Solutions to exercises from Lecture 6 Task allocation and self-assembly in swarms

TEK5010 Multiagent systems 2020

Question 1

a) We have one task, i.e. a stimuli s, and two types of workers of different thresholds θ_1 and θ_2. Model and explain the threshold model $T_\theta(s)$

* Model I : Biological model

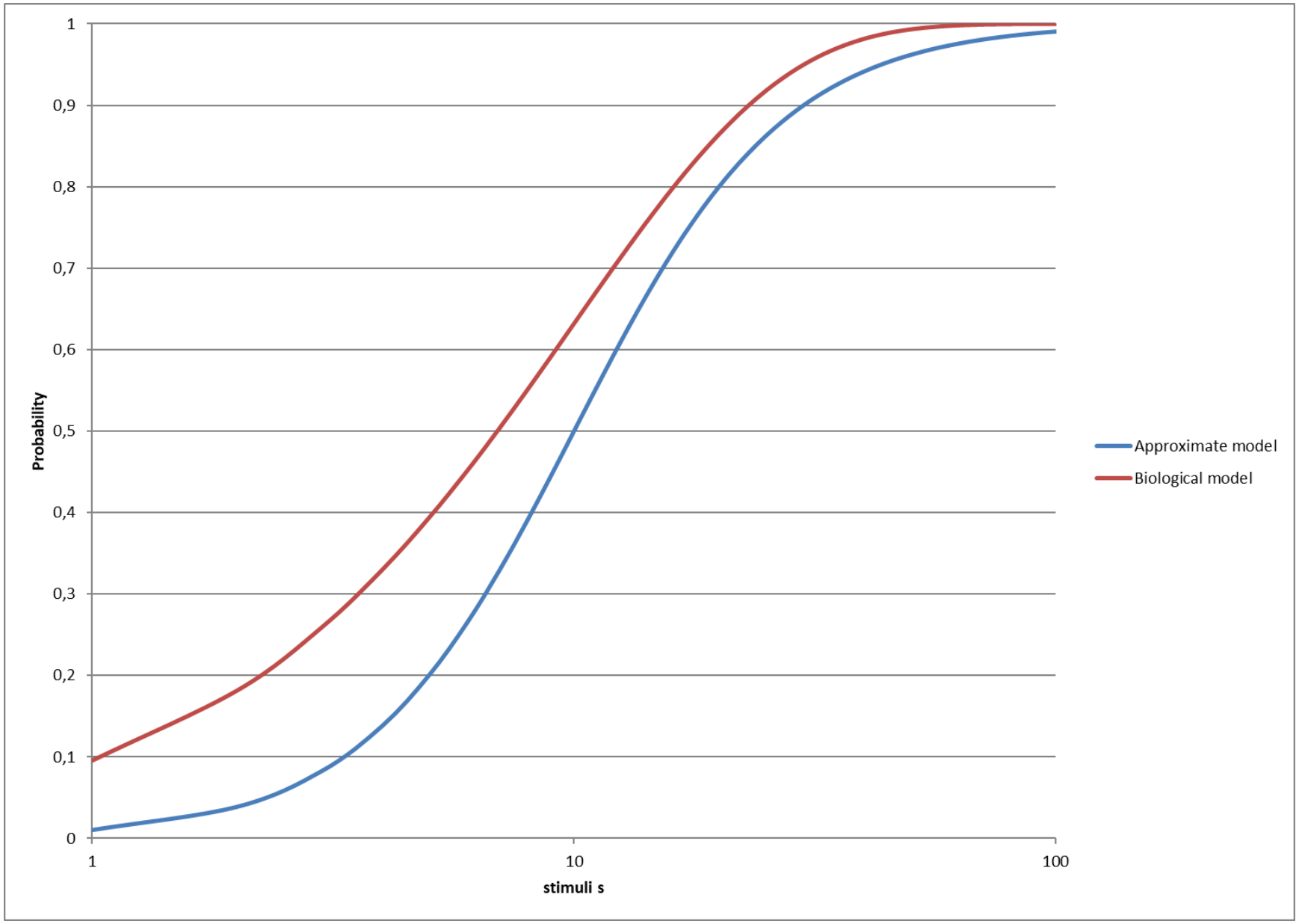
$$T_\theta(s) = 1 - e^{-s/\theta}$$

Hard to work with analytically

* Model II : Approximation

$$T_\theta(s) = \frac{s^n}{s^n + \theta^n}$$

where s is stimuli
θ is threshold
n is steepness of threshold


1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
Probability
1
10
100
stimuli s
Approximate model
Biological model

$n = 2$

$\theta = 10$

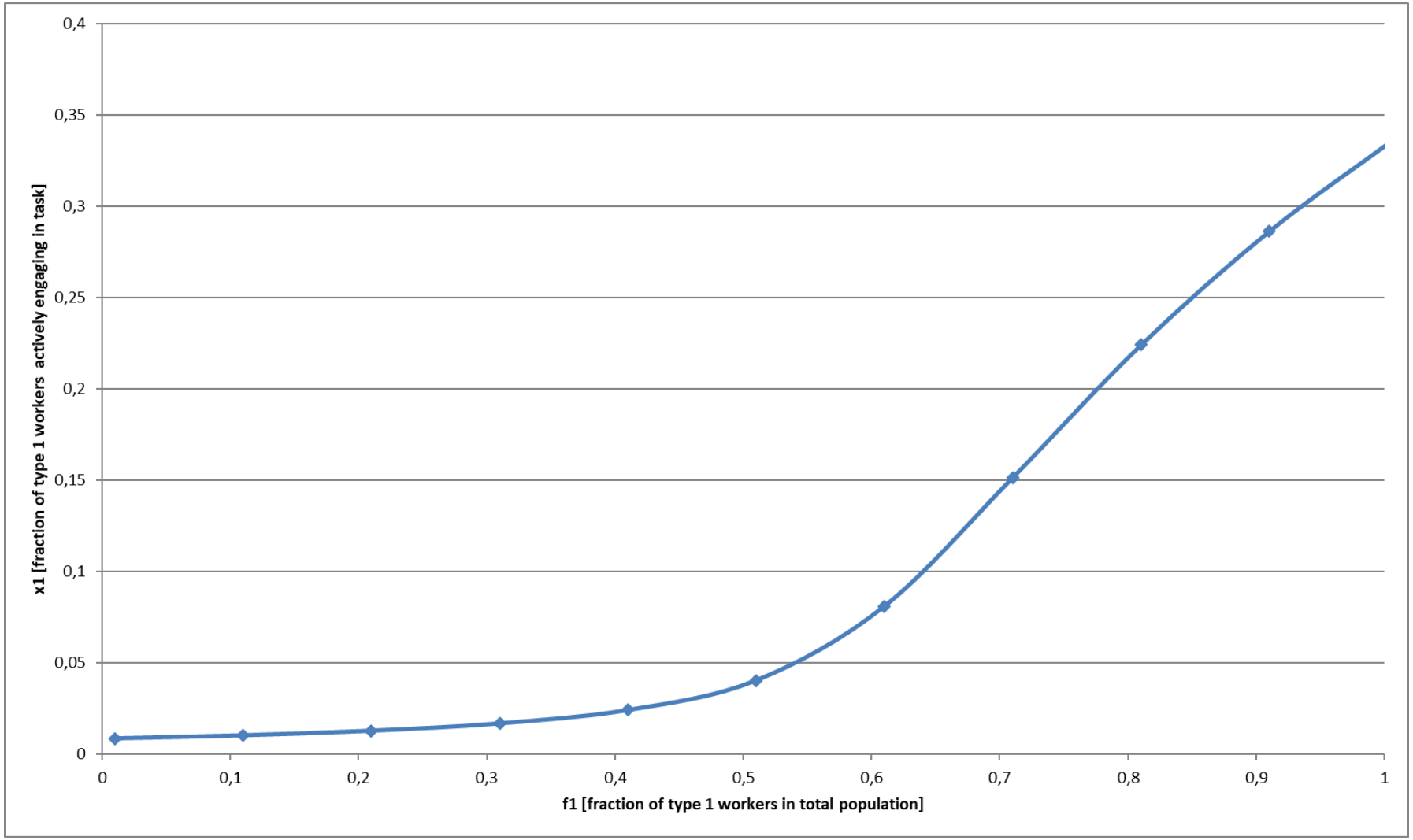
$\Delta << 0$ low probability of doing task

$\Delta >> 0$ high probability of doing task

$\Delta \approx 0$ 50/50 probability of doing or not doing task

$\Rightarrow n = 2$ gives nice differential equations possible to solve analytically.

b) Model using $\theta_1 = 8$, $\theta_2 = 1$, $\rho = 0{,}2$, $\delta = 1$, $\alpha = 3$

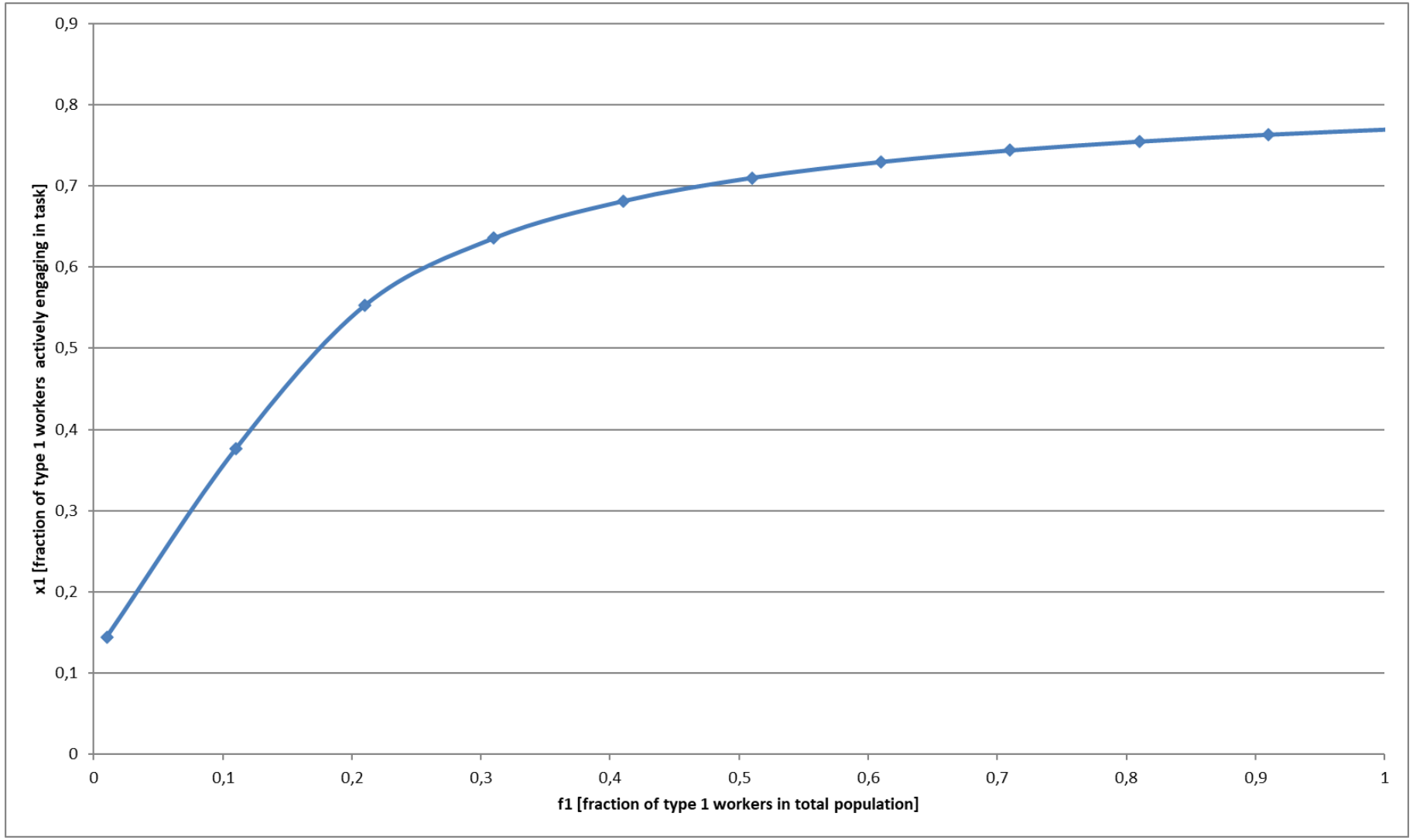


Worker 1 is the specialist ($\theta_2 << \theta_1$)

c)

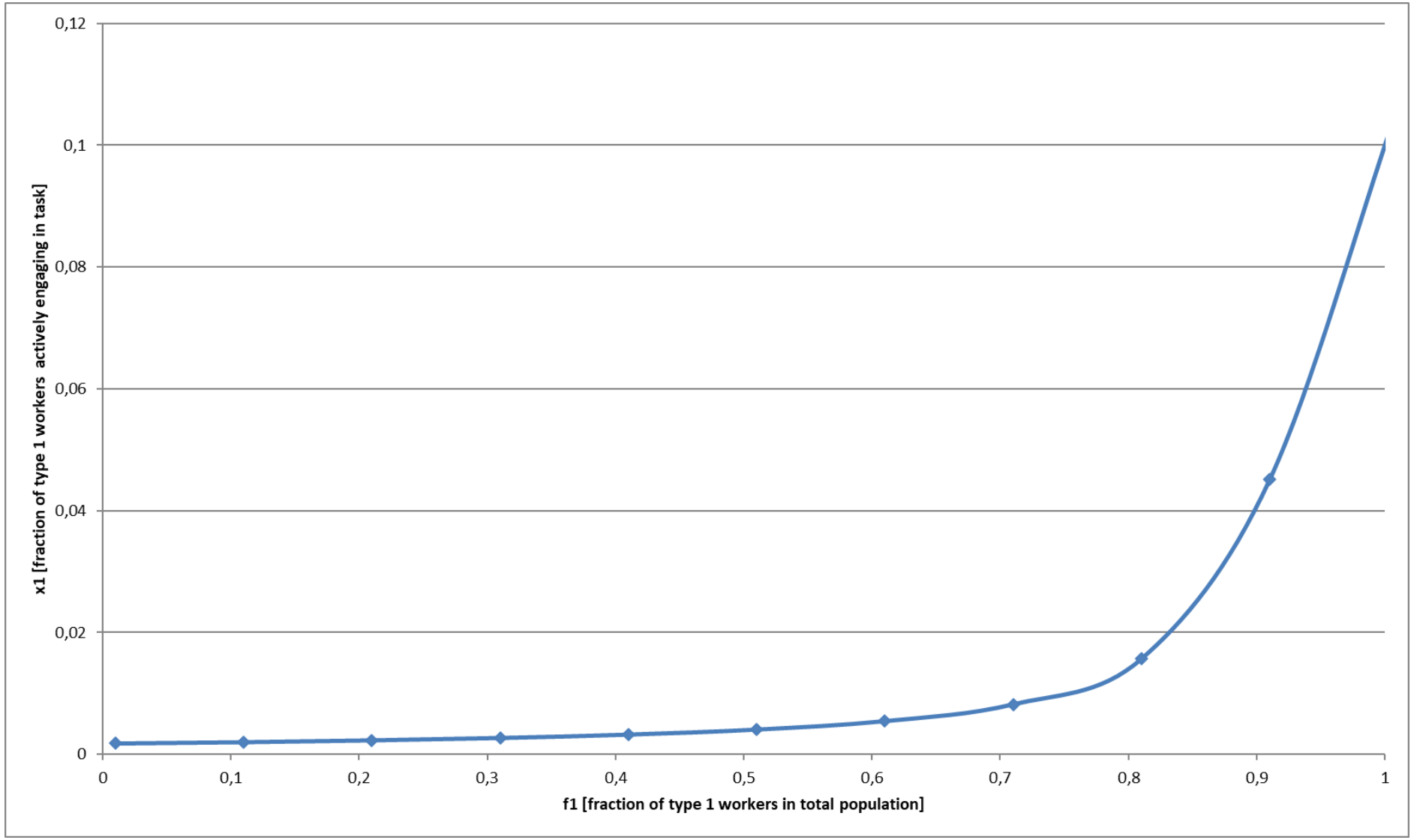
* When $\alpha \approx \delta$ the efficiency of doing both get less and less for both workers, meaning that both types of workers have to devote more workers into both in order to keep stimuli low.

$\theta_1 = 8$, $\theta_2 = 1$, $\rho = 0.2$, $\delta = 1$ ≈ $\alpha = 1,3$



- when $\alpha \gg \delta$ the efficiency of doing task is high. Most of the work is done by workers of type 2, and when α sufficiently high only a small fraction of the total population needs to participate in task.

$\theta_1 = 8$, $\theta_2 = 1$, $p = 0.2$, $\delta = 1$, $\alpha = 10$



* What about the explicit modelling of worker type 2?

I: $\frac{N_1 + N_2}{N} = f x_1 + (1-f) x_2$

II: $\delta_t s = \delta - \alpha \frac{N_1 + N_2}{N}$

I and II: $\delta_t s = \delta - \alpha f x_1 - \alpha (1-f) x_2 = 0$ in equilibrium

$\Rightarrow \quad x_2 = \frac{\delta - \alpha f x_1}{\alpha (1-f)}$

$\theta_1 = 8,\ \theta_2 = 1,\ p = 0.2,\ \delta = 1,\ \alpha = 3$