Thank You very much for Your comments.

## **GENERAL COMMENTS**

Market imperfections. It is not true, that the paper is only concerned with physical and not with economic aspects. Maximizing welfare under productive, consumptive, environmental and technological constraints is a typical economic problem. What is true is that the paper is only concerned with economics from the perspective of the social planner. It is well known however, that the planner's solution can be replicated by the market if market imperfections do not distort the solution. Market failures have been much studied and are rather well understood in economics. Therapies against this illness have been also suggested by economic doctors. The same types of market imperfections, operating elsewhere, would also affect materials processing in the economy and could be also cured, at least to some extent, by well-known economic prescriptions. I think for this reason that it is better to focus on aspects that are less familiar to economists (You recognize that this is the case for the mass conservation principle, eco-efficiency and recycling), rather than repeating what is well known and has already been studied elsewhere with great success.

Comparative statics vs. dynamics. The point of view adopted in the paper is the point of view of comparative statics and not the point of view of dynamic analysis. For this reason, all variables are constant, not just human capital. There is therefore no technical change, but also no accumulation of physical capital. Although the variables are constant, they are endogenous i.e. chosen and not given. The paper compares optimal choices of the variables following from changes in one exogenous parameter, which is population. The model presented in the paper is perfectly suitable for dynamic analysis and could be also studied in a dynamic setting, in which physical capital and the pollution stock accumulate and technical change takes place as a consequence of human capital accumulation. Why did I decide, in writing the paper, to adopt the point of view of comparative statics rather than dynamic analysis? The reason is, that I prefer to study the model structure in its simplest form, in order to better understand the structural role of the materials conservation constraint, of eco-efficiency and recycling. Dynamics would add additional aspects, as transitional dynamics and, in particular, discounting, which are certainly relevant issues, but are better postponed to future analysis than allowed to further complicate a paper which is already 40 pages long.

Finite vs. infinite human capital. Although human capital is endogenous, and therefore chosen, in my paper society chooses human capital of a finite, instead of an infinite, size. Knowledge is certainly an immaterial, and therefore non-polluting, entity, but the question is whether this immaterial entity requires or not a physical infrastructure supporting it. If no infrastructure is

needed, clearly there cannot be any reason why knowledge could not "increase indefinitely", as You write. If a physical infrastructure is needed, as I assume in my paper, (e.g.: universities, laboratories, particle colliders, etc.), knowledge can only "increase indefinitely" if "infinite" knowledge can be supported by a finite infrastructure. My paper assumes that this is not the case, and that society therefore chooses to be satisfied with finite knowledge (which can be, of course, very high, depending on the other model specifications). Why? The crucial assumption is that marginal productivity from human capital declines, whereas marginal costs of supporting the physical infrastructure of knowledge are constant. If marginal productivity of knowledge were constant and greater than marginal costs, human capital could increase without limits, since the physical infrastructure could be "substituted" by productivity gains and a constant, or even declining, physical infrastructure could therefore support the growth of human capital without bounds. In this case, human capital could generate more and more human capital out of itself without additional physical capital, in a similar way, as Baron Münchhausen got himself out of the bog, by simply pulling at his own hair. I do not think, that Baron Münchhausen's methodology can adequately describe human capital accumulation, but I am fully aware, that many economists would readily admit that infinite spiritual entities (as infinite knowledge) can be based on finite material infrastructures. The debate is open. I have only contributed my personal opinion.

"The model is nice but the outcome of the model is not extremely insightful". You are obviously perfectly free to decide, whether You are interested in the model's results, or not, but I am rather surprised that You make this general statement without discussing <u>any</u> of the model results which are extensively presented in section 5 and in the conclusions.

## SPECIFIC COMMENTS

° I do not think that Your suggestion would improve the readability of the paper. If I understand You correctly, You suggest I should first describe the model out of static equilibrium. This implies, I should first write down the laws of motion of stocks. This is easily done. The laws of motion are:

$$\dot{K} = y - c - \delta_K K$$

$$\dot{D} = e - a$$

$$\dot{H} = (\pi K_H)^{\lambda} (\gamma l_H)^{1-\lambda} - \varphi H$$

After writing down these dynamic equations I should inform the reader that I do not intend to perform dynamic analysis and set therefore:  $\dot{K} = \dot{D} = \dot{H} = 0$ . From this, equations 2, 6 and 21 in

the text and the rest of the analysis would follow. Summing-up: 3 additional dynamic equations only to state that I shall not use them and take time derivatives of stocks to be zero. This is feasible, but not very useful, because readers can at any time, if they are interested, easily derive laws of motion by simply looking at Figure 1, since changes in stocks derive from mismatches between inflows and outflows.

° It is a matter of taste, in which order arguments are presented. Equation 1 is a very general equation and I thought that this was not the right place to discuss more specific issues, as e.g. consumption, which has a specific section 2.3., a few pages later. If physical capital and pollution are the only material stocks, this implies that no other stocks (as e.g. consumer durables) exist. This is also familiar, since most economic models reduce consumption to its flow aspect. I have no objection however to anticipating this in a footnote.

°  $\lambda$  and  $1-\lambda$  are the exponents of capital and labour in a Cobb-Douglas production function. This material is covered in undergraduate classes in microeconomics. Do You think it is necessary to rehearse this for readers of this journal?

° Interpreting human capital as an externality is perfectly correct. Public goods are usually understood as being non-rival and non-excludable. Knowledge is certainly non-rival, but is excludable in principle, since patents may prevent the diffusion of knowledge. Since patents are not considered in the paper however, public good would do equally well. I think this is an irrelevant issue about words, since the meaning is clear from the text.

° You are right. Fortunately, no confusion can arise, since equations 18 and 20 are not used any longer after page 13. It would be more correct however to substitute the function symbol in 23 and 24, (and obviously also in 32), as You suggest. For instance:

$$\pi = \widetilde{\pi}(\eta) \tag{23}$$

$$\mathcal{G} = \widetilde{\mathcal{G}}(\eta) \tag{19}$$

 $^{\circ}$  You are perfectly right. After a last-minute change in variable names, I forgot to modify Figure 1. V in Figure 1 should be substituted by S. Sorry!

## COMMENT ON THE COMMENT

To state that "the model is nice" is very nice indeed, but what does this mean?