KREMER'S O-RING MODEL

* **Basic idea**: modern production requires each of many activities to be done well for the output to have high value – strong complementarity in technology. (within firm or across)

* name of theory: the O-ring (that cost less than $1) which caused the Challenger shuttle crash.

Formally:

* suppose a production process is broken down into n tasks.
* $0 \le q \le 1$ is a task's level of skill required. The higher q the higher the probability the task will be successfully completed
* production f-n (putting the tasks together into a product):

$$\text{output, } y = F(q_1, q_2, ..., q_n) = q_1 q_2 ... q_n$$

* assume competitive labor markets, workers all supply 1 unit of labor.

* important property of this technology: *positive assortative matching*

* this means that workers with high skills q will find it best to work with other workers with high skills (because of the complementarity in skills – working with better skilled colleagues increases each worker's marginal product (and hence wage).

* **Example:** Suppose there are 4 workers, 2 with high skill, qH and 2 with low skill, qL < qH. Suppose 2 workers are required per firm. How will the four workers match up?
* If H,H and L,L match together total output is Ymatched: $q_H^2 + q_L^2$
* if we have two H,L pairs instead total output is Yunmatched: $2q_H q_L$
* the former is higher – total output is higher if skill matching takes place (the results holds for any number of skills, not just two).
* Why? Intuition: everyone wants to have a skilled partner, but skilled people want it more (the increment in output from switching a partner from L to H for an H person is: $q_H^2 - q_H q_L = q_H(q_H - q_L)$ while the same amount for an L person is: $q_L q_H - q_L^2 = q_L(q_H - q_L)$ which is smaller since qH > qL. Thus, the H skilled can always 'outbid' the low-skilled and have another H as partner. Same holds for firms who look for workers. A firm with one H workers can always outbid (pay higher wage) to get another H worker, than the firm starting with an L worker.

* if more skill levels, same result – top-skill match together, then second-best, and so on, until the least skilled are matched too. Examples: orchestras, expensive restaurants, sports teams

* Connection to development?
- think of countries – a country which has H skilled would attract more of them while a country who has low-skilled workers is left with them (cannot attract/keep H skilled). Think of the so-called 'brain drain' process (migration of skilled individuals from less developed to richer countries).

* For the Kremer model to work need two crucial assumptions:
A1. workers of different skills must be sufficiently imperfect substitutes for each other.
If not, e.g. if one H worker can be replaced by say two L workers there's no prediction of matching (any mix of workers could be possible in equilibrium).

A2. there must be sufficient complementarity of tasks in production
If not, e.g. if we had y = q1 + q2 then (H,H) and (L,L) produce exactly the same total output as two pairs of (H, L) – no positive assortative matching.

IMPLICATIONS OF THE O_RING THEORY
1. firms tend to employ workers with similar skills for the several production tasks necessary

2. workers performing the same task each higher wages in a firm with higher-skilled co-workers (and are more productive there – higher MP)

3. because of the positive matching wages increase in q at an increasing rate! Thus, if we have two firms or countries with skill levels qH = 2qL and three tasks, the wage level in the high-skilled country will be 4 times that in the low-skilled. *Why? Remember, in equilibrium the wage equals the marginal product of labor (MPL) for any person, so in the (H,H,H) firm/country with technology Y=q1q2q3, for any worker (e.g. worker 1) we have* $wH=MP_1= q2q3 = (qH)^2$ *while in the (L,L,L) firm/country we have* $wL=MP1=(qL)^2$*. So wH/wL = 4, two-times the skill difference. If n>3 tasks, the wage gap will be even higher.*
Relatively small skill differences can lead to much bigger inequality in income (possibly matching the cross-country evidence we saw).

4. If workers can invest (e.g. in education) to improve their skills they will consider the level of human capital investment made by others they work with. When those around you have higher average skills – the greater your incentives to acquire more skills (because the increment in your MPL is magnified by the others' skills). Returns to education are much higher in countries that already have higher average education level.
E. g. suppose qL = 1, qH = 2. If I am paired with an L worker and improve my skill to 1.2, firm output raises by .2; while if I am paired with an H worker output raises by .4 – twice more! The difference will be much bigger if there are more workers in the firm (verify as exercise for 3 or 4 worker).

5. <u>bottleneck effects</u>: in the Kremer technology a low-skilled worker in certain task 'drags down' the whole firm by reducing the MPL of all his colleagues (due to the complementarity). *Example: if all workers are at q currently, and one's skill falls to q/2 (or dies and needs to be replaced with q/2 skilled worker), the total firm output falls by 50%! This reduces other agents' incentives to invest in upgrading their skills, those can depreciate too, and enter a vicious circle.*
Implication: isolationist policies – which can likely produce such low-efficiency bottleneck sector can drag down the whole economy in the Kremer model, opening up can then help (e.g. by replacing this sector's products by imports, or by being able to import better technology through FDI, etc.) A case for openness to trade and capital investment.

6. choice of technology: for a country with many low-skilled workers is hard to use/adopt modern, complex technologies since they require many high-skilled workers doing different tasks that cannot be simply replaced by low-skilled workers. Thus poorer countries may be stuck with lower-skilled technologies (where making a mistake in production is less costly), which gives less incentives for workers to acquire skills.

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from Easterly ch. 8

* Easterly makes the argument that knowledge/ideas have such complementarity property (ideas build on themselves): the more existing knowledge there is, the higher the return to each new bit of knowledge. So knowledge would flow to richer countries.

* so why then doesn't all knowledge/skill go to a single place?
Congestion (the agency, coordination costs discussed above).
knowledge leaks (others can copy)

* **circles**: virtuous circle can be created – knowledge creates more knowledge, etc. But if very low knowledge at the beginning – can't get the cycle started (can't cover initial investment or generate initial required rate of return) – a vicious circle – knowledge decreases (no incentives); government can help by making this initial investment in knowledge to get the virtuous circle started (e.g. public education)

* government policy if multiple equilibria because of matches/complementarities:
1. government intervention may be needed to get the economy out of a low-level trap
2. be careful how gov't policy affects incentives (e.g. if finance education but tax private investment)
3. bad government policies can be the reason of the trap
4. gov't can help by partnering with business to coordinate

*** Evidence for complementarities and matches:**

- cities: where high-skilled people match; e.g. in US, urban incomes are 32% higher than in rural areas. Why pay huge downtown rents if not to be together with other similar people?
- another study finds that the wage of a person with a given skill and education is higher in cities with whose populations have higher average skill.
- 'brain drain': under DRS (e.g., the Solow model) unskilled workers should want to migrate to capital-abundant countries (where labor is scarce) while high-skilled workers should want to stay in poor countries where it is scarce. In practice we observe the opposite (e.g. an educated Indian is 14 times more likely to emigrate than an educated one).
- similar story can apply to financial capital – flowing to countries where its current return is higher.
- example with real estate: a dilapidated house in a neighborhood may drag down prices of all other houses. Fancy houses are clustered together.

* THUS, the matching/complementarity model could be a possible explanation for some of the aspects of the data that did not match the Solow model (see previous notes).