Reacting to Samuelson: Early Development Economics and the Factor-Price Equalization Theorem

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Abstract. Paul Samuelson's famous 1948 "factor price equalization theorem" was his main contribution to international trade theory. He demonstrated conditions under which trade in goods only would lead to full equalization of the remuneration of productive factors across countries. In practice, general factor-price equalization has not been a feature of the international economy, as Samuelson acknowledged. His theorem came out when development economics was starting to emerge as a new field of research and policy, largely based on the observed international income asymmetries between poor and rich countries. The paper investigates how development economists reacted mostly (but not always) critically to that theorem, with attention to the methodological issues involved and to Samuelson's own perception of the theorem's relevance.

Key words. Samuelson, factor-price equalization, development economics, trade theory

JEL codes. B20, B27, B30

Resumo. O famoso teorema de 1948 da "equalização dos preços dos fatores" de Paul Samuelson foi sua principal contribuição à teoria do comércio internacional. Ele demonstrou condições sob as quais o comércio de bens iria conduzir à plena equalização das remunerações dos fatores entre os países. Na prática, a equalização dos preços dos fatores não tem ocorrido em geral, como Samuelson reconheceu. O seu teorema veio à tona quando a economia do desenvolvimento estava começando a emergir como nova área de pesquisa e política, baseada largamente nas assimetrias internacionais de renda observadas. O trabalho investiga como economistas do desenvolvimento reagiram em geral (mas não sempre) de forma crítica àquele teorema, com atenção às questões metodológicas envolvidas e à própria percepção de Samuelson da relevância do seu teorema.

Palavras-chave. Samuelson, equalização dos preços dos fatores, economia do desenvolvimento, teoria do comércio internacional

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Área Anpec. Área 1

1. A devastating boomerang?

In 1948 Paul Samuelson put forward his seminal "Factor-Price Equalization" (FPE) theorem of international trade theory, further developed in Samuelson (1949, 1953-54). Together with another well-known theorem advanced in his 1941 joint article with Wolfgang Stolper – that the relatively abundant factor gains, and the relatively scarce factor loses, in both relative and absolute terms, when a country opens up to free trade – Samuelson's FPE theorem formally grafted the Heckscher-Ohlin trade model (sometimes called Heckscher-Ohlin-Samuelson) onto the general equilibrium analysis of the relation between commodity and factor prices, which had been only partially accomplished by Eli Heckscher ([1919] 1991) and Bertil Ohlin ([1924] 1991; 1933). Whereas the Stolper-Samuelson result was about the effects of trade on income distribution in a single country, the FPE theorem concerned the impact of trade on factor remunerations in different countries.

Samuelson showed that, for countries sharing the same (constant returns to scale) production functions and for given world demand conditions, free trade is sufficient to equalize factor remunerations across countries even if factors are internationally immobile, as long as the number of factors is not larger than the number of commodities and international differences in factor endowments are not large enough (in the sense that they lie in the same "cone of diversification") to cause specialization in one commodity only. Eventually, it became clear that those assumptions were also enough to produce the Heckscher-Ohlin factor-proportion model proposition that a country will export commodities that are intensive in the country's relatively abundant factor, and import commodities intensive in the country's scarce factor (see Chipman 1966, pp. 19-25; De Marchi 1976, pp. 110-12; Jones 1983, pp. 84-93; Niehans 1990, pp. 428-29). Samuelson's theorem of international convergence of factor prices (particularly wages) – and its implication that free trade ensures world Pareto optimality and maximization of production – went significantly beyond the classical (Ricardian) comparative advantages theory that trade would bring about mutual gains for all trading countries.[1]

Development economics, with its focus on international economic heterogeneity, emerged as a new economic sub-discipline in the post-war period, around the same time when Samuelson published his FPE articles (see Arndt 1987, chapter 3; Meier 2005, chapters 4 and 5; Perrotta 2016; Alacevich and Boianovsky 2018a; Alacevich 2018). According to Albert Hirschman ([1977] 1981, p. 60) – who was of course one of the prominent development pioneers (Hirschman 1958) – that was not just a coincidence: the widespread attention commanded by development economists' burgeoning explanations of international inequalities was elicited precisely by the apparent contradiction between Samuelson's "brilliant theoretical capstone of classical and neoclassical theory" of international trade and the increasing perception of acute widening income differences.

> While in Kuhn's scientific revolution sequence, the accumulating facts is supposed to gradually contradict the paradigm, here the theory contributed to the contradiction by resolutely walking away from the facts. As a result, Samuelson's findings – even though they have been put forward with all due warnings about the unrealistic and demanding nature of the assumptions on

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[1] Abba Lerner demonstrated factor-price equalization in a seminar paper presented at the LSE in 1933, but published only in 1952, under Lionel Robbins initiative, upon the publication of Samuelson (1948a).

which they rested – acted as a *devastating boomerang* for the traditional theory and its claim to usefulness in explaining the problems of the real world. (Hirschman [1977] 1981, p. 60; italics added)

Hirschman (ibid) ascribed the credibility of the less refined challenges advanced by Raul Prebisch (1950) and Hans Singer (1950) – based on the hypothesis of secular declining terms of trade of primary commodities exported by developing countries, called the "Prebisch-Singer thesis" – to the double fact that they tackled upfront the international asymmetry issue and to the "self-inflicted wound from which the classical theory was … suffering" after Samuelson's FPE articles.

Historians of development economics have endorsed Hirschman's claim (see e.g. Love 1980, p. 63; Streeten 1981, p. 102). However, as discussed in the present paper, the general picture is more complex and nuanced than suggested by Hirschman's suggestive but all too brief remarks. Prebisch and Singer, the authors mentioned by Hirschman, did not refer to Samuelson's FPE theorem – or to the Heckscher-Ohlin model for that matter – at the time.[2] Instead, they criticized the classical Ricardian approach to the international division of labor. Ragnar Nurkse (1961a, 1961b), another influential development economist, expressed his bewilderment at Samuelson's FPE proposition and, like Prebisch and Singer, took classical trade theory instead as his main target. Surely, the absence of explicit reactions – which may be regarded as a sort of reaction – to the FPE theorem by Prebisch, Singer and some other development economists (such as Arthur Lewis 1954, 1955) does not imply that they were unaware of it, but the reasons for they not referring to that theorem should be taken into account.

Explicit critical reactions to Samuelson (1948a, 1949), from the perspective of development economics, came from Thomas Balogh (1949) and, especially, Gunnar Myrdal (1957, chap. 11), who fits best Hirschman's claim. However, Gottfried Haberler and others disputed Myrdal's interpretation and criticism of the FPE theorem at the time. Both Balogh and Myrdal rejected the "static" equilibrium approach of Samuelson's trade model, and urged the adoption of "dynamic" formulations featuring increasing returns and cumulative causation. Their reactions reflected misgivings about the broader issue of formal modeling as a method of economic enquiry, of which Samuelson was a major representative at the time (see Morgan 2012). Development economics as a whole did not join the drive for formalization that dominated economics after World War II, in part because of the intrinsic difficulty of concepts such as multiple equilibria and coordination failures, deployed by early development economists.[3]

Development economists did not generally engage with the mathematical debates about the validity of Samuelson's proofs of the FPE theorem. Tinbergen (1949) was an exception, written before his path-breaking contributions to the theories of economic policy and development planning in the 1950s. He called attention to the problems posed by specialization After Samuelson (1953-54), the main theoretical issue involved in the FPE theorem turned out to be whether factor

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[2] It was only much later that Singer (1998, p. 23) would refer to the contradiction between the "assumption of a tendency towards global convergence implicit … in the Stolper-Samuelson [sic] thesis of an equalization of factor prices" and the empirical evidence.

[3] See Krugman (1993, p. 26), who contrasts Samuelson's mathematical formulation of the Heckscher-Ohlin model with the largely verbal approach of contemporary development economics.

prices are uniquely determined from goods prices in a general equilibrium world of many factors and goods (see Chipman 1966, pp. 25-35; De Marchi 1976, pp. 116-17). The formal theoretical concern with uniqueness was alien to development economists' overall preoccupation with the empirical implications of the theorem.

Interpreting Samuelson's (1948a, 1949, 1953-54) trade model was anything but straightforward. Samuelson was, of course, aware that his theorem was violated by conspicuous differences in observed international factor prices. Sections 10 and 11 of his 1948 article presented a discussion of the reasons behind persistent differences in wages and other factor prices even under free trade conditions. As he acknowledged, "I cannot pretend to present a balanced appraisal of the bearing of [the FPE theorem] upon interpreting the actual world, because my own mind is not made up on this question" (Samuelson 1949, p. 181). He seemed torn between the purely theoretical and pedagogical relevance of the theorem and its empirical validity.[4] Paul Rosenstein-Rodan's (1957, 1961), author in 1943 of a pivotal article often regarded as the founding analytical text of development economics (see Alacevich 2018), interpreted Samuelson's theorem as relevant for specifying the circumstances explaining the observed *absence* of international factor price equalization. That does not square with Hirschman's ([1977] 1981) thesis. At the time, Rosenstein-Rodan was Samuelson's colleague at MIT, where they interacted about development issues, which increases the likelihood that his reading of the theorem was relatively close to Samuelson's own meaning.

Samuelson was well informed about the booming literature on economic development, as witnessed by the new chapter about that topic (one of the first in an introductory textbook) and by his non-critical mention of Prebisch's terms-of-trade argument, introduced in the third and fourth editions respectively of his hugely successful *Economics* (Samuelson 1955, 1958). Indeed, Samuelson's new chapter placed him as part of the development economics landscape, even if he could not be called a development economist *per se* (see Boianovsky 2019a). Samuelson was affected by the general interest in economic development (and growth) that took the economic profession by storm in the 1950s and 1960s, which Hirschman overlooked. *Economics* is full of references to the widening gap between rich and poor countries, called "Two Worlds" in the book (Samuelson 1961, pp. 116-18). Interestingly enough, as pointed out by John Toye and Richard Toye (2003, p. 441), Samuelson asserted in the final pages of his 1948 article the empirical declining trend of the terms of trade of primary producers, shortly before its canonization by Prebisch and Singer.

Significantly, *Economics* contained, from the first edition, a subsection on "International commodity movements as a partial substitute for labor and factor movements" (Samuelson 1948b, p. 557), which presented Ohlin's ideas about the tendency to *partial* equalization of factor prices, with reference to his 1933 book. Puzzling enough, there was no mention of Samuelson's own theorem put forward that same year.

Samuelson's (and Lerner's) FPE theorem raised mixed reactions from trade economists. Gottfried Haberler ([1955] 1961), p. 19) – who had taught Samuelson trade theory at Harvard in the 1930s – concluded in his well-known survey that the

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[4] Samuelson (1948b, p. 8) insisted that "the test of a theory's validity is its usefulness in illuminating observed reality. Its logical elegance and fine-spun beauty are irrelevant. Consequently, when a student says, 'That's all right in theory but not in practice', he really means 'That's not all right in the relevant theory,' or else he is talking nonsense."

theorem, "though formally correct, rests on such restrictive and unrealistic assumptions that it can hardly be regarded as a valuable contribution to economic theory." Haberler's reaction is significant also because he was a development economist, although he belonged (together with Jacob Viner, Peter Bauer and Gerald Meier) to what was then the neoclassical minority view that opposed such notions as the Prebisch-Singer thesis, disguised unemployment and the role of market failures in explaining underdevelopment phenomena (see Little 1982, chapter 4). This indicates that Hirschman's ([1977] 1981) association between orthodox trade theory and the FPE theorem should not be taken at face value.

Some of the methodological issues involved in the interpretation of the FPE theorem came to the fore when Fritz Machlup (1964) used it as evidence against Samuelson's (1963) indictment of theories that deploy unrealistic assumptions, as in Milton Friedman's economic methodology. Unlike Haberler (and closer to Rosenstein-Rodan), Machlup, who was also a trade theorist, argued for the relevance of the FPE theorem as instrumental in showing how divergences between real economic conditions and the assumed ideal ones could account for actual factor-price differentials. Clearly, Samuelson's theorem offered distinct reading possibilities, not least by development economists. Such hermeneutic issues should not surprise historians of economics (see e.g. Brown 2003).

2. Samuelson vs. Ohlin on Factor-Price Equalization

In a Swedish article published in 1919 (translated in part in 1949 and in full in 1991) as part of a controversy with Knut Wicksell, Eli Heckscher had argued, but not proved, that factor-price equalization through trade would be complete under the assumption that (linear homogenous) production functions are the same across countries. International trade stemmed from differences in factor endowments, unlike the Ricardian version of comparative costs, which stressed instead relative differences in productive efficiency under the assumption of a single productive factor (labor). From the perspective of Ricardian trade theory, factor price equalization could only be the result of perfect international mobility of productive factors, but that would eliminate the reasons for trade altogether. David Ricardo's classical model led necessarily to specialization, instead of diversification as in Heckscher's neoclassical formulation. Heckscher, however, did not believe factor-price equalization was actually observed. The main reason was specialization à la Ricardo, caused by the high probability that factor proportions would be outside of (what is now called) the cone of diversification, so that no good is produced in both countries (Heckscher [1919] 1991, pp. 54-55, 58-59; Flam and Flanders 1991, pp. 8-10).

Ohlin ([1924] 1991; 1933) combined Heckscher's trade theory with Walrasian general equilibrium, which he had learned in Stockholm from Gustav Cassel, adding several new elements on the way. As a result of the shift towards enlarged production of those commodities in which the abundant factors predominate, trade will bring about an increase of the price of such factors and reduction of the price of the scarce factors in each country. Hence, there will be a tendency, deemed necessarily incomplete by Ohlin, towards an equalization of factor prices between trading countries. Commenting on Heckscher's suggestion of factor-price equalization, Ohlin (1933, p. 38) asserted that "such a result is, however, almost unthinkable and certainly highly improbable"; but, as Samuelson (1948a, pp. 167-69) pointed out, he did not produce a proof that equalization is necessarily partial. Despite Ohlin's mathematical appendix, formal modeling had not yet reached the dominance Samuelson would

achieve with his 1947 *Foundations* and many models he put forward before and after that, particularly in trade theory, his favorite subject. As put by Edward Leamer (2012, p. 53), a mathematician like Samuelson would never say that a theorem is "unthinkable" and "highly improbable". The mere statement of a theorem "makes it thinkable and whatever the theorem says, it is true, false, or not decided yet".

Samuelson (1948a, p. 169) set out to prove Ohlin's claim of partial FPE. Instead, to his own surprise, he established that factor-price equalization was not only "possible" and "probable" but in a wide variety of circumstances "inevitable" (ibid). Given the assumptions listed in section 1 above, and restricting the argument to two countries, two factors (labor and capital) and two goods, the first step in the demonstration is that trade, in the absence of transportation costs and tariffs, equalizes the relative prices of the two goods between the two countries. Second, in each country the marginal product of each factor in each industry depends only on the capital/labor ratio in that industry (because of the linear homogeneity assumption). Costs depend only on the relative amount of inputs, not on the scale of output. Third, factor intensities in each industry are determined by the relative prices of goods in each country, which implies that, since both countries have the same production functions, their factor intensities are the same in each industry, even if factor endowments are different. Finally, with the same factor intensities, the marginal productivity of each factor is also the same in both countries, which means that factor prices are equalized. If, under free trade, factor-prices were not equal, then costs and commodity prices could not be equal (Samuelson 1948a; see also Meade (1955, chapter 20; Haberler [1955] 1961, pp. 18-19; Niehans 1990, pp. 429-30).[5]

Ohlin had fallen into the "fallacy that *regions with divergent endowments could not without contradiction generate exactly equal factor returns*" (Samuelson 1991, p. ix; italics in the original). However, in his 1941 article with Stolper, Samuelson still endorsed Ohlin's argument about partial equalization and went as far as making the fallacious point that "It is clear that equalization is only partial because otherwise we would be involved in the contradiction that differences in comparative cost would disappear, and there would be no trade" (Stolper and Samuelson 1941, p. 59). In fact, the Stolper-Samuelson theorem was derived as a direct extension of the Heckscher-Ohlin original concern with the effects of trade on distribution. Ohlin (1967, pp. 27, 310) accepted Samuelson's "penetrating" analysis of the conditions under which complete equalization occurs, but warned against excessive emphasis on the factor proportions (Heckscher-Ohlin) model as compared to the investigation of the influence of practical matters such as the roles of transportation costs and taxation in trade.

Samuelson's language changed between the Stolper-Samuelson and the FPE theorems. The proof of the Stolper-Samuelson was essentially verbal, with some help from graphs. The mathematical proof of factor-price equalization increased in complexity throughout Samuelson's three original articles on the topic (see Leamer

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[5] Samuelson (1953-54) later extended the demonstration to *n* goods*, n* countries and *n* factors, establishing in the process the general "mapping" proposition that to a given set of commodity prices there corresponds a certain set of factor prices, which raised criticism and further mathematical proofs from H. Kuhn, D. Gale, H. Nikaido, L. McKenzie and I. Pearce, among others (see Chipman 1966, pp. 29-31, Takayama 1972, chap. 18). Haberler ([1959] 1985, p. 507) referred to that literature as a "highly esoteric disputation," an opinion probably shared by (other) development economists at the time.

2012, pp. 54-60). In 1949 he took into account the possibility of factor-intensities reversals and their implication for multiple equilibria and for the relationship between factor prices and commodity prices, which would prevent factor-price equalization, as Lerner had pointed out in 1933 (Samuelson 1949, p. 188; Jones 1983, pp. 88-89). The controversial character of the FPE theorem persisted, nevertheless. As Samuelson (undated, p. A3) recalled, "the theorem is in the fascinating range of being almost, but not quite, obvious. My first exposition was evidently a provocative one; it certainly evoked an explosion of discussion, and a tempest of refutations and doubts".[6] That was not true of the Stolper-Samuelson theorem, which from the beginning was far less polemical. The same may be said of Ohlin's argument about partial factor-price equalization, often regarded as more general than Samuelson's 1948 theorem.

Haberler's ([1955] 1961, p. 18) verdict – that the assumptions behind the FPE theorem are so unrealistic that it can be said to prove the opposite of what it seems to intend, "namely that there is no chance whatsoever that factor prices will ever be equalized by free commodity trade" – proved to be influential. Instead, Ohlin's "more modest and somewhat imprecise contention", of a tendency to partial factor-price equalization, seemed to be a valid empirical proposition (Haberler [1955] 1961, p. 19).[7] That illustrated, from Haberler's (ibid) perspective, the trade-off between uncertain and approximate results based on realistic general assumptions on one side, and precise and unambiguous conclusions generated by highly specific assumptions on the other. Leamer would come close to Haberler's assessment years later: "Ohlin was suggesting something useful, not necessarily valid; Samuelson was offering something valid, not necessarily useful" (Leamer 2012, p. 50).

Samuelson's (1948b, p. 557) mention of Ohlin's (1933) partial equalization, instead of referring to his own theorem of complete equalization, suggests that he shared the view about the generality of Ohlin's proposition. It might also reflect the fact that he was not willing to discuss, in an introductory textbook, the assumptions behind the FPE theorem. According to Samuelson, Ohlin made an important addition to the classical doctrine of comparative costs:

> Free movements of labor and capital between countries will tend to equalize wages and factor prices between countries. *However, even without any movements of productive factors across national boundaries, there will result a partial (but not necessarily complete) equalization of factor prices from the free movements of goods in international trade.* (Samuelson 1948b, p. 557; italics in the original)

Samuelson (ibid) emphasized the implications of the "Ohlin proposition" for the impact of free trade on income distribution, along the lines of the Stolper-Samuelson 1941 theorem, which he mentioned on p. 565. The fact that free trade acted as partial substitute for the immigration of labor into the United States meant that labor scarcity in that country would be alleviated by increasing production and exports of labor-saving goods – aggregate output would go up, but the relative and

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[6] Balassa (1961) produced a first survey of the literature.

[7] Charles Kindleberger (1968, p. 33), Samuelson's colleague at MIT, deemed the FPE theorem an "intellectual curiosity," whereas the trend toward partial equalization was considered a "significant" proposition for the "real world". James Meade (1955, chapters 20-23 and appendixes 6 and 7) provided a first detailed verbal, mathematical and arithmetical discussion of the theorem (from the perspective of welfare economics), with the conclusion that maximization of world production would require international movement of production factors.

absolute share of workers in income would decline (Samuelson 1958b, pp. 564-65). The subsection on Ohlin was kept until the joint edition with William Nordhaus in 1985, when it was removed. In the 4th edition (1958), Samuelson deleted the word "partial" from the subsection title, but kept the wording of the relevant passage quoted above. That was changed in the 9th edition, when he mentioned a "tendency toward equalization of factor-prices" (Samuelson 1973, p. 690) without the qualification "partial (not necessarily complete)". Despite moving closer to his own FPE theorem, Samuelson, throughout successive editions of *Economics*, referred only to Ohlin (1933) in that connection. Surely, factor-price complete equalization was incompatible with lack of international convergence of income per capita discussed elsewhere in that book (see, e.g., Samuelson 1961, pp. 117, 778).

Upon proving his FPE theorem, Samuelson (1948a, p. 178) asked whether he had not "proved too much", since factor-prices differentials had persisted even in periods when trade was relatively free, as between the last quarter of the 19th century and the first decade of the 20th. In order to account for such persistence, Samuelson pointed to the problematic realism of three assumptions. The first was the absence of transportation costs. Second, factor-price equalization would be prevented by complete specialization provoked by huge differences in factor endowments or by use of productive factors in the same proportion in different commodities. Finally, and most importantly from Samuelson's (1948a, p. 181) perspective, Ohlin's proportions-of-the-factors trade theory suffered from some fundamental shortcomings, as it was based on two debatable assumptions: (i) production functions are the same all over the world and (ii) productive factors are homogenous and commensurable across countries. Ohlin thought it self-evident that the production function should be the same in every country, since the same causes everywhere produce the same effects, which he called the "laws of nature" (see also Haberler [1955] 1961, p. 19, n. 6). Samuelson disagreed.

> The laws of nature may be the same "everywhere," but the laws of nature and the economically relevant production function, relating maximum output obtainable from specified concrete inputs, are two quite different things. Effective knowledge ("know-how") is probably as important a variable in understanding economic history and geography as is specific factor endowment … The "effective organization" is different. (Samuelson 1948a, p. 181)

Differences in productivity among countries, for the same amount of productive factors, could not be accounted by assuming that "knowledge" is "scarce" in one country relative to another. The factor of "technical knowledge" should be regarded as an input in the production process, but with its peculiarities, Samuelson claimed: "knowledge is *not* an input such that the more you use of it, the less there is left" (Samuelson 1948a, p. 181). This pointed to the specificity of knowledge (or "ideas") as non-rivalrous economic goods, leading to increasing returns. Samuelson left it at that. The issue would become central to models of endogenous technical progress and growth developed by Paul Romer and others in the 1980s and 1990s (see Boianovsky and Hoover 2014).

3. Development, trade and international divergence

3.1 Rosenstein-Rodan, Nurkse and balanced growth

Samuelson's (1948a, 1949) discussion of factor-price equalization and the reasons for persistent divergence across countries caught Rosenstein-Rodan's (1957, 1961) attention in his contribution to the first ever international conference on economic development, held by the International Economic Association in Rio in 1957. Rosenstein- Rodan was a member of the MIT Center for International Studies (CENIS), a foremost research center on economic development, which circulated his conference paper (Rosenstein-Rodan 1957; see also Boianovsky and Hoover 2014). The paper was probably read by Samuelson, who referred often in his *Economics* to Rosenstein-Rodan's influential argument about the role of external economies, indivisibilities and increasing returns in explaining underdevelopment, as well as the balanced growth and big push development strategies (see Boianovsky 2019a). Apart from his research activities at CENIS, Rosenstein-Rodan taught development economics at the MIT economics department. According to the reading lists of courses on "Economic Development" at some of the main American economics departments (MIT, Harvard, Chicago, Columbia and Yale), collected as "Readings in Economic Development" in the *American Economist* in 1963, Samuelson (1948a, 1949) figured only in the bibliography for the MIT development course (of course, those articles were listed in the bibliographies for international trade courses nearly everywhere).

Rosenstein-Rodan (1961, pp. 63-65) discussed whether the international market could solve the problems of complementarity and indivisility of demand in closed developing economies, and by that obviate the need for a minimum quantum of investment to get such economies out of their low level equilibrium trap. He argued that the international mobility of products was an imperfect substitute for the mobility of factors. Trade reduced, but did not eliminate, the size of the minimum push required. The argument was based on Samuelson (1948a, sections 10 and 11), to which Rosenstein-Rodan referred while discussing the three reasons for persistent inequality given by Samuelson. The great expansion of the world market in the 19th century did not brought about equalization or even reduction in price-factor inequalities. The reasons were not transport costs or complete specialization. Transport costs had been sharply reduced up to mid twentieth century, and partial specialization become increasingly important. "Therefore," argued Rosenstein-Rodan (p. 64), "the main explanation of why this tendency to a growing equalization of factor rewards did not materialize – why, in fact, labor rewards tended to become more unequal – must rest on the assumption that production functions are different in various parts of the world." That was, of course, Samuelson's own explanation of the observed divergence. Rosenstein-Rodan quoted Samuelson's remarks about the character of "knowledge" as an input, and noticed its role as a major source of increasing returns.[8]

From a methodological perspective, Rosenstein-Rodan's reading of Samuelson's FPE theorem was relatively close to Machlup's (1964) later interpretation, although in a different context. Machlup was critical of Samuelson's (1947, 1963) claims that economists should restrict themselves to "operationally

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[8] External economies also explained why, despite lower wages in underdeveloped countries, foreign investment in those areas had not been big enough to reduce the international inequality of factor rewards (Rosenstein-Rodan 1961, pp. 66-67).

meaningful theorems" and avoid using "unrealistic" assumptions as in Friedman's *as if* methodology, called "F-twist" by Samuelson (1963) (see also Blaug 1980, pp. 99-103, 113, 213, and Caldwell 1982, pp. 189-95, who both side with Machlup's counter-criticism). According to Machlup (1964; see also Machlup 1978, p. 455), Samuelson's formulation of the FPE theorem showed that he often did not practice operationalism and was in fact close to Friedman's version of falsificationism. That theorem, Machlup pointed out, is deduced from a large set of abstract, unrealistic assumptions, some of which are patently counterfactual. Machlup noticed how Samuelson (1948a, sections 10 and 11; 1949, pp. 196-97) introduced several "qualifications" to reconcile the abstract analysis with the observed absence of equalization.

> These "qualifications" to the theorem furnish Samuelson with the "causes" of the factor-price diversities. In other words, he does not hesitate, quite rightly in my view, to explain the observed facts of life – factor-price differentials – by divergences of real conditions from the ideal ones which form the basis of the factor-price equalization theorem … Samuelson … produces his best work when he deduces from unrealistic assumptions general theoretical propositions which help us to interpret some of the empirical observations of the complex situations (Machlup 1964, p. 735)

Machlup's assessment of Samuelson's FPE theorem was quite distinct from Haberler's ([1955] 1961), who claimed that its unrealistic assumptions and the conflict between its predictions and the data rendered it largely useless. That reflected their different methodological standpoints, as Haberler was closer to T. Hutchison's approach, called "ultra-empiricist" by Machlup (see Blaug 1980, pp. 96-97; Boianovsky 2000).[9]

> Nurkse's (1961a) comments on Rosenstein-Rodan's Rio paper illustrated the general resistance among trade and development economists alike in replacing classical (Ricardian) trade theory for Samuelson's new theoretical framework. Ricardian comparative advantage was a "static doctrine, showing how, under given conditions, output and welfare can be maximized" (Nurkse 1961a, p. 77). Persistent and even widening differences in real wages and income per capita levels, in spite of international trade, was not incompatible with the classical trade model (see also Haberler [1955] 1961, p. 17). In this sense, Samuelson's (1948a, 1949) FPE theorem, built on a "special set of carefully selected assumptions," represented, from Nurkse's point of view, not so much a refinement of but a break with the classical paradigm. His difficulty to come to terms with Samuelson's analysis is clear.

> I should be grateful for further instructions on this point, but my impression is that international income differences are a modern obsession. At any rate by nineteenth-century classics (of whom Samuelson is not one) trade was supposed to *raise* income levels in all countries. Was anything said about its tending to *equalize* incomes as well? (Nurkse 1961a, p. 78; italics in the original)

Static classical (and, for that matter, Heckscher-Ohlin) trade analysis did not go a long way illuminating the process of economic development and growth. Dynamic economics – as defined by Roy Harrod, cited by Nurkse (1961b, p. 252) in that

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[9] Haberler, Machlup and Rosenstein-Rodan were colleagues at the University of Vienna in the early 1920s. Rosenstein-Rodan's first articles reflected his Austrian background, which is also noticeable in some aspects of his contributions to development economics.

connection – involved rates of change, as in the case of the values of price and income elasticities of demand for primary commodities abroad in a growing international economy. If world demand for those commodities should fail to expand at the same pace as the rate of growth of income in advanced countries, Rosenstein-Rodan's complementarity of consumers' wants argument becomes relevant as a basis for the balanced growth strategy of home market expansion (Nurkse 1961a, p. 77; 1961b, pp. 250-52).

3.2 Myrdal, Balogh and dynamics

Instead of Nurkse's discontinuity between classical and neoclassical (Samuelsonian) trade theory, Myrdal (1957, chapter 11) – in a book that attracted wide attention, even more so because Myrdal was then ending his term as Executive Secretary of the United Nations Economic Commission for Europe – stressed continuity. A prominent Swedish economist, contemporary of both Heckscher and Ohlin, he was familiar with and critical of their trade model, which he saw as faithful to the heritage of classical trade doctrine and its system of static assumptions, *laissez-faire* bias and harmony of interest (Myrdal 1957, p. 151; see also Myrdal [1932] 1953). Myrdal perceived Samuelson (1948a) as the culmination of a trend of thought started by the classical doctrine, with its "implicit" notion that trade contributed to a tendency towards partial and gradual factor-prices equalization.[10] The notion of trade as a substitute for, or an alternative to, factor movements became explicit in the Heckscher-Ohlin model (ibid, p. 148). "Upon this foundation", Myrdal (pp. 148-49) reported, a lively discussion took place in the post-war years between "econometricians", ignited by Samuelson's FPE theorem, which he cited.

> We thus see the strange thing that in recent decades, while international income inequalities have been growing and recently also become of more and more pressing practical concern in international politics, the theory of international trade has developed in the direction of stressing more and more the idea that trade initiates a tendency toward a gradual equalization of factor prices and incomes as between different countries … This discord between facts and theory has not generally been stressed. (Myrdal 1957, pp. 149, 154)[11]

This is close to Hirschman's ([1977] 1981) claim, quoted in section 1 above, although he did not refer to Myrdal in that connection. Myrdal took Samuelson's FPE theorem at is face value, without discussing the nature of the assumptions and, consequently, Samuelson's own misgivings about factor-price equalization in practice, which raised criticism from Haberler ([1955] 1961, p. 18) and Gerald Meier (1958, p. 284) that Myrdal had misread Samuelson.

Myrdal's main criticism was that trade theory in general – and the FPE theorem in particular – did not address the main feature of the international economy,

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[10] Haberler ([1955] 1961, p. 17; [1959] 1985, pp. 506-07)) took Myrdal to task for his interpretation and criticism of classical trade theory in that regard. "What classical theory really teaches us," he claimed, "is that trade will benefit every country, rich and poor, but not that mere trade will necessarily remove or even reduce international inequality" (Haberler [1959] 1985, p. 507).

[11] Myrdal, like Nurkse and other development economists, tended to treat factor-price equalization and income per capita convergence as the same or very close phenomena. Factor-price equalization will indeed tend to induce income convergence, but actual convergence will depend also on factor quantities and their distribution (see Slaughter 1997).

that is, inequality between developed and underdeveloped countries. He ascribed that to the overall concern with static equilibrium and disregard for circular cumulative disequilibrium processes that could explain increasing international disparity, caused by strong "backwash effects" and weak "spread effects" in poor countries (Myrdal 1957, chapters 5 and 11). Myrdal's claim that trade not just did not lead to equalization but contributed to increasing international differences was challenged by Meier (1958, p. 284; 1963, pp. 163-64) and Balassa (1961, p. 120), who both charged him for mixing up static and dynamic issues. Instead of claiming that trade is the cause of international inequality, it would be more appropriate to conclude, argued Meier, that actual conditions had deviated from the optimum conditions assumed in the FPE theorem. Accordingly, Myrdal's policy conclusion of protectionism did not follow, but rather the conclusion that it was necessary to remove domestic market imperfections and obstacles to international factor mobility, so that the trend to factor-price equalization was intensified. Only by "misinterpreting the factor-price equalization theorem, and by ignoring all the other dynamic benefits of trade, can the absence of equal factor prices be constructed as indicating that trade makes no contribution to development," Meier (1963, p. 165) contended.[12]

Even though Myrdal (1957) was the best-known critical reaction to the FPE theorem by a development economist at the time, the first thorough account came from another heterodox economist interested in economic development, the Oxford émigré Hungarian economist Thomas Balogh (1949). Balogh's immediate reaction to and familiarity with Samuelson's work may be in part explained by the fact that they both had contributed chapters about the post-war "dollar shortage" problem, featured in Seymour Harris's (1948) well-known collection. He was aware that Samuelson (1948a) was representative of the new role of abstract theoretical models in economic reasoning (Balogh 1949, pp. 191-92). However, from Balogh's standpoint, models are as good as the assumption they make. Samuelson's "great merit" was to bring to light the assumptions necessary to engender the factor-price equalization result, as well as the unrealistic character of many of them. Balogh's first impression was that Samuelson's (1948a) goal was to produce a damaging *reductio ad absurdum* of the assumptions that underlie Heckscher-Ohlin trade theory. However, closer reading indicated that Samuelson retained "considerable tenderness for the assumptions which lead to such strange conclusions; nor do the conclusions seem so strange to him as they do to others" (Balogh 1949, p. 193).

Like Myrdal (1957), Balogh focused his criticism on Samuelson's concern with static equilibrium, instead of dynamic processes associated with increasing returns to scale, endogenous capital supply and economic interaction between countries of different levels of development. It should be noted – although Balogh did not mention it – that Ohlin (1933) had discussed increasing returns and elastic (instead of given) factor supplies and their implications for the pattern of trade and factor-price equalization. According to Ohlin (1933, p. 124), factor "supply reactions", as the remuneration of the abundant factor rises, "tend to offset the price-equalizing tendencies of trade", because of increasing specialization caused by ensuing higher disparity in factor supplies (see also Stiglitz 1970). Samuelson (1949b, pp. 195-96) was aware of Ohlin's remarks about the relevance of increasing returns for trade and international disparities, but it was not clear how to formalize those effects, mainly

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[12] However, according to modern trade theory (see Leamer 2012, p. 76), if countries before trade have significant technological differences, then trade can *cause* divergences in factor prices, which vindicates aspects of Myrdal's contention.

because of the problem of modeling imperfectly competitive market structures.[13] Balogh (1949, p. 198) did not formalize either, but praised Samuelson's "brilliant mathematical feat" for setting out the basis of static modern trade theory and clearing the way for a "new dynamic approach to this essentially dynamic problem".

3.3 Lewis, CEPAL and the terms of trade

Arthur Lewis (1954), who based his seminal model of development in closed dual economies on classical economic foundations, made clear that a new framework was necessary for the study of development in open economies. He moved away from both Ricardian and Heckscher-Ohlin static trade models – although he preferred the classical version of comparative advantages, with its emphasis on relative differences in productive efficiency among countries. Lewis's (1954, section on "The open economy") model of terms of trade between underdeveloped and underdeveloped economies – specialized in the exports of "tropical" primary commodities and manufactured goods respectively – assumed that wages in the former are determined by a perfectly elastic labor supply and by average productivity in the production of food (see Boianovsly 2019b, pp. 127-31, and references there cited). Falling terms of trade followed from the lower productivity of the food sector in relatively poor countries. That was quite different from Samuelson's FPE theorem, which Lewis did not mention.

Prebisch (1950, 1959) – Executive Secretary of the United Nations Economic Commission for Latin America (CEPAL) from 1950 to 1962 and Secretary General of the United Nations Conference on Trade and Development (UNCTAD) from 1963 to 1969 – was also concerned with falling terms of trade as determinants of the growth dynamics of open underdeveloped economies. Like Lewis, he did not refer to Samuelson (1948a). In his 1956 essay about the "Evolution of economic thought in the last quarter century and its influence in Latin America", CEPAL economist Juan Noyola referred to Samuelson's chapter about the "dollar shortage" in Harris (1948), but not to Samuelson's FPE article. Ricardian comparative advantages still stood out as the standard trade theory against which CEPAL's arguments about the unequal division of gains from trade between the underdeveloped "periphery" and industrialized "center" were raised (Noyola 1956, pp. 276-77). It was only as late as 1977 that Samuelson's FPE theorem was discussed in any detail in a CEPAL publication (Cardoso 1977, pp. 9-11) – by apparent coincidence, in the same year when Hirschman's argument about Samuelson's FPE theorem and the history of development economics came out.

Fernando H. Cardoso (1977, pp. 10-11) – co-author of the "theory of dependence", with strong links with CEPAL – noted, with reference to Haberler ([1955] 1961), that the FPE theorem was not a product of Ricardian trade theory, but of Samuelson's (1948a) "more extreme (and weaker)" assumptions, which he "no longer maintained in later articles." In any event, Prebisch's staring-point was not the neoclassical Heckscher-Ohlin-Samuelson theory of trade, but classical comparative advantages theory (Cardoso, p. 12). According to Prebisch's (1950, p. 1) reading, classical theory asserted that the benefits of technical progress tend to be evenly distributed over the whole international economy, either by reduction of prices or

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[13] It was only in the 1980s and 1990s that Paul Krugman and others devised models of international trade under increasing returns and imperfect competition (see Maneschi 1998, chap. 9 on "The Heckscher-Ohlin Theory encounters the New Trade Theory").

increase of incomes. Hence, producers of primary commodities would benefit from Ricardian international division of labor, with no need to industrialize in order to have access to manufactured goods. Contrary to the predictions of classical economics, though, data indicated that the terms of trade of primary goods had deteriorated since mid 19th century. Whereas productivity advances had led to factor-price increases (with constant commodity prices) in the industrial "center", relative prices of primary commodity had declined in the "periphery", largely due to rural disguised unemployment and elastic labor supply throughout the business cycle.

Prebisch (1950, p. 16; 1959, p. 269) claimed that a process of factor-price and income equalization would take place only if the "classical" assumptions of free mobility of factors (especially labor) were valid. But there were great obstacles to labor migration from the periphery to the center.

> Since prices do not keep pace with productivity … another solution has been found by the classical theory. If the advantages of technique were not passed on through prices, they would be extended to the same degree by the raising of income … This is what happened in the United States as well as in the other industrial centers. It did not, however, occur in the rest of the world. It would have required throughout the world the same mobility of factors of production … as in the internal economy of the United States. In fact … a series of obstacles hampered the easy [international] movement of productive factors … Thus the observation of one of the essential rules of the classical game would have resulted in a considerable lowering of the standard of living of the United States … But the classic rules of the game form an indivisible whole. (Prebisch 1950, p. 16)

Surely, Prebisch's interpretation of the "classical" process of income equalization as grounded on labor mobility did not take into account Samuelson's theorem that under certain conditions free trade of goods is a complete substitute for factor movements. Moreover, Prebisch assumed complete specialization, which is incompatible with that theorem (see also Boianovsky and Solís 2014).[14]

By 1967, Celso Furtado – who had served as head of CEPAL's development division from 1950 to 1957 – provided in his economic development textbook, written for his classes at Sorbonne University, an account of Samuelson's FPE theorem. Furtado (1985, p. 225) probably learned of FPE while attending Meade's classes in Cambridge in 1957-58. Modern trade theory was perceived as just an aspect of static general equilibrium theory (Furtado, 1967, chapter 15; cf. De Marchi 1976 and Blaug 1980 chap. 11 for a similar assessment). The Heckscher-Ohlin-Samuelson paradigm had led to a "double optimist thesis": international trade was an element of transmission of "dynamic impulses" that tended to equalize factor prices across countries. However, due to the operation of Engel's Law (stressed by H.W. Singer) and other influences, trade had caused instead income concentration in favor of industrialized countries through the deterioration of terms of trade (Furtado 1967, pp. 180-82). Furtado's distinction between static trade theory and dynamic international divergence was close to Myrdal (1957), which he mentioned in that regard.

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[14] Flanders's (1964, p. 310) interpretation that Prebisch assumed FPE in his argument about falling terms of trade is inaccurate.

4. Samuelson's vindication

In his contribution to the Haberler *Festschrift*, possibly as a reaction to Haberler's (and others') criticism, Samuelson (1965, pp. 45-46) distinguished between "global" and "local" FPE theorems. Even if the actual world does not display a single pattern of factor prices, trade may still equalize factor prices for distinct sets of countries belonging in the same cone of diversification, that is, with similar factor endowments. Unlike the "global" theorem, Samuelson claimed that its "local" version was formally and empirically more accurate. Hence, trade would equalize factor prices for a set of countries formed by Australia, New Zealand, Canada and the United States, and for labor-rich countries such as China, India, Pakistan, and so forth.

He added a twist to the argument in one of his last (and most controversial) articles. Samuelson (2004) came back to his FPE theorem, now from the point of view of American international trade performance in connection with outsourcing, international competition and their effects on employment and real wages. He argued that if China or South Korea made technical progress (probably through imitation) in producing goods in which the US previously had comparative advantage, this would cause a permanent decline in real wages in the US, especially of unskilled workers. The result would be the same if mass immigration to the US of similar workers were allowed, accompanied by a substantial increase in income of the new immigrants as compared to their previous income before immigration. The apparent ability of Samuelson's theoretical result to explain observed facts in the early 21st century, he claimed, vindicated his FPE theorem advanced in 1948/1949.

> Therefore, as a result of my 1948-1949 revival and perfecting of the 1919-1933 Heckscher-Ohlin argumentation of *factor price quasi-equalization by trade in goods alone*, one could have foreseen the following at World War II's end. Historically U.S. workers used to have a *de facto* monopoly access to superlative capitals and know-hows…of the United States … However, after World War II, this U.S. capital and know-how begun to spread faster away from the United States. That meant that in a real sense foreign educable masses – first in Western Europe, then throughout the Pacific Rim – could and did genuinely provide the same kind of competitive pressures on U.S. lower middle class wage earnings that mass migration would have threatened to do (Samuelson 2004, p. 144; italics in original).

Samuelson's argument was that, to the extent that American technology spreads to other countries, the assumption of identical production functions – which he had criticized in 1948 and 1949 – becomes reasonable and so does the FPE theorem. His point about trade as a substitute for migration may be found as well in his 1948 article and in his 1964 reply to Machlup. Indeed, writing before the Marshall Plan, the "practical moral" he took from his theorem concerned the dubious wisdom of large-scale migration to Canada or Australia from Great Britain, a densely populated country that in the post-war period was suffering from loss of overseas investment income, "high food prices and adverse terms of trade" (Samuelson 1948a, p. 183). Widespread emigration was not the way out, since, "despite numerous qualifications", the core point of his article was that "relatively free commodity trade was a better substitute for mobility of factors of production that was hitherto thought to be the case." Such "strong polar case", he claimed, should shed some light on reality (Samuelson 1964, p. 737). British migration on large scale to work on food production abroad was not advisable even if the "abnormally favorable" agricultural terms of trade persisted. Moreover, he was skeptical that "this abnormal trend of the

terms of trade, counter to historical drift, will continue" (ibid, p. 184).[15]

Samuelson's mention of declining agricultural terms of trade as part of his application of the FPE theorem to a specific case indicates that he did not see them as incompatible with one another, but as standing on different levels of analyses. Samuelson (1955: 682-683) had given qualified support to protectionist industrialization policies based on the Prebisch-Singer influential thesis of falling terms of trade against agricultural goods exported by Latin American countries. According to Samuelson (ibid; italics in original), Prebisch's point was "really an argument about what will be the *future* comparative advantage of the countries in question. To the degree that governments are smarter than private investors in discerning trends threatening to the terms of trade, a valid case can be made for their interfering with free market forces."

A main difference between Samuelson's (1948a, 1949) general equilibrium international trade theory and trade models put forward by development economists, as discussed above, was the assumption about labor supply and wage determination. As put by Edmar Bacha (1978: 319) in his restatement of Prebisch's unequal exchange thesis in a Ricardian model of international trade with surplus labor and specialization, trade under these conditions is unequal to poor countries in the normative sense that "its terms of trade are lower then they would be under a Pareto-efficient trade arrangement allowing for perfect international labor mobility." Samuelson (1981) would eventually acknowledge the effects of low wages on the terms of trade and unequal economic development. As part of an exercise in the forecasting of economic development trends, he stated that, only after underdeveloped countries experienced their "industrial revolutions" and demographic transitions,

> Only then will the affluent nations stand to lose some of the historic consumer surplus that they have enjoyed from international trade – trade that has historically involved imports of fiber, food, and ores produced in the tropics by low-wage populations … If that happy day comes when South-east Asia, Africa and Latin America afford a comfortable middle class standard of living to their stabilized populations, we should be content to depend upon mechanized mines and farms for our needed raw materials, uncomplainingly paying the necessary costs for the goods we need (Samuelson 1981, p. 412).

That "happy day" eventually came to some parts of the underdeveloped world, as Samuelson (2004) would claim.

The view that Samuelson's FPE theorem does not hold across countries, and that its relevance comes from testing the various reasons why it does not hold – despite Samuelson's vindication in some circumstances – gained increasingly assent from trade theorists and econometricians (see e.g. Kemp 1964, p. 45; Leamer and Levinsohn 1995, pp. 1536-37; Baldwin 2008, chapter 5). This is close to Rosenstein-Rodan's (1957, 1961) interpretation and to Machlup's (1964) methodological assessment. The reactions to and the consequences of Samuelson's 1948 theorem proved to be more complex and diversified than Hirschman ([1977] 1981) suggested.

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[15] Samuelson's source was probably Kindleberger (1943), who had argued forcefully that data pointed to secular declining terms of trade of primary commodities. Samuelson contributed a chapter to that same volume in which Kindleberger's essay came out.

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