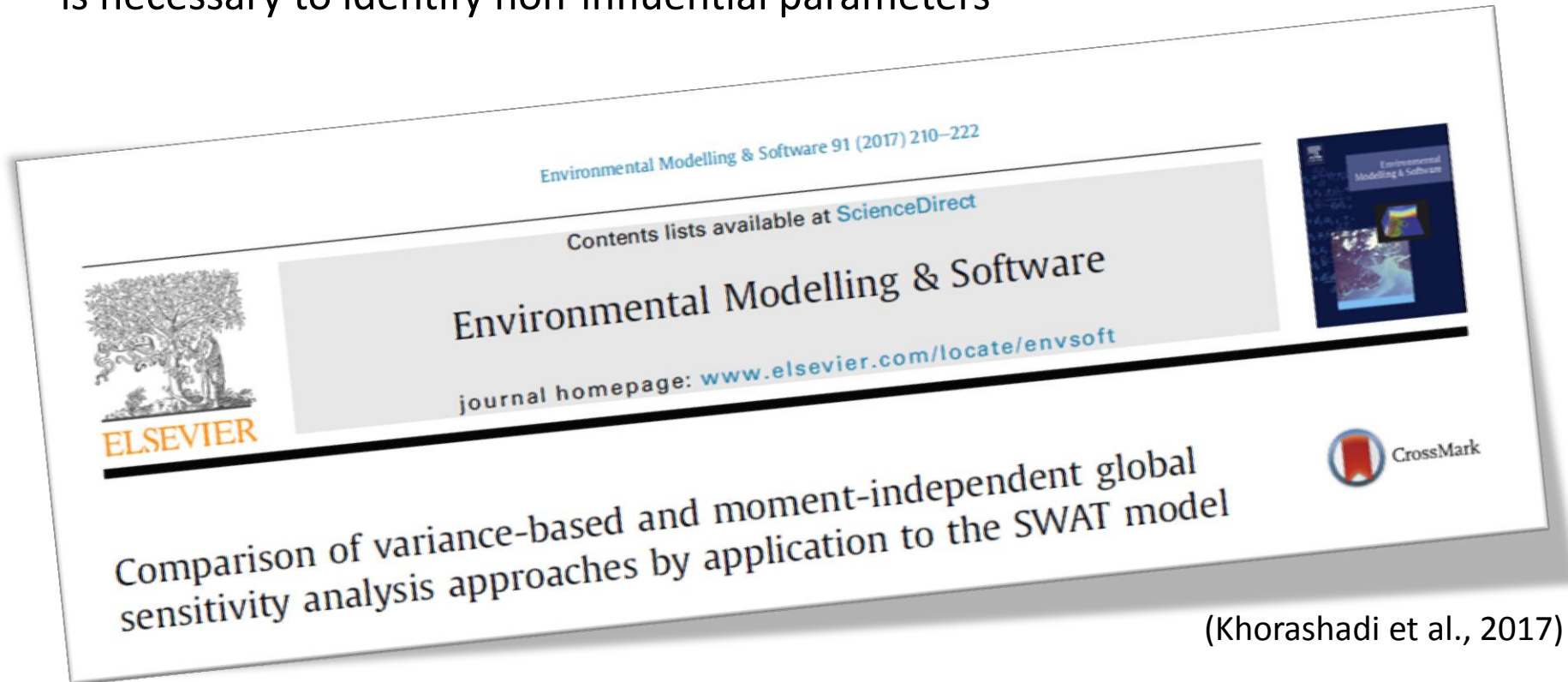


A threshold for parameter screening
is necessary to identify non-influential parameters



(Khorashadi et al., 2017)

A threshold for parameter screening
is necessary to identify non-influential parameters



(Khorashadi et al., 2017)

The sensitivity index of a dummy parameter
can serve as a practical threshold to identify
influential and non-influential parameters

Two GSA methods are employed
to test the use of the dummy parameter



A dummy parameter has been introduced
and has no influence on the model output or its equations

The threshold set by the dummy parameter
allows to identify influential and non-influential parameters

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Two GSA methods are employed
to test the use of the dummy parameter



Sobol' (Sobol', 1990)

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Sobol' (Sobol', 1990)

Variance-based

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Sample and resample matrix

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PAWN (Pianosi and Wagener, 2015)

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PAWN (Pianosi and Wagener, 2015)

Density-based, moment-independent

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Density-based, moment-independent

Distance between CDFs (KS)

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Sobol' (Sobol', 1990)

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Density-based, moment-independent
Distance between CDFs (KS)

SWAT (Arnold et al., 1998)

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Semi-distributed hydrological model

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Variance-based
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Density-based, moment-independent
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Semi-distributed hydrological model

Conceptual WQ model (under development)

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No influence on the model output

$$f(x) = a x^2 + b x + c$$

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$d \Rightarrow$ no influence on $f(x)$

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$$\# \text{ factors in SA} = \# \text{ model parameters} + 1$$

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Additional model evaluations?

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Additional model evaluations?

Method dependent and limited!

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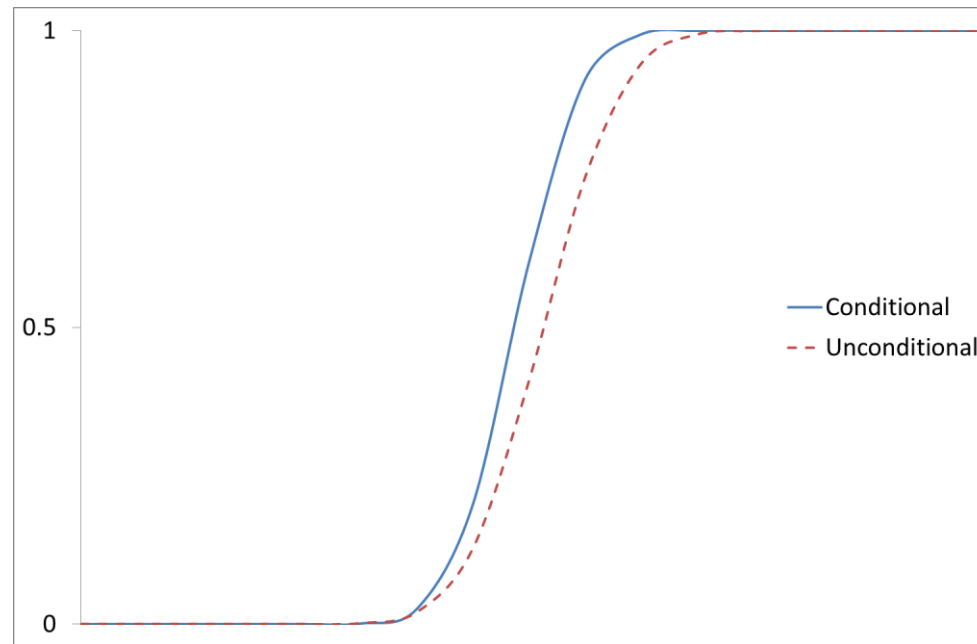


PAWN

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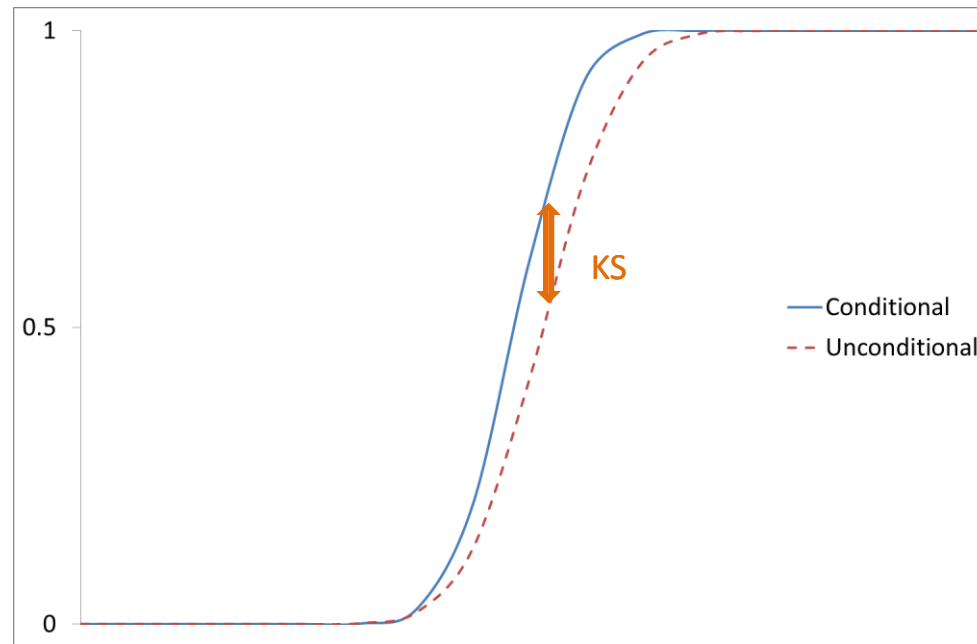
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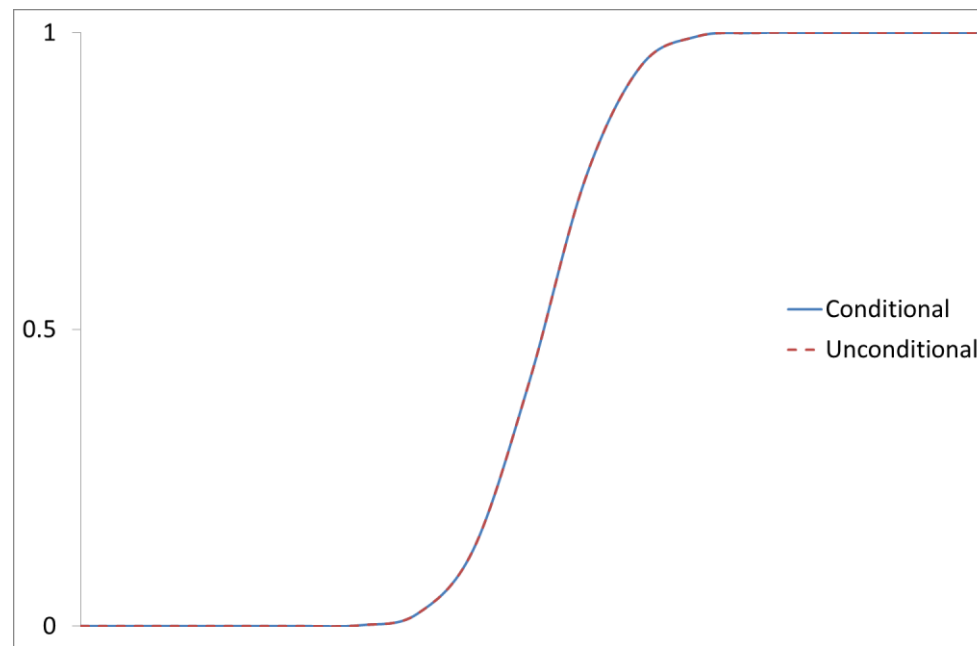
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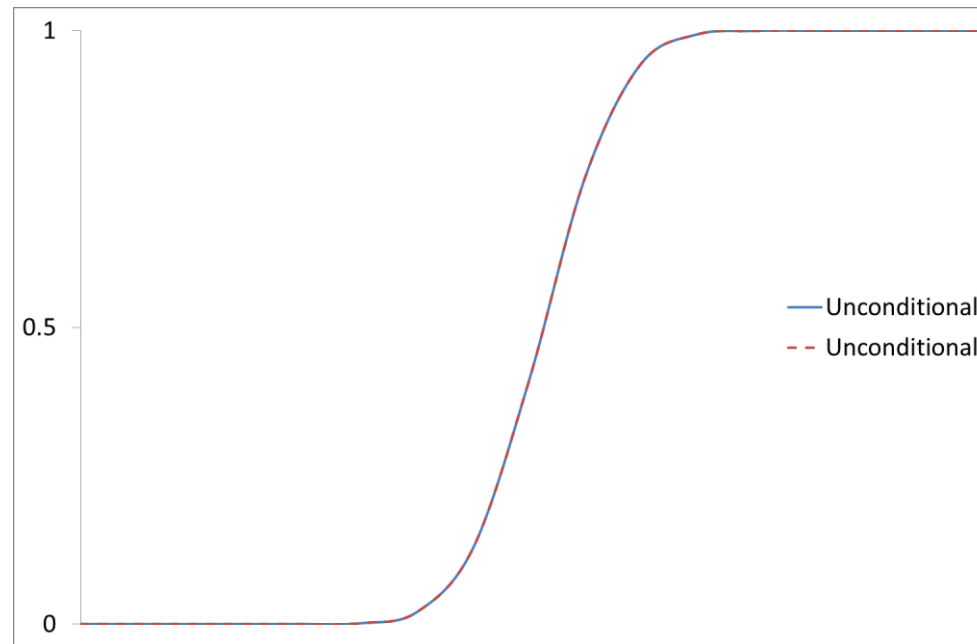
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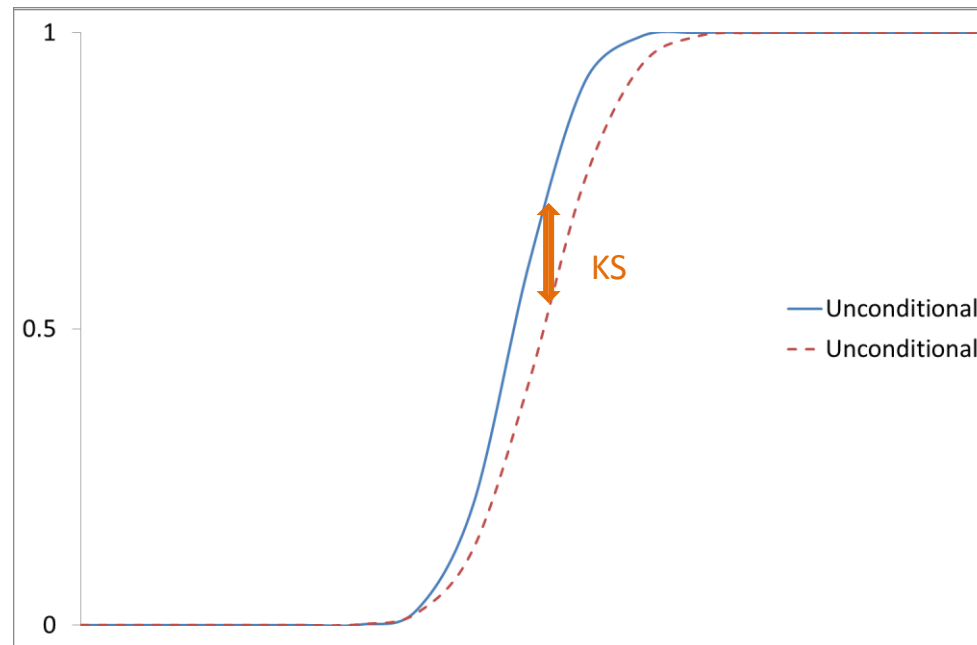
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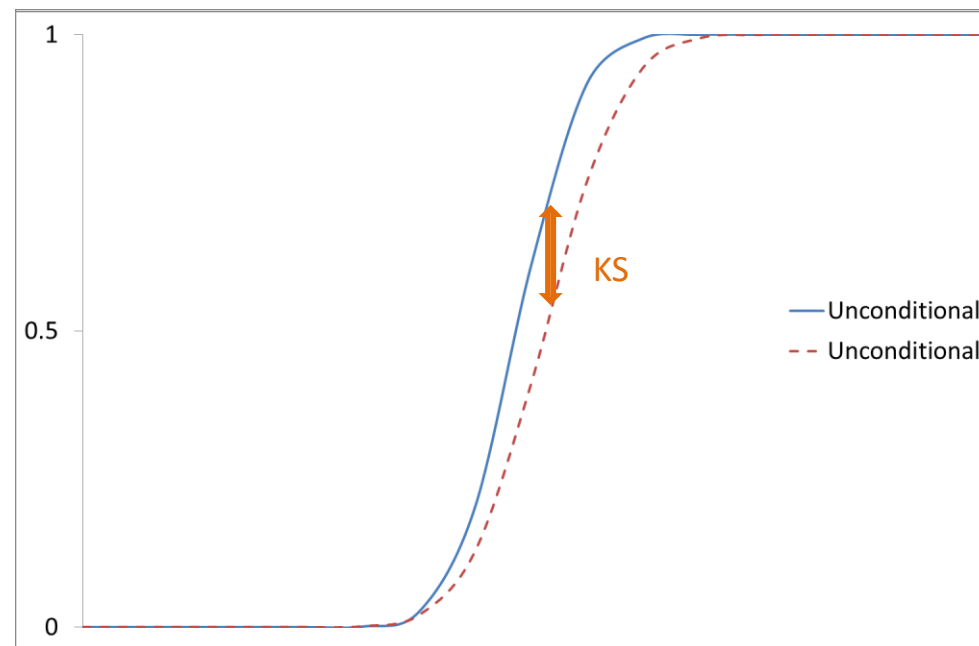
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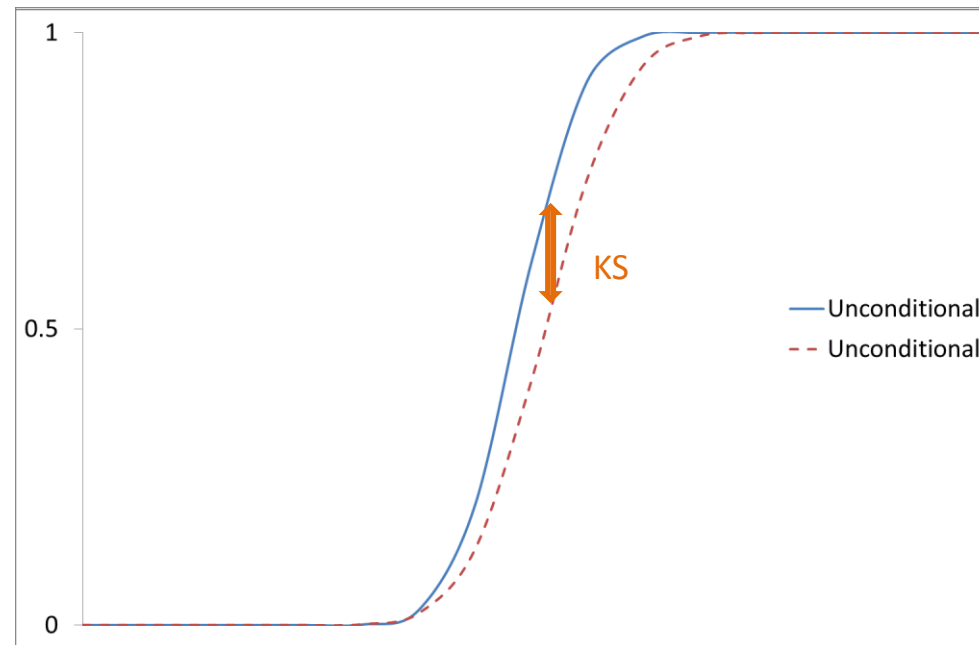


Generate additional unconditional CDF

A dummy parameter has been introduced
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PAWN



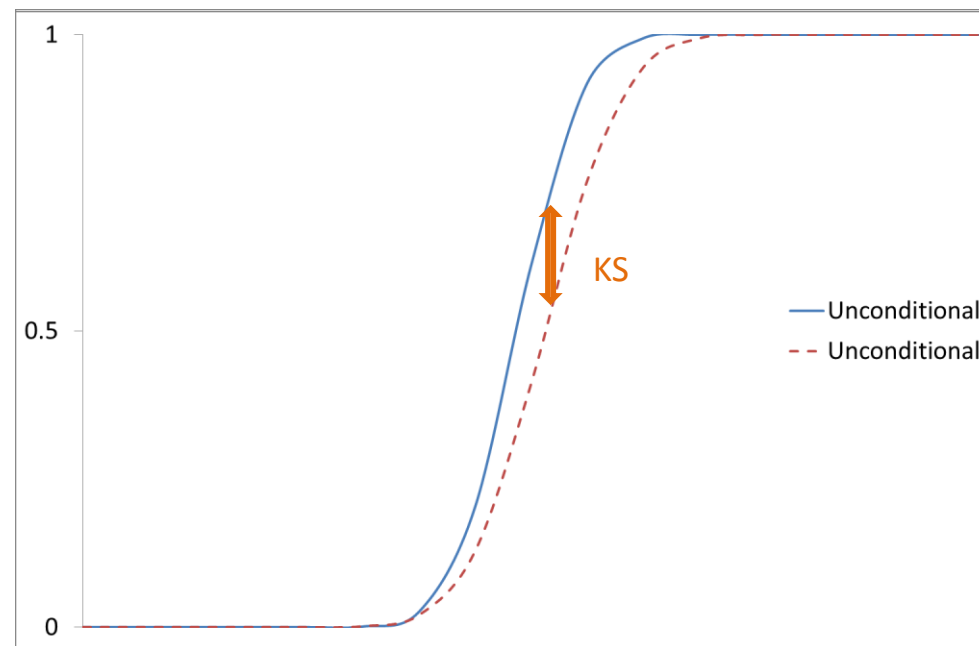
Generate additional unconditional CDF

10 000 model evaluations

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PAWN



Generate additional unconditional CDF

10 000 model evaluations

<> 261 000 model evaluations

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Sobol'

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Sobol'

a1	b1	c1
a2	b2	c2
a3	b3	c3
a4	b4	c4

A dummy parameter has been introduced
and has no influence on the model output or its equations



Sobol'

a1	b1	c1
a2	b2	c2
a3	b3	c3
a4	b4	c4

X

A dummy parameter has been introduced
and has no influence on the model output or its equations



Sobol'

a1	b1	c1	d1	e1	f1
a2	b2	c2	d2	e2	f2
a3	b3	c3	d3	e3	f3
a4	b4	c4	d4	e4	f4

X

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Sobol'

a1	b1	c1	d1	e1	f1
a2	b2	c2	d2	e2	f2
a3	b3	c3	d3	e3	f3
a4	b4	c4	d4	e4	f4

X

X'

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Sobol'

a1	b1	c1	d1	e1	f1	a1	e1	f1
a2	b2	c2	d2	e2	f2	a2	e2	f2
a3	b3	c3	d3	e3	f3	a3	e3	f3
a4	b4	c4	d4	e4	f4	a4	e4	f4
X			X'					

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Sobol'

a1	b1	c1	d1	e1	f1	a1	e1	f1	d1	b1	f1
a2	b2	c2	d2	e2	f2	a2	e2	f2	d2	b2	f2
a3	b3	c3	d3	e3	f3	a3	e3	f3	d3	b3	f3
a4	b4	c4	d4	e4	f4	a4	e4	f4	d4	b4	f4
X			X'								

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a1	b1	c1
a2	b2	c2
a3	b3	c3
a4	b4	c4

X

d1	e1	f1
d2	e2	f2
d3	e3	f3
d4	e4	f4

X'

a1	e1	f1
a2	e2	f2
a3	e3	f3
a4	e4	f4

d1	b1	f1
d2	b2	f2
d3	b3	f3
d4	b4	f4

d1	e1	c1
d2	e2	c2
d3	e3	c3
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Sobol'

a1	b1	c1	d1	e1	f1	a1	e1	f1	d1	b1	f1	d1	e1	c1
a2	b2	c2	d2	e2	f2	a2	e2	f2	d2	b2	f2	d2	e2	c2
a3	b3	c3	d3	e3	f3	a3	e3	f3	d3	b3	f3	d3	e3	c3
a4	b4	c4	d4	e4	f4	a4	e4	f4	d4	b4	f4	d4	e4	c4
X			X'											

$$\hat{V}_{\sim i} = \frac{1}{N-1} \sum_{r=1}^N \left\{ f(X'_{r1}, X'_{r2}, \dots, X'_{rp}) \times f(X'_{r1}, X'_{r2}, \dots, X'_{r(i-1)}, X_{ri}, X'_{r(i+1)}, \dots, X'_{rp}) \right\} - \hat{f}_0^2$$

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a1	b1	c1
a2	b2	c2
a3	b3	c3
a4	b4	c4

X

d1	e1	f1
d2	e2	f2
d3	e3	f3
d4	e4	f4

X'

a1	e1	f1
a2	e2	f2
a3	e3	f3
a4	e4	f4

d1	b1	f1
d2	b2	f2
d3	b3	f3
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X

d1	e1	f1
d2	e2	f2
d3	e3	f3
d4	e4	f4

X'

a1	e1	f1
a2	e2	f2
a3	e3	f3
a4	e4	f4

d1	b1	f1
d2	b2	f2
d3	b3	f3
d4	b4	f4

d1	e1	c1
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d3	e3	c3
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Dummy combination matrix

A dummy parameter has been introduced
and has no influence on the model output or its equations



Sobol'

a1	b1	c1
a2	b2	c2
a3	b3	c3
a4	b4	c4

X

d1	e1	f1
d2	e2	f2
d3	e3	f3
d4	e4	f4

X'

a1	e1	f1
a2	e2	f2
a3	e3	f3
a4	e4	f4

d1	b1	f1
d2	b2	f2
d3	b3	f3
d4	b4	f4

d1	e1	c1
d2	e2	c2
d3	e3	c3
d4	e4	c4

$$\hat{V}_{\sim i} = \frac{1}{N-1} \sum_{r=1}^N \left\{ f(X'_{r1}, X'_{r2}, \dots, X'_{rp}) \times f(X'_{r1}, X'_{r2}, \dots, X'_{r(i-1)}, X_{ri}, X'_{r(i+1)}, \dots, X'_{rp}) \right\} - \hat{f}_0^2$$

Dummy combination matrix $\Longrightarrow X'$

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a1	b1	c1	d1	e1	f1	a1	e1	f1	d1	b1	f1	d1	e1	c1
a2	b2	c2	d2	e2	f2	a2	e2	f2	d2	b2	f2	d2	e2	c2
a3	b3	c3	d3	e3	f3	a3	e3	f3	d3	b3	f3	d3	e3	c3
a4	b4	c4	d4	e4	f4	a4	e4	f4	d4	b4	f4	d4	e4	c4
X			X'											

$$\hat{V}_{\sim i} = \frac{1}{N-1} \sum_{r=1}^N \left\{ f(X'_{r1}, X'_{r2}, \dots, X'_{rp}) \times f(X'_{r1}, X'_{r2}, \dots, X'_{r(i-1)}, X_{ri}, X'_{r(i+1)}, \dots, X'_{rp}) \right\} - \hat{f}_0^2$$

Dummy combination matrix $\Longrightarrow X'$

$\hat{V}_{\sim dummy}$ = variance of matrix X'

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Sobol'

a1	b1	c1	d1	e1	f1	a1	e1	f1	d1	b1	f1	d1	e1	c1
a2	b2	c2	d2	e2	f2	a2	e2	f2	d2	b2	f2	d2	e2	c2
a3	b3	c3	d3	e3	f3	a3	e3	f3	d3	b3	f3	d3	e3	c3
a4	b4	c4	d4	e4	f4	a4	e4	f4	d4	b4	f4	d4	e4	c4
X			X'											

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Dummy combination matrix $\Longrightarrow X'$

$\hat{V}_{\sim dummy}$ = variance of matrix X'

No additional model evaluations required!

Two GSA methods are employed
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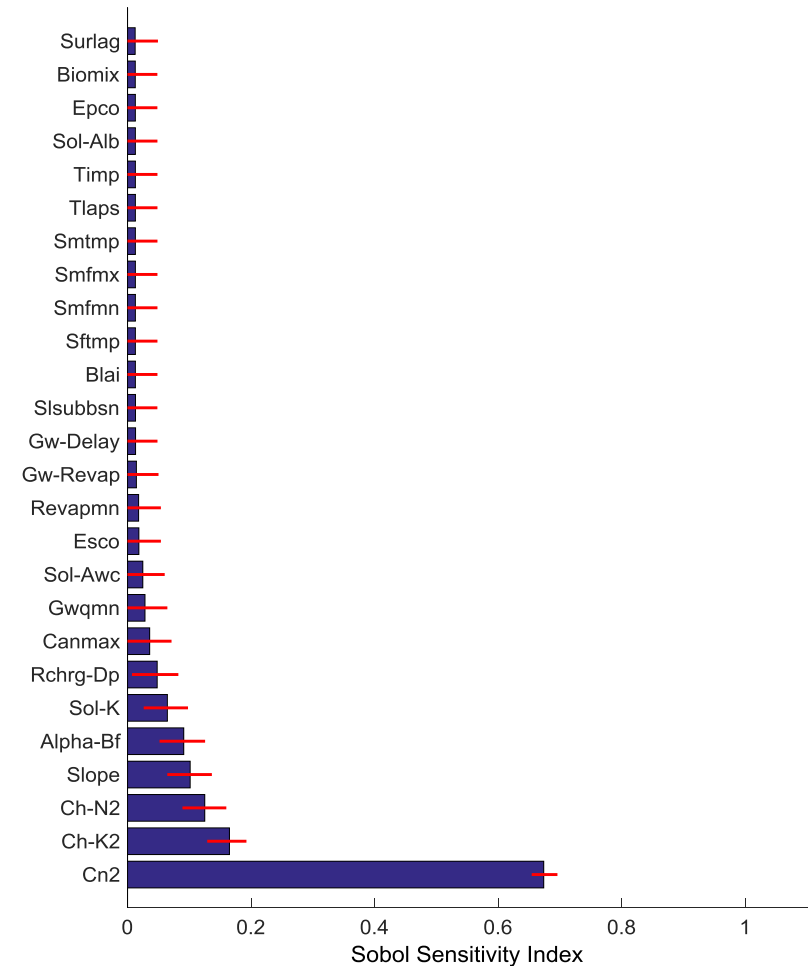
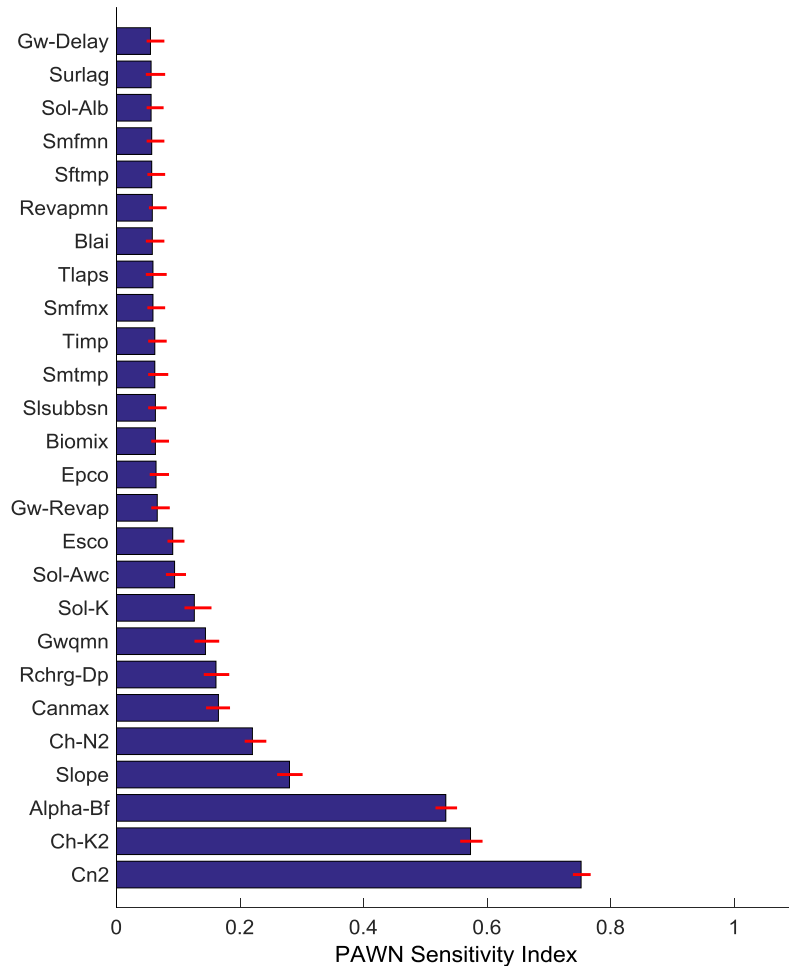
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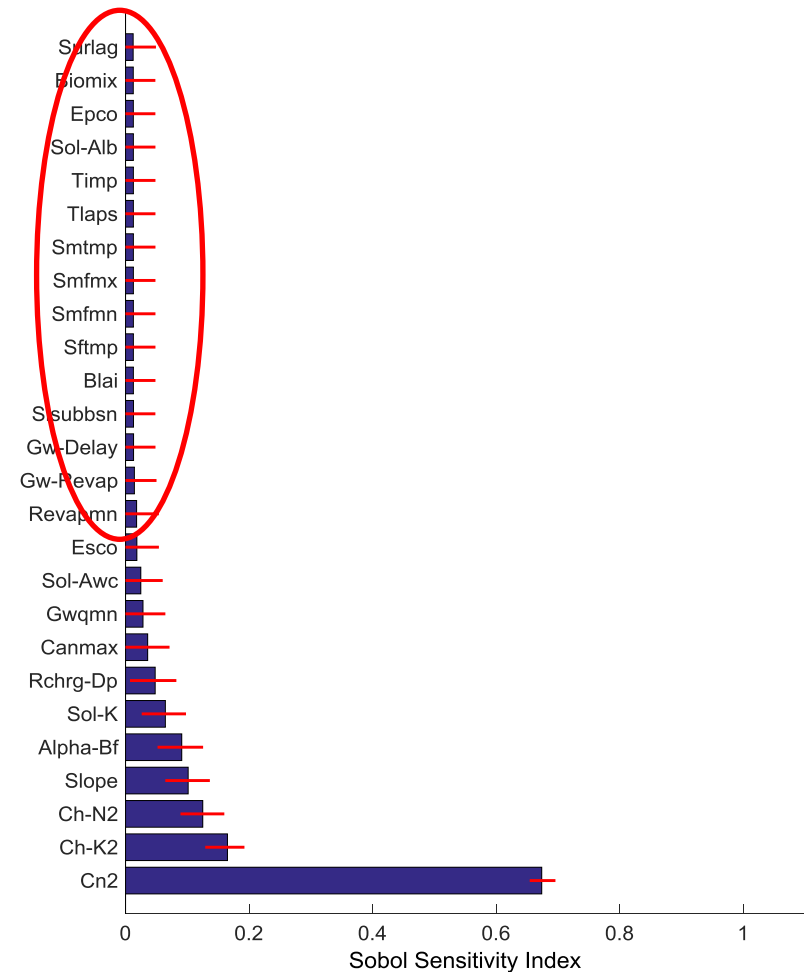
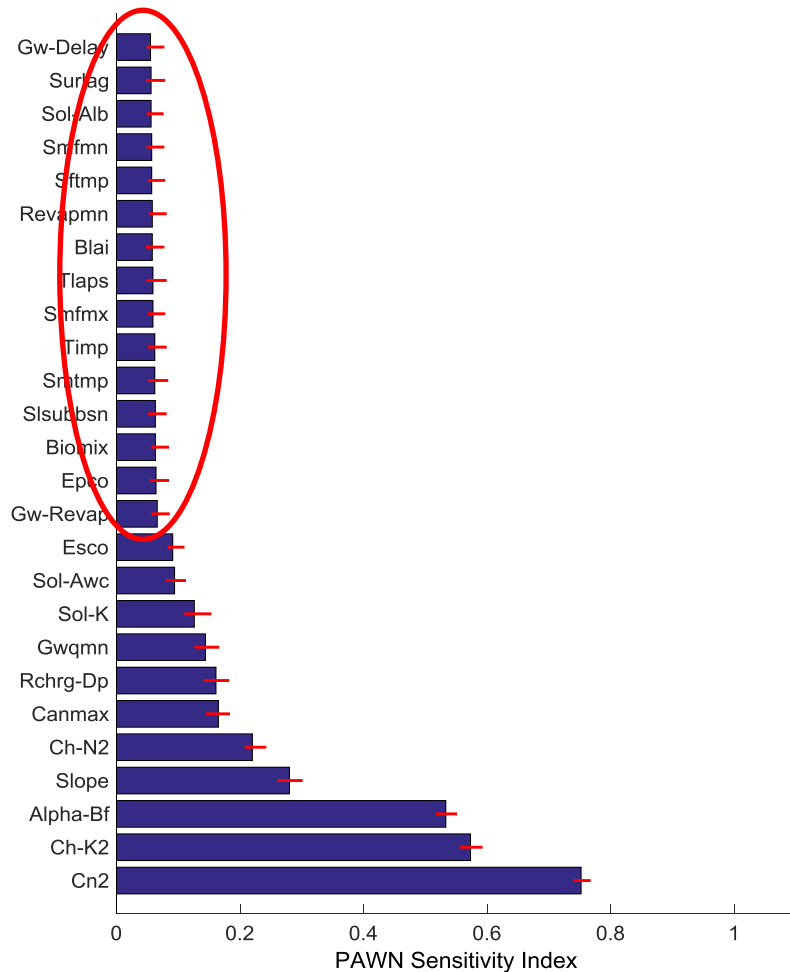
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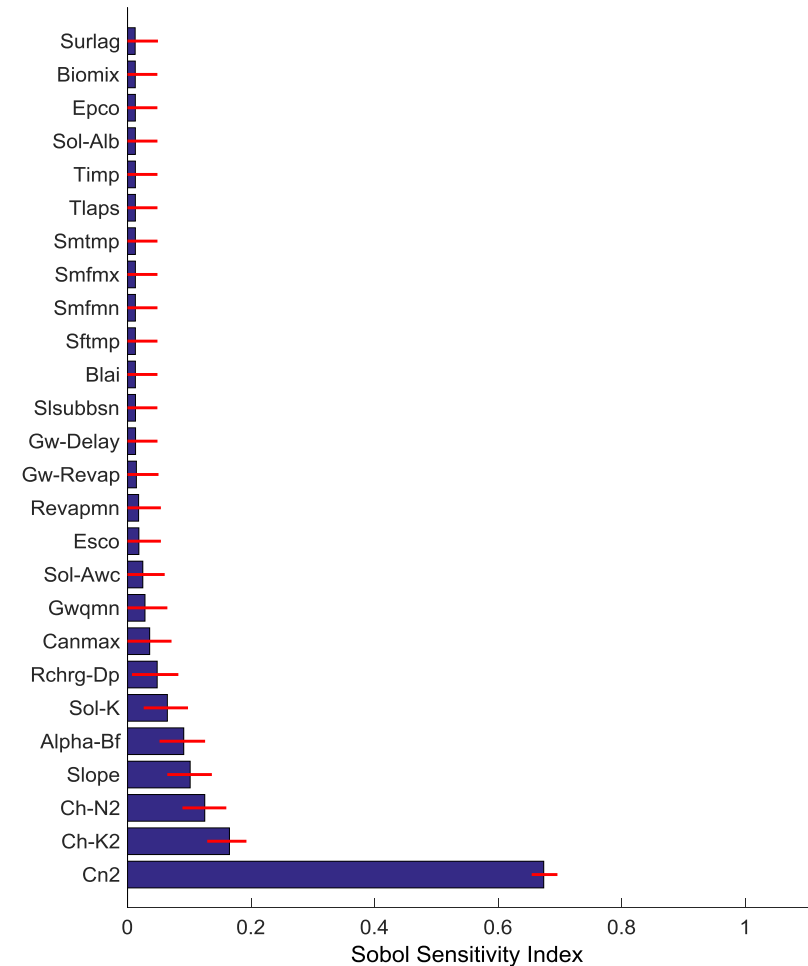
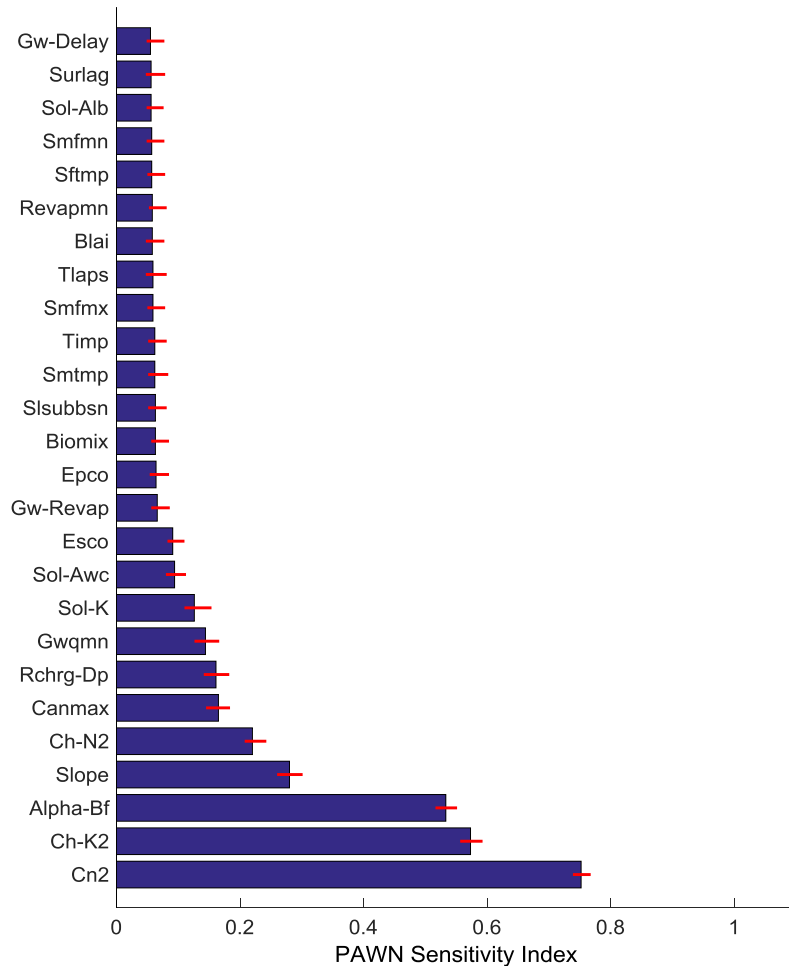
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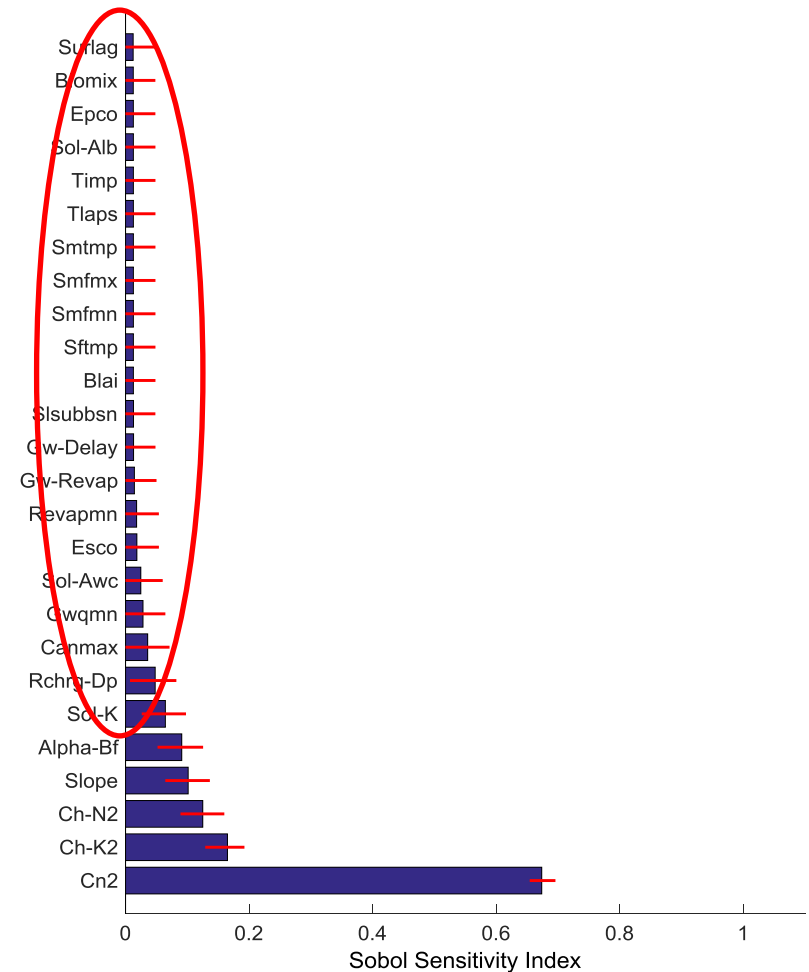
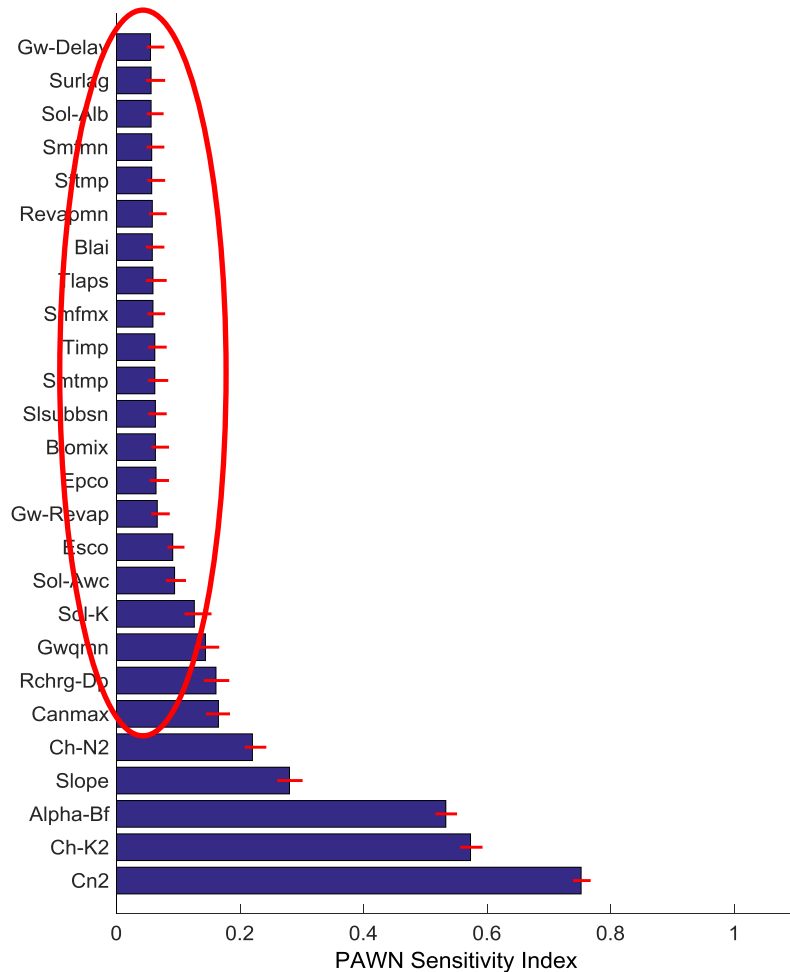
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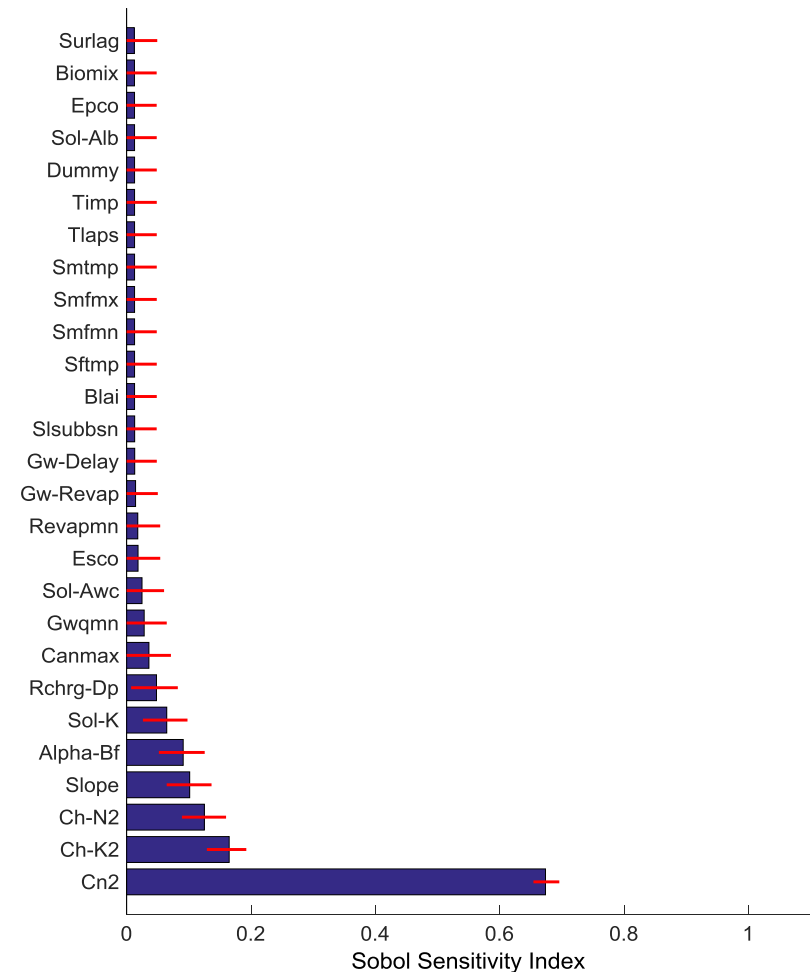
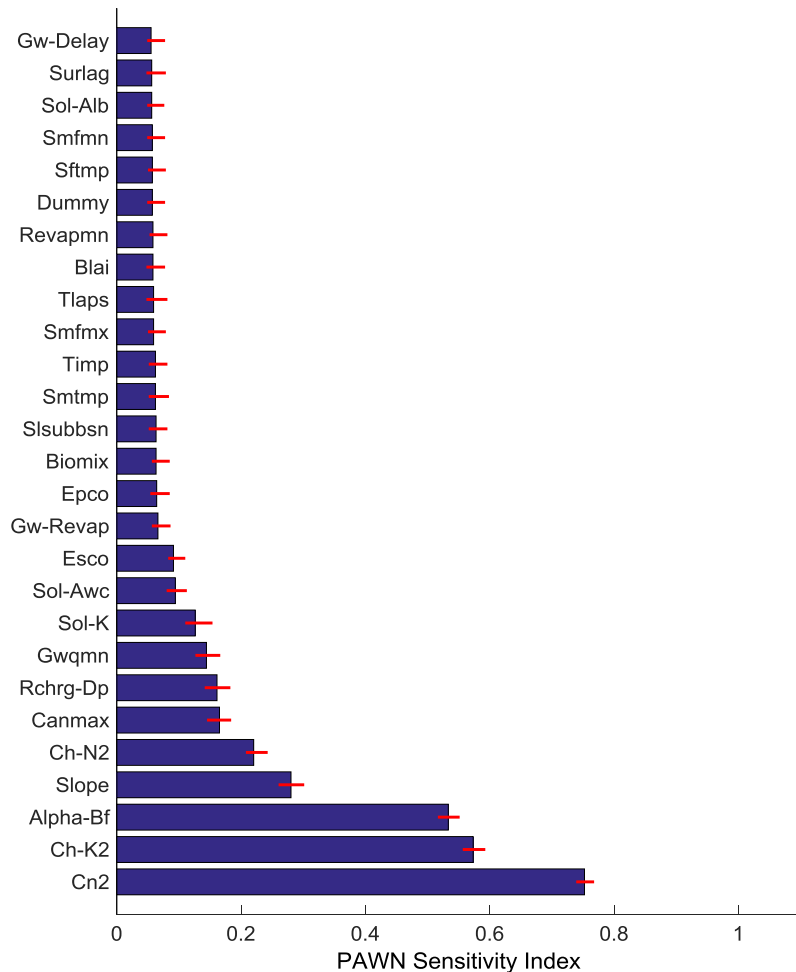
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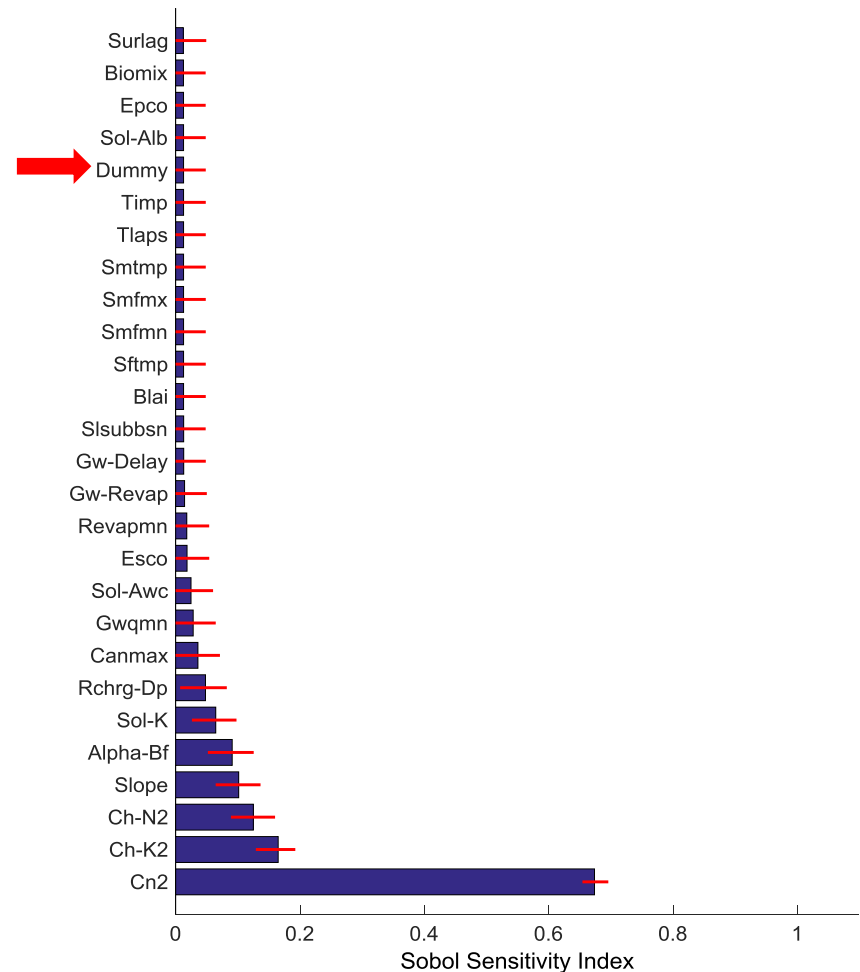
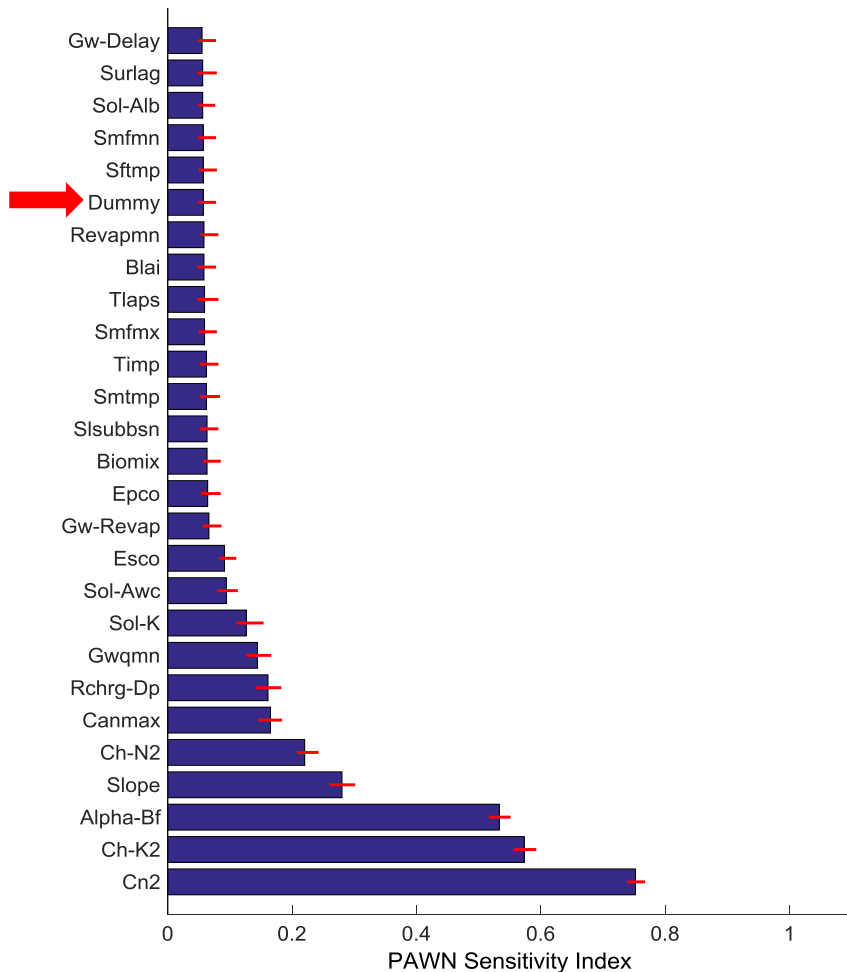
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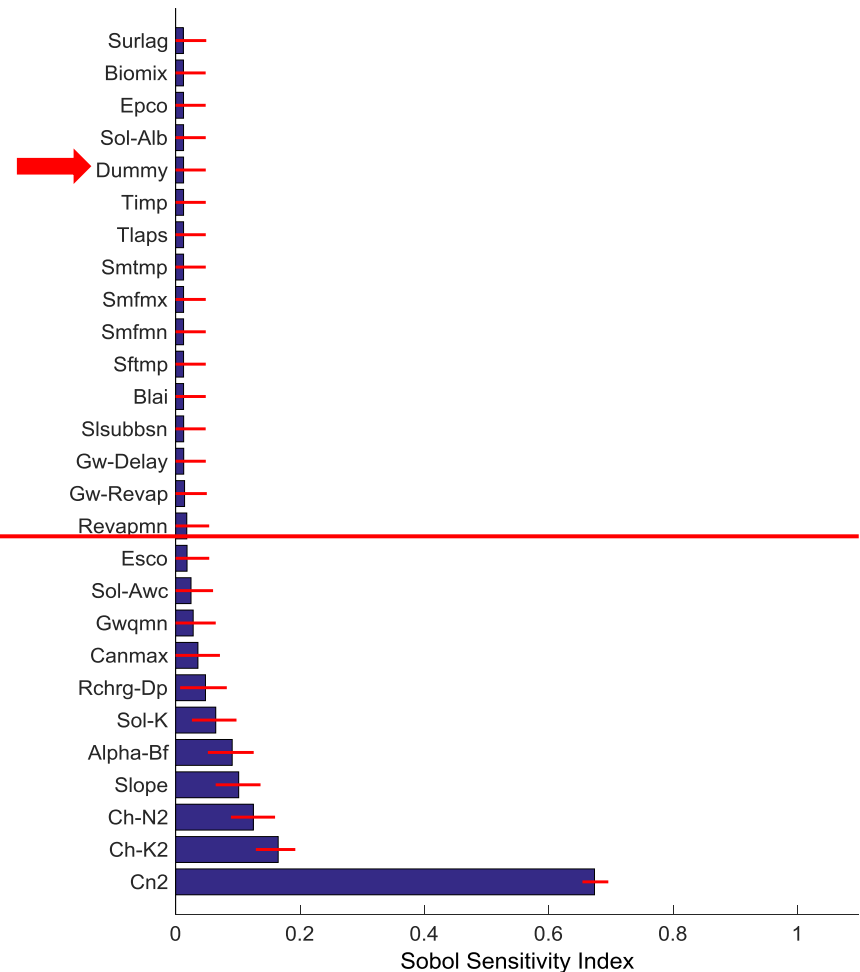
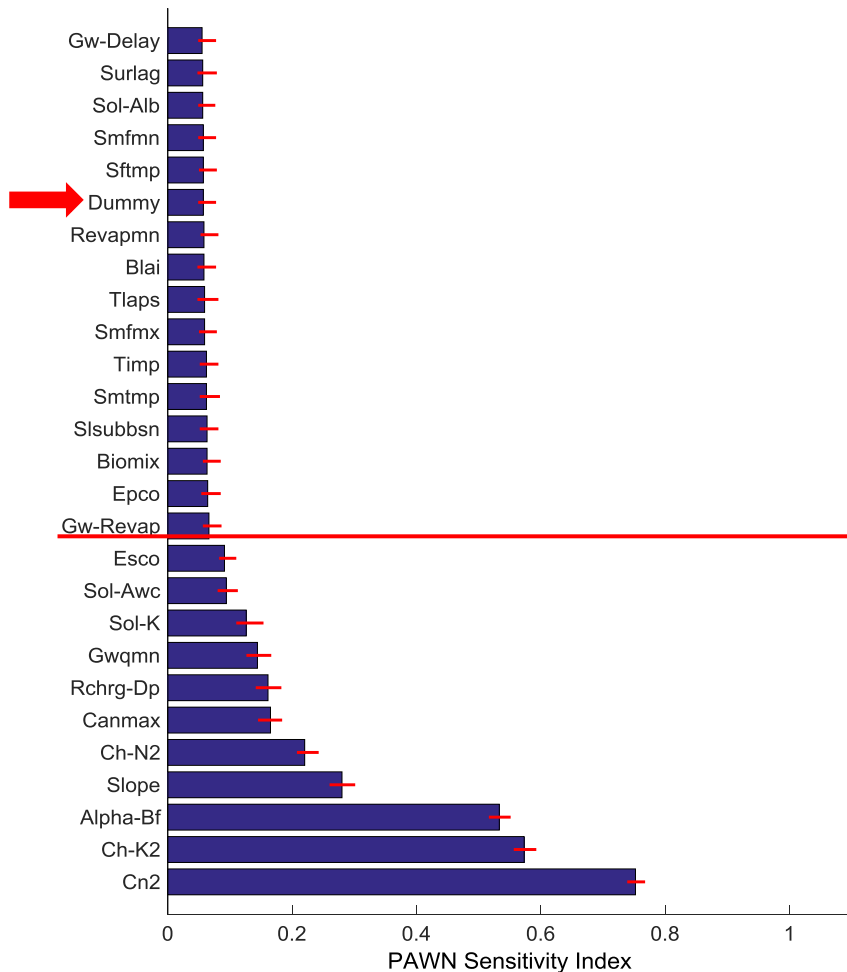
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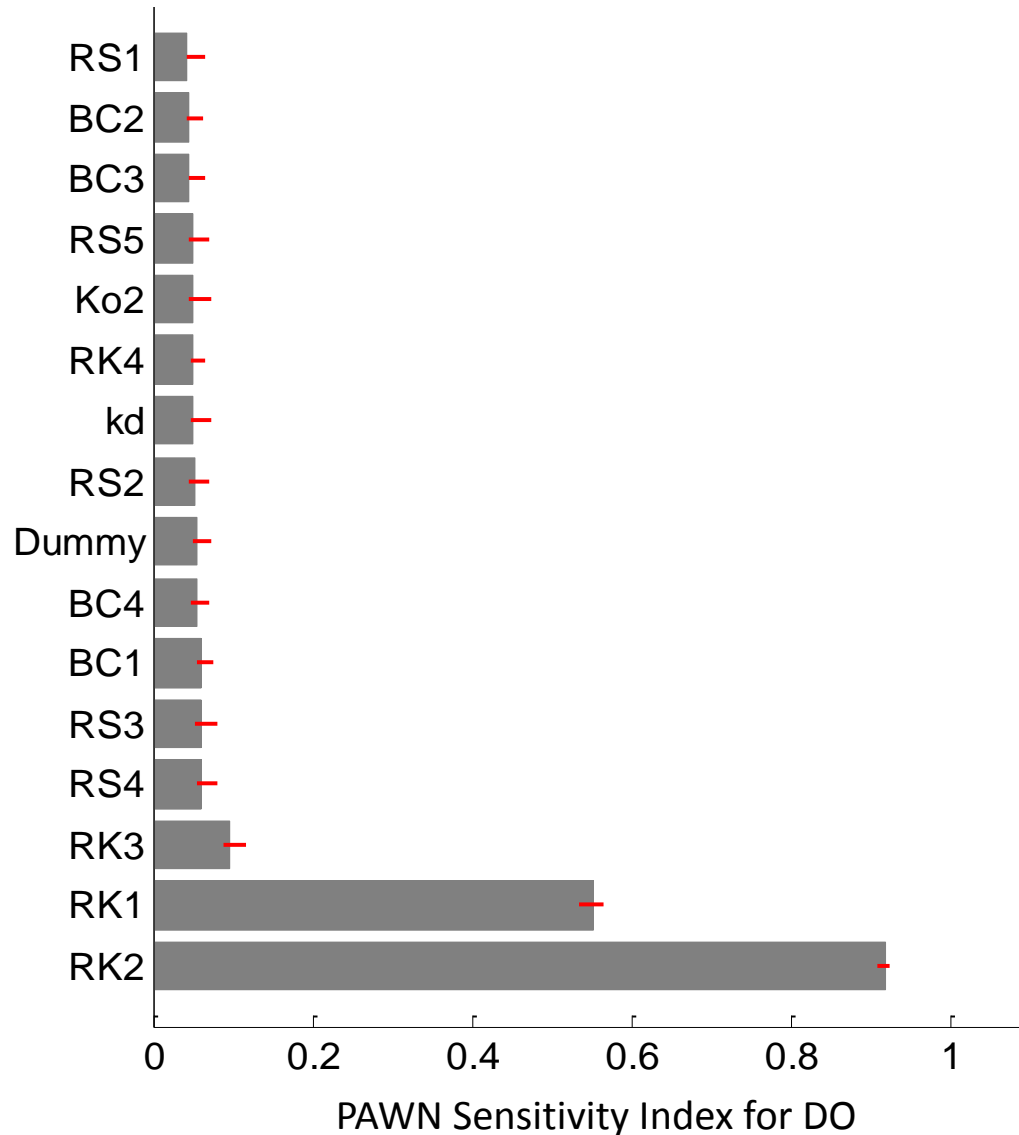
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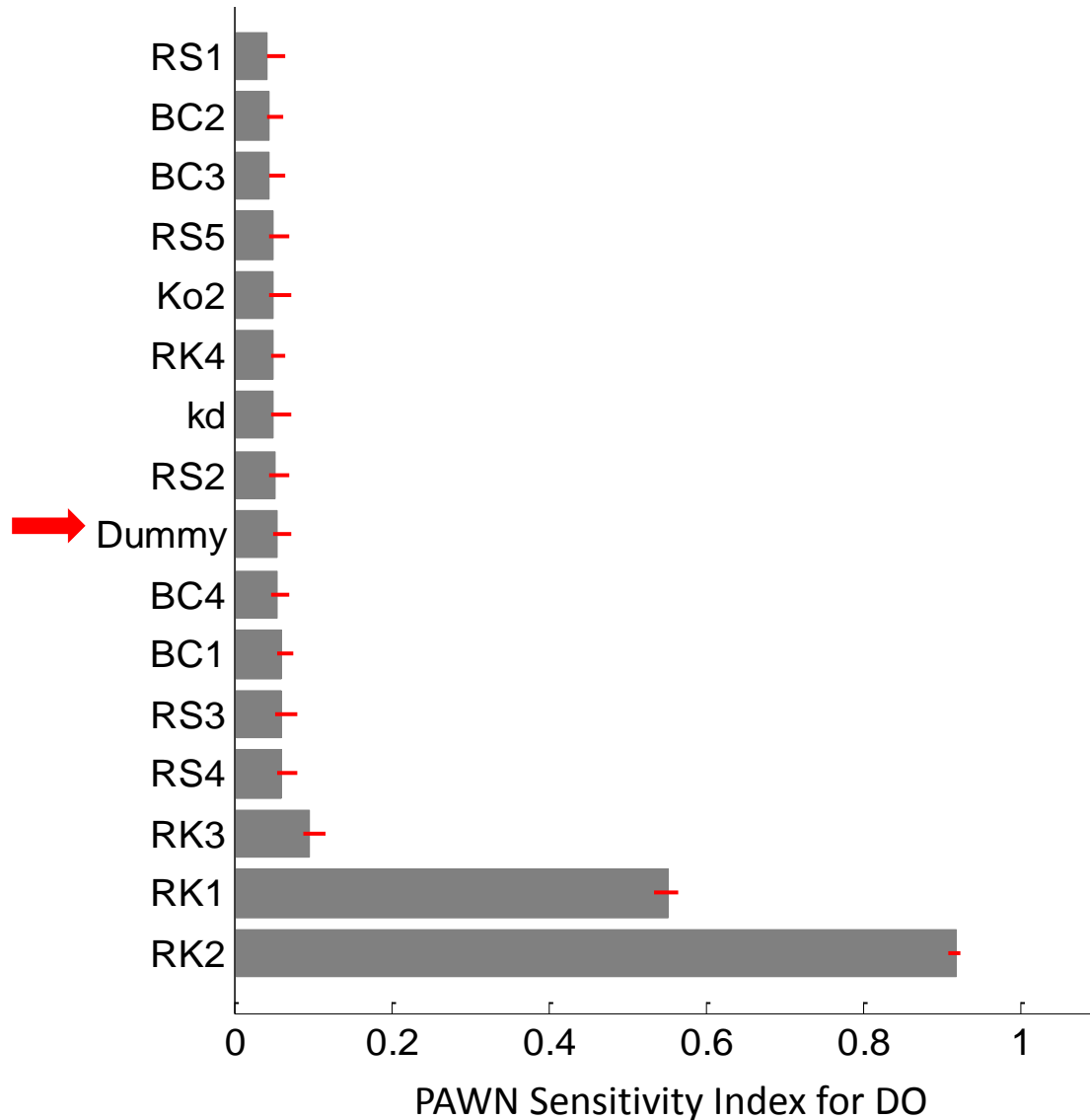
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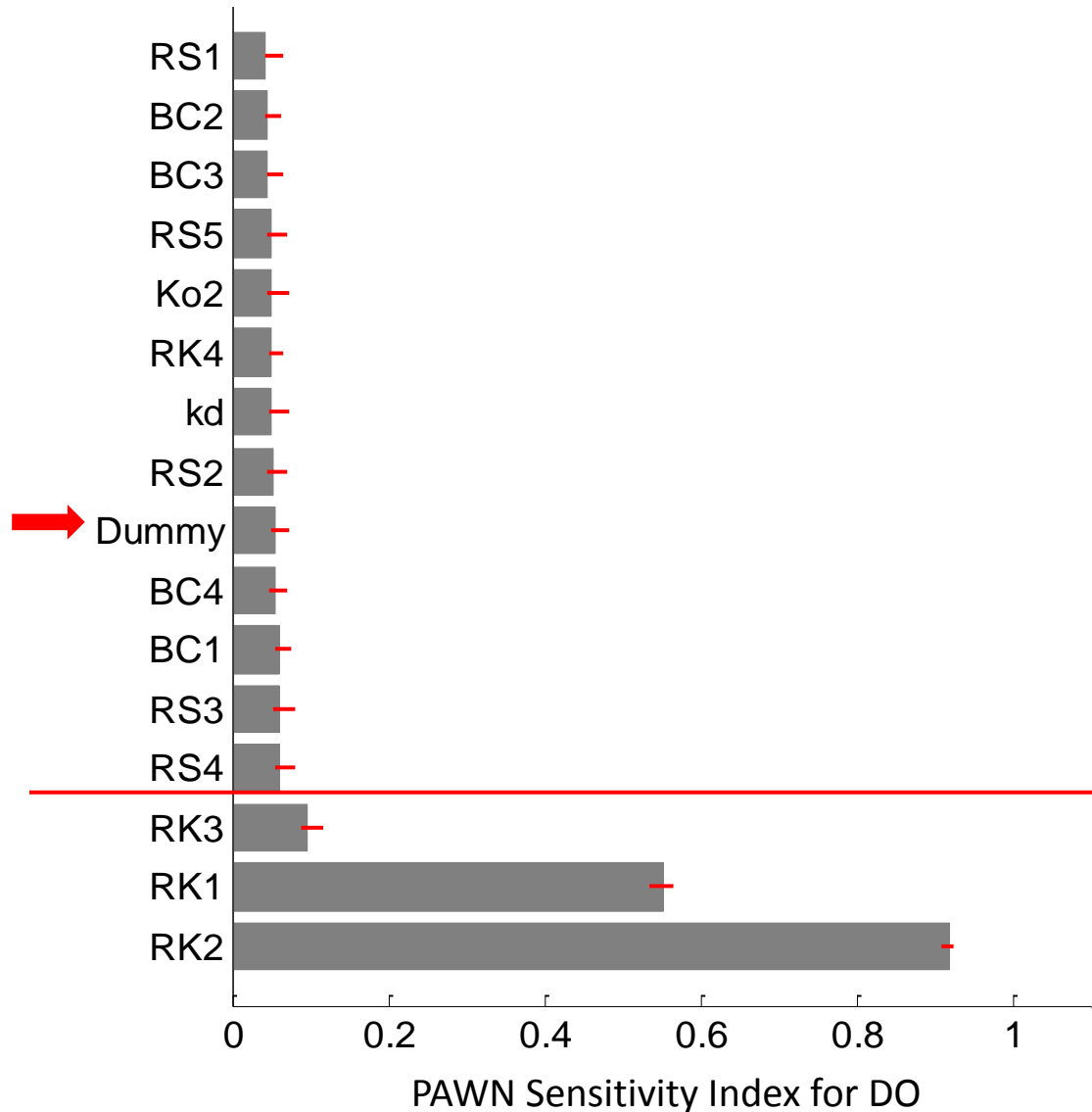
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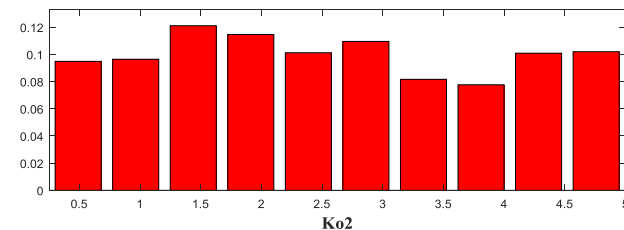
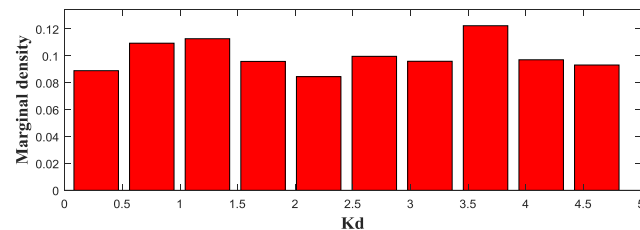
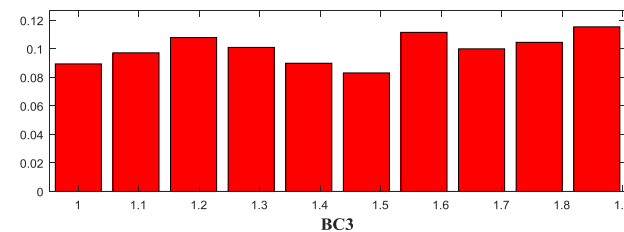
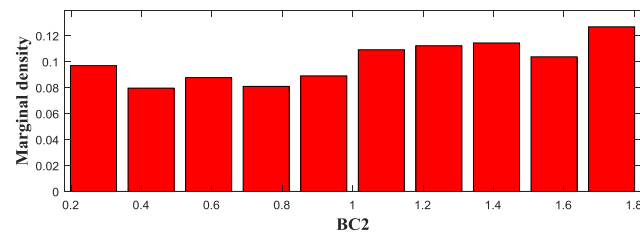
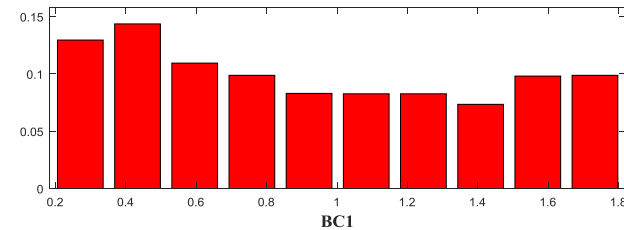
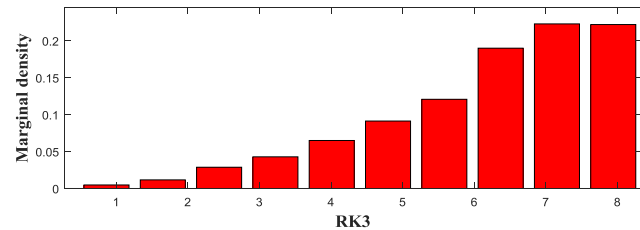
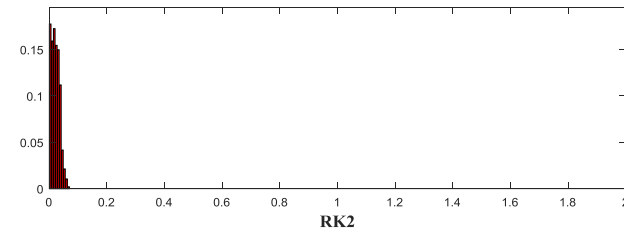
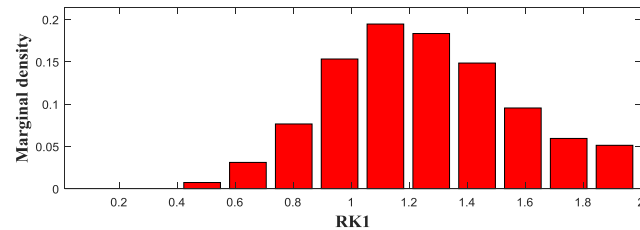
The threshold set by the dummy parameter allows to identify influential and non-influential parameters



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Two GSA methods are employed
to test the use of the dummy parameter



A dummy parameter has been introduced
and has no influence on the model output or its equations

The threshold set by the dummy parameter
allows to identify influential and non-influential parameters

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The dummy parameter provides the filter that we need to adequately perform parameter screening



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Parameter screening: the use of a dummy parameter to identify non-influential parameters in a global sensitivity analysis

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Ann van Griensven and Willy Bauwens