Multiple technologies in an input–output framework: the role of constrained primary resources

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To allow for 'multiple technologies' to produce a homogeneous output in input–output models, Duchin and Levine [(2011) Sectors may use multiple technologies simultaneously: the rectangular choice-of-technology model with binding factor constraints. Economic Systems Research, 23(3), 281-302] propose an optimization model constrained by primary resources. Sectors can use more than one technology to minimize total factors costs for a given exogenous final demand. In the initial situation production factors are in sufficient supply and sectors use only one technology. An additional technology, which is relatively more expensive, is activated as soon as a binding factor constraint is encountered.

In this paper we show that the Duchin-Levine model contains two different mechanisms by which multiple technologies can arise, both linked to different strands of economic theory. The different mechanisms are a consequence of the fact that factors can be used economy-wide, sector-wide or technology-specific.

If the factor in short supply is used economy-wide or sector-wide, the underlying mechanism is based on how efficient this factor is used. To be able to use this type of factor interchangeably in multiple technologies, the factor has to be homogeneous in the sense that an additional technology can readily replace an inefficient technology, where both use exactly the same factor. In fact, higher-cost technologies that are more efficient in resource use effectively push out inefficient lower-cost technologies. In such a case, scarcity rents are earned by all technologies that use the factor in short supply, relative to how intensively they use the factor. An example of multiple technologies with a sector-wide factor is the use of different irrigation techniques.

In contrast, if the factor in short supply is technology-specific, higher-cost technologies complement the original lowest-cost one, which stays active. The technology-specific factor cannot be used as input by an alternative technology even though it produces the same output. Therefore, a constraint on a technology-specific factor will only limit the use of the (single) technology that uses this factor. The original, lowest-cost technology will be used to produce output until it exactly exhausts the scarce factor, after which additionally required output will be produced by a higher-cost technology using a different primary factor. The rents that are generated by the scarce factor can be directly attributed to the technology-specific factor, or to the single related technology, in contrast to the distributed rents of economy-wide or sector-wide factors. An example of multiple technologies in case of technology-specific factors is the simultaneous use of different technologies to extract oil. Extracting oil from a Saudi Arabian field requires a distinctively different technology than extracting oil from deep sea oil fields.

The fact that a property of a factor has such large consequences for the prices of the produced commodities, the quantities produced by each technology and the earned rents, means that users of the model must carefully consider which property they wish to attribute to a factor.