

SBML Model Report

Model name: “Smallbone2013 - Metabolic Control Analysis - Example 3”



May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by the following two authors: Vijayalakshmi Chelliah¹ and Kieran Smallbone² at May first 2013 at noon. and last time modified at April eighth 2016 at 5:29 p. m. Table 1 shows an overview of the quantities of all components of this model.

Table 1: Number of components in this model, which are described in the following sections.

Element	Quantity	Element	Quantity
compartment types	0	compartments	1
species types	0	species	11
events	0	constraints	0
reactions	6	function definitions	0
global parameters	0	unit definitions	3
rules	0	initial assignments	0

Model Notes

Smallbone2013 - Metabolic Control Analysis - Example 3

Metabolic control analysis (MCA) is a biochemical formalism, defining how variables, such as fluxes and concentrations, depend on network parameters. In this paper, owing to its limitations,

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it is shown with three example models (MODEL1305030000-2) that the algorithm with slight modification can be applied to all models.

This model is described in the article: [Metabolic Control Analysis: Rereading Reder](#) Kieran Smallbone Quantitative Methods; Tue, 28 May 2013.

Abstract:

Metabolic control analysis is a biochemical formalism defined by Kacser and Burns in 1973, and given firm mathematical basis by Reder in 1988. The algorithm defined by Reder for calculating the control matrices is still used by software programs today, but is only valid for some biochemical models. We show that, with slight modification, the algorithm may be applied to all models.

This model is hosted on [BioModels Database](#) and identified by: [MODEL1305030000](#).

To cite BioModels Database, please use: [BioModels Database: An enhanced, curated and annotated resource for published quantitative kinetic models](#).

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2 Unit Definitions

This is an overview of five unit definitions of which two are predefined by SBML and not mentioned in the model.

2.1 Unit substance

Definition dimensionless

2.2 Unit time

Definition dimensionless

2.3 Unit volume

Definition dimensionless

2.4 Unit area

Notes Square metre is the predefined SBML unit for area since SBML Level 2 Version 1.

Definition m^2

2.5 Unit length

Notes Metre is the predefined SBML unit for length since SBML Level 2 Version 1.

Definition m

3 Compartment

This model contains one compartment.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
cell	cell	0000290	3	1	dimensionless	<input checked="" type="checkbox"/>	

3.1 Compartment `cell`

This is a three dimensional compartment with a constant size of one dimensionless.

Name `cell`

SBO:0000290 physical compartment

4 Species

This model contains eleven species. The boundary condition of seven of these species is set to `true` so that these species' amount cannot be changed by any reaction. Section 6 provides further details and the derived rates of change of each species.

Table 3: Properties of each species.

Id	Name	Compartment	Derived Unit	Constant	Boundary Condi- tion
x1	x1	cell	dimensionless dimensionless ⁻¹	<input type="checkbox"/>	<input type="checkbox"/>
x2	x2	cell	dimensionless dimensionless ⁻¹	<input type="checkbox"/>	<input type="checkbox"/>
x3	x3	cell	dimensionless dimensionless ⁻¹	<input type="checkbox"/>	<input type="checkbox"/>
y1	y1	cell	dimensionless dimensionless ⁻¹	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
y2	y2	cell	dimensionless dimensionless ⁻¹	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
y3	y3	cell	dimensionless dimensionless ⁻¹	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
y4	y4	cell	dimensionless dimensionless ⁻¹	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
y5	y5	cell	dimensionless dimensionless ⁻¹	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
y7	y7	cell	dimensionless dimensionless ⁻¹	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
x4	x4	cell	dimensionless dimensionless ⁻¹	<input type="checkbox"/>	<input type="checkbox"/>

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
y8	y8	cell	dimensionless dimensionless ⁻¹	· <input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

5 Reactions

This model contains six reactions. All reactions are listed in the following table and are subsequently described in detail. If a reaction is affected by a modifier, the identifier of this species is written above the reaction arrow.

Table 4: Overview of all reactions

Nº	Id	Name	Reaction Equation	SBO
1	v1	v1	$y1 + x2 \xrightleftharpoons{y1, x2, x1, x3} x1 + x3$	0000176
2	v2	v2	$y4 + x3 \xrightleftharpoons{y4, x3, y5, x2} y5 + x2$	0000176
3	v3	v3	$x1 \xrightleftharpoons{x1, y2} y2$	0000176
4	v4	v4	$x1 \xrightleftharpoons{x1, y3} y3$	0000176
5	v6	v6	$y7 \xrightleftharpoons{y7} x4$	0000176
6	v7	v7	$x4 \xrightleftharpoons{} y8$	0000176

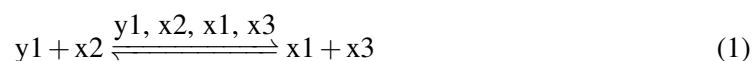
5.1 Reaction v1

This is a reversible reaction of two reactants forming two products influenced by four modifiers.

Name v1

SBO:0000176 biochemical reaction

Reaction equation



Reactants

Table 5: Properties of each reactant.

Id	Name	SBO
y1	y1	
x2	x2	

Modifiers

Table 6: Properties of each modifier.

Id	Name	SBO
y1	y1	
x2	x2	
x1	x1	
x3	x3	

Products

Table 7: Properties of each product.

Id	Name	SBO
x1	x1	
x3	x3	

Kinetic Law

SBO:0000430 enzymatic rate law for modulated unireactant enzymes

Derived unit contains undeclared units

$$v_1 = \frac{e1 \cdot (p1 \cdot [y1] \cdot [x2] - [x1] \cdot [x3])}{1 + [y1] + [x2] + [x1] + [x3] + [y1] \cdot [x2] + [x1] \cdot [x3]} \quad (2)$$

Table 8: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
e1			1.0	dimensionless	<input checked="" type="checkbox"/>
p1			10.0	dimensionless	<input checked="" type="checkbox"/>

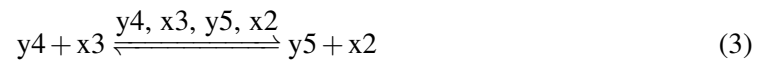
5.2 Reaction v_2

This is a reversible reaction of two reactants forming two products influenced by four modifiers.

Name v_2

SBO:0000176 biochemical reaction

Reaction equation



Reactants

Table 9: Properties of each reactant.

Id	Name	SBO
y4	y4	
x3	x3	

Modifiers

Table 10: Properties of each modifier.

Id	Name	SBO
y4	y4	
x3	x3	
y5	y5	
x2	x2	

Products

Table 11: Properties of each product.

Id	Name	SBO
y5	y5	
x2	x2	

Kinetic Law

SBO:0000430 enzymatic rate law for modulated unireactant enzymes

Derived unit contains undeclared units

$$v_2 = \frac{e2 \cdot (p2 \cdot [y4] \cdot [x3] - [y5] \cdot [x2])}{1 + [x3] + [x2] + [y4] + [y5] + [x3] \cdot [y4] + [x2] \cdot [y5]} \quad (4)$$

Table 12: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
e2			1.0	dimensionless	<input checked="" type="checkbox"/>
p2			10.0	dimensionless	<input checked="" type="checkbox"/>

5.3 Reaction v3

This is a reversible reaction of one reactant forming one product influenced by two modifiers.

Name v3

SBO:0000176 biochemical reaction

Reaction equation



Reactant

Table 13: Properties of each reactant.

Id	Name	SBO
x1	x1	

Modifiers

Table 14: Properties of each modifier.

Id	Name	SBO
x1	x1	
y2	y2	

Product

Table 15: Properties of each product.

Id	Name	SBO
y2	y2	

Kinetic Law**SBO:0000430** enzymatic rate law for modulated unireactant enzymes**Derived unit** contains undeclared units

$$v_3 = \frac{e3 \cdot (p3 \cdot [x1] - [y2])}{1 + [x1] + [y2]} \quad (6)$$

Table 16: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
e3			1.0	dimensionless	<input checked="" type="checkbox"/>
p3			50.0	dimensionless	<input checked="" type="checkbox"/>

5.4 Reaction v4

This is a reversible reaction of one reactant forming one product influenced by two modifiers.

Name v4**SBO:0000176** biochemical reaction**Reaction equation****Reactant**

Table 17: Properties of each reactant.

Id	Name	SBO
x1	x1	

Modifiers

Table 18: Properties of each modifier.

Id	Name	SBO
x1	x1	
y3	y3	

Product

Table 19: Properties of each product.

Id	Name	SBO
y3	y3	

Kinetic Law

SBO:0000430 enzymatic rate law for modulated unireactant enzymes

Derived unit contains undeclared units

$$v_4 = \frac{e4 \cdot (p4 \cdot [x1] - [y3])}{1 + [x1] + [y3]} \quad (8)$$

Table 20: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
e4			1.0	dimensionless	<input checked="" type="checkbox"/>
p4			10.0	dimensionless	<input checked="" type="checkbox"/>

5.5 Reaction v6

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name v6

SBO:0000176 biochemical reaction

Reaction equation



Reactant

Table 21: Properties of each reactant.

Id	Name	SBO
y7	y7	

Modifier

Table 22: Properties of each modifier.

Id	Name	SBO
y7	y7	

Product

Table 23: Properties of each product.

Id	Name	SBO
x4	x4	

Kinetic Law

SBO:0000430 enzymatic rate law for modulated unireactant enzymes

Derived unit dimensionless⁻¹

$$v_5 = e6 \cdot p6 \cdot [y7] \quad (10)$$

Table 24: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
e6			1.0	dimensionless	<input checked="" type="checkbox"/>
p6			1.0	dimensionless	<input checked="" type="checkbox"/>

5.6 Reaction v7

This is a reversible reaction of one reactant forming one product.

Name v7

SBO:0000176 biochemical reaction

Reaction equation



Reactant

Table 25: Properties of each reactant.

Id	Name	SBO
x4	x4	

Product

Table 26: Properties of each product.

Id	Name	SBO
y8	y8	

Kinetic Law

SBO:0000430 enzymatic rate law for modulated unireactant enzymes

Derived unit dimensionless

$$v_6 = e7 \cdot p7 \quad (12)$$

Table 27: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
e7			1.0	dimensionless	<input checked="" type="checkbox"/>
p7			1.0	dimensionless	<input checked="" type="checkbox"/>

6 Derived Rate Equations

When interpreted as an ordinary differential equation framework, this model implies the following set of equations for the rates of change of each species.

Identifiers for kinetic laws highlighted in gray cannot be verified to evaluate to units of SBML substance per time. As a result, some SBML interpreters may not be able to verify the consistency of the units on quantities in the model. Please check if

- parameters without an unit definition are involved or
- volume correction is necessary because the `hasOnlySubstanceUnits` flag may be set to `false` and `spacialDimensions` > 0 for certain species.

6.1 Species `x1`

Name `x1`

SBO:0000247 simple chemical

Initial concentration 0.05625738310526 dimensionless · dimensionless⁻¹

This species takes part in six reactions (as a reactant in `v3`, `v4` and as a product in `v1` and as a modifier in `v1`, `v3`, `v4`).

$$\frac{d}{dt}x1 = v1 - v3 - v4 \quad (13)$$

6.2 Species `x2`

Name `x2`

SBO:0000247 simple chemical

Initial concentration 0.76876151899652 dimensionless · dimensionless⁻¹

This species takes part in four reactions (as a reactant in `v1` and as a product in `v2` and as a modifier in `v1`, `v2`).

$$\frac{d}{dt}x2 = v2 - v1 \quad (14)$$

6.3 Species `x3`

Name `x3`

SBO:0000247 simple chemical

Initial concentration 4.23123848100348 dimensionless · dimensionless⁻¹

This species takes part in four reactions (as a reactant in [v2](#) and as a product in [v1](#) and as a modifier in [v1](#), [v2](#)).

$$\frac{d}{dt}x_3 = v_1 - v_2 \quad (15)$$

6.4 Species [y1](#)

Name [y1](#)

SBO:0000247 simple chemical

Initial concentration 10 dimensionless · dimensionless⁻¹

This species takes part in two reactions (as a reactant in [v1](#) and as a modifier in [v1](#)), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{d}{dt}y_1 = 0 \quad (16)$$

6.5 Species [y2](#)

Name [y2](#)

SBO:0000247 simple chemical

Initial concentration 0 dimensionless · dimensionless⁻¹

This species takes part in two reactions (as a product in [v3](#) and as a modifier in [v3](#)), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{d}{dt}y_2 = 0 \quad (17)$$

6.6 Species [y3](#)

Name [y3](#)

SBO:0000247 simple chemical

Initial concentration 0 dimensionless · dimensionless⁻¹

This species takes part in two reactions (as a product in [v4](#) and as a modifier in [v4](#)), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{d}{dt}y_3 = 0 \quad (18)$$

6.7 Species y_4

Name y_4

SBO:0000247 simple chemical

Initial concentration 1 dimensionless · dimensionless⁻¹

This species takes part in two reactions (as a reactant in [v2](#) and as a modifier in [v2](#)), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{d}{dt}y_4 = 0 \quad (19)$$

6.8 Species y_5

Name y_5

SBO:0000247 simple chemical

Initial concentration 1 dimensionless · dimensionless⁻¹

This species takes part in two reactions (as a product in [v2](#) and as a modifier in [v2](#)), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{d}{dt}y_5 = 0 \quad (20)$$

6.9 Species y_7

Name y_7

SBO:0000247 simple chemical

Initial concentration 1 dimensionless · dimensionless⁻¹

This species takes part in two reactions (as a reactant in [v6](#) and as a modifier in [v6](#)), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{d}{dt}y_7 = 0 \quad (21)$$

6.10 Species x_4

Name x_4

SBO:0000247 simple chemical

Initial concentration 1 dimensionless · dimensionless⁻¹

This species takes part in two reactions (as a reactant in [v7](#) and as a product in [v6](#)).

$$\frac{d}{dt}x4 = v_5 - v_6 \quad (22)$$

6.11 Species [y8](#)

Name [y8](#)

SBO:0000247 simple chemical

Initial concentration 0 dimensionless · dimensionless⁻¹

This species takes part in one reaction (as a product in [v7](#)), which does not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{d}{dt}y8 = 0 \quad (23)$$

A Glossary of Systems Biology Ontology Terms

SBO:0000176 biochemical reaction: An event involving one or more chemical entities that modifies the electrochemical structure of at least one of the participants.

SBO:0000247 simple chemical: Simple, non-repetitive chemical entity

SBO:0000290 physical compartment: Specific location of space, that can be bounded or not. A physical compartment can have 1, 2 or 3 dimensions

SBO:0000430 enzymatic rate law for modulated unireactant enzymes: Kinetics of enzymes that react with one substance, and whose activity may be positively or negatively modulated

SBML²TeX was developed by Andreas Dräger^a, Hannes Planatscher^a, Dieudonné M Wouamba^a, Adrian Schröder^a, Michael Hucka^b, Lukas Endler^c, Martin Golebiewski^d and Andreas Zell^a. Please see <http://www.ra.cs.uni-tuebingen.de/software/SBML2LaTeX> for more information.

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