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Appendix A

As in the text, we define h in such a way that $m = 1, 2, ..., (h = i)$. Once there is an improvement along the learning curve described by (19), the series continues in the following way: $m = 1, 2, ..., h, (h + 1 = i)$. In this appendix we show when process innovations which increase the value of h as defined above, end up with a smaller (higher) value of b_i. In other words, we show when b_h is higher (lower) than b_{h+1}.

We know from the definition (26) that

$$b_h \equiv \frac{n_h \gamma_h^{1-\sigma}}{\sum_{j=1}^{h} n_j \gamma_j^{1-\sigma}} \quad \text{and} \quad b_{h+1} \equiv \frac{n_{h+1} \gamma_{h+1}^{1-\sigma}}{\sum_{j=1}^{h+1} n_j \gamma_j^{1-\sigma}}$$

Hence, we derive that $b_h > b_{h+1}$ when

$$n_h \gamma_h^{1-\sigma} \sum_{j=1}^{h+1} n_j \gamma_j^{1-\sigma} > n_{h+1} \gamma_{h+1}^{1-\sigma} \sum_{j=1}^{h} n_j \gamma_j^{1-\sigma}$$

or, equivalently, when

$$n_h \gamma_h^{1-\sigma} \sum_{j=1}^{h} n_j \gamma_j^{1-\sigma} + n_h \gamma_h^{1-\sigma} n_{h+1} \gamma_{h+1}^{1-\sigma} - n_{h+1} \gamma_{h+1}^{1-\sigma} \sum_{j=1}^{h} n_j \gamma_j^{1-\sigma} > 0 \tag{40}$$

Expression (40) is true when

$$\frac{\sum_{j=1}^{h} n_j \gamma_j^{1-\sigma}}{\sum_{j=1}^{h-1} n_j \gamma_j^{1-\sigma}} > \frac{n_{h+1} \gamma_{h+1}^{1-\sigma}}{n_h \gamma_h^{1-\sigma}}$$

We substitute n_{h+1} from (21) and we obtain

$$l \equiv \frac{\sum_{j=1}^{h} n_j \gamma_j^{1-\sigma}}{\sum_{j=1}^{h-1} n_j \gamma_j^{1-\sigma}} > \frac{L_R \gamma_{h+1}^{1-\sigma}}{a \gamma_h^{1-\sigma}} = \frac{L_R}{a} \left(\frac{\gamma_h}{\gamma_{h+1}} \right)^{\sigma-1}$$

where the left term in the inequality, l, is always larger than 1. Therefore, given that $\gamma_{h+1} < \gamma_h$, we may at least state that $b_h > b_{h+1}$ is true, when $\frac{L_R}{a} \left(\frac{\gamma_h}{\gamma_{h+1}} \right)^{\sigma-1} < l$. That is when

$$1 < \left(\frac{\gamma_h}{\gamma_{h+1}} \right)^{\sigma-1} < \frac{a}{L_R} l \tag{41}$$

Expression (41) says that when the process innovation produces a reduction in γ which is not relatively high, then b_i decreases.

Appendix B

Following Grossman and Helpman (1991, p. 63) we define the index of the manufactured output

$$D \equiv \left(\sum_{m=1}^{i} n_m x_m^{\alpha} \right)^{\frac{1}{\alpha}}$$

where $\alpha = \frac{\sigma-1}{\sigma}$, while the ideal price index of final goods is p_D.

The gross domestic product (GDP), G, is defined as the sum of the value added in manufacturing and in the R&D sector

$$G \equiv p_D D + v_i \dot{n}_i$$