1. When applying the stencil to the 2D matrix, each point executes 9 floating-point operations (5 multiplications and 4 additions). So for horizontal slabs of size $n \times (n/p)$, the computation of each process is

$$9\,\gamma\,\frac{n^2}{p}.$$

In this case, the communication between neighbors is only the adjacent rows between processes, which can be communicated using sendrecv in $O(n)$ time. Since each process except for the first and last has two neighbors, the communication cost can be approximated as

$$2\big(\alpha + \beta\, n\big).$$

Therefore the speedup is

$$\frac{9n^2\,\gamma}{\frac{n^2}{p}\,9\,\gamma + 2\,\alpha + 2\,\beta\, n} \quad = \quad \frac{p}{1 + \dfrac{2p\big(\alpha + \beta\, n\big)}{9\, n^2\,\gamma}}.$$

The efficiency thus simplifies to

$$\frac{1}{1 + \dfrac{2p\,\alpha}{9\,n^2\,\gamma} + \dfrac{2p\,\beta}{9\,n\,\gamma}}.$$

For a fixed memory $M = n^2/p$, the efficiency becomes

$$\frac{1}{1 + \dfrac{2\,\alpha}{9\,\gamma\,M} + \dfrac{2\,\sqrt{p}\,\beta}{9\,\sqrt{M}\,\gamma}}.$$

Since

$$E \sim \frac{1}{\sqrt{p}},$$

this approach does not scale weakly.

2. When the domain is divided into patches of size $(n/\sqrt{p}) \times (n/\sqrt{p})$, the computation of each process remains the same, but the communication cost becomes

$$4\big(\alpha + \beta \, \tfrac{n}{\sqrt{p}}\big)$$

since each process does a sendrecv with its 4 neighbors.

The speedup is then

$$\frac{9\, n^2\, \gamma}{\frac{n^2}{p}\, 9\, \gamma + 4\, \alpha + 4\, \beta\, \frac{n}{\sqrt{p}}}.$$

The efficiency is

$$\frac{1}{1 + \frac{4\, p\, \alpha}{9\, n^2\, \gamma} + \frac{4\, \beta\, \sqrt{p}}{9\, n\, \gamma}}.$$

For the fixed memory $M = n^2/p$, it becomes

$$\frac{1}{1 + \frac{4\, \alpha}{9\, M\, \gamma} + \frac{4\, \beta}{9\, \sqrt{M}\, \gamma}}.$$

Since this is a constant, this approach scales weakly.

Plugging in the given numbers, the time spent on computation of each processor is 9 seconds, and the communication time is $\approx 1.305 \times 10^{-4}$ seconds.