International Factor Price Equalization in a limited-substitutability technology framework ☆

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Abstract

This paper generalizes the Heckscher–Ohlin trade theory summarized in Samuelson's [Samuelson, P.A., 1949, International Factor Price Equalization Once Again, The Economic Journal 59, 181–197.] calculus treatment to the domain of non-differentiable technologies characterized by discrete alternative Leontief–Sraffa techniques. Demonstrated here is how the close qualitative parallelisms between limited-substitutability technologies and neoclassical marginal-productivity models permit the validity of the theorems of international factor price equalization and their well-known extensions even when smooth marginal productivities cannot obtain.
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1. Introduction

By applying the limited-substitutability technology framework of Etula (in press), which was directed only at autonomous domestic economies, this paper constructs a two-good two-factor model, which generalizes the theorem of International Factor Price Equalization of Samuelson (1949) to the domain of discrete alternative Leontief–Sraffa techniques.[1] The analysis will demonstrate how the isomorphism between limited-substitutability models and continuum differentiable neoclassical technologies permits post-Sraffian technologies to handle the Heckscher–Ohlin trade theory in the same parallel qualitative manner as the conventional continuous neoclassical counterparts.

A number of recent Samuelson and Etula investigations established close qualitative parallelisms between neoclassical marginal-productivity technologies and limited-substitutability technologies of classical and post-Sraffian type. If the authors expected that post-Sraffians would see this as a certification of enhanced usefulness of Sraffian–Robinsonian analogies, initial irritations from some peer-reviewers corrected their naiveté.

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   [1] At the same time, the current analysis also generalizes Heckscher's (1919) seminal paper, which was the one that first introduced Heckscher-Ohlin-Samuelson Factor Price Equalization. Heckscher's original analysis did not involve neoclassical marginal productivities.

Table 1
Limited-substitutability technology

	Subtechnique	α_T	α_L	β_F	β_C
Food sector	a	3	2	1	0
	b	7	1	1	0
Clothing sector	A	1	5	0	1
	B	2	4	0	1

Subtechniques in the Food sector are denoted by lower-case letters and subtechniques in the Clothing sector are denoted by upper-case letters. Convexity is respected.

Concretely, Samuelson and Etula (2006a) had already exhaustively shown the general parallelisms for one-scalar-capital one-sector scenarios. The sequel in Etula (in press) had expanded the domain of proved qualitative parallelisms further by examining Thünen (1850)'s *two*-sector scalar-capital model.[2] That two-sector two-factor scenario, in its neoclassical Clark–Wicksteed–Ramsey–Solow mode, was seen to be patently isomorphic with the Heckscher–Ohlin–Samuelson factor price equalization structure; it was consequently suggested to me that I work out for the first time just how the pre-Ohlin and post-Ohlin results do still obtain, even when the Land and Labor (say) in the US and in the EU have only limited substitutability in producing Food and Clothing final goods.[3] That is, Samuelson (1949)'s use of calculus being ruled out, would it still be the case that trade in goods between countries could effectuate the same tendency toward the complete or partial equalization of absolute real wage and real land rents as free (or limited) migration of people between countries?[4]

The current task is to prove that under the conditions specified in the hypotheses of Samuelson (1949), free trade in goods can wipe out all divergencies in geographical factor prices: the US and the EU can evolve into complete factor price equality when their identical technologies are characterized by a finite number of discrete production subtechniques and when their Labor/Land endowment ratios are not *too far apart*. It suffices to focus here on the two-good two-factor specification where Food and Clothing are produced in separate sectors from Labor and Land inputs.[5] All the many post-1949 extensions to many goods and many factor inputs, hitherto established only for neoclassical differentiable production functions, will no doubt have their similar aping when technologies lack the ability to define $\frac{\partial\,\text{output}_i}{\partial\,\text{output}_j}$ Newtonian derivatives everywhere in the space.

2. Two countries, two commodities, two factors

The mainstream economics that Piero Sraffa and Joan Robinson deplored[6] could simply specify for the US and the EU, say,

$$Food = Land^{\frac{3}{4}} Labor^{\frac{1}{4}}, \quad Clothing = Land^{\frac{1}{4}} Labor^{\frac{3}{4}} \tag{1}$$

Here, à la the Leontief–Sraffa camp, we instead stick with a limited number of alternative ways to produce Food and Clothing: in both the US and the EU there are, say, a, b ways for Food production and A, B ways for Clothing production. Table 1 lists these subtechniques in each sector in the order of increasing Land intensities; by the hypothesis of Samuelson (1949), Food is relatively uniformly Land-intensive and Clothing is relatively Labor-intensive. In the Food sector, subtechnique a employs $\alpha_T^a = 3$ of land (T) and $\alpha_L^a = 2$ of labor (L) to produce $\beta_F^a = 1$ of Food (Q_F); in the Clothing sector, subtechnique A uses $\alpha_T^A = 1$ of land (T) and $\alpha_L^A = 5$ of labor (L) to produce $\beta_C^A = 1$ of Cloth (Q_C); and so forth for b and B subtechniques.

Let us assume that the US is especially Land-rich and the EU is especially Labor-rich. Say, the Labor/Land ratio of factor endowments in the US is $(\frac{L}{T})^{US} = \frac{3}{4}$ and the ratio of factor endowments in the EU is $(\frac{L}{T})^{EU} = \frac{4}{3}$. When only proportions matter, one can choose the scale of the countries without altering the qualitative results. For expositional purposes, the analysis in the current paper fixes the endowments in the US to $(T, L)^{US} = (4, 3)$ and in the EU to $(T, L)^{EU} = (3, 4)$.

[2] See also: Samuelson and Etula (2006b), Samuelson and Etula (2006c), Samuelson and Etula (in press).
[3] In the Specific Factors Model of Haberler–Jones–Samuelson similar isomorphism occurs but factor price equalization is at best only partial.
[4] Heckscher (1919), Ohlin (1933), Caves, Frankel and Jones (1999), McKenzie (1967).
[5] Caves and Jones (1973, pp. 138–161) obtain the parallel result for the Leontief case of single unique proportions for each commodity. The current analysis generalises their treatment to the domain of multiple alternative subtechniques in each sector.
[6] Sraffa (1960), Robinson (1956).