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Solutions to Problem Set No. 3

1. (a) *In year 0 before the new factories arrive, what is the average product of labor (i.e., corn output per worker) in a farm? What is the marginal product of labor (i.e., incremental corn output if one more worker were to be employed)? What proportion of the economy's labor force is surplus labor?*

Since each family has 10 siblings who participate equally in the farm work and $10 > 5$, total output of corn is 5, generating an average product of labor in year 0 of $\frac{5}{10} = \frac{1}{2}$.

In year 0, marginal product of labor is 0 because removing any single worker will have no effect on farm output.

There are 5 surplus workers; therefore the surplus labor ratio in year 0 is:

$$\frac{10-5}{10} = 0.5$$

(b) *In year 1,* 30 *new factories arrive. With wages in the agricultural sector set equal to the average product of labor there, and free movement of workers between sectors, what will the wage rate in the industrial sector be (in units of shirts)? How many workers will each factory employ in year 1?*

The wage rate will be the average product of labor in agriculture (0.5 units of corn), times 2 (the price of corn in terms of shirts), i.e., 1 shirt per worker hired.

A factory wants to hire workers upto the point where the wage rate equals its marginal revenue. If marginal revenue of a factory is measured in units of shirts, it equals the marginal product $15 - y$.

Hence each factory will employ workers upto the point that

$$15 - y = 1 \Rightarrow y = 14$$

(c) *Calculate the total employment in the industrial sector in year 1.*

Total factory employment:

$$30 * y = 30 * 14 = 420$$

(d) *Will there be surplus labor in agriculture in year 1?*

Yes, because 420 people will be employed in industry, leaving 580 employed in agriculture, implying a surplus of 80 workers. Hence the marginal product of labor in agriculture is still zero in year 1.

(e) *Calculate the profits per factory in year 1. (Hint: remember how to calculate the area of a triangle.)*

We obtained $w = 1$ and $y = 14$ from part (b), so profit of each factory is:

$$\frac{1}{2}14(15 - 1) = 98$$

(f) *How many factories will there be in year 2?*

Total saving of entrpreneurs is

$$(0.1 * 98)30 = 294$$

Hence the number of new factories built at the end of year 1 is:

$$\frac{294}{98} = 3$$

So the total number of factories in year 2 will be:

$$3 + 30 = 33$$

(g) *Will there be surplus labor in agriculture in year 2?*

In year 2 with the industrial wage rate at 1 shirt per worker, each factory will employ 14 workers. With 33 factories, industrial employment will be 14*33=462, so agricultural

employment will be 538. So there will still be surplus labor (of 38 workers) in agriculture in year 2.

(h) *Calculate GDP in year 0, 1 and 2 respectively (in units of shirts).*

In year 0, GDP equals 500 units of corn, multiplied by 2 (price of corn in shirts) = 1000 shirts.

In year 1, corn output is still 500. Output per factory (in units of shirts) equals its total revenues, in turn equal to the sum of profits (of 98) plus wages (of 14, since there are 14 workers employed at a wage of 1). So output per factory equals 112 shirts. With 30 factories, industrial output equals 3360. So GDP equals 1000+3360=4360 shirts in year 1.

In year 2 there are 33 factories, all else is unchanged. So GDP equals 1000 plus 3696=4696 shirts.

Growth thus slows down from the first year to the next: it grows by 336% in year 1 and $\frac{336}{4360} * 100$ =7.7% in year 2. This owes to the large growth of factories (30 new factories) in the first year, relative to the second (3 new factories). Also the base output in year 0 is a lot slower than in year 1.

(i) *Will there be surplus labor in agriculture in year 3?*

In year 2 profit per factory will continue to be 98, so savings will be 9.8 per factory. Total savings will be (9.8)(33), and there will be $\frac{9.8*33}{98}$ new factories built in year 3. Rounding off, there will be 3 new factories in year 3, so 36 factories in total. This will raise industrial employment to 36*14 = 504 in year 3, so agricultural employment will fall to 498. In year 3 there is no surplus labor in agriculture.