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Série Textos para Discussão

## **Wicksell on Technical Change, Real Wages and Employment**

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## **SÉRIE DE TEXTOS PARA DISCUSSÃO**

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# *Wicksell on Technical Change, Real Wages and Employment*

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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 I know, exist (Wicksell, 1890, p. 257).

## **1. Introduction**

Knut Wicksell's analysis of the influence of technical changes on rents and wages in volume 1 of his *Lectures* ([1901] 1934, pp. 133-44) has been described as "the first modern discussion of technical change and distribution" by Paul Samuelson (1965, p. 354). Wicksell was the first economist to apply the then new marginal productivity theory of distribution to the treatment of the effects of technical change on income shares. His discussion of technical progress was in great part motivated by the new chapter "On Machinery" in the third edition of David Ricardo's ([1821] 1951) *Principles*, in which Ricardo changed his previous opinion that the introduction of machinery is beneficial to all classes of society, including workers. Ricardo claimed in that chapter that invention of machinery could reduce aggregate output, the demand for labour and (although only implicitly) real wages. Wicksell contended that Ricardo was only partly right, since labour-saving technical progress reduces indeed real wages, but cannot lower national income. Wicksell's criticism of Ricardo has been discussed in the literature (see Sylos-Labini, 1969, pp. 133-36; Hansson, 1983; Coleman, 1985; Samuelson, 1988, 1989), with emphasis on Wicksell's claim that the fall in real wages

increases the profitability of old labour-intensive technology and leads to the reabsorption of workers displaced by the (partial) introduction of new technology.

We shall argue that, despite Wicksell's full-employment result in the argument of the *Lectures*, his careful interpretation of Ricardo's machinery problem is relevant for his notion of technological unemployment developed later on in the 1920s. Wicksell's insight that technical progress may be accompanied by falling marginal productivity of labour and, therefore, falling real wages was unique in the neoclassical literature of his time, where it was argued that, since the average productivity of labour and aggregate output increase with technical change, real wages must also be higher (see, e.g., Marshall [1890] 1990, pp. 596-97; Clark, [1899] 1965, pp. 405-06; Walras [1898] 1936, p. 273; Carver, 1908; Cassel [1918] 1932, pp. 340-41). According to Wicksell ([1923] 1981 and undated manuscript), labour-saving technical change could reduce real wages below their subsistence level or even to zero, turning labour into a free good and causing permanent unemployment. The next section discusses Wicksell's (1890) interpretation of the relation between technical change and real wages in his pre-marginalist days, when he sided with the "compensation" view that technical progress cannot be harmful to workers. Section 3 shows how Wicksell used the concept of marginal productivity to put forward a distinction between land-saving, labour-saving and neutral forms of technical change in the printed *Lectures* and in an unpublished lecture delivered in Lund in the spring of 1900. As shown in section 4, Wicksell applied his model of the effects of technical change on real wages to the interpretation of the continuously high rates of unemployment of the 1920s. Section 5 concludes.

## 2. The Compensation View

"Empty Stomachs - and Full Warehouses", published in 1890 in the Norwegian magazine *Samtiden*, was Wicksell's first article in economics (see Gårdlund, 1958, p. 126). It contains a criticism of the theory of overproduction and an embryo of Wicksell's approach to the business cycle (see Boianovsky, 1995, pp. 391-93). He was particularly critical of the Marxian view that, in Wicksell's interpretation, ascribes both overproduction and underconsumption to the replacement of labour power by machinery. The contradiction between higher production made possible by the introduction of machinery on one side and

the reduction in consumption caused by the dismissal of workers and lower wages on the other side is the main feature of the “Marxist school” according to Wicksell. Capitalists react to the disappointment of lack of markets and lower profits by increased use of machinery with “overproduction and underconsumption reciprocally creating each other in a pernicious cycle” (1890, pp. 251-52).<sup>1</sup> Wicksell disputed Marx’s analysis both on factual and conceptual grounds, and pointed out that this “paradox” - that the economic downswing should be seen as the result of the introduction of labour saving production methods and technical progress in general - has arisen “simply through an incomplete analysis of the economic phenomena” (p. 255).

Wicksell’s rejection of the Marxian discussion of technical change was based on the notion that the long-run effects of labour-saving methods are beneficial to workers through three mechanisms associated with cost reductions caused by technological change. The first and most important one is an increase of the demand for consumption goods brought about either by lower prices or by higher profits. If consumers and entrepreneurs should increase their saving instead, the demand for capital goods would rise correspondingly. Finally, if consumers should react to lower prices by increasing leisure and supplying less labour (that is, a negative income-effect), the dismissed workers would take their place in the labour market.

If the introduction of machinery and improved labour methods makes a certain amount of human labour superfluous, then it follows from that as a simple corollary, after all, that the production cost is also reduced by exactly as much as was previously paid out in wages to the now superfluous workers. The producers now either stuff the entire profit into their pockets or, as should generally be the case, they are forced to share it with the consumers through cheaper prices. In both cases, this profit represents a saving, a retained income, which in one way or another must be employed. If it is used for the consumption of new consumption goods ... there then arises a new demand for products, and thereby for labour power, which is capable of completely absorbing the unemployed. If the producer and the consumer prefer to capitalize their gain instead of immediately consuming it, the result is exactly the same ... A third possibility is that consumers would, instead of seeking new uses for their income, content themselves with a smaller income, that is to

say, work less themselves. But in this case there would be access to the occupations partly vacated in this manner... (Wicksell, 1890, pp. 255-56)

Wicksell's discussion of the reabsorption mechanisms is here very close to the so-called "compensation theory" put forward by J.B. Say ([1821] 1971, p. 87), J. R. McCulloch ([1825] 1965) and others as a reaction to Ricardo's new chapter on machinery (see Gourvitch [1940] 1966, pp. 63-64; Woirol, 1996, p. 18; Hagemann, 1995, pp. 39-40). Nevertheless, Wicksell wrote the passage quoted above as a criticism of Marx, not Ricardo, since he put emphasis in the 1890 article on the compensation mechanisms mentioned by Ricardo himself in the rest of his new chapter.<sup>2</sup> Indeed, Wicksell (p. 256; italics in the original) completed his discussion by pointing out that "one qualification, already partly pointed out by Ricardo [see *Principles*, Sraffa edition, p. 393], is that to be effective the new demand must naturally be directed towards necessities (or personal services) where the ratio of human labour to value is *as strong a proportion* as for the articles which have been made cheaper by machines. If this condition remains unmet, then one cannot claim that a complete compensation takes place". Wicksell (p. 256) believed that the empirical evidence suggested that such conditions had been met and that the introduction of machinery had been accompanied by higher real wages and employment opportunities. The upshot is that "besides the occasional frictions and the difficulties involved in changing from one occupation to another, it is consequently impossible to see how the labour saving methods or these machines could damage the workers, when it is self-evident that in their capacity as consumers they have precisely the same benefit as all other consumers from commodities having become cheaper" (p. 255).<sup>3</sup> The relation between technical progress and the business cycle is, according to Wicksell (1890, sections 9 and 10; see Boianovsky, 1995), the opposite of the one suggested by the Marxian overproduction approach. The pace of technical progress affects aggregate effective demand through its impact on investment in fixed capital, and unemployment is explained by excess saving in the downturn.

Wicksell did not repeat his 1890 "compensation" analysis in the *Lectures*, except in part for a brief discussion of the history of the debates over the apparently conflicting effects of the introduction of machinery on the welfare of workers.

The most striking feature of machinery is that it replaces human labour, i.e. allows us to produce the same quantity of goods as before with less labour; and consequently, as a rule, more goods with the *same* labour. On the one

hand, it may be thought that the greater productivity of labour ought to bring about ... the payment of higher wages; on the other hand, it is commonly supposed to render a number of labourers superfluous, so that competition among the unemployed would depress wages ... Opinions on this point have varied in the course of time. Formerly, under the influence of the mercantilist theory, no doubt at all was felt that labour-saving machinery took the bread from the mouths of workers ... The victory of the physiocratic school produced a sudden change, especially as formulated by J. B. Say, goods must always ultimately exchange against, and therefore constitute a demand for, other goods; an increased productivity of labour should of itself lead to an increased demand for goods hitherto not consumed, or consumed only on a small scale, and therefore for labour to produce them. Hence, machinery would, at most, cause temporary unemployment and inconvenience to certain group of labourers. In the long run it would be beneficial, would lead to increased opportunities for labour, and would rise and not lower wages. (Wicksell [1901] 1934, pp. 134-35).<sup>4</sup>

This description of the compensation mechanism fits very well Wicksell's own interpretation in 1890. The "Law of Markets" approach to the effects of technical change on employment and real wages became dominant during the theoretical disputes over technological unemployment in the 1930s, especially after the 1931 book by P. H. Douglas and A. Director (see Neisser, 1942, section 2; Woirol, 1996, ch. 3). Ricardo's challenge in his new chapter that the introduction of labour-saving methods may be profitable to employers even when it involves a decrease in the size of the product was almost completely passed over as empirically unlikely or theoretically unthinkable from McCulloch ([1825] 1965; part I, ch. VII) to Marx ([1905] 1968, pp. 560-61) and Kaldor (1932, p. 186), among many others. Not by Wicksell, though. He argued that the "optimistic view" received a set-back when Ricardo's new chapter came out, since in this case "the labourers could not be compensated by an increased demand for other commodities" (Wicksell [1901] 1934, p. 135). Wicksell had already mentioned in his 1890 (p. 256) piece that the compensation mechanism would not work "if the introduction of particular agricultural machines (for example, hay making machines) made it advantageous for the landowner to turn the fields over to permanent pasture. He would then be employing a smaller number of workers, achieving thereby

perhaps a higher net profit, but the gross yield would be decreased” (cf. Ricardo [1821] 1951, p. 394), but did not dwell on that. In the *Lectures*, however, Ricardo’s machinery problem provided the starting point for Wicksell’s own analysis of the impact of labour-saving technical change on real wages and employment, this time based on the theory of marginal productivity instead of an application of Say’s Law to the labour market (see Neisser, 1942, for a distinction between the “Law of Markets approach” described above and the “neoclassical equilibrium approach” based on the analysis of the effects of changes in real wages on the margin of substitution between production factors). As discussed next, Wicksell argues in the *Lectures*, against Ricardo, that labour-saving technical progress cannot bring about a reduction in aggregate output in the long run, but this does not vindicate the “Law of Markets” view, since real wages fall in the process. As Wicksell put it in a letter of 1924 to J. M. Keynes, “when [McCulloch] says that the case supposed by Mr Ricardo is ‘possible but exceedingly unlikely ever to occur’, he turns the argument upside down: in fact Ricardo’s *suppositions* are not at all unlikely to occur, but the *conclusions* drawn from them are impossible” (Jonung, 1981, p. 199).

### 3. The machinery problem and real wages

Schumpeter (1954, pp. 943-44) has pointed out that the development between 1870 and 1914 of the theory of marginal productivity of labour as a determinant of demand for labour and real wages was a slow process that did not fully show its usefulness in application to particular problems. “In consequence of this”, according to Schumpeter, “we find that many labour problems continued to be treated by means of the tools that had served the ‘classics’. This holds in particular for the machinery problem. It received plenty of attention but analysis rarely rose above the old arguments pro and con the ‘compensation theory’”. Schumpeter’s assessment certainly applies to most neoclassical economists of that period, but not to Wicksell, who, immediately after his summing up of the historical development of the debate on the machinery problem, observed that “the theory of marginal productivity will enable us, I believe, to put it on a firmer foundation, and to substitute something better for this vague, and even in part erroneous, analysis” ([1901] 1934, p. 135).<sup>5</sup> The first task, according to Wicksell, was to clarify the meaning of the expression “productivity of labour” by distinguishing average from marginal productivity. It was in that context that he made the

fundamental remark that “an increase in the total product as a result of technical changes in the process of production need not by any means lead to an increase - and certainly not a uniform increase - in the marginal productivity of both factors of production [land and labour]” (ibid). This remark is followed by a discussion of the several possible cases of change in marginal productivity of land and labour induced by technical changes (pp. 135-36), but the treatment is clearer in Wicksell’s manuscript lecture notes on technical change, delivered in Lund in the 1900 spring term and held in the Wicksell archives (Lund University Library).

Wicksell started his lecture notes by pointing out that it is impossible to tell a priori which tendency will prevail when technical change increases the average productivity of labour: higher wage caused by an increase in [average] productivity or lower wage brought about by excess supply in the labour market. He then distinguished between three cases, according to the effect of technical change on the marginal productivity of production factors land and labour: (i) “a more or less even rise in [average] productivity can take place”, so that both the marginal productivity of land and labour are increased, together with real wages and land rent (see figure 1); (ii) “it can, however, happen that the productivity curve mainly rises on the right, such that the increase in the marginal productivity of labour is greater than the increase in the average productivity”, so that wages rise, “but mainly at the cost of rent”, since the marginal productivity of land is reduced when technical change is land-saving (see figure 2); (iii) “it can also happen (and this is a very important, though often overlooked case) that the increase takes place on the left side of the productivity curve, whereas the right side is lowered”, so that “the average productivity of labour rises significantly more than the marginal productivity”, and rent rises at the cost of wages (see figure 3). In all figures, the old technique is expressed by alpha and the new one by beta. The third case, corresponding to the introduction of labour-saving machinery in agriculture, is discussed in detail by Wicksell in the *Lectures* (pp. 137-40), while the second case is briefly mentioned (pp. 135-36) and the first one is only implicitly discussed (p. 143). One of the striking features of figures 2 and 3 is that the curves of marginal (and average) productivity of the old and new technique intersect, that is, the average productivity of labour in one technique never exceeds the average productivity of the other technique at all land/labour ratios. As pointed out by Coleman (1985, pp. 356, 364), this is in marked contrast with modern analysis of technical change in terms of labour (or land) “augmenting”, and is behind Wicksell’s result in his *Lectures* (again in contrast with the usual current approach) that *both* techniques will be used in equilibrium.

Coleman's comment that Wicksell did not contemplate the possibility of technical change increasing the average productivity of labour at all labour/land ratios applies only (in part) to the printed *Lectures*, since in the lecture notes he discussed it as case (i), which may be regarded as "neutral" technical change in Wicksell's framework. As is clear from figure 1, in that case only the new technique will be used, just like in the modern "augmenting" approach. This is implicit in Wicksell's ([1901] 1934, p. 143) remark that his previous analysis "does not exclude the possibility that the great majority of inventions and technical improvements may be beneficial in both directions; i.e. may in themselves tend to increase the marginal productivity of both labour and land".

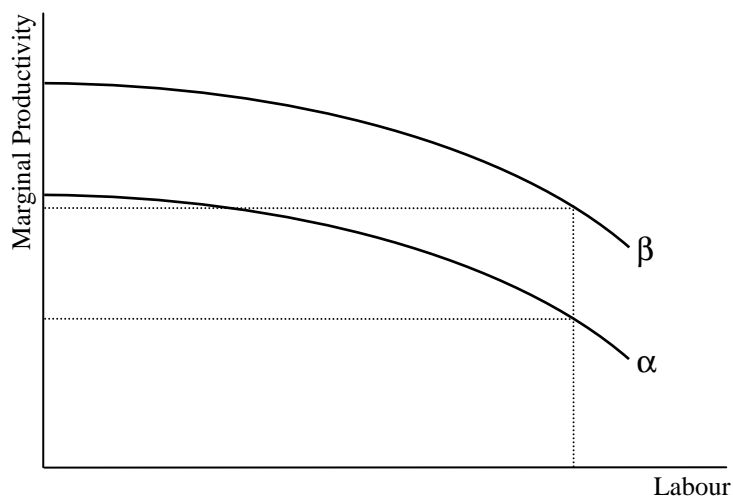


Figure 1. NEUTRAL TECHNICAL CHANGE  
Source: Adapted from Wicksell (1900 Lecture Notes).

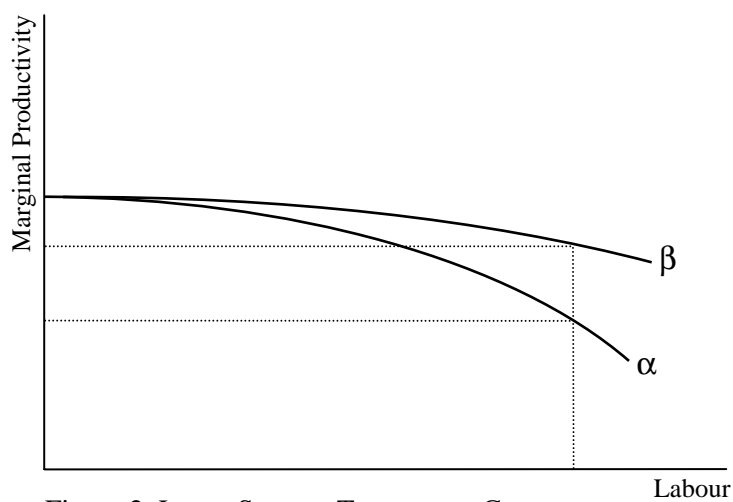


Figure 2. LAND-SAVING TECHNICAL CHANGE  
Source: Adapted from Wicksell (1900 Lecture Notes).

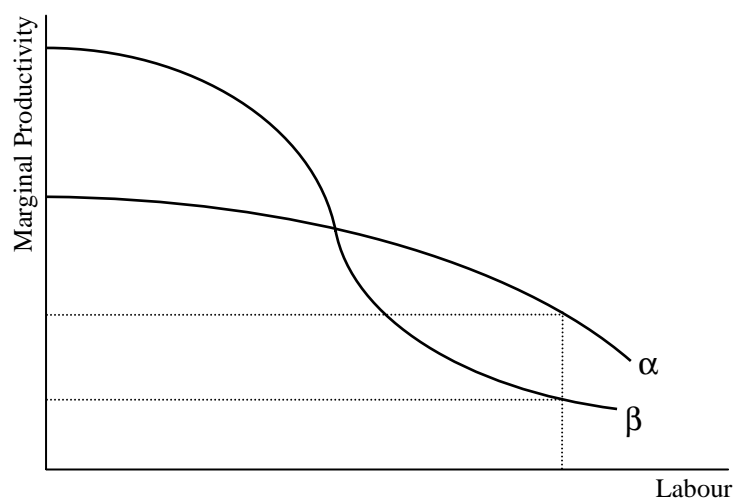


Figure 3. LABOUR-SAVING TECHNICAL CHANGE  
Source: Adapted from Wicksell (1900 Lecture Notes).

Wicksell focused on the labour-saving innovation case in the *Lectures* because of his critical interest in Ricardo's claim that the introduction of a competitively viable invention (that reduces average costs of production) may reduce output. Ricardo's analysis of the machinery problem represents, as observed by Wicksell ([1901] 1934, p. 137; [1913] 1958, p. 169), an important apparent objection to the proposition that free competition must result in the maximum possible output, that is, the notion that perfect competition is Pareto optimal.

But what is of the greatest importance - and what Pareto, with all his learned formulae, has quite forgotten - is to explain the apparent or real contradiction between this proposition and the impressions and opinions of everyday life. No less an economist than Ricardo attempted to show, in the well-known chapter 'On Machinery' added to the third edition of his *Principles*, that the private advantage of a producer might very well be better suited by a *decrease* of his gross product, instead of an increase, and in doing so he appears to have been expressing what experience teaches us ... Nevertheless, the proposition mentioned is presumably quite correct: Ricardo did not follow the thread of his reasoning to its end (Wicksell [1913] 1958, pp. 169-70; italics in the original; see also [1901] 1934, pp. 196-97).

Wicksell, however, was at pains to stress that Pareto optimality only applies to the maximization of production in free competition, not to maximum utility or satisfaction. As shown elsewhere in the *Lectures* (pp. 72-83) as criticism of Walras and Pareto, this is only true if the utility functions are the same for all agents and if the final equilibrium is independent of the final quantity of goods possessed, which is the case when all parties are initially equal economically (see also Myint, 1948, pp. 104-114). Hence, as illustrated by Wicksell's analysis of the machinery problem, the maximization of output may be associated with a reduction on the distributive share of one of the factors of production (labour in this case). "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 [1901] 1934, p. 141).

The conclusion that, under free competition, a diminution of output cannot result from technical innovation was regarded by Wicksell ([1901] 1934, p. 137; see also [1913] 1958, p. 168) as "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". However, the demonstration of the proposition is nothing but self-evident, since it involves the notion that the transition to production with smaller output at the new labour-saving technique cannot be universal, only partial. In order to carry out such a demonstration, Wicksell clearly separated in the *Lectures* the issue of the effects of labour-saving innovation on the distributive shares from the question of the production of the new machines by conversion of circulating capital into fixed capital (that is, a change in the structure of capital, in Wicksellian terms). These two issues were generally mixed together by Ricardo and the classical economists, since they usually assumed that real wages are determined by the wage-fund (circulating capital) in the short run and that machinery is rival to labour (see Samuelson, 1994, on the what he calls the "classical classical fallacy" that fixed capital is prejudicial and circulating capital favourable to labour). Wicksell discussed changes in capital structure caused by technical change elsewhere in the *Lectures* (pp. 163-64) and later on dealt with the Ricardian wage-fund formulation of the machinery problem ([1923] 1981, pp. 201-03). His detailed treatment of technical change in the *Lectures* (pp. 133-44) was based on an economy with land and labour only, since he was mainly concerned at that stage with the quality of machinery of "modifying the conditions under which labour and land replace each other at the margin of production", not with the fact that it represents capital. "In other words, we shall regard machinery as *indirectly* employed (not as saved or

‘stored up’) labour and land” (p. 134). Wicksell assumed, just like in the passage quoted above from his 1890 article, that labour-saving machinery is introduced into agriculture and makes pastoral agriculture more profitable than arable farming, so that the value of product (per farm), “though certainly less, produces a larger net yield, owing to the saving of labour” (p. 137). This is in the spirit of Ricardo’s ([1821] 1951, p. 394; see Samuelson, 1989, pp. 50-51) example of horse-labour that replaces man-labour, as pointed out by Wicksell ([1923] 1981, p. 203).

Wicksell ([1901] 1934, p. 136) mentioned the objection that the immediate negative effects of labour-saving innovation on real wages could be compensated by the expenditure of the increased land rents on consumption of luxury articles, “so that wages would again rise. But this circumstance is, as will easily be seen, only of secondary importance. It may more or less modify the first probable result but can scarcely reverse it” (see also Samuelson, 1988, p. 278, for a similar result). In order to prevent this secondary complication and simplify the analysis, Wicksell assumes that only one commodity is produced, which is the assumption usually made in his aggregate theory of production and distribution throughout part II of volume I of the *Lectures* (see, e.g., p. 103). The introduction of labour-saving machinery is interpreted as a change in the production function of the economy, along the lines of the third case of his lecture notes of 1900. Instead of depicting the old and new marginal productivity curves on the same diagram as in the lecture notes (see figure 3), Wicksell ([1901] 1934, p. 139) uses two diagrams to illustrate the technical change (see figures 4.1 and 4.2), but the essential idea that the curves intersect is of course present in figure 4. As explained by Wicksell (*ibid*), in figure 4.2 a smaller number of workers are employed on an equal area of land, with a smaller gross product (the total area under the curve at the initial real wage) but a greater “net profit” (that is, land rent, measured by the upper part of the area under the curve). The equilibrium allocation of land and labour between the two techniques is decided by profit (rent) maximization by landowners, which leads to an allocation such that the marginal productivity of labour and land are the same under both the new and the old technique, as well as real wages and rent (see figure 5). A crucial assumption behind Wicksell’s argument is that the introduction of the new technique is gradual, that is, only one or a few farmers/entrepreneurs have access to new production method, which assures them a temporary extra (“Schumpeterian”) profit and stimulates other producers to follow (see Ricardo [1821] 1951, p. 387, for a similar assumption; cf. Wicksell [1923] 1981, p. 202, bottom). The final equilibrium allocation is explained by the effects of

lower real wages (caused by the dismissal of workers from the farms adopting the new technique) on the profitability of the old (labour-intensive) production method.

The direct consequence [of the introduction of labour-saving machinery] must be that one or more farmers will go over to the more profitable form of production. If all were to follow their example, there would certainly be more or less considerable diminution of the total output (or of its exchange value), *but this does not happen*. For as soon as a number of labourers have been made superfluous by these changes, and wages have accordingly fallen, then, as Ricardo failed to see, the old methods of production ... will become more profitable; they will develop, using labour more intensively and absorb the surplus of idle labourers. It can be rigorously proved that equilibrium in this case necessarily presupposes a *division* of production between the old and the new methods so that net profits of the entrepreneur will be equally great in both branches of production and the total product, or its exchange value, will reach the maximum physically possible, and will thus finally increase, and not decrease (Wicksell [1901] 1934, pp. 137-38).

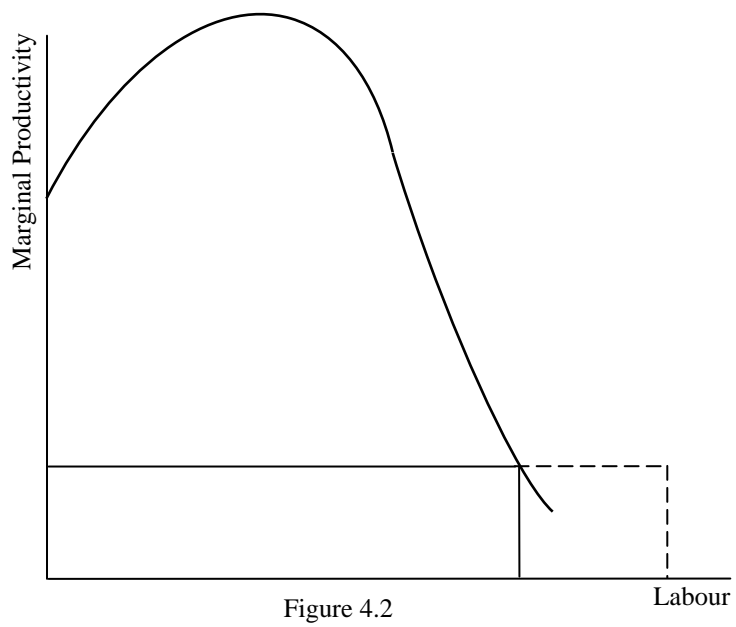
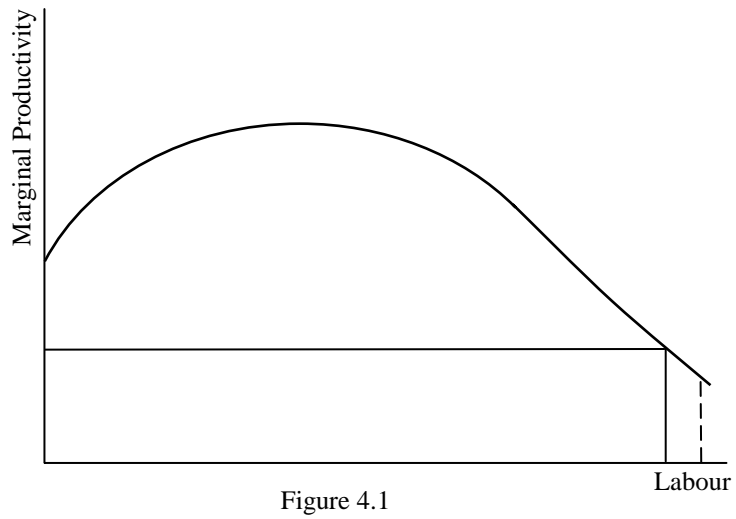


Figure 4. OLD AND NEW TECHNIQUES  
 Source: Wicksell ([1901] 1934, p.139).

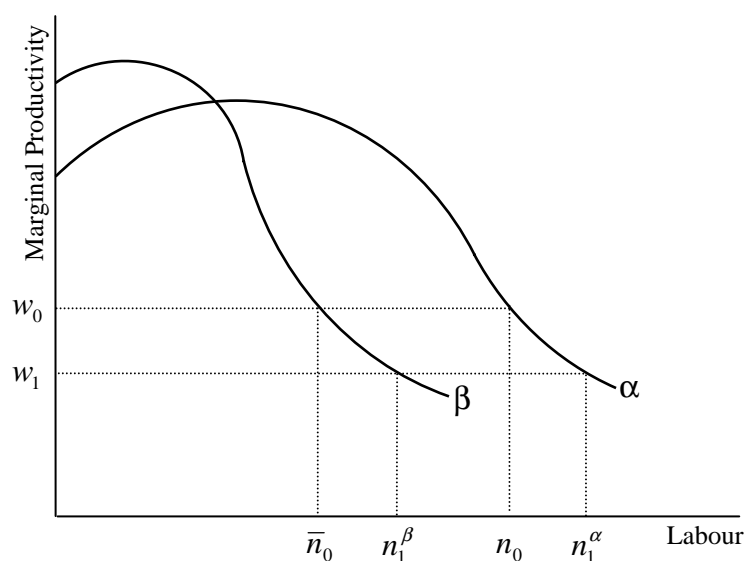


Figure 5. EQUILIBRIUM ALLOCATION BETWEEN OLD AND NEW TECHNIQUES.  
Source: Adapted from Hansson (1983, p.52) and Coleman (1985, p.361).

Wicksell then shows by means of a numerical example, and by diagrammatic and algebraic analysis that the conditions necessary to maximize profit are the same necessary to maximize output, which refutes Ricardo's analysis of technological unemployment (pp. 138-40; see also Lederer, 1938, p. 201, for a discussion of Wicksell's numerical illustration; and Hansson, 1983, and Coleman, 1985, for a discussion of Wicksell's mathematical and graphical arguments). The numerical example shows that the fall in wages brings about some reabsorption of workers in the farms that adopt the new technique, but that the decisive factor is that the "old" farms are more favoured by the wage reduction than the "new" ones, so that they will eventually have the same profit and the inducement to go over to the new technique will disappear. It is only implicit in Wicksell's exercise the assumption that the aggregate demand for labour in the new equilibrium will not exceed the number of workers. If there is excess demand for labour this will not be an equilibrium; instead, real wages will go up (although not as high as their level before technical change) and only the new technique will be adopted. This, however, does not affect Wicksell's original result of maximum output and full employment after the technical change (see Hansson, 1983, p. 53; Coleman, 1985, p. 361).<sup>6</sup>

After all the effects of the labour-saving innovation are accounted for, the economy will settle at a higher aggregate output and the same (full) level of employment, but the absolute and relative shares of workers in national income will be lower. As pointed out by

Wicksell ([1901] 1934, p. 140), the wage reduction in the new equilibrium follows from the assumption that output is less in the farms cultivated by the new method, that is, the average product of land in the new technique is lower than in the old one. As shown by Coleman (1985, pp. 358-60), this is equivalent to the condition that the (profit-maximizing) average product of labour in the new technique is higher than in the old one, although the marginal product is lower. This means that the elasticity of output with respect to labour (measured by the ratio between the marginal product and the average product of labour) is reduced by the labour-saving innovation (see Kliman, 1997, p. 39). Since that ratio is also equal to the relative share of labour under the assumption of a Cobb-Douglas production function (introduced by Wicksell in his production theory), the effect of technical change on income distribution is readily seen. It is worth noting that the equilibration mechanism put forward by Wicksell does not involve a reversion to old methods of production, but an interruption of the spreading of the new method. It is not, therefore, subject to the criticism (see, e.g., Vivarelli, 1995, p. 38) that such a reversion could not take place because of “locked in” technologies. Furthermore, the notion (see Vivarelli, p. 36) that Wicksell inaugurated the neoclassical view that wage flexibility renders permanent technological unemployment impossible must be examined with care, since (apart from Lederer, 1938, and especially Neisser, [1932] 1990 and 1942), Wicksell’s analysis of labour-saving technical change and of the equilibration mechanism had no impact on the literature on technical change started in the 1930s. Both Hicks ([1932] 1963, p. 121) and Kaldor (1932, p. 186) refer to the German edition of Wicksell’s *Lectures* in support of their dismissal of Ricardo’s claim that output can be reduced by the introduction of machinery, but there is no mention at all of Wicksell’s careful discussion of the equilibrating mechanism and its consequences for the determination of real wages. Furthermore, although Wicksell assumed in the *Lectures* a neoclassical production function with continuous substitution between land and labour, this is not necessary for his main result, which is based on the profitability of different techniques at various factor prices ratios. This is clear from Samuelson’s (1989, pp. 51-52) “classical numerical example”, where he assumed linear production functions and came to the same conclusion as Wicksell regarding the effects of a labour-saving innovation on the real wage and on the coexistence of the new and old techniques in the new equilibrium with maximum output and full employment. As discussed in the next section, this result also comes out of Wicksell’s ([1923] 1981) reexamination of Ricardo’s wage-fund model under the assumption of fixed

coefficients of production. But in the 1920s Wicksell's main motivation for going back to the machinery problem was not anymore purely theoretical.

#### 4. Capital, population and unemployment

In 1923 Wicksell submitted to the *Economic Journal* a manuscript on "Ricardo on Machinery and the Present Unemployment" where, instead of reproducing his marginal productivity analysis of the *Lectures*, he attempted to tackle the machinery problem in Ricardo's own terms, that is, by assuming a wage-fund model. The paper was rejected by the then editor J. M. Keynes, on the grounds that "the time has gone by for a criticism of Ricardo on purely Ricardian lines" (Jonung, 1981, p. 199). It was eventually published with an introduction by Lars Jonung in 1981. Wicksell's 1923 paper on machinery was motivated by the continuous high rate of unemployment in Sweden and elsewhere in the 1920s, which could not be described just as part of a downturn of the business cycle (see Jonung, 1981, p. 195, and Boianovsky and Trautwein, 2003, section 7). As Wicksell put it in his reply to Keynes in 1924,

The true refutation of Ricardo's doctrine shows that he was *right* in believing that the introduction of machinery would cause the wages to fall; and indeed this falling of wages would in this case be a necessary condition for the gross product reaching its great amount. In other words the *total* product will increase but the *marginal* product will diminish, and if this latter goes far enough, unemployment will be the unavoidable consequence *unless labour is partly supported from other sources than wages* (Jonung, 1981, p. 200; italics in the original).

Despite Wicksell's mention of marginal product in the letter, the argument of his 1923 paper is based on a critical restatement of Ricardo's ([1821] 1951, pp. 388-90) discussion of the introduction of machinery through the conversion of circulating into fixed capital. In his numerical example Ricardo assumed that, before the introduction of the new technique, the capitalist has a capital stock of £ 20,000, divided into fixed (£ 7,000) and circulating capital (£13,000). The rate of profit is 10% and consequently the gross product is £15,000, formed by wages (£13,000) and net product (£ 2,000). In the following (interim) period a new

machine is built with half of the workers hitherto used in the production of consumption goods, which involves a corresponding cut in its output. The flow of total output (now formed by consumption and capital goods) in the interim period is thus maintained at its initial level. However, once the transition to the new technique has been made in the next period and the new machine is fully used, the economy reverts to the production of consumption goods only, which remains at the same reduced level of the interim period (£ 7,500). Hence, only £ 5,500 can now be allocated to generate demand for labour. As pointed out by Barkai (1986, p. 601) in his careful description of Ricardo's example, the phasing in of the new technology involves at the same time a reduction in the labour/output ratio and a rise in the capital/output ratio. The sum of the two changes - the reduction in the output of consumption goods in the interim period, and the reduction in the labour coefficient in the last period - diminishes the demand for labour from 130 units to 55, under the assumption (made by Wicksell [1923] 1981, p. 202, and by Barkai, p. 599) that the initial wage determined by the wage fund is £100. Ricardo stops his numerical exercise at this point, but, according to Wicksell (*ibid*), the logic of the wage fund model suggests that the competition among the 75 unemployed men will lower wages and "as soon as as they have diminished by only 1% or even somewhat less, there will be room, i.e. capital enough, for one labourer more in each of those businesses [assuming that there are other 75 capitalists with the same business as the one mentioned by Ricardo], so that the redundancy of labourers will cease". Although all capitalists are benefited by this reduction of wages, the employers in the old fashioned businesses are benefited in a greater extent (say £ 100) than the new fashioned (£ 50), so that a point of equilibrium will be reached where no further transition will take place, just like in his previous marginal productivity discussion in the *Lectures*. Again, the increase of output in the old fashioned businesses outweighs the reduction of output in the new fashioned businesses, since (under Ricardo's assumption of fixed coefficients and absence of diminishing return), the 75 disengaged men will produce in their new engagements the same amount as before, but the 55 remaining men will (by Ricardo's assumption) produce more than before. Hence, Wicksell's previous result of an increase of aggregate output through a reduction of real wages is replicated by an application of the Ricardian original wage-fund model to labour-saving technical change. He now generalizes the argument for an economy with more than one commodity and some degree of real wage rigidity.

An important and most remarkable thing is that the fall of wages in this case becomes a necessary condition for the production of the maximum of the

aggregate. Of course it may well be the case that the discharged labourers, in order to avoid competition with their comrades, turn to other branches of industry. If so, perhaps all the farmers will adopt the new methods, and the point of equilibrium will then, as it were, be situated not in that particular branch of business, but in some other, but even then our general conclusion remains intact, at any rate so long as the country itself can be regarded as an isolated community ([1923] 1981, p. 203).<sup>7</sup>

In his books Wicksell was, of course, critical of the wage-fund approach to capital theory, since the division of the capital stock between the part used to pay for the wages (circulating capital) and the part accumulated as durable capital goods (fixed capital) should not be seen as given by technology, but as an economic decision determined by the wage level itself (see Wicksell [1983] 1954, p. 145; Boianovsky, 1998, pp. 546-47). In the *Lectures* he introduced the concept of stratification of capital through time, that is, the notion that the capital structure has both a vertical and a horizontal dimension. The former refers to the proportion of primary factors (land and labour) annually invested in the replacement of capital goods of different maturity dates, while the latter describes the length of time for which the various capital goods are invested (see Wicksell [1901] 1934, part II, ch. 2; Uhr, 1960, ch. 5). It was in that context that Wicksell (p. 164) examined the effects of a technical invention that increases the marginal productivity of capital and renders long-term investment, for a given capital aggregate, more profitable than previously.

The consequence must necessarily be - as long as no further capital is saved - a diminution in the horizontal-dimension and an increase in the vertical-dimension, so that the quantity of capital used in the course of the year will be reduced; an increased quantity of current labour and land will consequently become available for each year's direct production; and, although this need not necessarily cause their marginal productivity and share in the product to be reduced - since the total product has simultaneously been increased by the technical discovery - yet a reduction may clearly result ... The great inventions by which industry has from time to time been revolutionised, at first reduced a number of workers to beggary, as experience shows, whilst causing the profits of the capitalists to soar ... That the 'transformation of circulating into fixed capital', i.e. the changes from short-term to long-term capital investments,

may frequently injure labour is beyond doubt. But Ricardo was mistaken in his belief that this consequence was due to the fact that the gross product is simultaneously reduced. This is, as may easily be proved, theoretically inconceivable.

As observed by Gourvitch ([1940] 1966, p. 117) as a comment to this passage, Wicksell “was one of the few modern economists writing before 1914 who pointed out the possibility of adverse effects of inventions upon the demand for labour”. It should be pointed out that the reduction in labour demand is caused in this case not by the introduction of labour-saving innovation *per se*, but by the fall in the annual replacement requirements per unit of primary factors invested as the capital structure becomes more vertical, which brings about the possibility of a reduction of the marginal productivity of labour *and* land. In the rest of the quotation Wicksell seems to assume that the “transformation of circulating into fixed capital” is often associated with the introduction of labour-saving machinery leading to an abrupt fall of real wages, although this is not necessarily the case.<sup>8</sup>

The view that the trend of technical progress was increasingly labour-saving and harmful to workers is noticeable in Wicksell’s writings on the topic in the 1920s, in contrast with the *Lectures* (p. 143). He pointed out ([1924] 1958, p. 256) that “most technical innovations, both in agriculture and in industry, tend to be *labour-saving*”. Capital and land are substituted for labour: “wholly or partly automatic machines, draught animals, or motor engines take the place of the old hand-power”. At the same time, “capital goods, machines and buildings are made more durable, so that less labour is required for their maintenance or successive renewal”. Hence, Wicksell put together in 1924 the two factors mentioned in the *Lectures*, that is, the substitution of capital (and land) for labour, and the introduction of long-term capital goods with lower replacement requirements. This leads to the “social paradox” that the efficiency of labour rises significantly because of technical progress, “whereas the *marginal* productivity of labour and therefore the wage for unskilled work falls very low, perhaps below the subsistence minimum” (ibid; italics in the original). This scenario is the same discussed in Wicksell’s 1923 paper and the policy conclusion is that the fixing of a minimum living wage would only give rise to “permanent unemployment” and diminish the social product ([1924] 1958, p. 257; cf. [1923] 1981, p. 205). In the long-run, of course, real wages below the subsistence minimum would be followed by a reduction in population size through emigration or limitation of births, which would reduce permanently

the labour supply and therefore the employment level (see Boianovsky, 2001, for Wicksell's views on population). However, as pointed out by Wicksell ([1923] 1981, p. 205), in the case of a reduction of real wages caused by labour-saving technical change it is likely that the social output is more than enough to yield a sufficiently high income per capita but at the same time the marginal productivity of labour is below subsistence level. Wicksell's suggested solution to the paradox is to make the difference between the equilibrium wage rate and subsistence by subsidies to workers. "The only completely rational way to achieve the largest possible production ... would be to allow all production factors to find their equilibrium positions unhindered, under free competition, however low they may be, but at the same time to discard resolutely the principle that the worker's only source of income is his wages. He, like every other citizen, ought rather to be entitled to a certain share of the earnings of the society's natural resources and capital..." ([1924] 1958, p. 257).

Wicksell's 1901 criticism of Ricardo has been rejected by Samuelson (1988, 1989, 1994) on the grounds that the introduction of labour-saving machinery is able to bring about a reduction of the social output through its effect on real wages and, therefore, on population and labour supply. Samuelson (1989, p. 47) claims that, despite the absence of clear textual evidence in the new chapter on machinery, Ricardo assumed that wages are at their subsistence level in long-run classical equilibrium before the introduction of machinery. According to Samuelson (p. 52), Wicksell overlooked the crucial role of the population mechanism in bringing about a reduction of output in Ricardo's machinery problem, so that the employment level falls but there is no unemployment in equilibrium after the introduction of the new machine. However, as should be clear from our discussion above, Wicksell did not neglect the implications for the population size of real wages below subsistence. Already in the *Lectures* (p. 141, first paragraph), Wicksell considered the possibility that real wages might fall below subsistence and briefly suggested the subsidy plan described above. In the first Swedish edition of the *Lectures*, that paragraph starts with an explicit comment on Ricardo that was later removed from the second and third editions, from which was made the English translation. The remark sounds like an anticipation of Samuelson's criticism: "One could object that, according to Ricardo's assumption, wages are already at their living minimum and therefore cannot be further reduced; this should then apparently justify his thesis, but actually not" (Wicksell, 1901, p. 168). Furthermore, Samuelson's (*ibid*) conclusion that in Ricardo's new equilibrium with less output, lower population and subsistence wage only the new technique will be used (instead of Wicksell's equilibrium with

new and old techniques) is formally the same one obtained by Wicksell ([1923] 1981, p. 204, italics in the original) under the assumption of a minimum wage: “If, on the other hand, the original wages were regarded by law as *minimum* wages and were not permitted to be diminished by the employers ... there would apparently be a general transition on the part of the farmers to the new-fashioned ‘labour-saving’ methods”. Therefore, contrary to the title of Samuelson (1989), we may say that “Wicksell was right!”.<sup>10</sup>

Wicksell’s conclusion that labour-saving machinery may diminish the marginal productivity and the real wages of labour below subsistence and all the way down to zero is important in order to assess his interpretation of “permanent” unemployment in the 1920s (for the distinction between normal, cyclical and permanent unemployment in Wicksell see Boianovsky and Trautwein, 2003). In an unpublished, undated and unfinished manuscript on unemployment, probably written in the 1920s, Wicksell referred to the fact that machinery had in some degree replaced labour in all areas of economic activity (the manuscript is translated as an appendix to Boianovsky and Trautwein, 2003). “If you think of all this, you will be no longer surprised by the [present] unemployment, but rather be puzzled that under these conditions human labour - and, in particular, ordinary, simple manual labour - can find a market at all”. Even if there is a demand for part of the labour force, permanent unemployment will eventually bring the short-run market clearing wages down to zero, since labour becomes a free good with zero marginal productivity. “Assume that a quarter of the existing labour force were sufficient to control the machines and to maintain them, then the other three quarters would become redundant and their work would not be of any value; actually all labour would become worthless, since one worker cannot receive more than the other, if both have the same skills”.

At first sight, the undated manuscript may look like a recantation of Wicksell’s previous analysis of the machinery problem in the *Lectures*, but actually it is a logical corollary of that analysis when the marginal productivity of labour keeps falling until it reaches zero level and the old techniques are not used anymore. Indeed, Wicksell refers in the manuscript to the fact that in his “childhood days” there was a great demand for manual labour in jobs where machines had not been invented yet, that is, the old production methods were still used. Sylos-Labini (1969, p. 135) has realized that, under the assumption that mechanization of production is an uninterrupted process in Wicksell’s framework, wages would tend to zero. However, the inference from this is not, contrary to Sylos-Labini’s criticism of Wicksell, that the continuance of mechanization is logically incompatible with

perfect downward flexibility of real wages, but that the system would converge to a position at zero wages with only part of the labour force absorbed, as suggested by Wicksell in the manuscript. Such a scenario has been discussed by Samuelson (1988, pp. 277-79; 1989, pp. 50-51; 1994, p. 633) under the assumption of a strong labour-saving technical change.

The notion of labour as a non-scarce production factor with zero price can be found also in Wicksell's published writings. In his well-known review of Cassel ([1918] 1932), Wicksell repeated his thesis that, although free competition tends to maximize aggregate output, it does not generally lead to a distribution of that product consistent with maximum satisfaction. In particular, Wicksell ([1919] 1934, p. 228) stressed that Cassel's simultaneous equations in general equilibrium "are no guarantee that any 'variable' cannot assume the value nil, even if we are discussing so important a social factor as wages". This was the first reference in the literature to what would become known later as the "rule of free goods" (see Neisser [1932] 1990). It should be noted that the undated manuscript is also consistent with Wicksell's general framework in the sense that, despite zero marginal productivity of labour and technological unemployment, output is at its maximum level. This situation is captured by J. S. Mill's ([1848] 1909, p. 79) famous phrase "demand for commodities is not demand for labour", of which Wicksell approved: "We must recognize the truth of Mill's well-known principle that demand for commodities is not the same as demand for labour - unless it results in the accumulation of new capital" (Wicksell [1901] 1934, p. 191). In the scenario entertained in the undated manuscript, unemployment can only disappear either through Malthusian elimination of three quarters of the population or via capital accumulation. As put by Wicksell, (*ibid*, p. 164), "the capitalist saver is ... fundamentally the friend of labour, though the technical inventor is not infrequently its enemy". Technological unemployment is, therefore, associated with capital shortage, a thesis that would be further developed by Hans Neisser and other members of the "Kiel School" in Germany in the late 1920s and early 1930s (see Hagemann, 1990).<sup>9</sup>

## 5. Conclusion

Our investigation of the development of Wicksell's views on technical change has shown that his notion of technological unemployment is not incompatible with the criticism of Ricardo in the *Lectures* and elsewhere, but a corollary of that criticism. The main conclusion of

Wicksell's careful discussion of labour-saving technical change in the *Lectures* and in the 1900 lecture notes is that it tends to reduce the marginal productivity of labour and push the wage rate downwards. This set him apart from most of the contemporary neoclassical literature and represented a change from his 1890 pro-compensation view. Together with Marx, Wicksell was one of the few economists who took seriously Ricardo's attempted demonstration that the introduction of machinery could be harmful to workers. However, Marx's and Wicksell's respective interpretations of how labour-saving technical change affects real wages and employment are, of course, quite different. Wicksell's analysis is based on the notion that, as labour-saving technical progress advances, the labour demand (that is, the marginal productivity) curve tends to become less elastic, which means that a larger reduction of real wages is necessary in order to induce employment to remain at its full level, until eventually (for a given capital stock) the market clearing wage rate reaches zero and the reabsorption of unemployed workers cannot take place; technological unemployment may also come about if real wages become rigid downwards below their subsistence level. Apart from Lederer (1938) and especially Neisser (1942; see Boianovsky and Hagemann, 2003, which is a follow up to this paper), Wicksell's insight on the effects of labour-saving innovations on wages and employment did not make a strong impact in the literature, since his concept of different forms of technical change differed from the framework developed by Hicks (1932), Robinson (1938) and others in the 1930s.

## Notes

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1. Wicksell's reading of Marx is consistent with interpretations found elsewhere in the literature. See, e.g., Gourvitch [1940] 1966, pp. 73-79; Hagemann, 1995.
2. One of the difficulties of Ricardo's new chapter was its uncharacteristic vagueness, which has left it open to different interpretations (see Schumpeter, 1954, p. 683).

3. See also Boianovsky and Trautwein (2003) for Wicksell's use of the phrase "normal unemployment" - consistent with equilibrium in the labour market - to describe unemployment of the frictional kind.

4. See also Gourvitch ([1940] 1966, pp. 20-33 and 46-48) on the treatment of the machinery question by the mercantilists, physiocrats and Say.

5. According to Marshall ([1890] 1990, pp. 596-97), "mechanical progress" is necessarily beneficial to the working classes, since it increases the "national dividend". In the same vein, Clark ([1899] 1965, p. 405) argues that an invention always raises real wages, for "wages now tend to equal what labor can now produce, and this is more than it could formerly produce". Like Marshall, Cassel ([1918] 1932, p. 340) claims that "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." See also Walras ([1898] 1936, p. 273) for a similar passage. Walras's comments attracted Wicksell's ([1899] 1999, p. 179) criticism: "Concerning the labour question, [Walras] shows no understanding for the drawbacks of labour-saving machines, to which already Ricardo had drawn attention".

6. Interestingly enough, Marx ([1867] 1938, p. 390) mentioned that a reduction in the real wage rate caused by the introduction of machinery could encourage capitalists to switch back to labour intensive methods and interrupt the process of diffusion of the new technology: "In the older countries, machinery, when employed in some branches of industry, creates such a redundancy of labour in other branches that in these latter the fall of wages below the value of labour-power impedes the use of machinery and ... renders that use superfluous and often impossible." Marx, however, did not draw Wicksell's conclusion about the effects of lower wages on the absorption of the dismissed workers.

7. For a discussion of Wicksell's application of his argument about technical change to an open economy see Herlitz, 2002, pp. 491-95.

8. In his 1902 lecture notes on economic crisis Wicksell suggested that this mechanism could clarify the argument by the classical economists about the upper turning point of the business cycle. "The classical economists pointed out that crises were preceded by an immobilization of circulating capital, thereby reducing the 'wage fund'. That certainly lacks clarity, like the whole theory of wage funds; but the truth in this argument could perhaps be expressed as follows: productive forces are detracted not only from the production of the usual necessities...but from the renewal of the more or less circulating or fixed capital employed in this production, too. In that case, workers cannot be employed before this capital is due to be replaced, etc." (Boianovsky and Trautwein, 2001, p. 358). See also Hayek (1941, app. II) for a treatment of Ricardo's machinery problem from the perspective of Austrian capital theory. According to Hayek, the transition from one capital structure to another may be incomplete if there is a lengthening of investment periods of some inputs without a compensating shortening of others. This can bring about capital scarcity in the crisis, but of a kind different from the one discussed by Wicksell and the Kiel School in connection with persistent unemployment in the 1920s (see the last paragraph of this section).

9. Wicksell usually assumed an exogenously given labour supply in his general theory of production and distribution, as well as in his treatment of the effects of technical change. As pointed out by Kliman (1997), if labour supply is a positive function of real wages, the

equilibrium level of employment will necessarily fall when labour-saving technical change is introduced.

10. Such a notion of technological unemployment can be also found in Dennis Robertson's (1931, pp. 50-51) careful discussion of the marginal productivity theory of real wages. "The tendency to industrial rationalisation is...a tendency to install such elaborate and expensive and durable plant, and to devise such a close and intimate co-ordination between it and the labour force required to work it, as to leave as little room as possible for the operation of the Principle of variation...A completely rationalised world might turn out to be one in which, if organised so as to obtain their *de facto* economic worth, a certain proportion of workpeople could find employment at a very high wages, while the remainder could hardly find it on any terms at all." In this scenario, Robertson and Wicksell assume implicitly John Cairnes's theory of non-competing groups in the labour market (see also Boianovsky and Trautwein, 2003).

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