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**Article**

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# Why did Wicksell change his mind about the machinery question?☆

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## Abstract

The article investigates Wicksell's change of mind about the machinery question between 1890 and 1900/1901. Wicksell at first sided with the so-called "compensation theory" that workers are not harmed by the introduction of machinery. In his lecture notes of April 1900, made available here for the first time, Wicksell deployed marginal productivity theory to discuss the effects of labour-saving technical progress, with inconclusive results. Finally, in his published 1901 *Lectures* and in his 1900 article about marginal productivity, Wicksell claimed that the introduction of machinery increases output and reduces wages. His analysis was based on the demonstration that free competition maximizes output, but not total utility. It is argued that Wicksell's change of mind and his mature formulation of the machinery question result from his critical assessment of the then new concept of Pareto optimality, together with his reinterpretation and rejection of Ricardo's (1821) contention that the introduction of machinery may diminish output and employment.

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*Keywords:* Wicksell; Machinery question; Ricardo; Free competition; Pareto optimality

## Resumo

O artigo investiga a mudança de opinião de Wicksell sobre a questão da maquinaria entre 1890 e 1900/1901. Wicksell inicialmente se aliou à "teoria da compensação" de que os trabalhadores não são prejudicados pela introdução de maquinaria. Em suas notas de aula de abril de 1900, tornadas disponíveis aqui pela primeira vez, Wicksell empregou a teoria da produtividade marginal para tratar dos efeitos do progresso técnico poupador de trabalho, com resultados inconclusivos. Finalmente, em suas *Lectures* de 1901, Wicksell argumentou que a introdução de maquinaria aumenta o produto e diminui salários. Sua análise se baseou na demonstração de que a livre concorrência maximiza o produto, mas não a utilidade total. O artigo mostra que a mudança de opinião de Wicksell e sua formulação madura da questão da maquinaria resultaram de sua avaliação crítica do então novo conceito de ótimo de Pareto,

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juntamente com sua reinterpretação e rejeição do ponto de Ricardo (1821) de que a introdução de maquinaria pode diminuir produto e emprego.

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*Palavras chave:* Wicksell; questão da maquinaria; Ricardo; livre concorrência; ótimo de Pareto

## 1. Prologue: from Ricardo's machinery to Pareto's optimum

The question of machinery's benefit or harm to workers was extensively discussed by classical economists living through the Industrial Revolution, especially after the publication of [Ricardo's \(1951 \[1821\], chapter 31\)](#) new chapter "On Machinery" in the third edition of his *Principles*. The "machinery question" ([Berg, 1980](#)) caught also Karl Marx's attention, until it receded into the background during the neoclassical era. It came to the foreground again in the interwar period, when the impact of technological change on employment and wages became an important topic of debate ([Gourvitch, 1966\[1940\]](#); [Woirol, 2006](#)). Part of the interwar literature was influenced by or reacted to [Wicksell's \(1958 \[1900\], 1934 \[1901,1911\], 1958 \[1913\]\)](#) criticism of Ricardo's argument that the introduction of machinery may bring about a reduction in the levels of output and employment. In the same vein, Wicksell's restatement – in terms of the then new marginal productivity distribution theory – of Ricardo's result that labour saving technical innovation would cause wages to fall also proved influential (see e.g. [Kaldor, 1932](#); [Hicks, 1932](#)). Indeed, Wicksell gave the first treatment of the machinery question that went beyond Ricardo's original analytical framework (see e.g. [Rashid, 2008](#)).

Wicksell's careful discussion of the effects of technical change on distribution and employment was rare among contemporary neoclassical economists. However, it was only gradually that Wicksell came to formulate the problem in the form eventually presented in his 1901 *Lectures* and in his 1900 article about "marginal productivity as the basis of distribution in economics". The topic had attracted [Wicksell's \(1890\)](#) attention from the very beginning of his work as an economist, but on that occasion he had not yet developed his contribution to marginal productivity theory. Instead, Wicksell then sided with the so-called "compensation" approach to machinery, and, accordingly, denied any permanent perverse effects of technical change on employment and wages.

It was in his lectures delivered in Lund in April 1900 that Wicksell applied, for the first time, marginal productivity concepts to the study of technical progress. Nevertheless, his lecture notes still bore the marks of his interpretation advanced ten years earlier, as Wicksell could not make up his mind whether labour-saving technical progress reduced or increased output and wages. A few months after delivering his Lund lectures, Wicksell's ambiguity gave room to a clear argument that the introduction of machinery under free competition would cause wages, but not output and employment, to fall ([Wicksell, 1958 \[1900\]](#)). Wicksell's initial vagueness reflected to some extent the general difficulty in interpreting what Ricardo "really meant" in the new chapter 31, shared by several commentators before and after him (see e.g. [Schumpeter, 1954](#), pp. 679–687).

The goal of the present paper is to discuss how Wicksell resolved the confusion in his own mind. In order to carry out the discussion, Wicksell's lecture notes are translated and reproduced below as [Appendix](#). Wicksell's final statement of the machinery question is only partly explained by his application of marginal productivity theory. Another important factor behind Wicksell's new approach was his critical interest on [Pareto's \(1894, 1964 \[1896–1897\]\)](#) claim that free competition leads to the maximum of satisfaction (*maximum d'ophélimité*) in the economic system, which contradicts some results of chapter 31 of Ricardo's *Principles*.

[Wicksell's \(1958 \[1897–1899\]\)](#) first reaction to Pareto's proposition appeared in his reviews of volumes 1 and 2 of the *Cours*, with no reference to the machinery question though. After [Pareto \(1971 \[1909\]\)](#) developed in more detail what would become known later as the "Pareto optimum" concept, [Wicksell \(1958 \[1913\]\)](#) would discuss in his review of the *Manuel* the apparent contradiction between Ricardo's machinery question and Pareto's optimality. The point came up in [Wicksell's \(1958 \[1900\], 1934 \[1901,1911\]\)](#) contention that Ricardo's objection was "theoretically untenable" under free competition because it conflicted with the technical conditions of optimum production. Those marginal conditions were put forward for the first time by [Wicksell \(1958 \[1900\], 1934 \[1901,1911\]\)](#), as part of his refutation of the notion that the introduction of machinery could reduce output. From Wicksell's new perspective, the machinery question made clear the distinction between the conditions to maximize aggregate output and to maximize satisfaction for consumers as a whole. That distinction was instrumental in his critical interpretation of Pareto's optimality concept.

## 2. A tough nut to crack

Wicksell's (1890) Norwegian article on "Empty stomachs – and full warehouses" was written in June that year in Paris. His visit to France closed the long cycle of economic studies abroad he had started in 1885–1886, which included as well stays in London, Strasbourg, Vienna and Berlin. In the spring term of 1889 Wicksell gave four popular lectures on the new theory of value (mainly Jevons and Walras) and capital (mainly Böhm-Bawerk) at the Stockholm Workers' Association. Those lectures later developed into his first book (Wicksell, 1954 [1893]), whose introductory chapter is a reproduction of the first of the 1889 lectures, about pre-marginalist value theory. By 1889 he had also drafted a manuscript on interest and prices, which contained the basic elements of his cumulative process of price level changes fully elaborated in book form nine years later (Gårdlund, 1958, pp. 121–28; Boianovsky and Trautwein, 2001, pp. 488–90). Wicksell's economic research agenda was already broadly outlined around 1890.

Despite Wicksell's familiarity with the "new theory" of value and capital, there are no traces of neoclassical concepts in his 1890 piece. Leon Walras is the only neoclassical author mentioned, but in connection with his criticism of J.S. Mill's proposition that "demand for commodities is not demand for labour" (Wicksell, 1890, p. 257, n. 1). The absence of neoclassical economics is explained not just by the fact that the issue tackled by Wicksell in that article – overproduction, unemployment and overpopulation – was largely foreign to its domain, but also because marginal productivity had not yet been incorporated into its theoretical framework. Wicksell (1890) discussed how low consumption ("empty stomachs") on one side and overproduction ("full warehouses") on the other could coexist.<sup>1</sup> His main target was the Marxian underconsumptionist approach, based on the notion of the "industrial reserve army", and its implications for wage determination and income distribution, which was particularly influential in Germany at the time. According to Wicksell's reading, the Marxian view of "modern industrial world" stated that

Through the concentration of capital and industry, and, as a result, the replacement of human labour-power for machine power, a large number of industrial workers become superfluous and are . . . thrown out onto the street . . . The workers unemployed in this manner constitute industry's large "reserve army", who, through their competition for employment, have the effect of forcing down wages . . . Despite the decrease in the numbers of employed workers, the manufacturer is, through the introduction of machinery, still able to significantly increase his production, and does so as a rule, but consumption demand does not increase to the same extent . . . The situation continues in this manner: overproduction and underconsumption reciprocally create each other in a pernicious cycle (Wicksell, 1890, pp. 251–252).

Unlike several contemporary authors (particularly in the United States; see Woirol, 1996, p. 20), Wicksell (p. 254) did not join the argument "most often directed against Marx", namely that workers' economic welfare had improved since the widespread introduction of machinery at the beginning of the 19th century. Compared to the rate of economic growth, any improvement in the workers' position was perceived as very "modest", if any at all. However, Wicksell claimed that such unfavourable turn of events took place not as a result thereof but despite technical progress.<sup>2</sup> The notion that the "actual cause of the evil" consisted in discoveries, labour-saving industrial methods and other technical changes was a "paradox" ascribed by Wicksell (p. 255) to an "incomplete analysis of economic phenomena". A full treatment of the question should bring into the picture the "most extreme ramifications" represented by compensation mechanisms that prevent the potential negative effects of the introduction of machinery on demand for labour and wages.

Marx (1938 [1867], chapter 15, Section 6) left out of his critical discussion of what he called the "theory of compensation" the essential element in McCulloch's (1825, part II, Section IV) argument against Ricardo's machinery chapter. Costs reductions caused by labour-saving technical changes must, under perfect competition, result in lower prices followed by the expansion of demand and output (see e.g. Blaug, 1985, chapter 6, Section 6). As put by Wicksell (1890, p. 255), producers "either stuff the entire profit" from cost reductions or, more likely, "they are forced to share it with consumers through the sale of their goods at cheaper prices". The increase in real income will be used by consumers and entrepreneurs for consumption or investment, with similar results in "completely absorbing the

<sup>1</sup> See Steiger (1971, pp. 66–73) and Boianovsky (1995, pp. 391–93) for accounts of how Wicksell's incipient macroeconomics of 1890 compares to his mature thought in later, better-known, works.

<sup>2</sup> As a neo-Malthusian, Wicksell stressed the influence of population growth on wages (see Boianovsky, 2001).

unemployed” workers made superfluous by the introduction of machinery and increasing wages. Wicksell (p. 256) considered also the possibility of a negative income effect on effort supply, which would cause a reallocation of workers but not unemployment.<sup>3</sup>

Interestingly enough, it was only at a later stage in the argument that Wicksell (p. 256) mentioned Ricardo’s machinery chapter. However, instead of referring to [Ricardo’s \(1951 \[1821\], pp. 388–390\)](#) attempted demonstration that the introduction of machinery may reduce output, real wages and employment, the Swedish economist considered Ricardo’s views on machinery as part of the “theory of compensation” – the notion that workers are eventually compensated for initial distresses, caused by the introduction of labour-saving technical change, by positive concealed effects. Wicksell apparently had in mind Ricardo’s (pp. 390, 392, 396) argument that saving and investment, as well as the demand for “menial servants”, increase due to higher real income provoked by price reduction upon the introduction of machines. Ricardo (p. 393) suggested that, under the assumption that luxury goods are not produced entirely by labour but by land input also, workers have an interest in the pattern of spending by the rich. The qualification about the spending pattern, “already partially pointed out by Ricardo”, meant that “to be effective, the new demand must be directed towards necessities (or personal services) where the ratio of labour to value is *as high as* the ratio for the commodities which have been made cheaper by machinery”. Otherwise one “cannot claim that a complete compensation takes place”. Hence, if lower prices drove proprietary classes to increase their consumption of expensive land-intensive food items instead, the result of labour-saving technical change would be “unemployment and reduced wages” ([Wicksell, 1890, p. 256](#)).

In particular, that would be the case if, for a given spending pattern, machinery that substitutes land for labour was introduced. If “the introduction of some agricultural machines (for instance haymaking machines) made it advantageous for the landowner to turn the fields over to permanent pasture, he would employ a smaller amount of workers, achieving thereby perhaps a higher net profit, but the gross output would be decreased” ([Wicksell, 1890](#)). Ricardo (p. 394) had discussed that same case in terms of substitution of horses for men. As pointed out by Wicksell, gross output would come down, provided food for horses was not included in the output but reckoned only as cost. Wicksell ruled out that case for empirical, not theoretical reasons. He claimed as a fact that the new demand from property owners had been “directed mainly towards those goods (or services) where the proportion of value due to land is less than that due to labour”. Likewise, steady population growth throughout the 19th century indicated that employment had increased and that machinery had prevented European population from falling “hopelessly prey to famine” ([Wicksell, 1890, p. 257](#)) – a reference to diminishing returns to land.

Wicksell would tackle again the machinery question ten years later, in his spring lecture notes reproduced below as [Appendix](#). The main difference, as compared to his treatment in 1890, was the use of marginal productivity theory to interpret the effects of technical progress on wages. [Wicksell \(1954 \[1893\]\)](#) had presented the first complete mathematical formulation of the marginal productivity theory of distribution ([Stigler, 1994 \[1941\], p. 293](#)). It was, however, presented in obscure form, to such an extent that it was only in his 1900 article, inspired by [Wicksteed \(1894\)](#), that [Wicksell \(1958 \[1900\], p. 93\)](#) gave what he regarded as a first full exposition.

There are no references to the machinery question or to Marx’s industrial reserve army in Wicksell’s *Value, Capital and Rent*. In an unpublished manuscript written the year before, [Wicksell \(1892\)](#) rejected the original notion of the industrial reserve army as a fraction of the working class permanently out of work. “It is absurd to assume such a state of things. Reality is not like that. Even though there is a certain minimum of unemployed people at every time of the year, these people are not the same every year”. He reinterpreted it as frictional or “normal” unemployment in equilibrium, which does not imply any downward pressure on wages. “A certain, not too large number of unemployed must be considered as a fully normal phenomenon, similar to the phenomenon of vacant rooms in big cities: a certain number of them is permanently unoccupied, but never the same rooms all the time” ([Wicksell, 1892](#); see [Boianovsky and Trautwein, 2003](#), pp. 395–402). Having removed the industrial reserve army concept from the machinery question context, Wicksell proceeded in his 1900 lecture notes with his first attempt to apply marginal productivity theory to the matter.

Wicksell picked up the discussion of the effects of technical progress on distribution from where he had left it in 1890. [Wicksell \(1890, p. 257, n. 1\)](#) had complained that “any fully satisfactory and comprehensive treatment of the problem, once discussed in such a lively manner, of machinery’s benefit or harm to workers does not, as far as

<sup>3</sup> A preliminary treatment of Wicksell’s early views on technical change may be found in [Boianovsky and Hagemann \(2005, pp. 70–72\)](#).

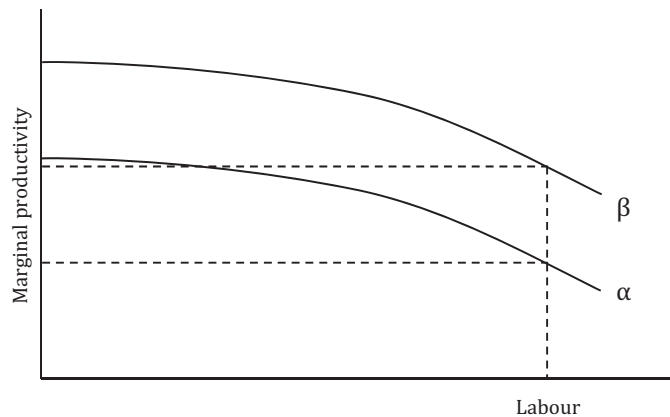


Fig. 1. Neutral technical change.

Source: adapted from [Appendix](#).

I know, exist”. He repeated in his 1900 lecture notes that that “important issue” had not been hitherto “satisfactorily treated” in the economic literature. Marginal productivity should provide the key to the problem, under the explicit assumption of a production function with constant returns to scale made by him at the outset of the notes. Wicksell, however, was not fully satisfied with his lecture notes, as immediately indicated by the Swedish interjection “obs!” (meaning “note”). The puzzle posed by the effect of technical progress on distribution originates from the operation of two opposing influences on wages: on one hand, higher productivity of labour ought to render possible the payment of higher wages; on the other hand, it may cause excess supply in the labour market and reduce wages (see also [Wicksell, 1958 \[1900\], p. 101, 1934 \[1901,1911\], p. 134](#), for a similar remark). The distinction between average and marginal productivities of labour could apparently provide a solution to the riddle.

Just like in volume 1 of his printed *Lectures* (pp. 108, 133–144) and in his 1900 article on marginal productivity, Wicksell discusses in his notes the effects of technical progress under the assumption of “non-capitalistic production” with just wage and rent as factor shares. Machinery modifies the conditions of substitution between land and labour at the production margin. In modern terms, he is analysing disembodied technical change ([Hansson, 1983, p. 50; Coleman, 1985, p. 355](#)). The first diagram drawn by Wicksell illustrates the determination of the wage rate by the marginal productivity of labour, and the division of product between land rent and wages (see also [Wicksell, 1934 \[1901,1911\], p. 115](#), for a similar diagram). Whereas that largely reproduces [Clark’s \(1899, chapter 13\)](#) well-known diagram, the other figures drafted by Wicksell in his notes show the first application of marginal productivity theory to the interpretation of technical change. Those figures are reproduced in [Appendix](#) as originally sketched by Wicksell; they are redrawn in this section for clarity reasons.<sup>4</sup>

An increase in the productivity of labour brought about by technical progress may occur in different ways, as discussed in Wicksell’s notes. The first case consists in a proportional increase in the average and marginal productivities of labour (and land as well, not shown) represented by a more or less parallel shift of the curve upwards, which benefits both workers and landowners ([Fig. 1](#)). It may be described as a “neutral” technical change that does not affect income distribution. Wicksell next considers the case of an increase in the marginal productivity of labour in a greater extent than in its average productivity, so that the former rises at the expense of the marginal productivity of land ([Fig. 2](#)). Consequently, the wage rate rises at the cost of land rent. He would argue elsewhere (particularly in his works on demography) that such inventions – that increase output per worker, not per acre – are especially relevant for promoting the “happiness of man” (see [Boianovsky, 2001, p. 133](#)). This may be described as “land-saving” technical progress, as

<sup>4</sup> Such adapted figures were first displayed in [Boianovsky and Hagemann \(2005, pp. 75–76\)](#), though not Wicksell’s original ones.

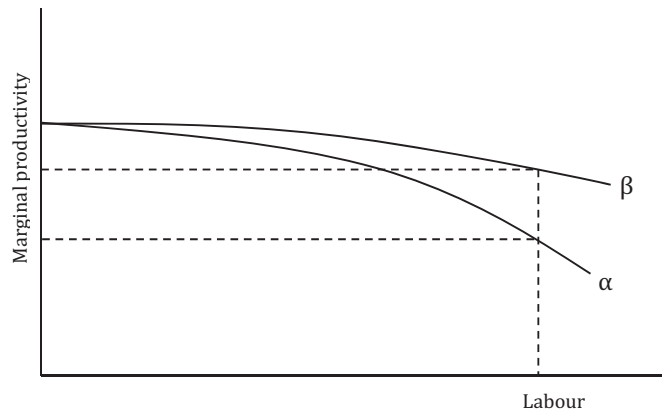


Fig. 2. Land-saving technical change.

Source: adapted from [Appendix](#).

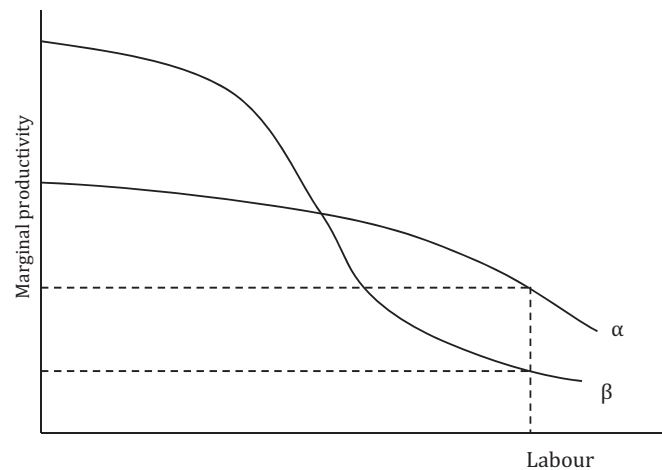


Fig. 3. Labour-saving technical change.

Source: adapted from [Appendix](#).

suggested by Wicksell's (1958 [1900], p. 102) argument that such inventions have the effect, as it were, of "increasing natural resources".<sup>5</sup>

Wicksell finally analyses in his lecture notes the case of an increase in the average productivity of labour greater than in its marginal productivity, associated with the introduction of labour-saving machinery. The old and new marginal productivity curves will intersect, as in Fig. 3. This is the case relevant for Ricardo's "machinery question". As discussed in the next section, the crossing of the two curves is behind Wicksell's claim in his *Lectures* that both old and new techniques will be deployed in the new equilibrium. However, in his lecture notes Wicksell does not analyze the allocation of production between the old and new techniques. Instead – and in contrast with his discussion of the previous two cases of technical change – his treatment is inconclusive. The outcome depends on what happens to output. If labour-saving technical change brings about an increase in agricultural production and rent, part of rural workers will

<sup>5</sup> "When the progress of agricultural chemistry a century ago taught us how we could abolish the system of keeping fallow fields and how to convert swamps into tillable soil, it was equivalent to an increase in the area of fertile soil" (Wicksell, 1953 [1907], p. 66; see also 1934 [1901, 1911], pp. 135–36). Cf. Ricardo, 1951 [1821], pp. 80–81.



shift to the industrial sector to produce goods demanded by landowners. Labour reallocation increases the marginal productivity of rural workers and prevents their wages from falling. Alternatively, agricultural gross output may fall, as it would happen, for instance, if the introduction of labour-saving machines were associated with a replacement of workers for horses. In this latter scenario wages must come down, a possibility mentioned but disregarded by [Wicksell \(1890\)](#) for empirical reasons, as discussed above. Again, he resorts in his lecture notes to data showing that the increase of employment in Swedish industry and other urban sectors during the last two decades of the 19th century more than compensated its contraction in agriculture.

Wicksell's claim at the end of his lecture notes – that marginal productivity provides a “guiding principle” to the effects of technical progress no matter how complex they are – is not warranted by his inconclusive analysis of the influence of labour-saving technical progress on factor prices. Indeed, despite his introduction of marginal productivity concepts, Wicksell's treatment of the machinery question in April 1900 was still influenced by the “theory of compensation” he had eagerly defended ten years before. This is evident in his argument that the effect of machinery on wages depends on whether it increase or reduces output – a far cry from the marginal productivity approach he would fully develop shortly afterwards. Wicksell seemed to be aware of that, as indicated by the question marks appended against the paragraphs about the alternative effects of machinery on output in his lecture notes. A few months later, the inconclusiveness of the lecture notes would give place to a clear discussion of the matter in Wicksell's article on marginal productivity theory. The change, however, may be explained not just by his further development of marginal productivity concepts, but also by his reaction to Paretian welfare economics, as discussed next.

### 3. Problem solved

By the time Wicksell wrote his 1900 article on marginal productivity and volume 1 of his *Lectures* (preface dated February 1901), it became clear that the main issue involving the machinery question was not empirical, but theoretical. If correct, the notion that a viable technical change (that diminishes production costs and increases net profit) may reduce output for a given amount of productive factors represented a blow to the proposition that perfect competition leads to maximum aggregate production. Such a proposition about the efficiency of perfect competition has been recognized as one of the main features of “Pareto optimum” since [Little \(1950, p. 89\)](#) introduced the term, but matters were still unsettled around 1900. Apart from Wicksell, [Barone \(1935 \[1908\]\)](#) and the mathematician [Scorza \(1903\)](#), Pareto's optimality concept did not receive much attention until after [Bergson \(1938\)](#) discussed it and turned it into one of the foundations of mainstream welfare economics. The optimality conditions were independently rediscovered and formulated by [Lerner \(1934a,b\)](#) in his articles about socialist economies, with no reference to Pareto (see [Niehans, 1990](#), pp. 329–332). Indeed, it was only in the 1930s that the entire set of marginal conditions of social optimum was stated explicitly.<sup>6</sup> As put by [Blaug \(1985, p. 592\)](#), “Pareto and Barone did not go very far beyond a statement of the optimum conditions of exchange”.

From Wicksell's perspective in the *Lectures*, [Pareto's \(1894, 1964 \[1896–1897\]\)](#) treatment of the optimality of perfect competition introduced a new essential element in the interpretation of the machinery question. This belonged to welfare economics, which was only implicit in [Wicksell \(1890\)](#). Surely, Pareto did not discuss Ricardo's machinery question, and neither did [Wicksell \(1958 \[1900\], pp. 100–106; 1934 \[1901,1911\], pp. 133–144\)](#) refer to Pareto in his sections about the influence of technical change on distribution. Nevertheless, those sections were written under the impact of and as a reaction to Paretian welfare economics. Wicksell's mature discussion of the machinery question introduced explicitly the distinction between maximum output and maximum social welfare, as part of his formulation of the marginal technical conditions for output maximization. [Wicksell \(1958 \[1900\], p. 103; 1934 \[1901,1911\], p. 137\)](#) built on Pareto's framework to show that the “objection raised by Ricardo is *theoretically untenable*”, but at the same time he used Ricardo's machinery question to argue, against Pareto, that output maximization may be associated with a reduction in wages and welfare of workers ([Wicksell, 1958 \[1913\], pp. 169–171](#)).

<sup>6</sup> The three sets of conditions are (i) the optimum exchange condition: marginal rates of substitution in consumption for any two goods must be the same for all individuals; (ii) the optimum production condition: marginal rates of technical substitution between any pair of factors must be the same for all producers; and (iii) as a consequence of (i) and (ii), the marginal rate of transformation in production equals the marginal rate of substitution in consumption.



Wicksell (1958 [1897–1899], pp. 142–144; 1934 [1901,1911], pp. 72–83) criticized both Walras (1954 [1874]) and Pareto (1964 [1896–1897]) for arguing that, under free competition, the gain from exchange is an absolute maximum for each trading agent and for the sum total of satisfactions of all agents as well. Wicksell rejected both claims (see also Samuelson, 1947, pp. 204–206). The first assertion – associated mainly with Walras – was based on confusion between the notion that the equilibrium position reached in pure competition is an optimum for each individual trader given its endowments and prices, and the view that pure competition produces optimal results. Another system of prices (fixed by the authorities or by monopolistic producers) may yield better results for traders. The second claim – developed particularly by Pareto – was only warranted under the assumption that the marginal utility of the commodities exchanged is the same for all individual traders, which means an approximate position of economic equality. Otherwise, it would be possible to replace competitive prices by another price system generating an increase in total utility, as demonstrated by Wicksell (1958 [1896–1897], p. 143, n. 1; 1934 [1901,1911], pp. 79–80).<sup>7</sup>

Such a demonstration, as acknowledged by Wicksell (1999 [1899], p. 179) in his review of Walras's *Études D'Économie Politique Appliquée*, was correct “to the extent that the utility or marginal utility of different people can be compared with one another at all”. It was in that context that Wicksell (Wicksell, 1999 [1899]) suggested that Walras's “misconception” about the welfare properties of free trade had led him to “show no understanding for the drawbacks of labour-saving machines to which Ricardo had already drawn attention”. This is a comment on Walras (1936 [1898], p. 273), where it is stated that the introduction of machinery is always beneficial to workers, as it only reduces the prices of commodities, not wages. At this point, however, Wicksell had not yet developed his argument that machineries must bring about an increase of aggregate output, even if not accompanied by higher real wages and a larger sum of total satisfaction.

Wicksell's first (implicit) mention of output maximization under free competition came out in his review of Pareto's *Cours*. Wicksell (1958 [1897–1899], p. 144) absolved Pareto from the charge – made against F. Bastiat and other harmony economists – that incomes imputed under free competition are optimal in the sense of rendering the best wealth distribution possible. But, “as soon as this distribution is accepted as a fact, Pareto says that free competition must provide everyone with the greatest satisfaction of needs (possible in the circumstances), since labour, land and capital are then applied to those uses which give the highest possible yield” (Wicksell, 1958 [1897–1899]). The argument was developed in sections 720–723 of Pareto's *Cours* and further elaborated in sections 109–115 of the mathematical appendix to the *Manuel* (see Chipman, 1976, pp. 90–93; Bergson, 1983, pp. 40–41). Pareto showed that the production coefficients in perfect competition are the same as the coefficients determined by a socialist state aiming at maximum utility for each individual. In an otherwise critical review of Pareto's *Manuel*, Wicksell remarked, in connection with what we now call Pareto optimality, that

The only thing that is correct and noteworthy in the whole of this reasoning is the fact that the current mode of production, depending on free competition . . . must from the theoretical point of view result in the greatest possible total of products or exchange value, in the same way as would rational production in some conceivable collective society; that is to say, if we consider just the question of *production*, and disregard both distribution and the pricing of finished goods . . . This proposition is obviously of the greatest significance and importance, and, as far as I can see, it is perfectly correct when formulated with due care (Wicksell, 1958 [1913], p. 169).<sup>8</sup>

Pareto's result was couched as part of his general proposition that free competition brings about an “optimum”, in the sense of a position where no single individual can improve its welfare without harming someone else's welfare (Pareto, 1971 [1909], chap. VI, Section 33). The distinction between the purely exchange (or subjective) conditions and the purely production (or physical) conditions for an optimum tends to become blurred in his formulation. Pareto's optimum point is not unique, as it depends on income distribution. The new definition was motivated by Pareto's wish to avoid the necessity of making interpersonal comparisons of utility and by his attempt to differentiate himself from Walras's interpretation of free competition optimality (Wicksell, 1958 [1913], pp. 167–169). However, differently from his previous treatment in the *Cours*, Pareto (1971 [1909]) would keep in the background the dependence of the optimum

<sup>7</sup> Scorza (1903) put forward similar objections to Walras and Pareto. He was unaware of Wicksell's previous criticism (see Chipman, 1976, pp. 89, 95–96).

<sup>8</sup> Barone's (1935 [1908]) proof, according to Wicksell, overlooked the necessary assumption that prices are constant and was, therefore, mistaken. See also Samuelson, 1947, pp. 215–217, for a different assessment of Barone's proof.

point on the initial distribution of income. From Wickcell's perspective, such infinite number of noncomparable optima and the relative character of Paretian maximum confirmed his previous argument that there is nothing to ensure that free competition will produce the "greatest possible social advantage", as pointed out in a passage added to the second (1911) edition of volume 1 of the *Lectures* (p. 83). More importantly, Pareto's definition of the optimum makes it difficult to appreciate the valid element of Paretian welfare economics, that is, the conception that national income is maximized under free competition.

Even in this new guise, Pareto's doctrine contributes nothing. And – what is worse – it tends to obscure the fact . . . that social production under free competition (with certain reservations) does really lead to a maximization, in the usual and proper sense, of the means of satisfying human wants (Wickcell, 1934 [1901,1911], p. 83).<sup>9</sup>

Wickcell (1958, [1913], p. 169) regarded the proposition about production maximization as a "matter of fact", since an optimum was defined as a situation in which no mutually profitable trade could be arranged – or, as expressed nowadays, there were no unexploited gains from trade. The proposition was based on the notion that if more products "could be achieved at any point of the field of production with the labour or other productive power available, the private economic interests would inevitably direct the necessary productive power to that point" (Wickcell, 1958 [1913]; see also Wickcell, 1934 [1901,1911], p. 83, for a similar remark). Indeed, he suggested that Pareto's description of maximum utility as part of the new concept of the optimum presented in the *Manuel* was almost trivial, since it boiled down to a tautological definition of the absence of mutually profitable trade under free competition (Wickcell, 1934 [1901,1911], pp. 82–83; 1958, [1913], p. 168; see also Dobb, 1969, pp. 11–12).

It was while discussing Ricardo's machinery question that Wickcell (1934 [1901,1911], p. 137) first maintained that a diminution in aggregate output as a result of technical progress was inconceivable under free competition, where there are no unexploited gains from trade. This "appears to be self-evident, for in that case anybody would be able, with the given means of production, to bring about at some point an increase of the product and thereby reap a profit as entrepreneur. Ricardo has here failed to draw the final conclusions from his own assumptions" (see also Wickcell, 1958 [1900], p. 103). Whether self-evident or not, Wickcell demonstrated, arithmetically, graphically and algebraically, that the introduction of machinery must bring about a larger output. He investigated Ricardo's example (mentioned above) of the introduction of labour-saving agricultural machinery that makes a predominantly pastoral agriculture more profitable than arable farming. The immediate effect is a reduction in the value of the product, wages and employment, accompanied by a larger net profit due to the saving of labour. The long-run permanent effect, however, is an increase in total product, which reaches the "maximum physically possible" when "net profit" (meaning rent per acre) is the same in both old and new techniques. Lower wages lead to absorption of idle workers in the old methods of production, which become more profitable, so that the transition to new methods is only partial (Wickcell, 1958 [1900], pp. 103–104, 1934 [1901,1911], pp. 137–138).

Wickcell (1958 [1900], p. 104, 1934 [1901,1911], p. 140) assumed, in his mathematical proof, that the (linear homogenous) production functions in the old and new methods are, respectively,  $f(x)$  and  $\varnothing(y)$ , where  $x$  and  $y$  represent the number of workers per acre on each method. He further assumed that  $m$  acres are cultivated on the old method and  $n$  acres on the new one. The problem is solved by finding the conditions under which the expression

$$mf(x) + n\varnothing(y)$$

attains its greatest value, where  $m + n = B$  and  $mx + ny = A$ ,  $B$  being the number of acres and  $A$  the number of workers available. Differentiation gives the conditions

$$f'(x) = \varnothing'(y)$$

and

$$f(x) - xf'(x) = \varnothing(y) - y\varnothing'(y)$$

The first equation means that the marginal productivities of labour (and therefore wages) are the same in both methods; the second that the rent per acre is also the same for both types of production. He claimed that this result shows that

<sup>9</sup> The "reservations" are basically related to the absence of increasing returns (see Uhr, 1962, p. 54).

“the partial change-over to the new type of production, which at first sight seemed to entail a decrease in the total product, actually leads to maximization” (Wicksell, 1958 [1900], p. 104, n. 1).

Wicksell also provided in his *Lectures* (pp. 139–140) a graphical demonstration, with two curves representing the marginal productivities of labour in the old and new techniques. The shapes of the curves are similar to the ones used in the illustration of labour-saving technical change in his 1900 lecture notes. They are, however, depicted in separate diagrams, instead of crossing as in the notes (see Appendix and Fig. 3); it is now only implicit that the curves cross. Differently from his notes of April 1900, Wicksell (1958, [1900]) now establishes graphically the new equilibrium in the allocation of labour between the two methods. The transition to the new technique ceases when a point is reached at which the net profit and wages are the same in both productions. During the transition, as dismissed workers are absorbed in the old technique due to falling wages, output increases until it reaches its maximum in the new equilibrium. Also differently from the lecture notes, Wicksell now focuses on labour-saving technical change, with no graphical illustration of land-saving and neutral technical progress.<sup>10</sup> This may be explained by Wicksell’s overall concern in that section of the *Lectures* with the implications of Ricardo’s machinery question for the interpretation of Pareto optimality.

Wicksell’s conditions for output maximization mean that the marginal technical rate of substitution between any pair of factors must be the same for all producers. This corresponds to the optimal technical condition fully elaborated by Lerner and others in the 1930s. Pareto did not explicitly state it. According to Hla Myint (1965 [1948], pp. 110–111), Wicksell, in his discussion of the machinery question, was the first “to give a clear formulation of this condition of optimum production in purely technical terms and to distinguish between the optimum at the physical level and the optimum at the subjective level”.<sup>11</sup> This condition is independent of market prices, which implies that it does not depend for its validity upon the fulfilment of the optimum exchange condition for consumers. As put by Dobb (1969, p. 53), “it is a pure Production Condition, which tells us that the most is being made of existing resources (with given technical knowledge), and is worth fulfilling in its own right”.

Wicksell (1958 [1900]), p. 105) found it “remarkable” that “from a technical point of view” production attains its maximum under free competition. He claimed throughout volume 1 of his *Lectures* (pp. 164–165, 196–197) the significance of his demonstration that the search for maximum net profit leads to maximum national income. Wicksell (ibid) acknowledged that he “proved this on the assumption of production without capital, but it will easily be seen that its essence remains unchanged, like the objection of Ricardo, which it was our purpose to refute, even if the argument is applied to capitalistic production”. As explained by Wicksell in part III of his *Lectures*, if capital accumulation is taken into account, production will reach its maximum when the economy is “satiated with capital”, at zero marginal productivity of capital and interest rate (this corresponds to the concept of “Ramsey’s Bliss” as the culmination of the capital accumulation process; see Boianovsky, 1998).

Although Pareto is not mentioned in the *Lectures*’ section about technical progress, it is clear that Wicksell’s restatement of the machinery question aimed not just at Ricardo’s chapter 31 but also at Pareto’s optimality:

Although we have so far only concerned ourselves with some of the forces at work, we may nevertheless proceed on the provisional conclusion that free competition is normally a sufficient condition to ensure maximization of production. But this maximization may very well be associated with, and even be conditional upon, a reduction in the distributive share of one of the factors of production – in this case labour. This shows the serious error of those who see in free competition a sufficient means for the maximum satisfaction of the needs or desires of all members of society (Wicksell, 1934 [1901,1911], p. 141).

In his review of the *Manuel*, Wicksell (1958 [1913], pp. 169–170) took Pareto to task for overlooking the contradiction between the notion that production is maximized under free competition and the “impressions and opinions of everyday life”. This was illustrated by Ricardo’s claim that the private gain of a producer might be better suited by a reduction of his gross product, which apparently expressed what “experience teaches us”. Wicksell referred to his argument that the transition to production with smaller gross return could only be partial, which vindicated Pareto’s result that

<sup>10</sup> Blaug (1985, p. 551) complained that Wicksell’s discussion of the influence of innovations on factor prices in the *Lectures* “lacks precision because of his failure to distinguish between labour-saving and land-saving innovations”.

<sup>11</sup> See also Samuelson (1947, p. 215). As pointed out by Samuelson, Wicksell’s demonstration was restricted to a case where the same product can be provided by different sources, instead of a general equilibrium system with many goods. This avoided the index-number problem of defining the “product” which is maximized.

production coefficients under free competition are the same as in a socialist economy. However, differently from a market economy, a socialist society would in principle ensure that the increase in output was not appropriated by a few while the welfare of the “broad mass” of the population worsened. Wicksell (pp. 170–171) observed that “there is no trace of any such considerations in Pareto. He is content to derive a more or less self-evident proposition by the elegant formulae of the calculus of variation”.<sup>12</sup>

In case the introduction of machinery brought wages all the way down below subsistence level, Wicksell (1934 [1901,1911], p. 141) suggested that, instead of enforcing minimum wage, a better solution would be to supplement the deficiency with transfer taxation paid by landowners, while letting wages fall to their full-employment marginal productivity level. As pointed out by Samuelson (1989, p. 55), Wicksell’s view that transfer payments can “bribe people into accepting a new Pareto-optimal equilibrium” anticipated some aspects of the 1930s new welfare economics’ notion of winners compensating losers (see also Humphrey, 2004, pp. 17–18). The concept of compensating payments enlarges the area of comparability between Pareto optimal positions (cp. Chipman, 1976, p. 92, who has shown that some elements of the Compensation Principle may be found already in Pareto, 1894). As a corollary of Wicksell’s analysis of the machinery question, any policy that leads to an increase in physical output is recommendable, regardless of the question of comparability of individual utilities, since individuals may be compensated and made better off without making others worse off (cf. Kaldor, 1939).<sup>13</sup> Surely, the meaning of “compensation” in this context is quite distinct from Marx’s “compensation theories” discussed in the previous section.

Wicksell also applied his framework, originally devised for interpreting the machinery question, to examine the effects on income distribution of shifts in relative prices of goods, in both closed and open economies. His output maximization result holds only for a closed economy. If the economy is open, the new position of equilibrium after the introduction of machinery is not reached until labour (or capital) “has been transferred abroad, so that the raising of the gross returns occurs only in the world economy, not in the restricted nationalistic sense”, with the same negative effects on domestic wages (Wicksell, 1958 [1913], p. 170). Changes in the demand for productive factors may be induced not just by technical progress, but also by shifts in relative prices. Wicksell (1919) argued that an increase in the international price of land-intensive primary commodities (such as iron ore and wood produced by Sweden), relatively to manufactured goods, brings about higher demand and price of the abundant factor (land) and a reduced demand and price of the scarce factor (labour). If the increase in relative price is strong enough, then, under competitive conditions, wage reduction may lead to migration. “For the *world economy* as a whole this would be highly advantageous; from the point of view of the world economy nothing is more beneficial than that those parts of the earth best suited to the production of raw materials be devoted to such purpose; for the Swedish people, as a nation, it is a different matter” (Wicksell, 1919, p. 17). Wicksell derived a Stolper–Samuelson effect in a two-good, two-factor model – related to the Dutch disease concept developed later in the 1970s – which would provide the starting-point for Eli Heckscher’s elaboration of his seminal trade model (see Boianovsky, 2013, pp. 63–64, and references there cited).<sup>14</sup> Once again, Ricardo was the benchmark, this time as a further development of his theory of comparative advantages.

#### 4. Epilogue: interpreting Ricardo

Wicksell’s change of mind about the machinery question was related to the way he interpreted Ricardo’s chapter 31. Whereas Wicksell in the *Lectures* stressed Ricardo’s claim that the introduction of machinery may reduce output and employment, in the 1890 article he focused instead on Ricardo’s qualifications, and in the 1900 lecture notes he still considered both possibilities without deciding for none. As recounted by Wicksell (1934 [1901,1911], pp. 134–35), the 17th century mercantilist view, that labour-saving machinery caused unemployment and “took the bread from the mouths of the workers”, was superseded by the victory of the physiocratic approach that, “especially as formulated by J.B. Say, goods must always ultimately exchange against goods”. From that perspective, an increased productivity of labour brought about by the introduction of machinery should lead to an increased demand for goods

<sup>12</sup> On Wicksell’s criticism of the Lausanne School of welfare economics see also Uhr (1962, pp. 51–55) and Pålsson Syll (1993). Both authors, however, miss Wicksell’s original contribution on the optimal conditions for output maximization.

<sup>13</sup> Kaldor (1939) may have been inspired by Wicksell, as he was a keen reader of Wicksell’s discussion of the machinery question (see Kaldor, 1932). In fact, Kaldor (1936, pp. 740–41) referred to Wicksell’s case for wage subsidies.

<sup>14</sup> A similar argument may be found in a note added to the section on technical progress in the second edition of Volume 1 of the *Lectures* (p. 142), about the income distribution and output effects of an increase in the domestic relative price of Swedish land-intensive forestry products.

and therefore for labour to produce them, with ensuing higher wages. According to Wicksell's historical reconstruction, "this optimist view received a set-back" when Ricardo established, as it seemed, that the introduction of machinery may be advantageous to employers even when it involves a decrease in the size of the product – "in such a case the labourers could not be compensated by an increased demand for other commodities" (Wicksell, 1934 [1901,1911]).

Interestingly enough, Wicksell's description of "compensation theory", in terms of Say's Law argument for labour reabsorption, corresponds to his own interpretation of the machinery question in the "Empty stomachs" article. Wicksell (1890) largely endorsed the reabsorption mechanism through price fall accompanied by increase in consumption and/or investment, outlined by McCulloch in the 1820s. Ricardo's (1951 [1821], chapter 31) "paradoxical manner of asserting one thing on one page and retracting it all on the next one", as described by Blaug (1985, p. 72), made life difficult for his interpreters. Indeed, in correspondence with Ricardo in 5 June 1821 McCulloch reacted strongly against the new chapter on machinery, and rejected Ricardo's reservations and qualifications by asserting that "it is impossible to fritter away your argument by fencing it about with conditions" (Sraffa, 1973a, p. 382). Schumpeter (1954, p. 683), on the other hand, regarded Ricardo's qualifications at the end of the chapter as a natural long-run extension of Ricardo's model, enough to name him the "father of what Marx called the Theory of Compensation".

Wicksell's (1958 [1900], [1901,1911] 1934) new interpretation – that Ricardo's chapter 31 presented the unmistakable thesis that machinery may reduce output and employment – is partly explained by the material made available by the Ricardo scholarship developed in the 1890s, particularly by J.H. Hollander. The publication by Hollander of Ricardo's letters to McCulloch in 1895 brought to light his reply (dated 18 June 1821) to McCulloch's criticism:

[The machinery's] erection must be profitable to every class of buyers as buyers, but the question between us, is whether it will or not diminish the number of the class of buyers. I say it will, because it will diminish the quantity of gross produce; and therefore the observation in your letter that it is not with greater or less gross or net produce that we have the smallest concern, cannot be well founded, for the whole question rests on the truth of this proposition. Diminish the quantity of exchangeable articles, and you diminish the demand for commodities; – you diminish the means of enjoyment of some one, or more, of the classes of the community (Ricardo, 1895, p. 107; also in Sraffa, 1973a, p. 388).

Ricardo's objection to machinery, as stated on the same letter, was not incompatible with Say's Law. It was not a matter of excess supply as in Malthus's over-production theory. On the contrary, "the use of machinery often diminishes the quantity of gross produce, and although the inclination to consume is unlimited, the demand will be diminished, by the want of means of purchasing" (Ricardo, 1895, p. 106; Sraffa, 1973a, p. 387). In another letter, dated 7 May 1822, while commenting on an early draft of McCulloch's *Principles*, Ricardo (1895, p. 136; Sraffa, 1973b, p. 194) reacted to the latter's claim that "the interests of individuals are never opposed to the interests of the public" by referring to "the case of machinery", where "the interests of master and workmen are frequently opposed" – a remark Wicksell would repeat in his 1899 review of Walras's *Études*. Moreover, Ricardo added, "I deny that we should be able to employ the workmen displaced by the employment of machinery". Hollander (1895, p. xx) pointed out in his editorial introduction the relevance of Ricardo's letters for the assessment of the machinery question. Wicksell's (1934 [1901,1911], p. 135) comment about the analytical novelty represented by Ricardo's argument of output reduction, quoted at the outset of this section, is very close to the gist of Ricardo's letter of 18 June 1821. That letter probably made an impression on him and clarified the central message of chapter 31 of Ricardo's *Principles* in Wicksell's own mind.

Ricardo's letter of 18 June 1821 to McCulloch was mentioned in J.M. Keynes's rejection letter (dated 9 January 1924) to Wicksell, upon submission to the *Economic Journal* of a manuscript titled "Ricardo on machinery and the present unemployment" (Jonung, 1981, p. 199). Keynes referred to that letter to deny what he believed to be Wicksell's claim that Ricardo's contemporaries had not taken up the machinery problem. Wicksell (undated) replied that he had mentioned McCulloch in the original manuscript, if not in the submitted version. But, he retorted to Keynes, "it is clear from Ricardo's letters to him as from McCulloch's own reflections in his *Principles of Political Economy* (1825, part II, sect. IV) that he never did hit the weak point of Ricardo's reasoning" – that is, that the introduction of machinery could never be universal, only partial (Jonung, pp. 199–201). Hence, it is likely that Wicksell was familiar with Ricardo's letters to McCulloch by the time he wrote volume 1 of his *Lectures*.

Wicksell (in Jonung, 1981, p. 201) observed that Ricardo's machinery question did not attract much attention from economists at the time, not even from Alfred Marshall (otherwise a careful reader of Ricardo), who "does not mention it at all". Actually, although Marshall did not refer to Ricardo's chapter 31, he did discuss, if only briefly, the machinery question. Marshall (1990 [1890], p. 433; see also pp. 449–450 and 553–554) denied that the marginal substitution



of capital (machinery) for labour in the aggregate economy – as opposed to particular industries – could negatively affect employment and wages. Whereas the competition of machinery for employment in any single trade “may put a particular kind of labour out of employment altogether”, the increased competition of capital in general for employment “cannot displace labour in general, for it must cause an increased employment of the makers of those things which are used as capital”. This is the naïve argument that workers displaced by labour-saving machinery will necessarily be absorbed in the production of the machines themselves, which had been put forward by J.B Say and rejected by Marx in his critique of compensation theory.<sup>15</sup>

Wicksell’s result – that the introduction of labour-saving technical change leads to an increase in the *total* product and a decrease in the *marginal* product of labour – could not be found in contemporary literature. His countryman (and frequent rival) Cassel (1932 [1918], pp. 340–341), for instance, argued that machinery could not reduce wages, since the demand for labour necessarily increases due to the double effect of higher demand for goods (caused by lower costs and prices) and increased output. “The assumed technical progress results in an increase in the total production of society and thus an increase in its total income. From this there results a general increase in the demand for labour”. Clearly, Cassel did not distinguish in that passage between average and marginal productivities of labour; consequently, he could not envisage an increase of output accompanied by a fall in wages.

The machinery question attracted also the attention of Schumpeter (1908, pp. 516–518; 1911, chapter 7), in connection with his theory of cyclical economic development and innovations. It was only hesitantly that Schumpeter introduced marginal productivity concepts and distanced himself from compensation theory. Much later, Schumpeter (1954, p. 684) would assert that the 19th century controversies about the machinery problem in the form of arguments pro and con compensation were “dead and buried”, as they “vanished from scene as a better technique [that is, marginal productivity analysis] filtered into general use”. Technological unemployment remained an important concept in Schumpeter’s framework, but interpreted as frictional or search unemployment caused by the reallocation of workers from old to new jobs for a given pace of technical progress (see Howitt, 1994; Boianovsky and Trautwein, 2010, Section 2.2, where the possibility of Wicksell’s influence on Schumpeter is also discussed).

In his 1923 paper unsuccessfully submitted to *EJ*, Wicksell referred to Ricardo’s attempt, “hardly with success, to mitigate somewhat his own conclusions” by considering the positive effects of an increase in savings, caused by price reduction upon the introduction of machinery. In contrast with his early 1890 argument, Wicksell now dismisses Ricardo’s qualification on the grounds that “it is difficult to see how this could be done” (Jonung, 1981, p. 202). Wicksell rejected in his *Lectures* (p. 136) another qualification by Ricardo, that expenditure of higher rents by landowners could increase labour demand and compensate for the immediate effects of machinery (again differently from his 1890 article). Such circumstance may “more or less modify” the output reduction result “but can scarcely reverse it”. More importantly, Wicksell assumed in his discussion of the machinery question in the *Lectures* – as he did throughout part II (“Theory of Production and Distribution”) of volume 1 of that book – that prices are given. He envisaged an economy that produces just one or a few goods and imports everything else it requires, at exchange values determined in the world market (Wicksell, 1934 [1901, 1911], pp. 103, 136, 196). In this case, there is “no question of compensation to the workers in the form of another demand for labour” (p. 137).

Wicksell’s assumption of constant prices was not just a simplification. It was necessary for his (and Pareto’s) demonstration that output is maximized under free competition.<sup>16</sup> This is made clear in the passage quoted in section 3 above from Wicksell (1958 [1913], p. 169), where he also refers to the fact that, if prices are variable, the proposition can only be “roughly” formulated, “since it is impossible to make a *direct* comparison of separate commodities and services”. Wicksell’s optimum production conditions are independent of prices and distribution, as Dobb (1969, p. 53) pointed out. In his 1923 manuscript, Wicksell (see Jonung, 1981, p. 201) stressed the potential effects of machinery in bringing out (what we now call) a new Pareto-optimal equilibrium through compensation payment: “The

<sup>15</sup> See also Vivarelli (1995, pp. 27–29) and Blaug (1985, pp. 189, 272) on Marx’s criticism. Vivarelli’s (p. 36) suggestion that Wicksell’s analysis of the machinery problem represented a “compensation mechanism via decrease in wages” is a distortion of terms. Compensation theory was about mechanisms that allegedly prevent machinery from harming workers in any sense, which was not Wicksell’s argument in the *Lectures*.

<sup>16</sup> “It can really be claimed, if commodity prices are assumed fixed, that the sum of exchange values of the goods produced and to that extent the total *earnings* from the total production of the economy (but not necessarily its total utility) must become a maximum under free competition, for if it could be increased at any point with the available means of production, the entrepreneur involved would of course necessarily pocket a profit” Wicksell (1997 [1900], p. 14, n. 4).



machinery will always have the effect of raising the gross produce of the country to its greatest possible amount, and in so far it will provide the *means* for bettering the economic conditions of the working men as well as of their employers”.

A substantial portion of Ricardo’s (1951 [1821], pp. 388–391) discussion of the machinery problem was based on the notion that the production of new machinery involves the transformation of circulating capital (the “wage fund”) into fixed capital. The diversion of labour previously used in the production of wage goods – a reduction of the wage fund – may bring down output and employment (see Barkai, 1986). Wicksell (1934 [1901, 1911], p. 134), in contrast with most commentators, claimed that the essence of Ricardo’s position on machinery did not reside in changes in the structure of capital but in the final output outcome per se. Those issues should be kept separated, since the negative effect on wages of the transformation of circulating into fixed capital (which Wicksell endorsed) was a completely different matter from the alleged output reduction, as he explained in the *Lectures* (p. 164). Hence, in his section about technical progress, Wicksell’s (p. 134) treated machinery not as capital, but exclusively as a modifier of the “conditions under which labour and land replace each other at the margin of production”. In the 1923 manuscript, however, Wicksell tackled Ricardo in his own terms by discussing in detail the wage fund model deployed in chapter 31 of the *Principles*. He concluded, just like in the *Lectures*, that the transition to the new production method is only partial, accompanied by increased output increases and lower wages (the latter is the valid element in Ricardo’s argument, as pointed out by Wicksell).<sup>17</sup>

The vicissitudes in the interpretation of Ricardo’s new machinery chapter are well illustrated by the evolution of Paul Samuelson’s assessment of Wicksell’s account. Samuelson (1947) was one of the first to mention Wicksell’s demonstration of the production optimum conditions, made as part of Wicksell’s criticism of Ricardo, as discussed above. In his well-known article about induced technical progress and economic growth, Samuelson (1965, pp. 353–354) stated that “Wicksell gives the first modern discussion of technical change and distribution”. In particular, “Wicksell corrected what appears to be one of Ricardo’s rare outright errors – namely the view that an invention might harm all of a competitive society.” Moreover, “in resurrecting Ricardo’s discussion, Wicksell called attention to the passages in which Ricardo is all but recognizing” that labour’s share is affected by a shift in the marginal productivity of labour.

In two articles written in the 1980s, however, Samuelson (1988, 1989) changed his mind about Ricardo’s machinery question. He argued that, although Wicksell was right in insisting that perfect competition is Pareto optimal, he was mistaken to hold that against Ricardo. In Samuelson’s new reading, the introduction of machinery leads to a reduction of output because of Ricardo’s assumption that population adjusts to long-run wages determined at subsistence level. Labour-saving innovation can lower the market-clearing real wage at the old labour/land densities, which causes population and the labour force to drop. The long-run outcome is a reduction in output, as claimed by Ricardo, which is, however, consistent with Pareto optimality since labour supply adjusts. Samuelson (1989, p. 47) acknowledged that “strictly speaking, we cannot find in Ricardo’s words what would pass today for an entirely satisfactory proof of his contention”, but claimed nevertheless that Ricardo’s “basic intuition is on the mark” (there is no mention of population change or subsistence wage in Ricardo’s chapter 31). Samuelson (p. 52) concluded that “Ricardo is right. Wicksell (and Kaldor and ...) are wrong”.

In 2003, while working on the paper that would be published as Boianovsky and Hagemann (2005), I corresponded with Samuelson about his criticism of Wicksell’s criticism of Ricardo (the letters are in my possession; copies are also held in the Paul A. Samuelson Papers, David M. Rubenstein Rare Books & Manuscript Library, Duke University). In correspondence of 22 January 2003, Samuelson wrote that “Ricardo is right to say ‘an invention can lower Q’. And Knut would be wrong to doubt this and do so on the grounds that ‘Pareto-optimality à la perfect competition precludes lower Q from the same old land and the now-lower quantity of labour input.’ Anyone can make a mistake, but why did Wicksell make the same mistake from 1890 to 1924?” In our correspondence, I did not ask him about his change of opinion between mid-1960s and late 1980s, but observed that Wicksell did not overlook the role of population change in his criticism of Ricardo, since he took into account the possibility of wages falling down or even below subsistence level. In a letter dated 30 April 2003, Samuelson retorted: “I never contended *that*. Gratuitously, Wicksell interpreted

<sup>17</sup> See Boianovsky and Hagemann, 2005, pp. 83–84. In connection with the wage fund theory, Wicksell (1890, p. 257, n. 1) mentioned that Mill’s ([1848] 1909, book I, chapter VI, Section 2) discussion of the machinery question was based on the notion that “demand for commodities is not demand for labour”. In that framework, labour demand was not determined by demand for goods (as in Say’s Law), but by capital accumulation. Hence, according to Wicksell, Mill did not belong in the “theory of compensation” criticized by Marx (see also Neisser, 1942).

Ricardo as believing that a viable invention could somehow lower what today we call ‘total factor productivity’. So too with Kaldor, Schumpeter, Stigler, et al. In my readings Ricardo’s imperfect exposition did not assert *that*.”

Hence, after his 1965 endorsement of Wicksell’s criticism, Samuelson (1988, 1989) sought elements of internal consistency in Ricardo’s new chapter 31. As it is well known, that chapter expressed Ricardo’s recantation of his previous opinion on the machinery question. Just like Samuelson, Wicksell too admired Ricardo’s analytical powers, but he was less concerned in finding internal coherence in Ricardo’s approach to machinery. Having at first interpreted Ricardo as a supporter of the so-called “theory of compensation”, Wicksell eventually realized that the central message of the controversial chapter 31 was the negative impact of machinery on output and employment. Instead of trying to fit that chapter in Ricardo’s long-run theory of distribution – as Samuelson would do later – Wicksell criticized it from the perspective of neoclassical marginal productivity theory with given factor endowments. It was in that context that Wicksell, under the impact of Pareto’s not fully developed claims about optimality of free competition, reformulated the machinery question to bring out the distinction between maximization of aggregate output and of total utility in welfare economics.

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## Appendix.

### *The influence of technical progress on rent and wages*<sup>18</sup>

By Knut Wicksell

Notebook 2, April 1900, Wicksell Papers, Lund University Library, Manuscripts and Archives.

Translated by Hans-Michael Trautwein and Mauro Boianovsky

Edited by Mauro Boianovsky

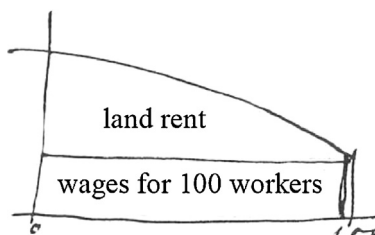
{p. 76} Recapitulation. That productivity is independent of the scale of production can be assumed as approximately correct at every stage of technical development. The advantages of large-scale {p. 77} production – better division of labour, lower costs of management and administration etc. – are to some extent balanced by the trouble that one necessarily has in procuring the raw materials from a wider area and, likewise, by having to look for markets in a wider area. To the extent that there is an improvement in the means of communication, however, these problems will play a smaller role while the advantages remain. This is why an increase of large-scale production can be predicted a priori, and it [that prediction] is also supported by experience.

Even though we have not yet considered the third production factor, capital, we can already take up a discussion of the important, hitherto never satisfactorily treated issue of the effects of technical progress and {p. 78} improvements on the shares of the different production factors in the total product, in particular on the wage level.

Technical progress is generally understood to imply an increase in the productivity of labour. From this [come] effects in two opposite directions: if the worker produces more, he should, one might think, get a higher wage; though, if production, on the other hand, requires less hands to such extent that an excess [of supply] will arise in the labour market, wages are depressed by the competition among workers. Which tendency will prevail? This is impossible to tell a priori. We can nevertheless get somewhat closer to the answer by sticking to the principle according to which

<sup>18</sup> The interjection “Obs!” appears just before the lecture title.

the wage rate is determined by the marginal {p. 79} productivity of labour (just like, on the other hand, the rent on land [is determined] by the marginal productivity of land). If we assume that economic equilibrium is achieved for the moment, such that the marginal productivity of labour is equal across all firms, we could, for a firm with 100 workers (for example, a large agricultural estate) determine the wage rate by the additional product of the 100th worker, as illustrated by the diagram.

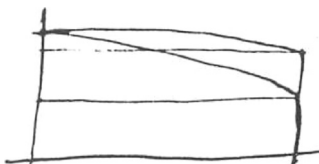


If now the productivity of labour is increased, this can happen in various ways and means basically completely different things with quite different effects.

A more or less even rise in productivity can take place, so that the marginal productivity of labour and thereby the wage rate [are] slightly increased, while the {p. 80} rent on land accidentally also rises. This should, for instance, be the case when better tools are introduced, such as iron ploughs in replacement of simple wooden tools, better drainage of the land, improved sowing, etc.



It can, however, happen that the productivity curve mainly rises on the right, such that – in other words – the increase in the marginal productivity of labour is greater than the increase in the average productivity; in this case, wage rises, but mainly at the cost of rent.

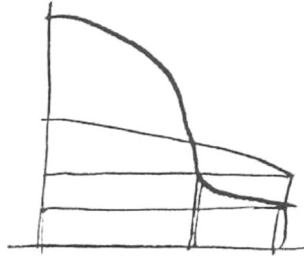


This is, for example, the case if the land under plough is extended, such as by making use of wetlands, by going over from two-shift or three-shift to crop rotation, whereby the acreage that lies fallow is reduced. Similar improvements are especially profitable for the individual {p. 81} landowner, but if they are introduced on a wide scale, the consequences will be adverse (for the landowners). What has actually happened is that the access to land has been increased, such that agriculture turns more extensive (unless the stock of labour is simultaneously increased) and the marginal productivity of land is reduced while that of labour is increased.\*

\* {note on the left page} The same thing happens, though more indirectly, when new fertile colonial countries are discovered, emigration, corn imports to the old countries, etc.

Finally, however, it can also happen (and this is a very important, though often overlooked case) that the increase mainly, no: exclusively, takes place on the left side of the productivity curve, whereas the right side is accidentally lowered. The average productivity of labour is perhaps rising significantly more than the marginal productivity, and therewith wage is lowered while the rent on land is increased handsomely. – This can easily happen {p. 82} when “labour saving” machinery is introduced to agriculture. A relatively small number of hands will then suffice for tilling

the land plus the sowing and, in particular, for managing the harvest. If the others are still employed in agriculture, their marginal product is likely to be very small and less than before (before the machines came into use).



If, however, a real increase in production (or, at least, no reduction) has taken place, the consequences for the worker will not be as fatal as it may have appeared at first sight. The increase in the landowners' demand for industrial products means that a part of the workers will get jobs in the industries. The number of rural workers is reduced, while the marginal productivity and the wage of rural labour rises, such that it can remain {p. 83} at its former level, or even rise above it. (In Sweden, the number of persons, including wives and children, employed in the agricultural sector has actually fallen from 3,078,274 in 1880 to 2,858,000 in 1898, an absolute reduction of 220,000 persons or 7 per cent within 18 years).<sup>19</sup>

The greatest risk is, however, that a reduction in the number of employees comes along with a reduction in the total product itself. The labour-saving machines demand, for example, an increase in the number of horses and oxen, whereby the humans' share in the agricultural produce is reduced. In this context, or even due to market conditions, the land will, to a greater part than before, be used for growing grass or other forage {p. 84}. The wage rate must thereby be lowered (unless a greater number of the workers can find employment in the industries that work for other countries' demand, hence living on those countries' surplus corn). For the landowners that kind of enterprise can nevertheless be most profitable,\*

\* {note on the left page} or simply because wages are brought down

such that their interests come in direct conflict with those of the workers.<sup>20</sup>

Actually changes in all three directions can take place simultaneously, and thereby partly compensate each other, while yet another moment is added by changes in the population itself (population growth). In our country, industry, trade and transport have absorbed about one million new persons over the last 20 years, or about 800,000 more than agriculture has lost (the problems arising from this development). However complex and {p. 85} complicated the problem presents itself in reality, marginal productivity provides a guiding principle to the analysis, at least of every different case.

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<sup>19</sup> A long question mark appears on the left page alongside this paragraph.

<sup>20</sup> A long question mark appears on the left page alongside this paragraph.

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