

ESS

so close, yet so far

**Dobler Ralph, Zoological Institute, University of Basel
Bern, 5th June 2008**

ESS

so close, yet so far

**behavioural stability of evolutionary stable strategies (ESS)
in the context of parent-offspring conflict resolution**

Outline

evolutionary stable strategies (ESS)

parent-offspring conflict (POC)

**behavioural stability of parent-offspring interactions
(model)**

conclusions

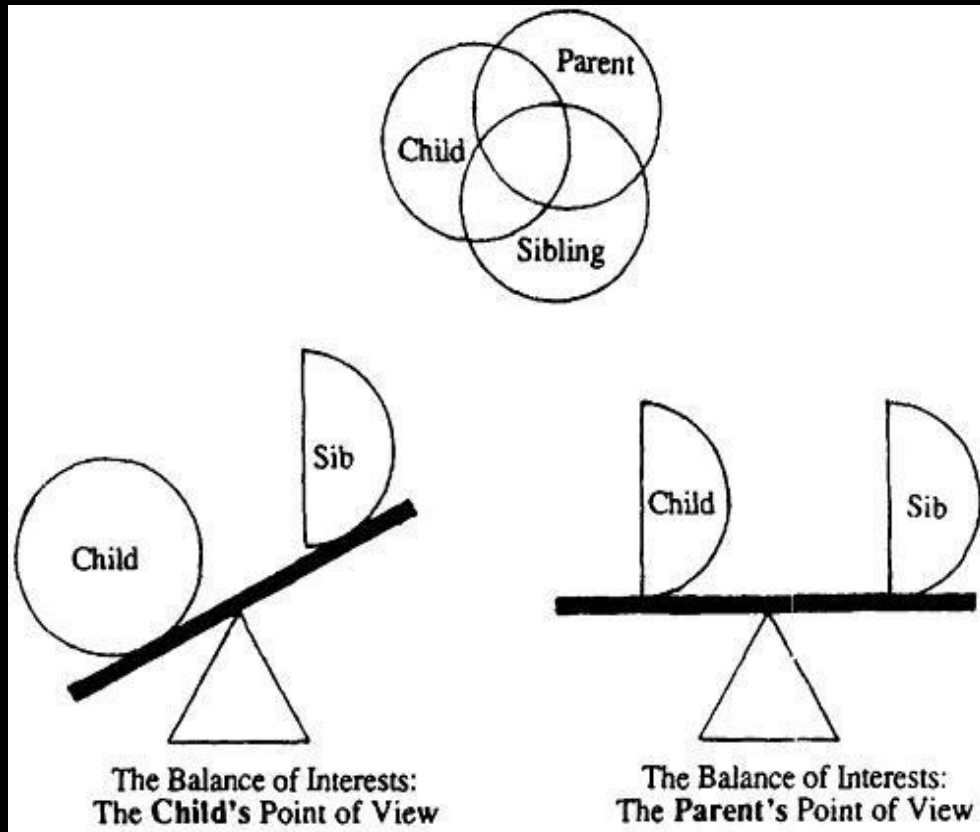
Evolutionary stable strategy

**ESS has highest inclusive fitness¹
can not be invaded by other strategies²**

**ESS for conflict resolution^{3,4}
e.g., parent-offspring conflict**

Parent-offspring conflict

POC: disagreement over care distribution



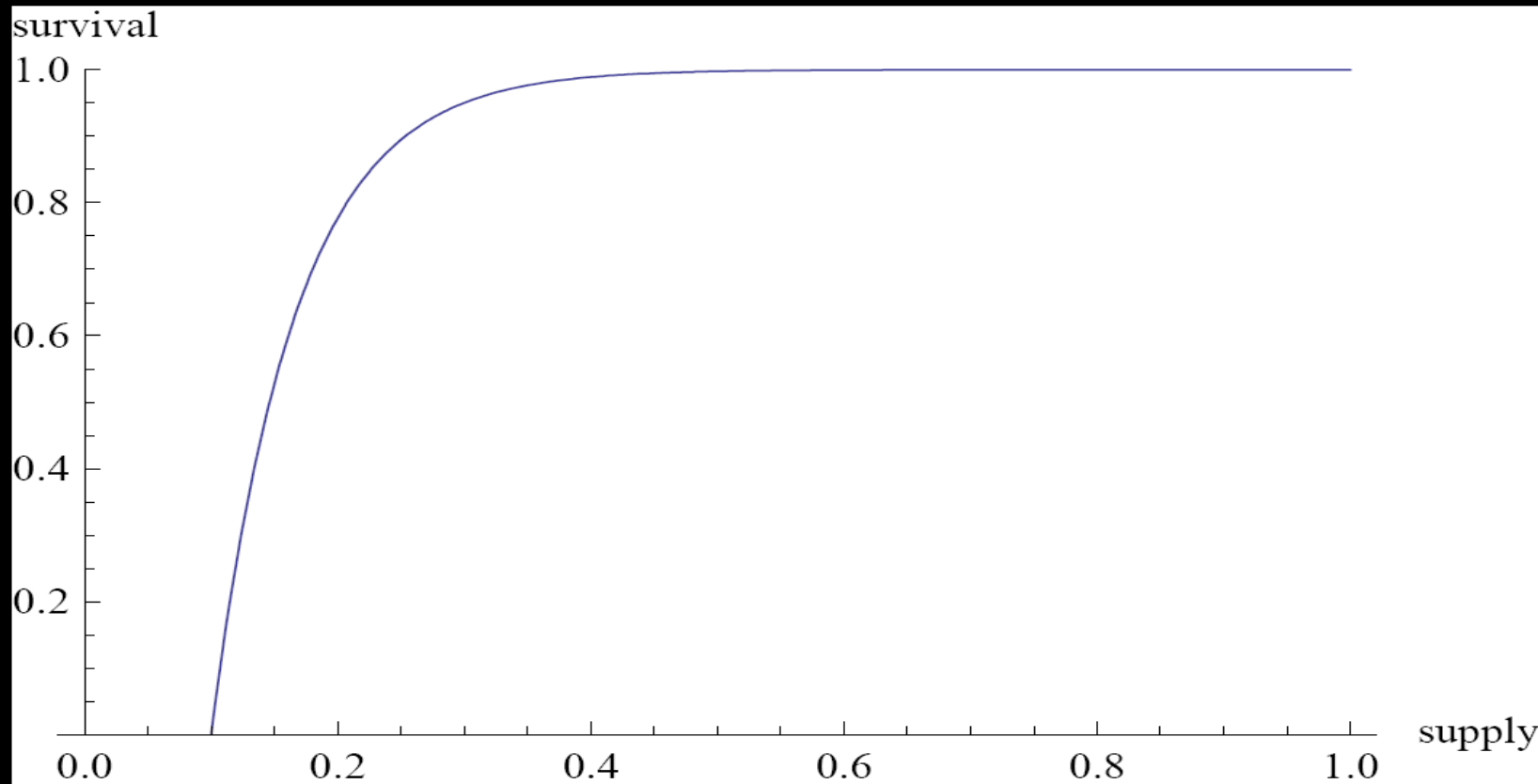
parent: all offspring have the same value¹

offspring: siblings are less valuable than itself¹

<http://www.pep-web.org/document.php?id=ppsy.007s.0005.fig005.jpg>

Parent-offspring conflict

POC: disagreement over care distribution

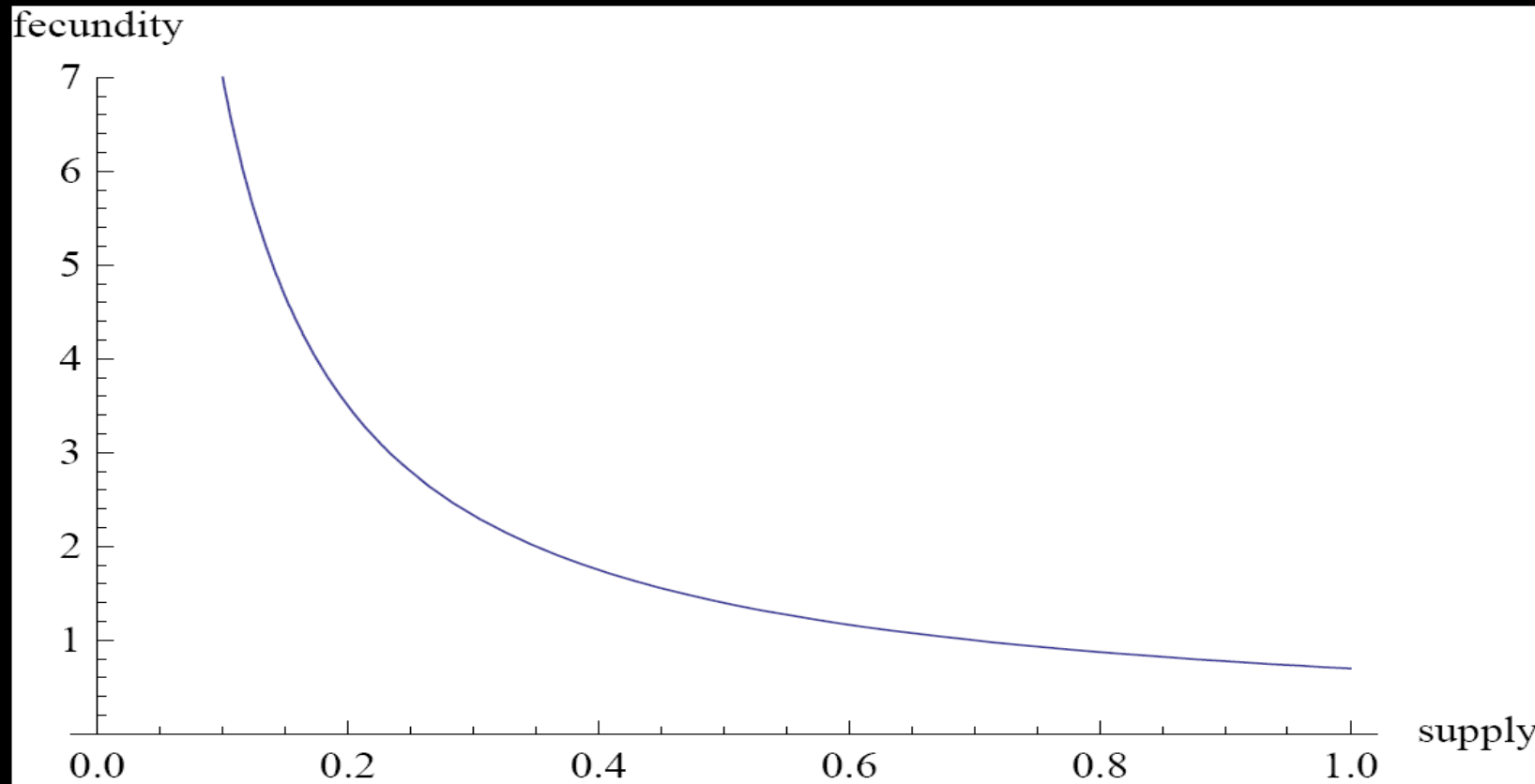


current vs. future fecundity^{1,2,3}

¹Trivers 1974; ²Trivers 1974; ³Parker & Macnair 1978

Parent-offspring conflict

POC: disagreement over care distribution



current vs. future fecundity^{1,2,3}

¹Trivers 1974; ²Trivers 1974; ³Parker & Macnair 1978

ESS in POC

honest signalling^{1,2}
scramble competition^{3,4}

static models
evolutionary time frame

some dynamic models^{5,6}
still in evolutionary time frame

**almost no models with dynamic in an ecological
time frame^{7,8,9}**

ESS in POC

almost no models with dynamic in an ecological time frame^{1,2,3}

**equilibria of dynamic interactions^{1,2}
symmetric dynamic interactions³**

no look on dynamical attainability of ESS⁴

are ESS-theory predicted equilibria behaviourally stable?

The model

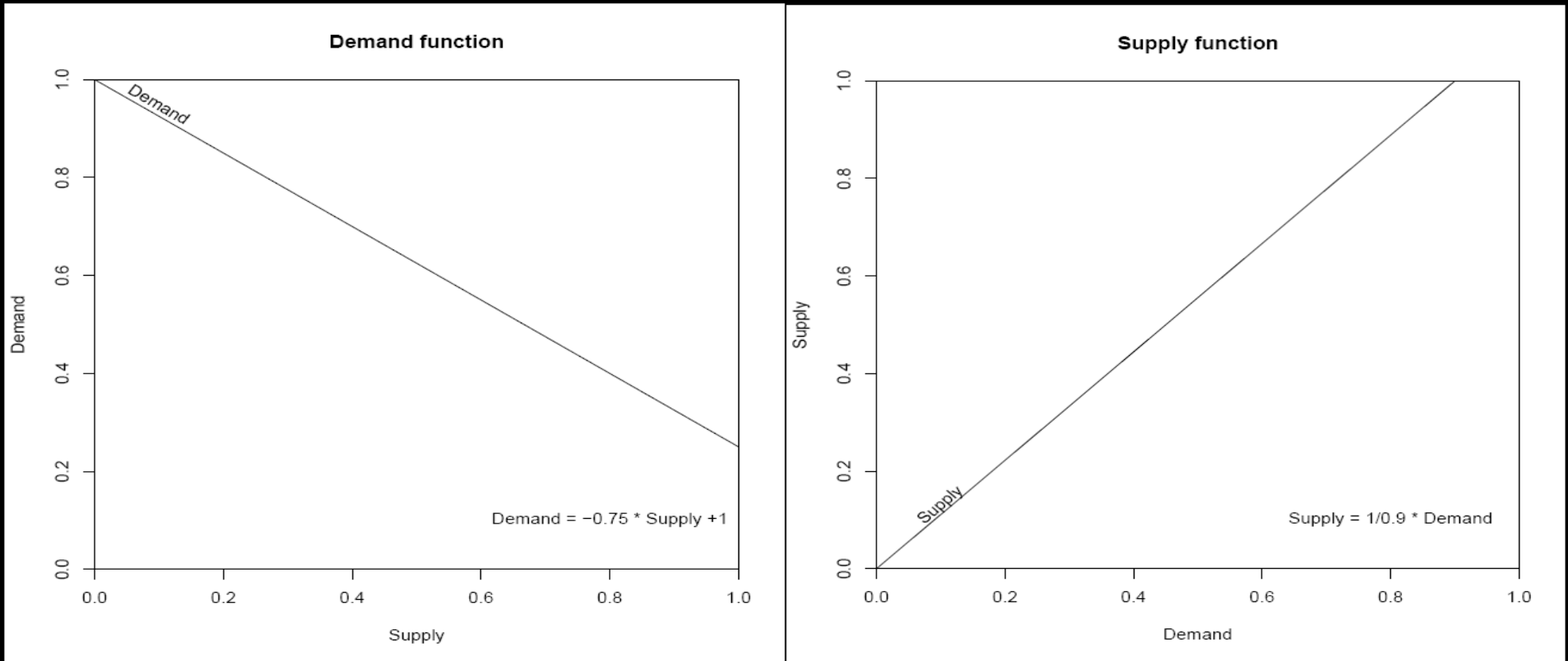
ESS

parent-offspring interaction

stability of interactions

The model

the parent-offspring interaction

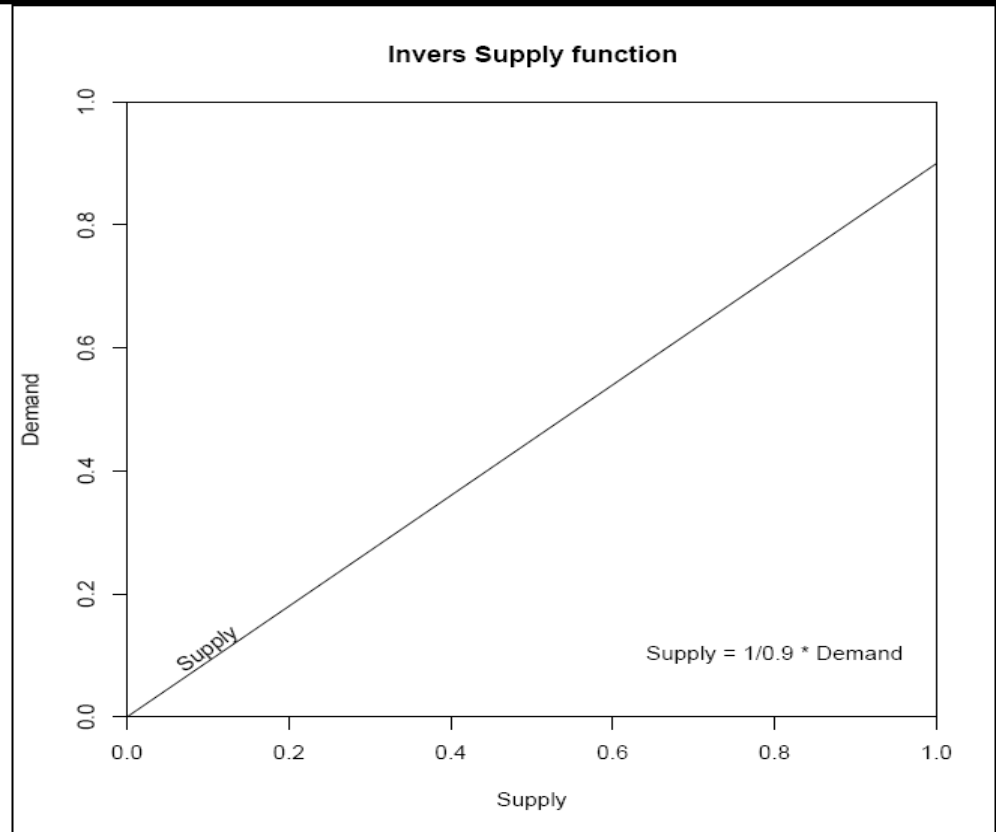
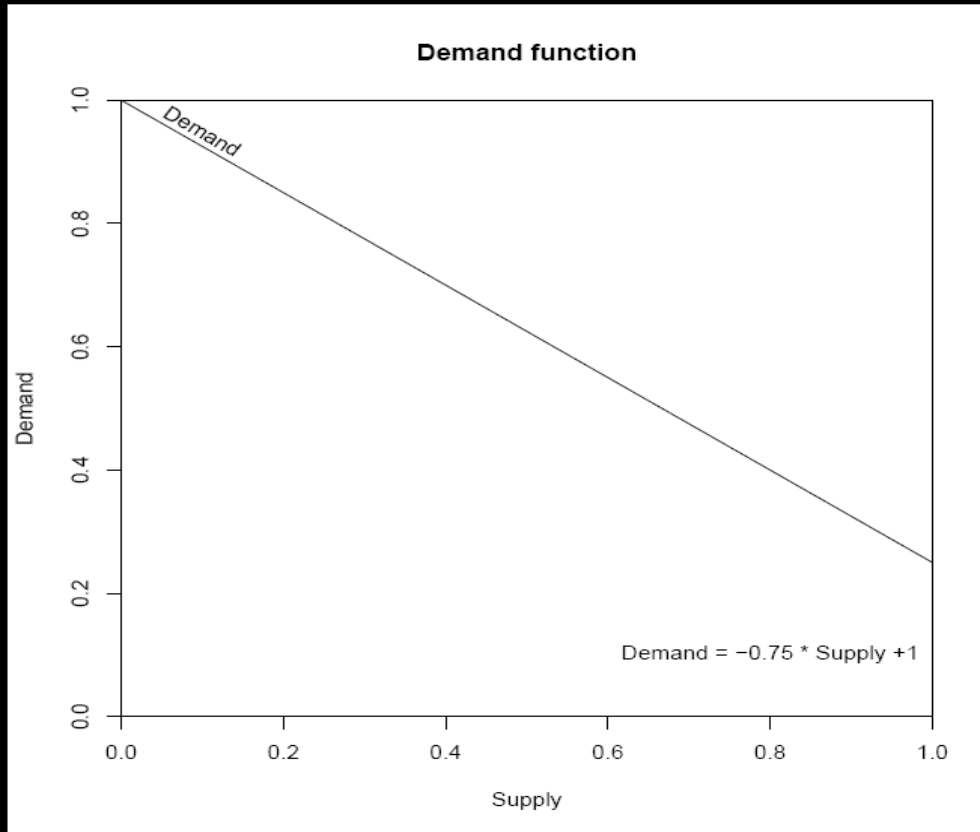


$$\text{demand} = f_d(\text{supply})$$

$$\text{supply} = f_s(\text{demand})$$

The model

the parent-offspring interaction

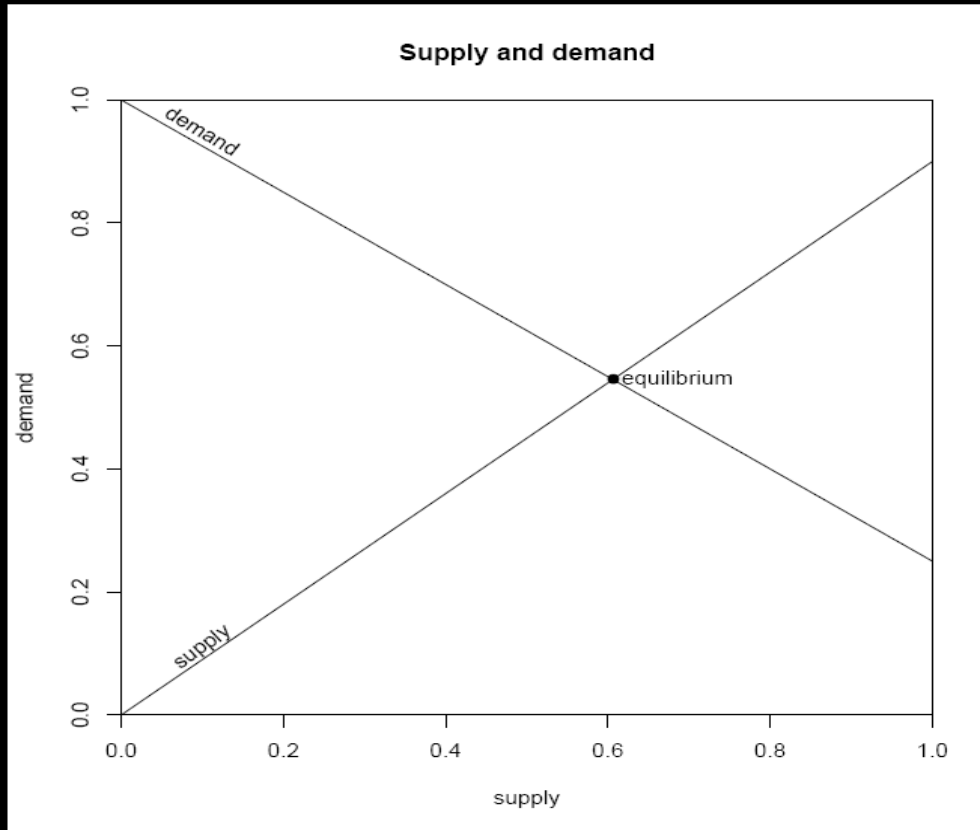


demand = $f_d(\text{supply})$

demand = $f_s^{-1}(\text{supply})$

The model

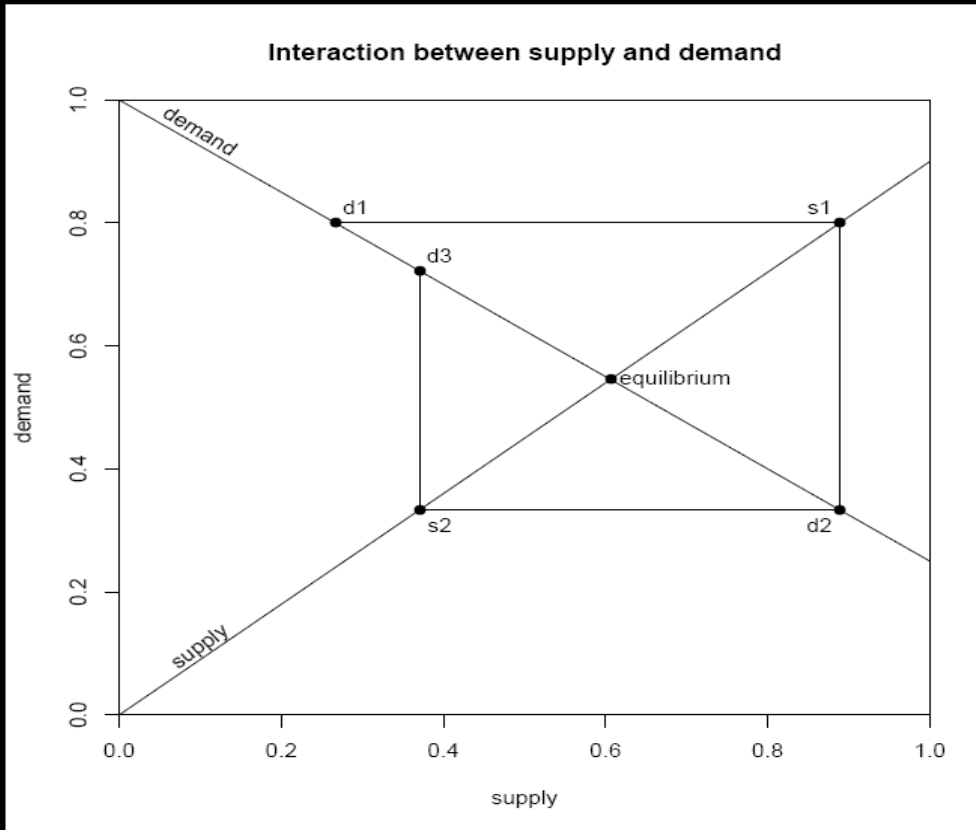
the parent-offspring interaction



f_s (swapped axes) and f_d
superimposed in one
graph

The model

the parent-offspring interaction



dynamic of the parent-offspring interaction¹:

$$d_1 \rightarrow s_1 \rightarrow d_2 \rightarrow s_2 \rightarrow d_3$$

endpoint equilibrium?

¹Hussel 1988

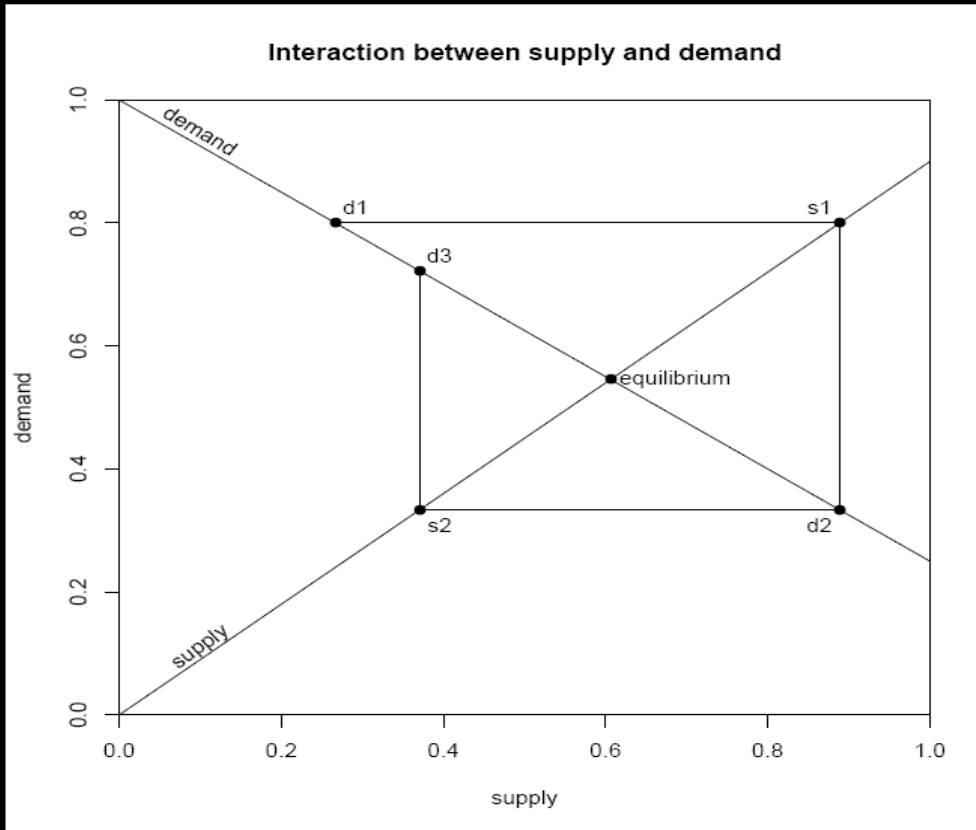
The model

the behavioural stable strategy (BSS)

BSS := stable interaction between parents and offspring at an optimal level for all of them for a given set of demand and supply functions

The model

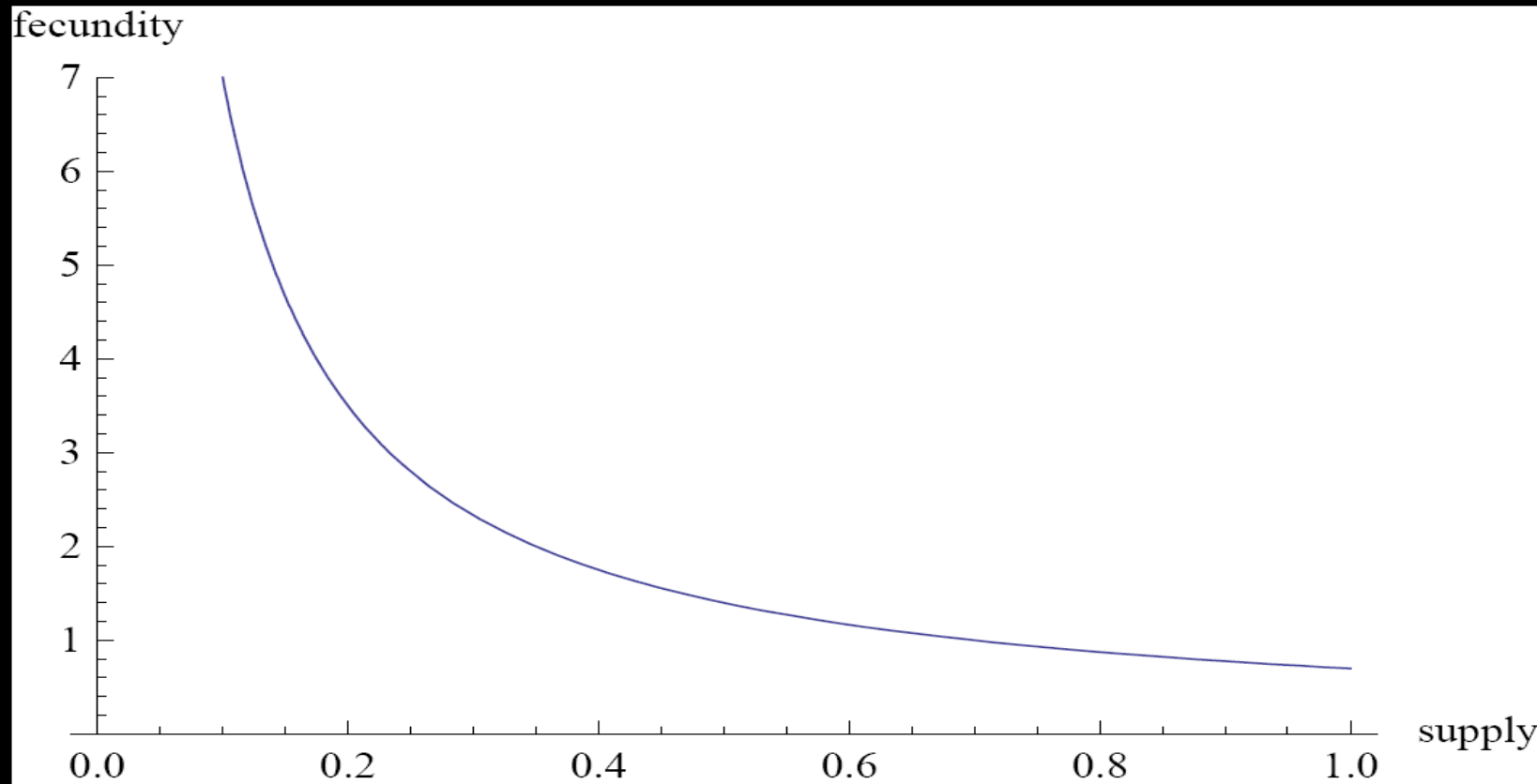
the behavioural stable strategy (BSS)



combination of f_s and f_d
where repeated interactions end at the equilibrium (for any given starting point)

The model

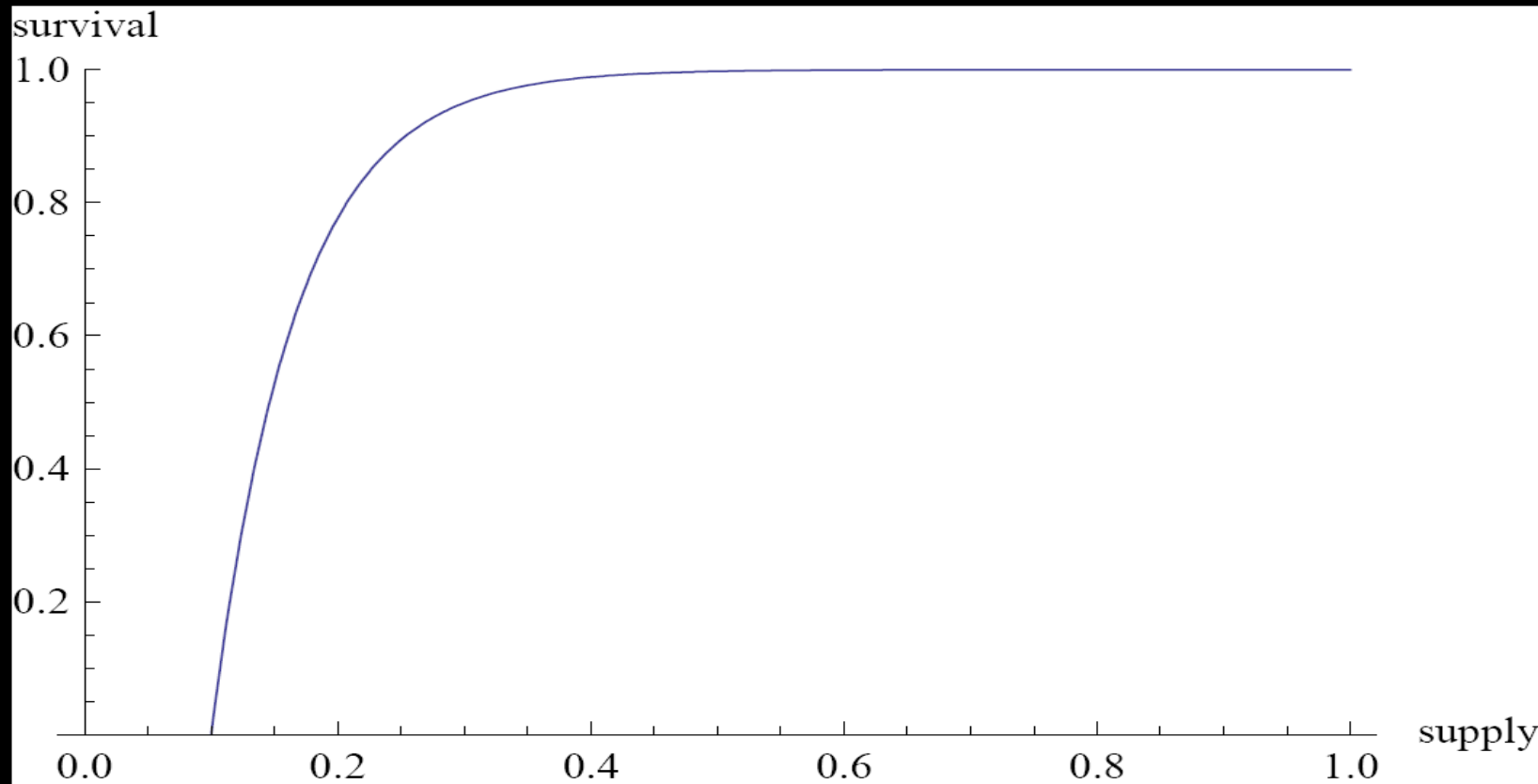
supply at the ESS



supply cost: fecundity = $M / (\text{supply} * \text{scale})^1$

The model

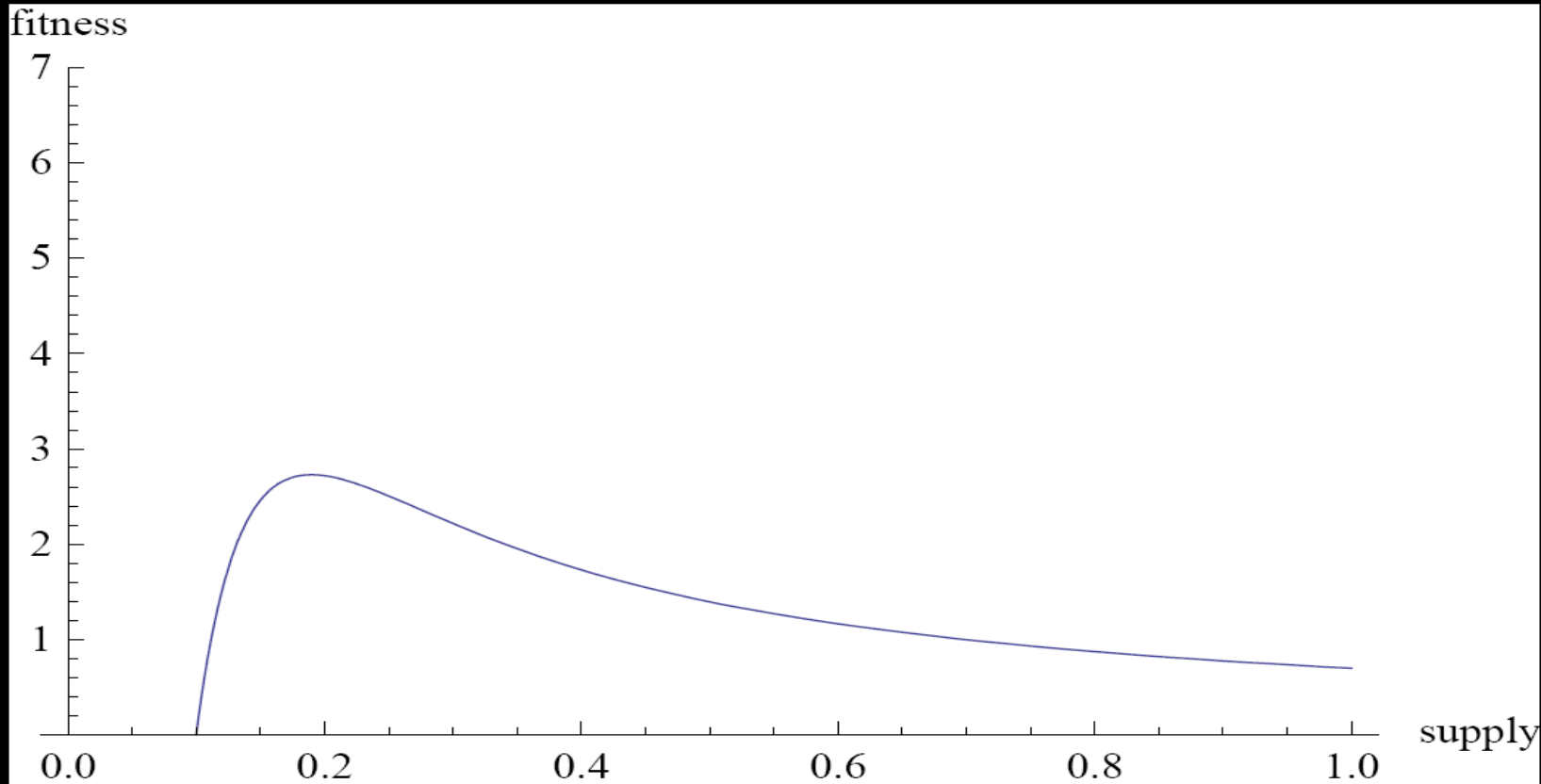
supply at the ESS



supply benefit: survival = $1 - e^{(-k \cdot \text{scale} \cdot \text{supply} + k)}$ 1

The model

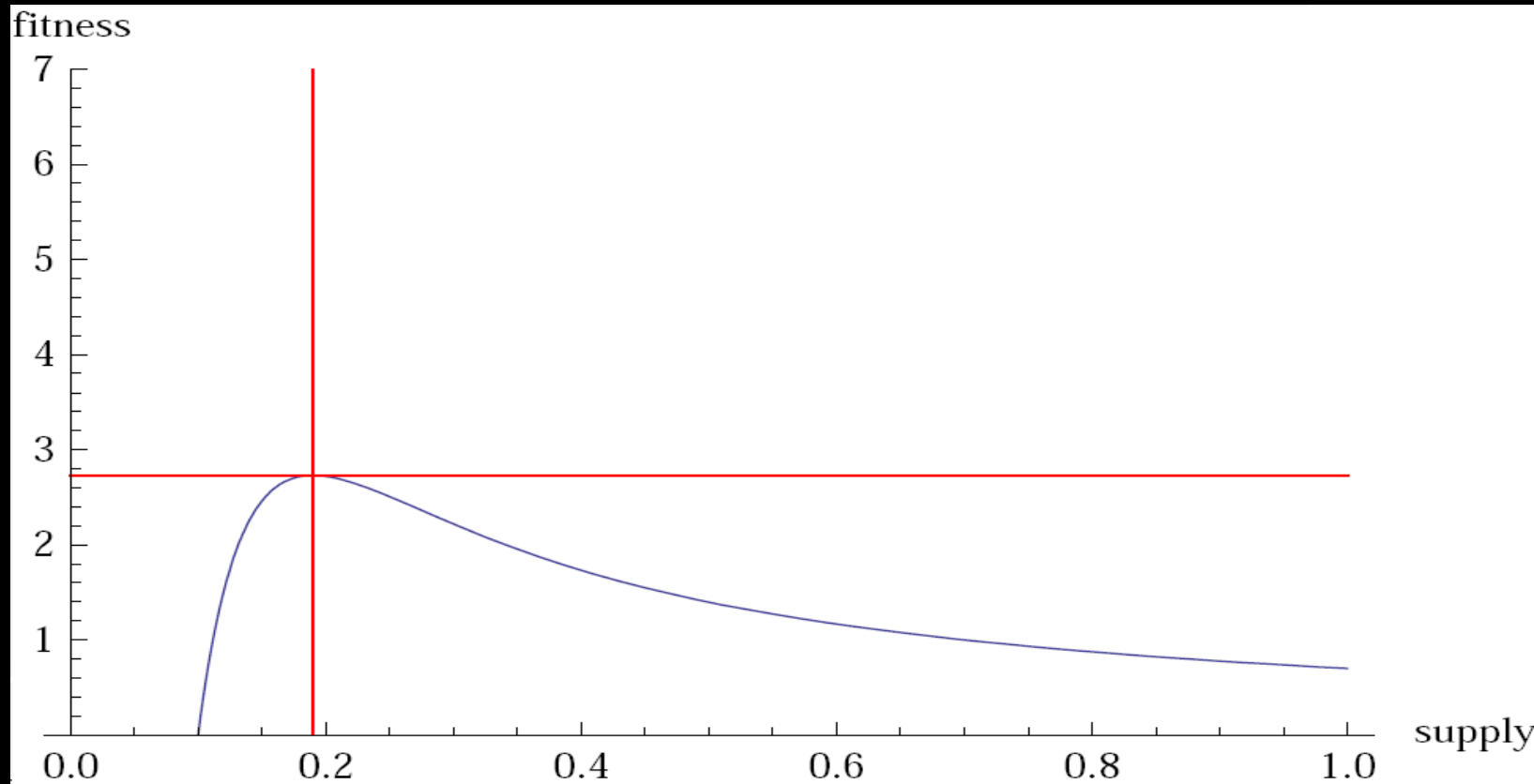
supply at the ESS



cost * benefit = fitness

The model

supply at the ESS



supply level with highest fitness

The model

assumptions

one parent-one offspring interaction

perfect interaction/no communication errors

two kind of functions

linear: supply = a*demand

demand = b*supply+1

power: supply = demand^a

demand = 1-supply^b

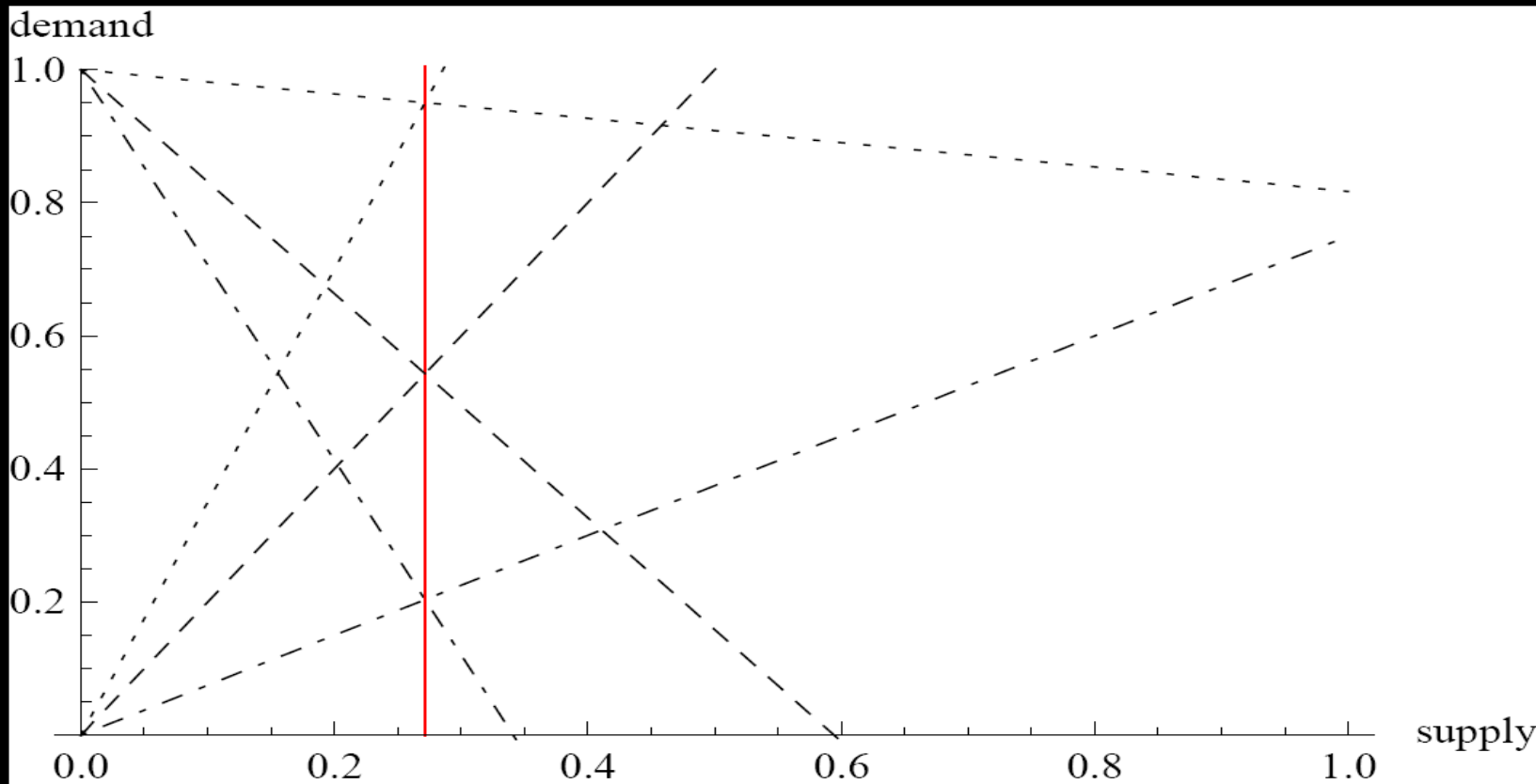
values between 0 and 1

no begging costs

one generation

The model

supply linear, demand linear



functions intersect at supply_{ESS}

The model

supply linear, demand linear

500 intersection points (slope combinations)

2000 parent-offspring interactions

initial begging level within 10% of equilibrium

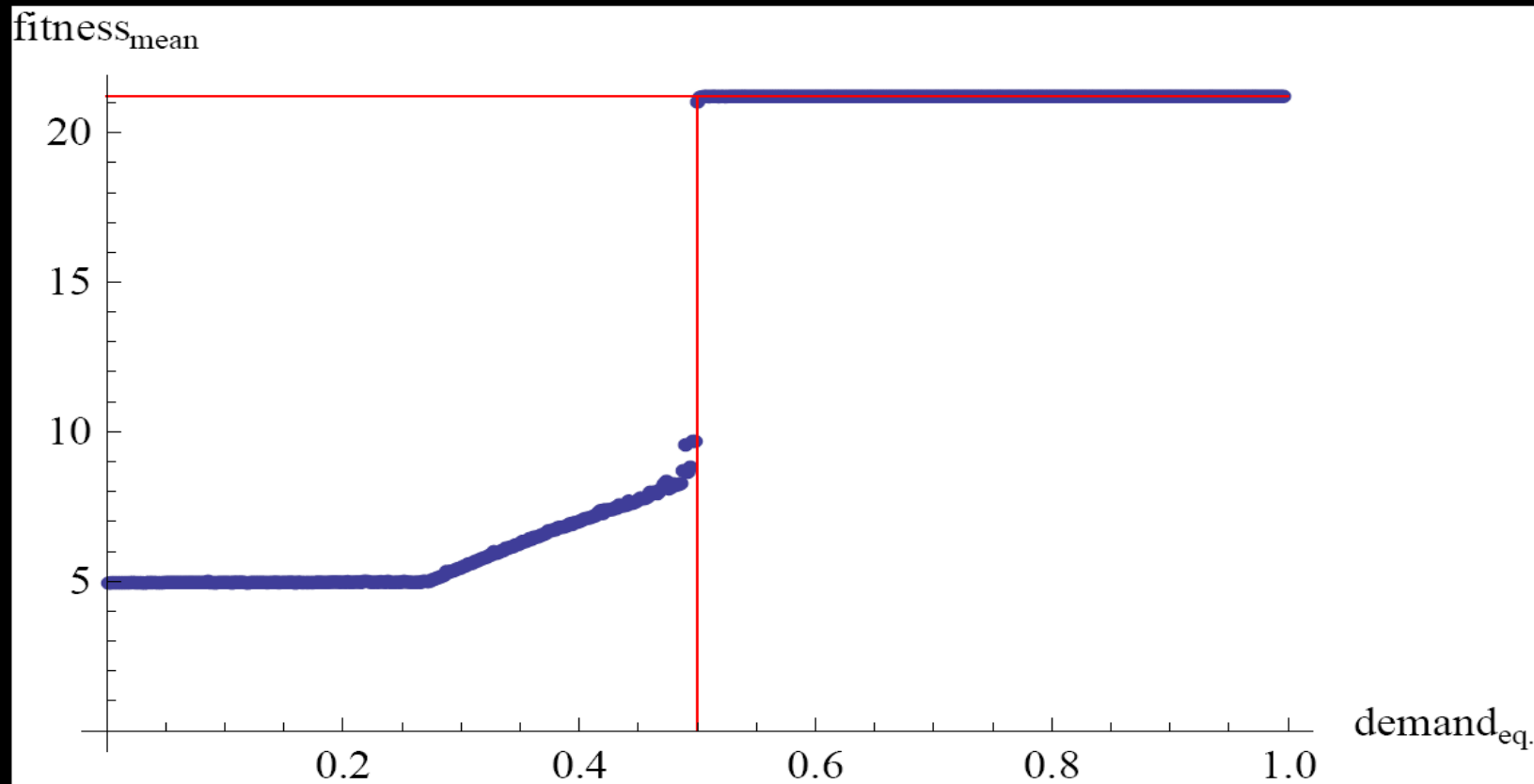
fitness calculated for each supply step

=> mean fitness for each slope combination

=> compare with maximal theoretical fitness

The model

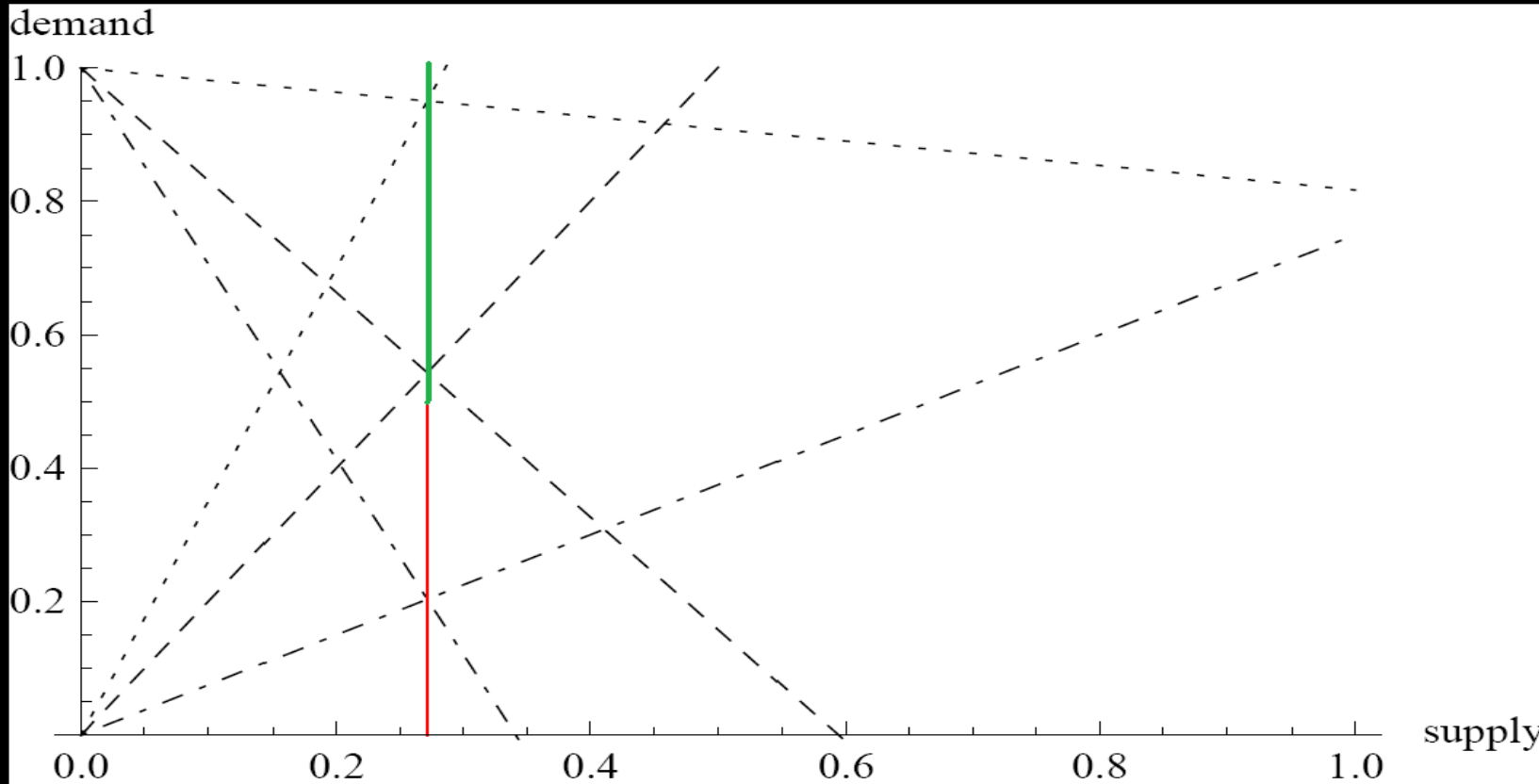
supply linear, demand linear



only half of the slope combinations have maximised fitness

The model

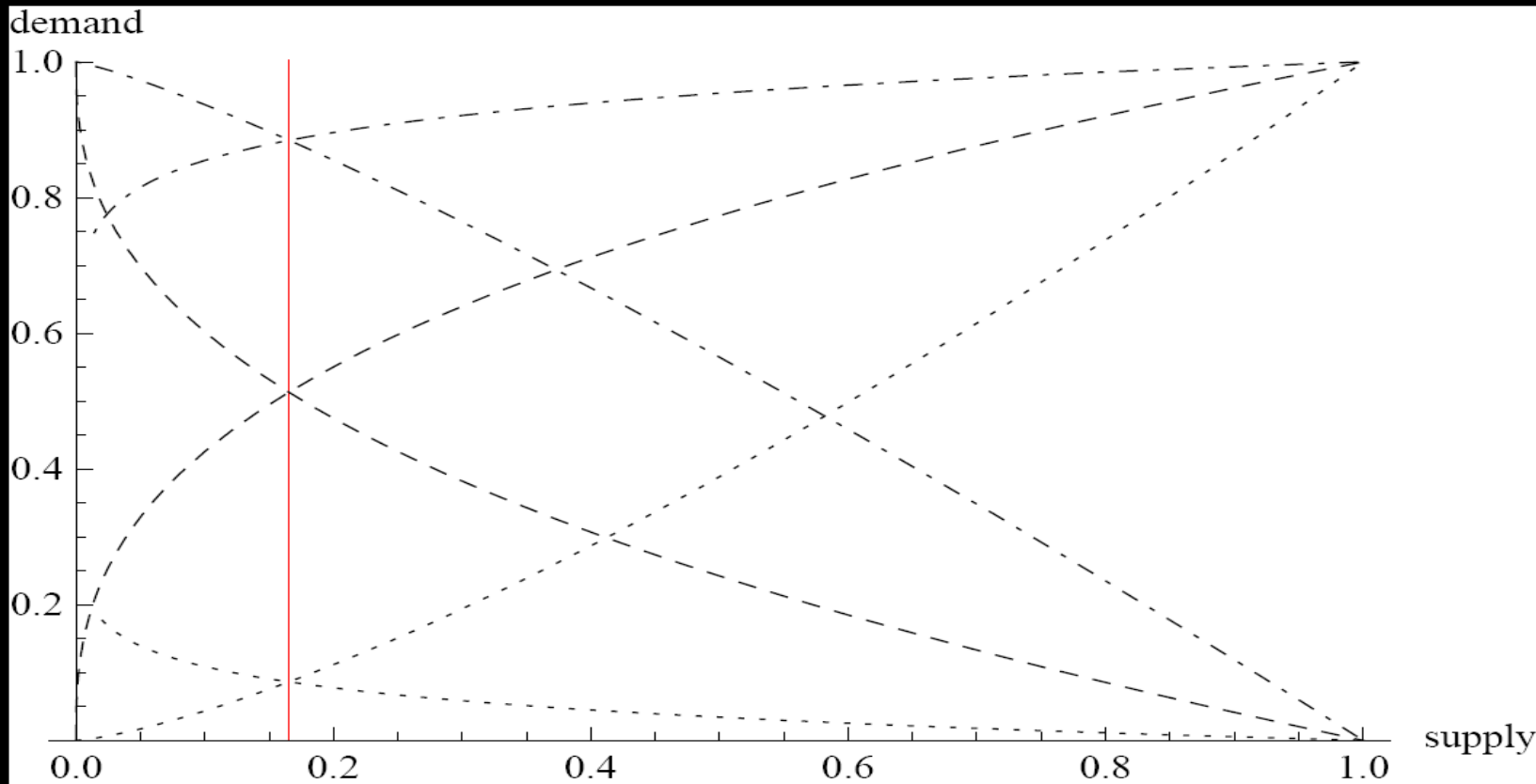
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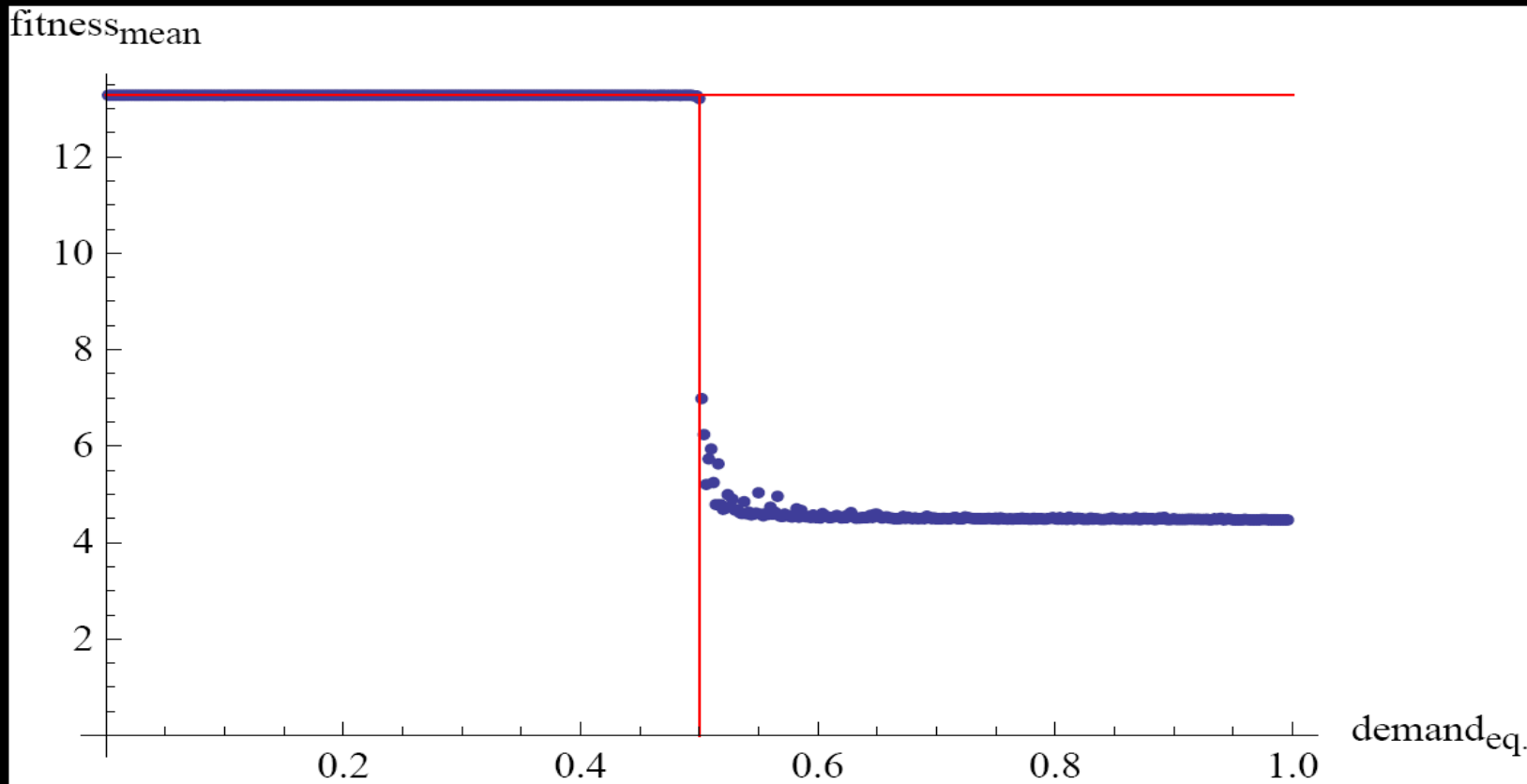
supply power, demand power



functions intersect at supply_{ESS}

The model

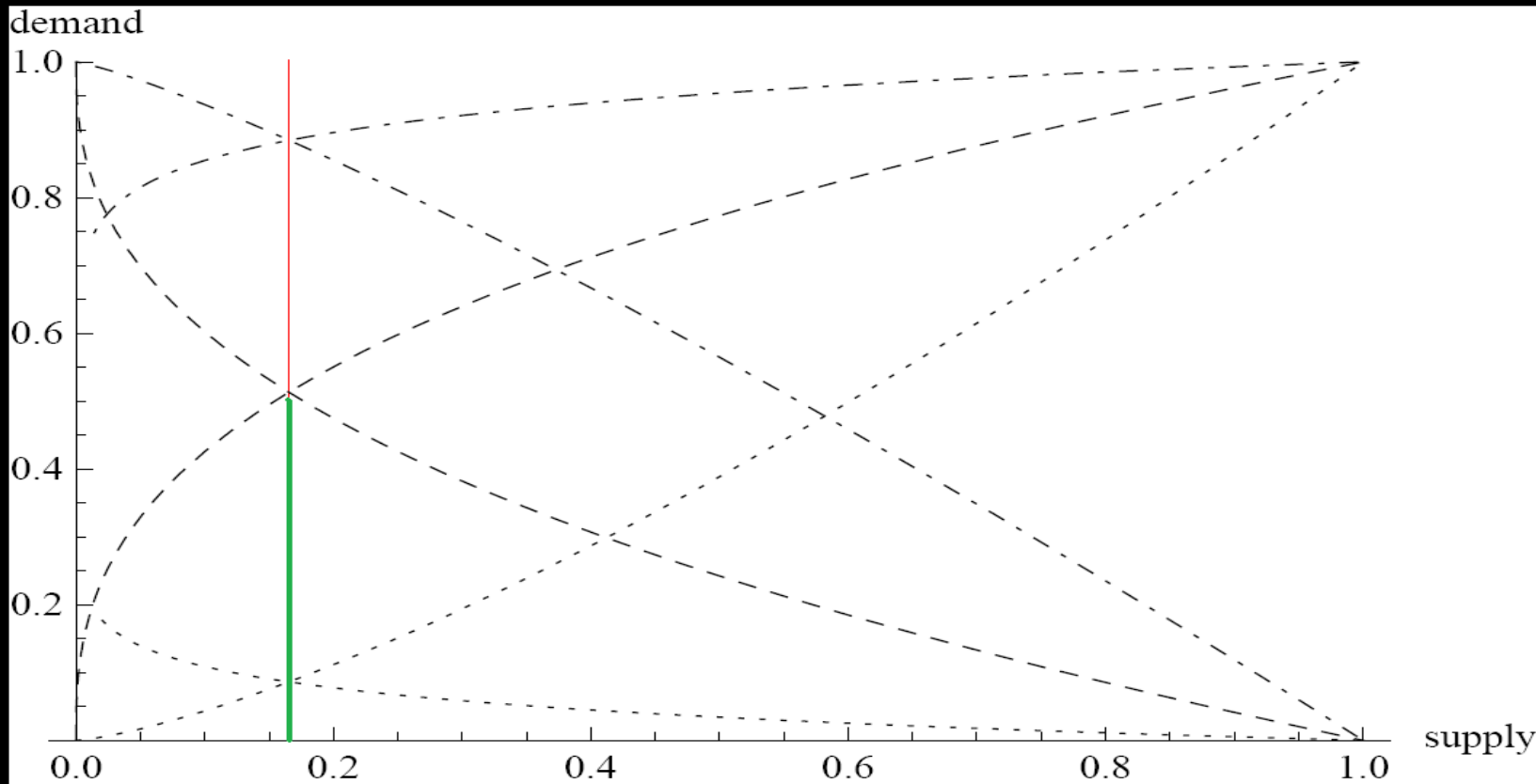
supply power, demand power



only half of the slope combinations have maximised fitness

The model

supply power, demand power



functions intersect at supply_{ESS}

Conclusions

not all ESS are BSS

shape of functions is important

ESS models overestimate the possibilities of conflict resolution

include (behavioural) interactions in future ESS models

Acknowledgement

Mathias Kölliker

University of Basel



SNF



You

Questions/Appendix

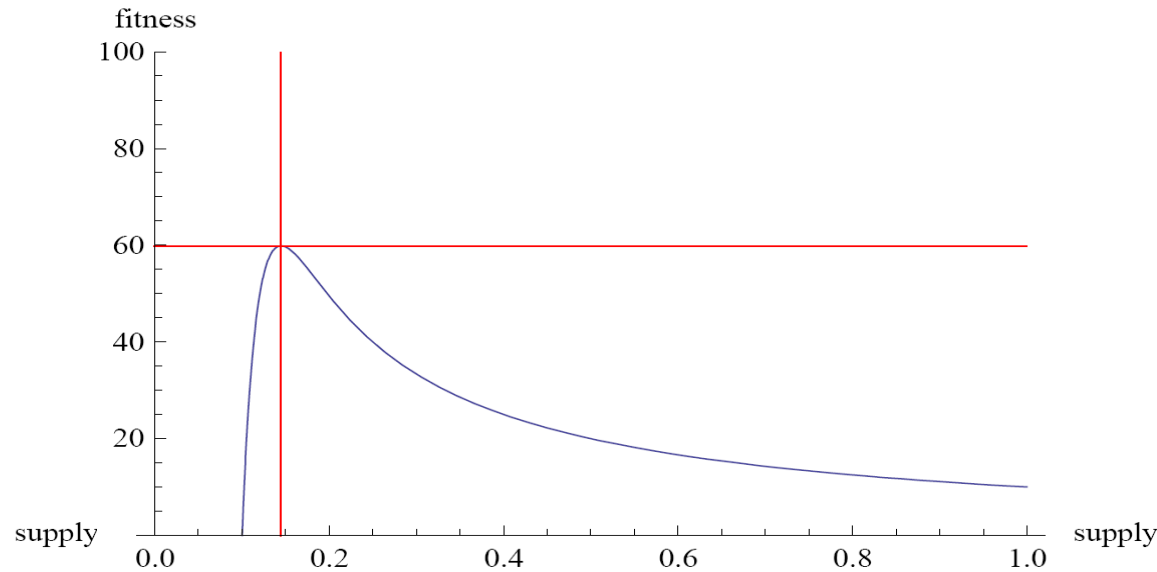
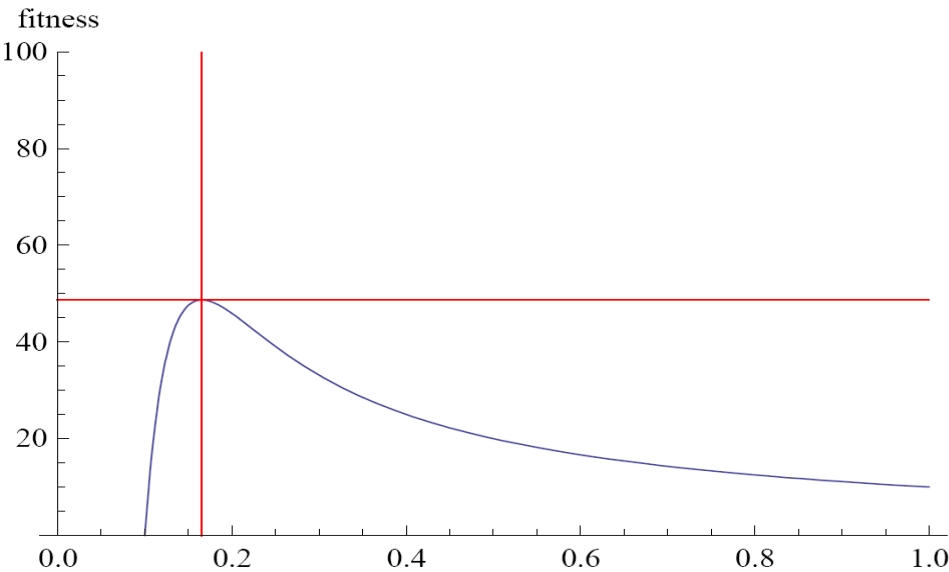
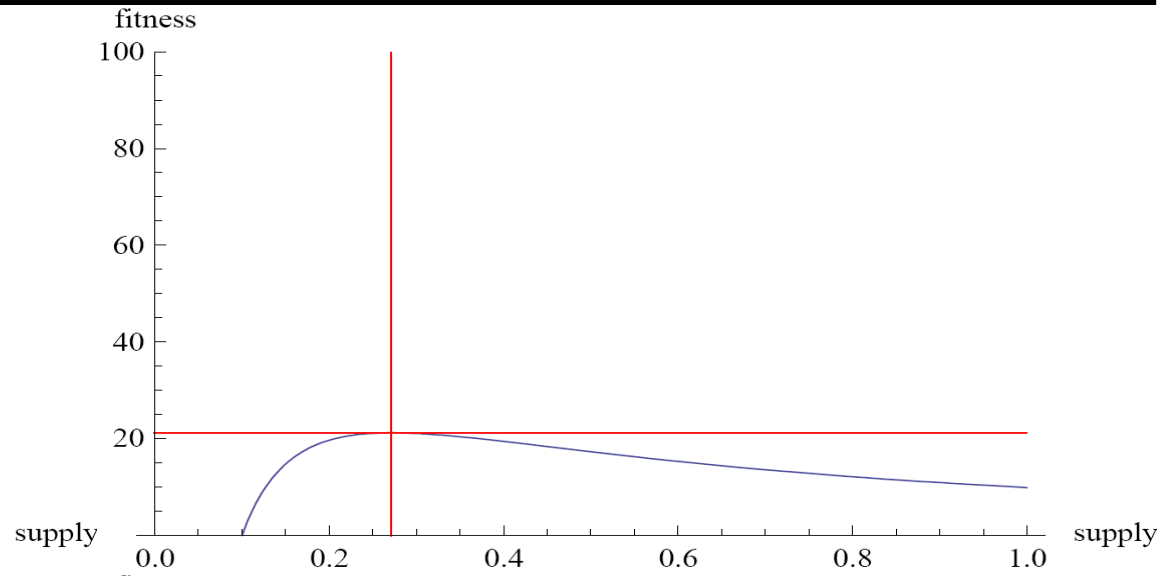
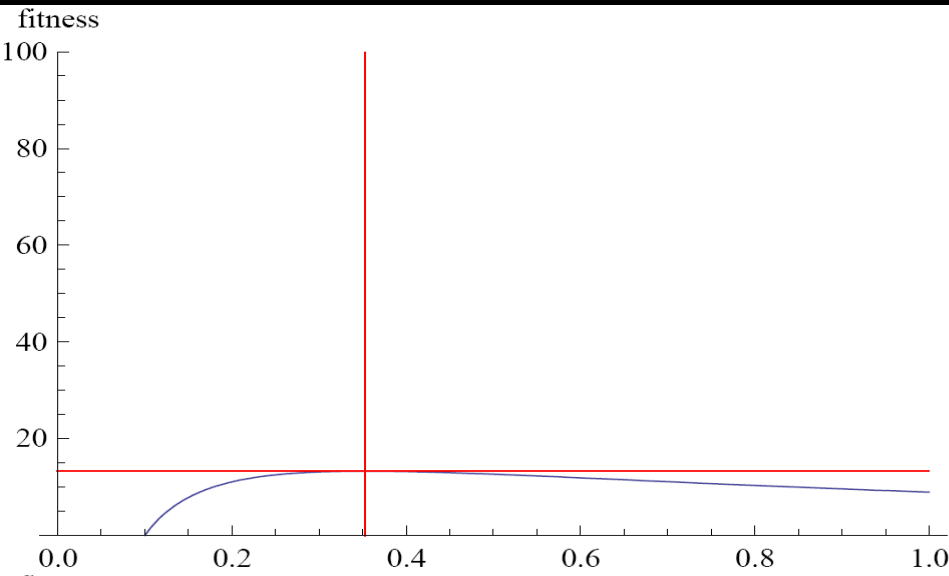
stability of parent-offspring interaction

$$|1| < f'_s * f'_d$$

linear approximation for any iteration over four points

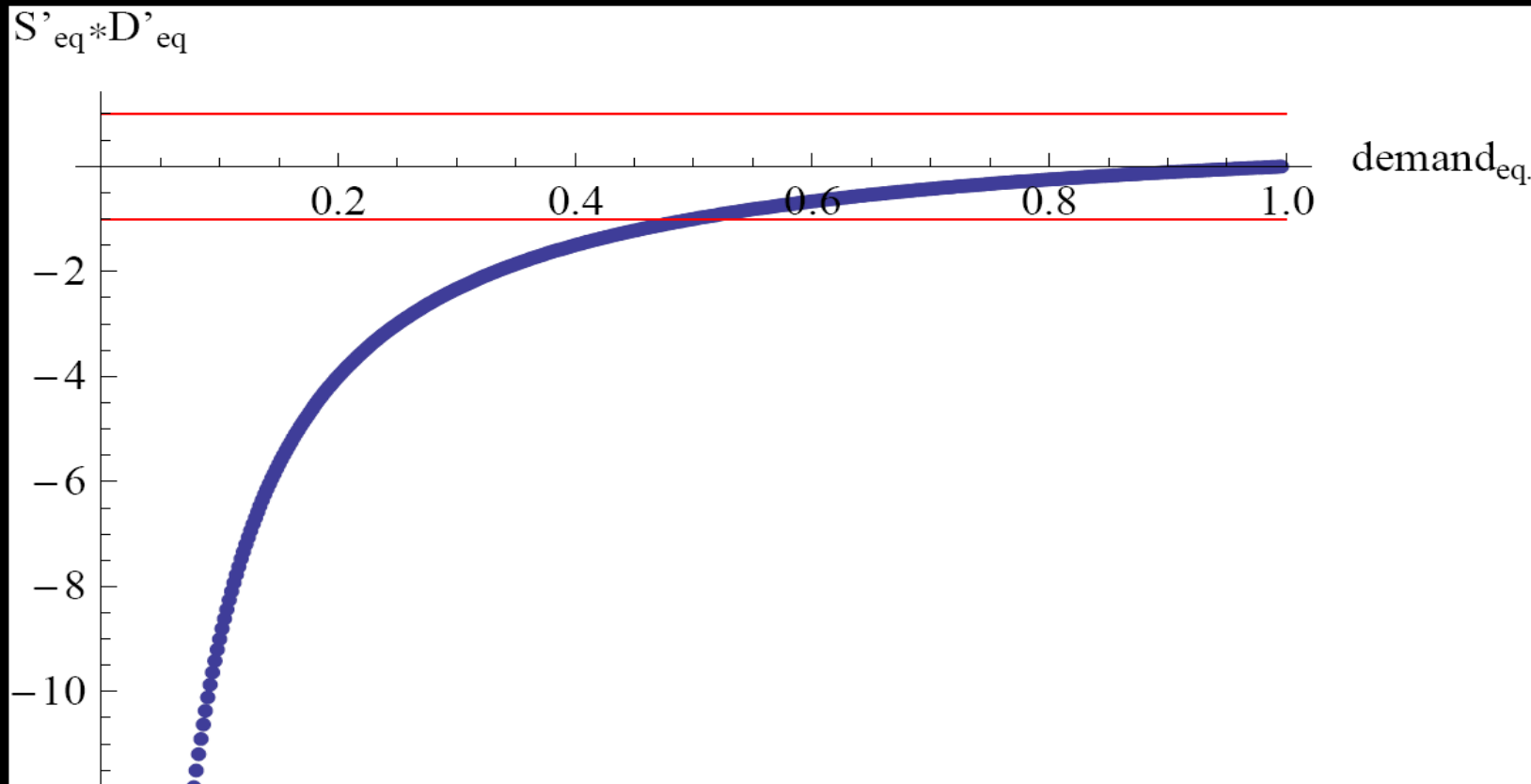
Questions/Appendix

effect of k on fitness (0.25;0.5;2.5;4.5)



Questions/Appendix

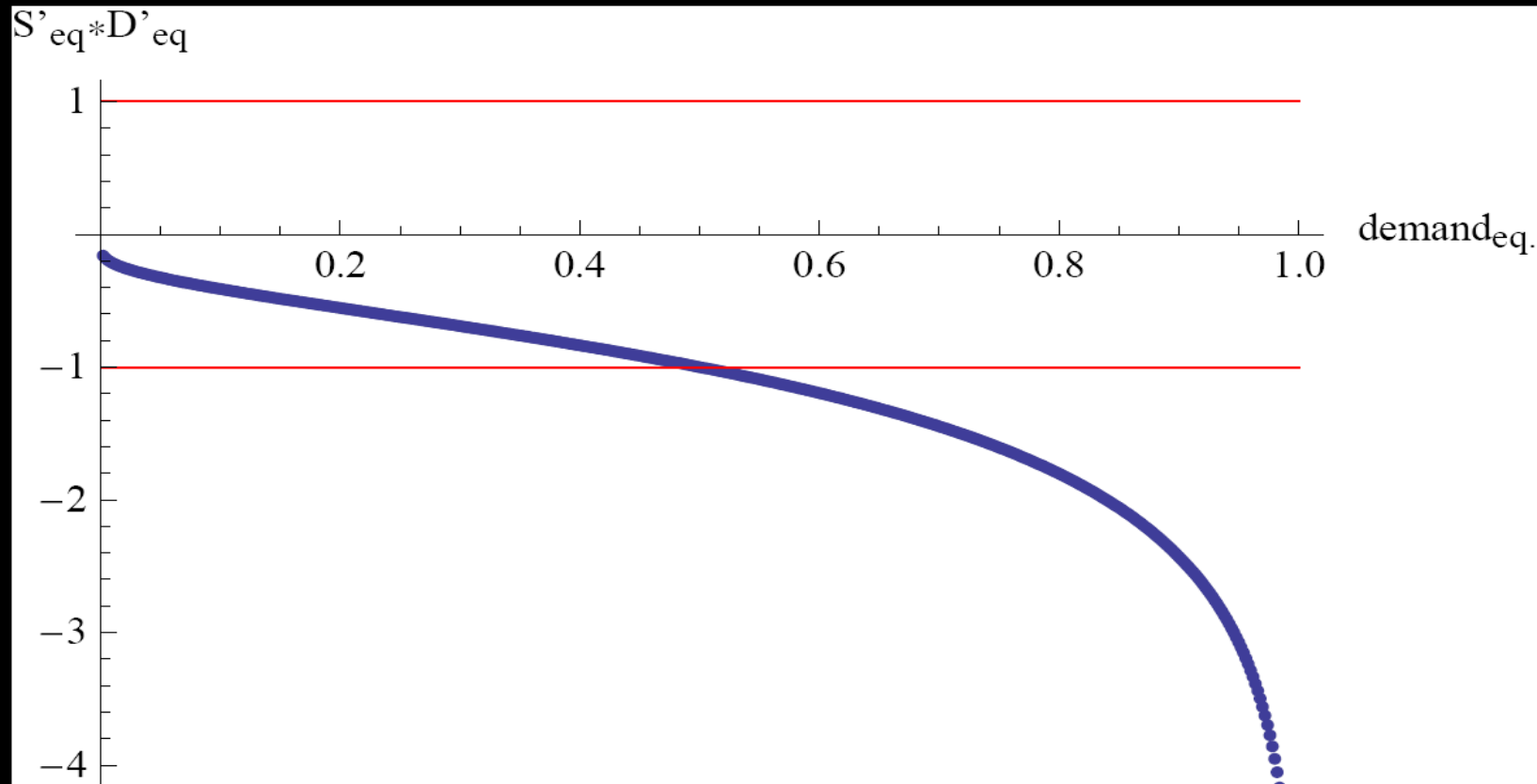
supply linear, demand linear



only half of the slope combinations have maximised fitness

Questions/Appendix

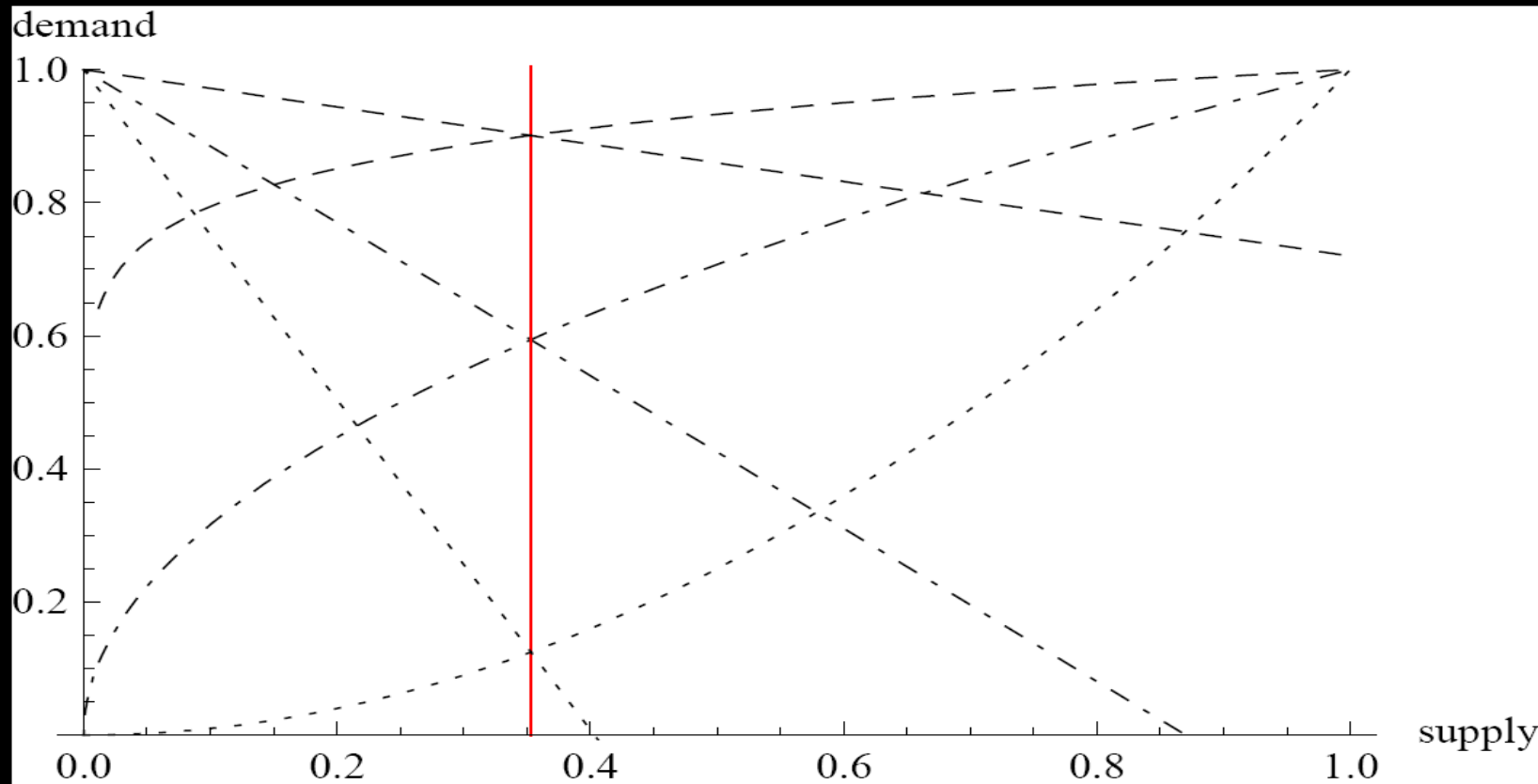
supply power, demand power



only half of the slope combinations have maximised fitness

Questions/Appendix

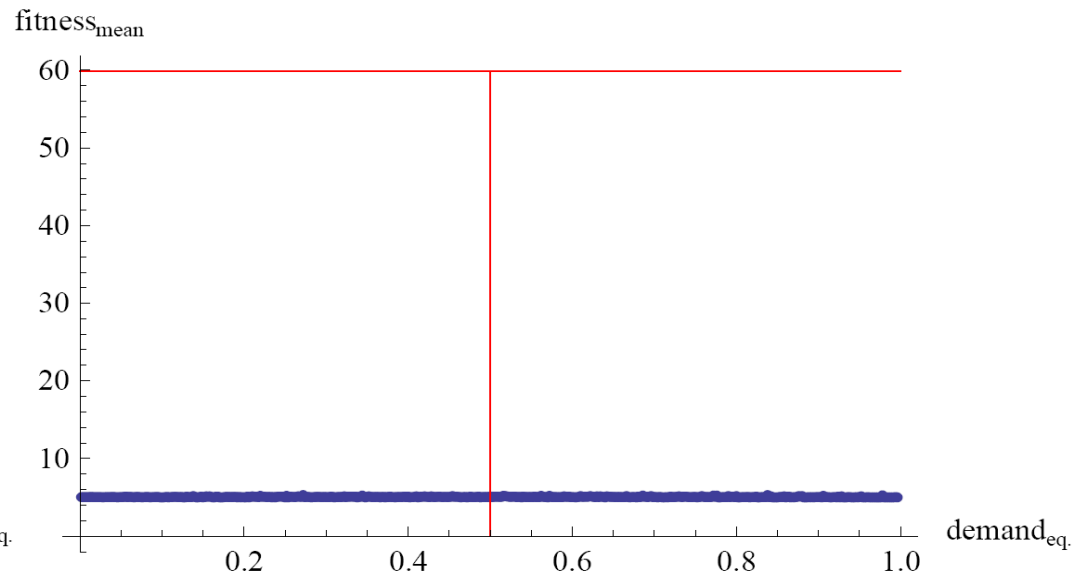
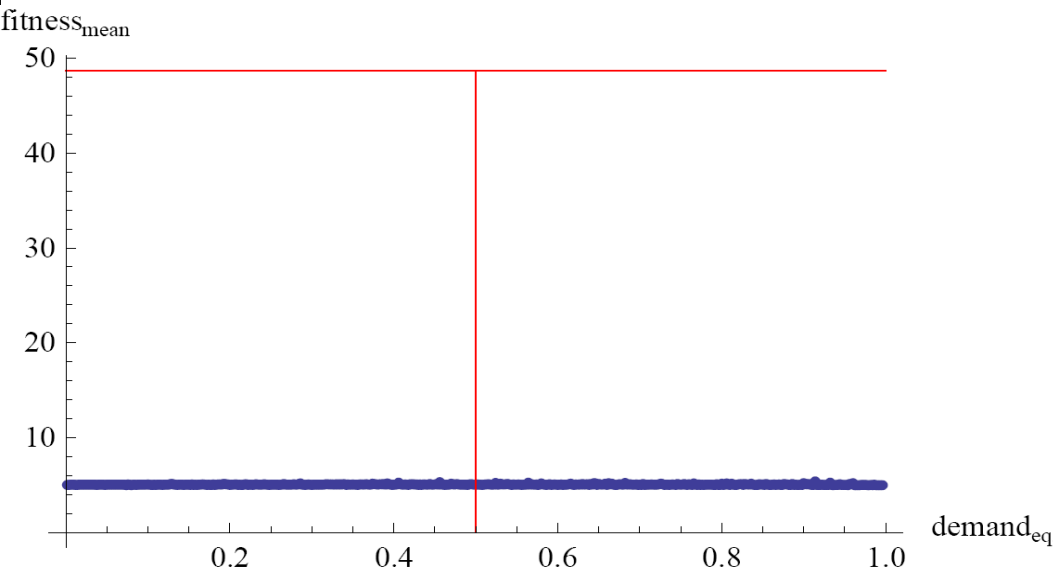
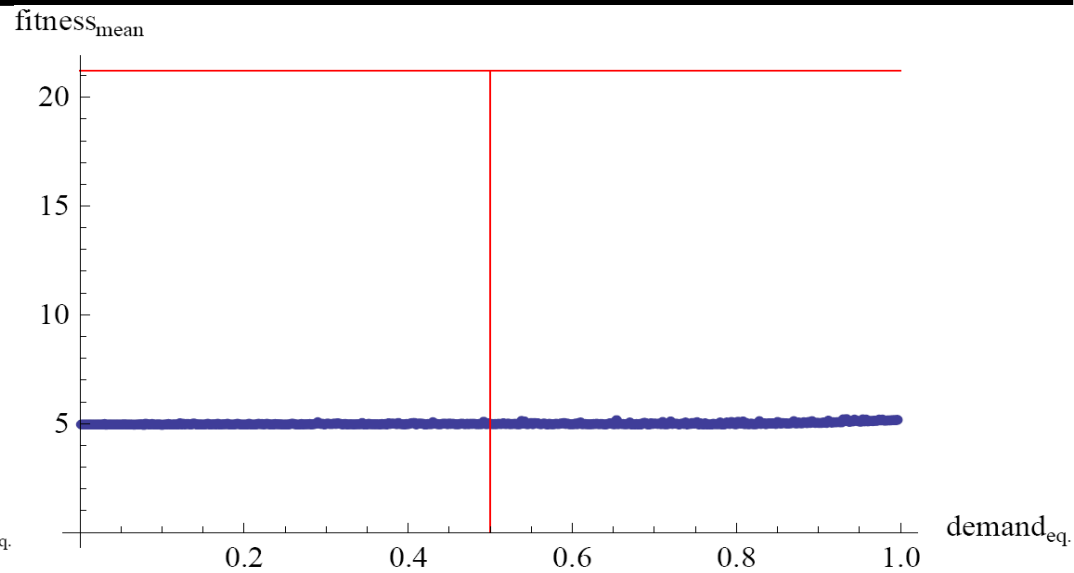
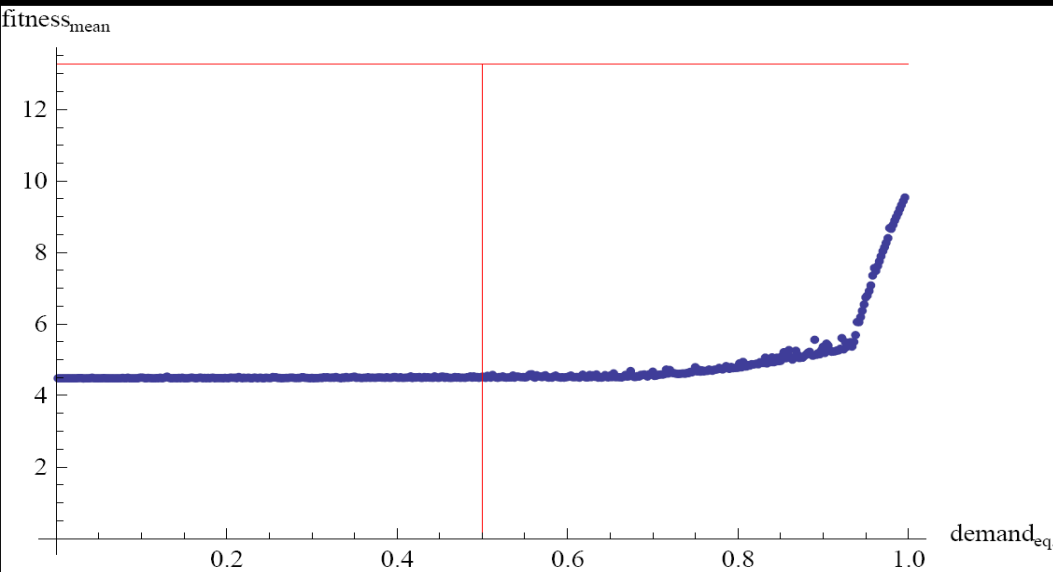
supply power, demand linear



functions intersect at supply_{ESS}

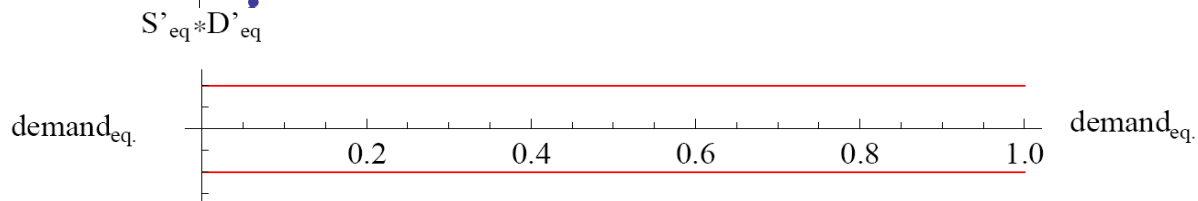
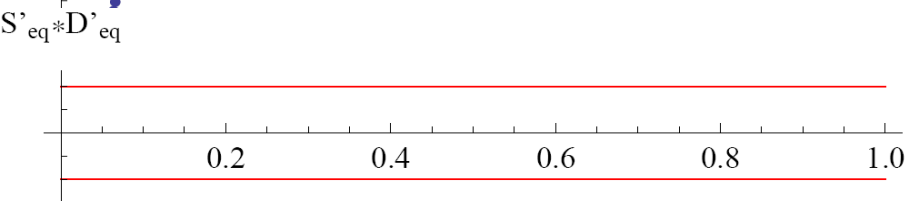
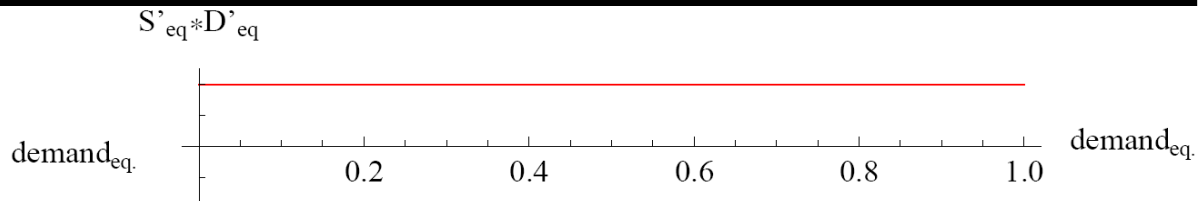
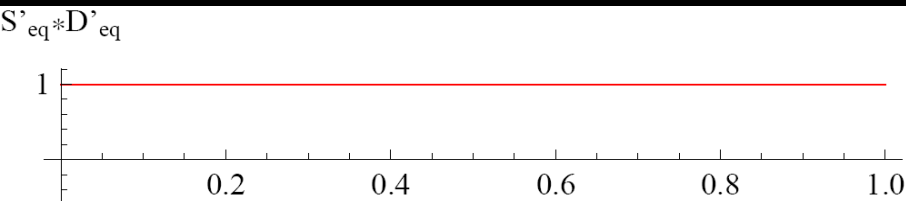
Questions/Appendix

supply power, demand linear ($k=0.25;0.5;2.5;4.5$)



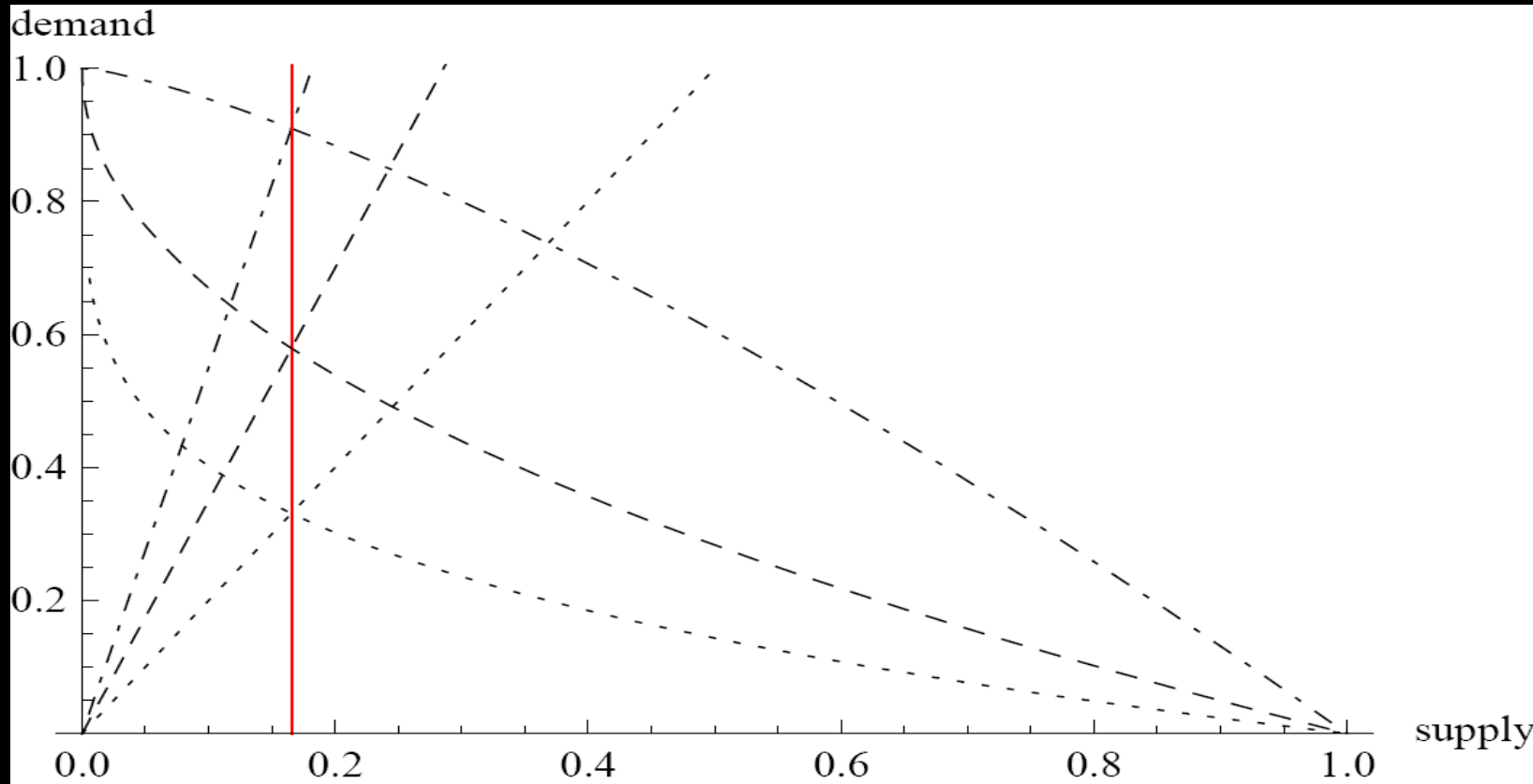
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supply power, demand linear (k=0.25;0.5;2.5;4.5)



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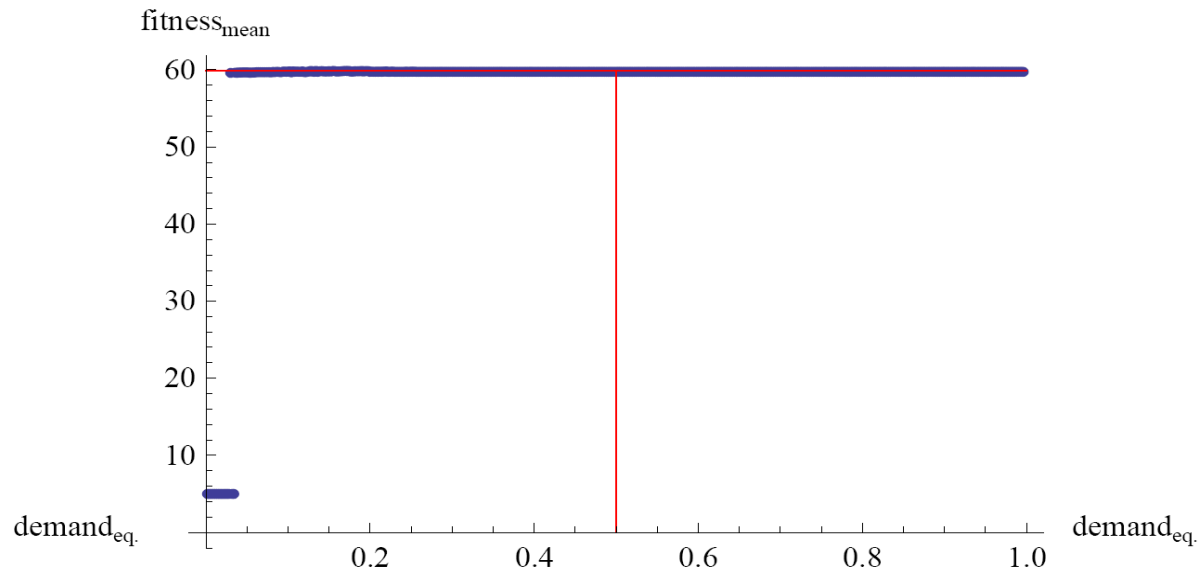
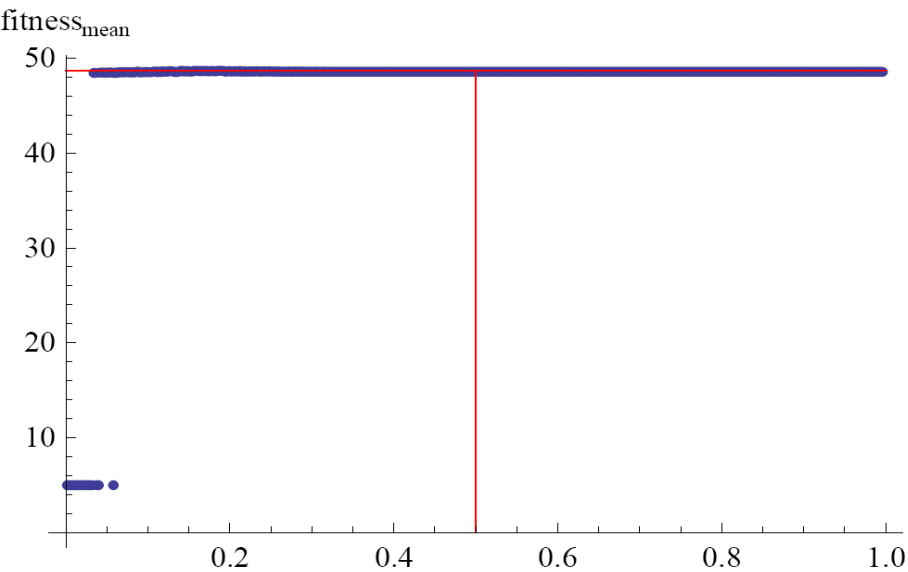
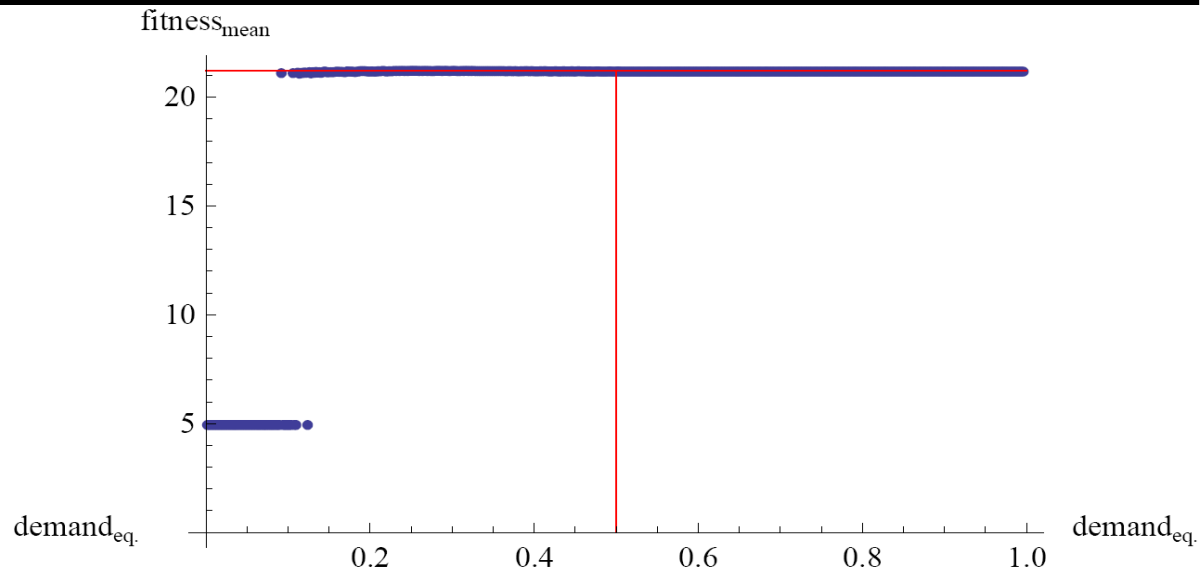
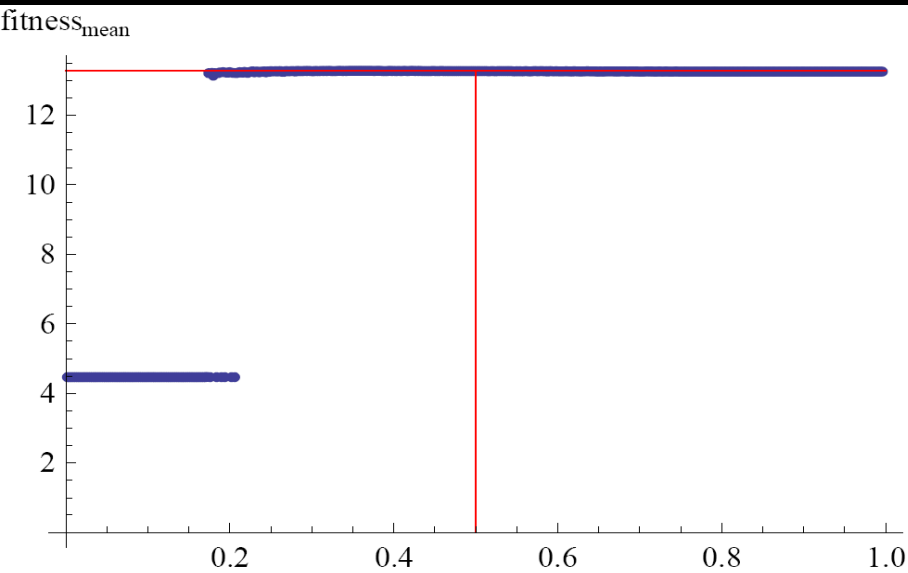
supply linear, demand power



functions intersect at $supply_{ESS}$

Questions/Appendix

supply linear, demand power ($k=0.25;0.5;2.5;4.5$)



Questions/Appendix

supply linear, demand power ($k=0.25;0.5;2.5;4.5$)

