Substitution: a Three-Factor Triangle

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1. Substitution: Two's Company; Three's a Crowd

To substitute A for B you must actually reduce the use of B. True substitution of A for B implies the presence of input C. A occupies C and displaces B. That is substitution. There must be three factors involved, as in the eternal triangle.

Thus, cheap water in agriculture may substitute for the capital used in water conservation: cement-lining canals, putting water in pipes under pressure, etc. Cheap water lets landholders grow alfalfa rather than vines, trees, or truck crops with their higher labor and capital requirements. Similarly, cheap energy in agriculture powers giant gas-guzzling machinery, which displaces farm labor but which is uneconomical with dear fuel.

One of the great faults of the Cobb-Douglas production function, widely used by economists, is the built-in assumption that inputs are all complementary, meaning that more of one raises the marginal product of the others. This is why you most often see the function used with just two inputs, labeled "Labor" and "Capital." It is hard to fit that to cases where capital or energy or water actually displace labor from land.

Capital in the form of cattle, sheep, and timber are great depopulators of the land. They do not fit into any Cobb-Douglas production function, torture it as you may. This is why I do not impose any Cobb-Douglas on you, even though we are mathematically ready, knowing that the exponent is the elasticity of production.

In a typical discussion of multiple inputs, an economist discusses trade-offs between inputs that are complementary, and turns to a Cobb-Douglas function to illustrate. The kind of trade-off usually discussed, as between nitrogen and phosphorus in growing crops, is not true substitution as discussed herein. Nitrogen and phosphorus complement one another: more nitrogen makes phosphorus work better, and vice versa. But picture the situation as it would be if adding phosphates were to reduce the marginal product of nitrogen. This would then require revision of much of conventional production economics.

Here is how such revision might proceed. First, simulate a 3-D graph in 2-D by the simple device of drawing a family of curves on the 2-D graph, giving each a different number, the number representing the value of the 3-D dimension, which is input B. Input A is on the left-right dimension; and output (or product, or revenue) is on the vertical dimension. Then draw the family of MP curves for labor as you add substitutive farm machinery. As the input of machinery rises, the MP curves for labor will become more highly arched, but drop off quicker, resulting in less labor use, but higher output per worker.

2. Substitution as Ousting: the Eternal Triangle of Economics

Conventional economists look at factor combos through rose-colored glasses: they all "support" and uplift each other. Alas, that is often like saying a family works better when a husband has two wives so they can spell each other. Workers need capital as an aid (the owners of capital keep telling us), but some capital owners aren't so sure they need workers. Lots of capital displaces workers. Sheep are capital, and in the 19th century sheep displaced working families throughout the Scottish Highlands. These persons before they were displaced were called "cottars," who lived in cottages, and "crofters" (small tenants). Eviction was euphemistically called "clearing." One of the less lovable traits of economists is either to rationalize or paper over this kind of thing, however inhumane: they seem to see it as their social role and duty to support depopulators.

Substitution in economics, as in love, must involve at least three parties, two of which preempt each other from the third. There is no substitution in a two-factor model. When capital substitutes for labor it is by dis*place*-ing it, and the *place* it takes is land. Examples parallel to sheep are cattle, timber, farm machines, and bar-code scanners. What about water? It makes an interesting case, with several variant effects. First, note that water itself is a natural resource, and so is the watershed from which it comes, along with the dam sites or aquifers used to store it. So applying water to land is, in a sense, simply expanding the land input. Second, water may be used to raise yields, using more labor and capital as well: this is the intuitive case. An equally common case, however, is using water to displace labor and capital, by obviating conservation measures, and growing water-thirsty, lower-yielding crops like irrigated pasture, alfalfa, hay, and rice.

An ordinary ousting[1] input may be recognized because it raises the AP of what remains of the partly ousted input, but lowers its MP.

The ousted input may include owner-managers themselves. Why would one want to oust oneself? Happens all the time: people own so much they are too busy to manage all of it intensively. As ordinary people grow old they lose energy but have gained property, and yearn to smell the roses. Empire-builders get hooked on acquisition but bored with managing what they acquire. People who want to be artists inherit electric arc-welding businesses. Misanthropes get fed up dealing with people problems. Rich heirs want to soak up sun and play tennis, or dolls.

Result? A lot of property owners choose to substitute land and capital, which are easy to manage, for labor, which isn't.

Capital in some other forms is different: it saves land and makes more jobs per acre. Examples are forklifts, skyscrapers, landfills, tunnels and bridges, fertilizer, high-yield hybrids, and narrow-band telecasting equipment. These are, of course, called "land-saving capital." They oust land and combine with labor.

[1]You may also call this a "substitutive" input, if you prefer long words in the pedantic tradition.

The kind of capital we get depends a lot on the relative costs of land and labor. Returns to investors are higher when they oust dear inputs for cheap ones. This, fortunately, makes the economy flexible and adaptable to changing needs. Dire forecasts of Malthusian doomsayers are offset by land-saving capital and technology; labor shortages are limited by labor-saving capital and technology; unemployment is limited by labor-using technology.[2]

3. Preemptive Inputs and the MNP

The MNP of an ousting input is not reduced by its need for associated inputs but the contrary: it is raised by its ousting (obviating) them. Instead of subtracting an increase of support costs you *add* to MNP the drop in the displaced inputs. ***Often, this drop is the larger part of MNP***.

In fact, an "ousting input" may not raise gross output at all. Some of them lower gross output: then, their MNP consists entirely in their lowering other costs by more than they lower output. Examples are all around us: seeding rice by airplane; using a flood of cheap water to oust vines for irrigated pasture; using energy and large machines to oust peach trees for small grains; converting pasture to a tree plantation; bulldozing homes and stores for parking lots; etc.

An input with this counterintuitive effect wants a special name. Economists have neglected the phenomenon, so it's up to us. I call them "preemptive inputs." These are a subclass of ousting inputs that actually lower production.

4. Preemptive Inputs: Lower Costs can Lead to Higher Prices

How often you hear it said that the prices charged by an industry "depend on costs." This is the "Fallacy of Automatic Pass-through"—see the paper of the same name, herein. It is baloney. Prices are determined by supply and demand.

Don't lower costs increase supply and lower prices? That's the usual line. It's false, though, when we are talking preemptive inputs: they lower costs but also lower supply. Lower supply raises prices. Conversely, a shortage of such preemptive inputs may well raise supply and lower prices. Water supply and energy are like that. This should make us feel more secure about future shortages of water and energy, both of which are often preemptive inputs that displace labor and lower yields.

Conrad Hammar found the labor/land ratio was higher on bad land in the Ozarks of Missouri than on the best land in the state, in the northwest. He first called this a case of market failure. Later he rationalized it, calling the Ozarks a land of "low efficiency but high capacity." Which Hammar was right? The jury is still out on interpretation, but not on the facts. This kind of

[2]"Technology" refers not just to applied new inventions, but to managerial organization and adaptation, and social organization, too. Some of it is high-tech, but a lot is just common sense. Some is low-tech but unexpected. For example, high turnover of capital is labor-using and capital-saving. See paper on "Baumol's Inventory Model."

imbalance between labor and land is most acute and obvious in Third World nations. These used to be called "less-developed," until that became PI. Many think this is why most of them are still less developed.