Breaking New Ground: The Significance of W.S. Jevons's Rent Theory[1]

Michael V. White*

***Abstract*:** In *The Theory of Political Economy* (1871), W.S. Jevons argued that his representation of rent theory in the form of the calculus had provided a 'clue to the correct mode of treating the whole science'. An explanation for the clue could cast some light on how Jevons's marginalist theory was produced, although he failed to do so. This article suggests that an explanation turns on identifying the way that Jevons had transformed his predecessors' rent theory. The explanation, in turn, clarifies how the calculus imposed a particular form of theoretical representation that constituted an analytical break with preceding work in British political economy.

W. Stanley Jevons's marginalist theory of value and distribution was first published as the *Theory of Political Economy* (*TPE*) in 1871. Jevons had begun work on the marginalist project in 1860, producing two versions of a summary, the 'Brief Account', in 1862. The first was read as a paper to the British Association for the Advancement of Science and eventually published in 1866 (Jevons 1866). The second and longer summary, the manuscript of which was recently discovered, was submitted to, and rejected by, the *London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* (Grattan-Guinness 2002). That manuscript helps clarify a number of arguments in the shorter published version. There is, however, a paucity of published or unpublished archival material that directly refers to the means by and the ways in which Jevons initially produced his theory in the early 1860s. The information that remains principally consists of some brief diary entries and two letters written by Jevons in 1860. The missing material includes Jevons's reaction to the rejection of his manuscript by the *Philosophical Magazine*, as the pages from his diary for the relevant period were ripped out.[2]

Jevons also changed the ordering of his analysis between 1862 and 1871. The 'Brief Account' first discussed the marginal utility theory of behaviour, including labour, then referred to the explanation of rent, which was followed by the theory of exchange (Jevons 1866, pp. 282-4). That was quite different from *TPE*, where the theory of exchange (chapter 4) preceded the analysis of labour (chapter 5) and the theory of rent (chapter 6). Although there are clear similarities in the analyses of 1862 and 1871, the different orderings suggest that an explanation of how Jevons produced his initial analysis will be hampered if it is assumed that *TPE* was simply a longer version of the 'Brief Account'.[3]

The priority given to the theory of rent in 1862 introduces the topic of this article. While Jevons did not produce a detailed explanation of how the 'Brief Account' and *TPE* were written, he did provide some hints, one example of which concerned the rent theory. Although Jevons was often highly critical of his predecessors, he noted in the 'Brief Account' that his depiction of rent was 'not materially different from that of Dr. Anderson (1777) and later writers' (Jevons 1866, p. 284).[4] Nine years later, the same impression of theoretical continuity was

conveyed by the more detailed discussion in *TPE*. The only difference, Jevons argued, was that he had replaced the 'clumsy arithmetical illustrations' of his predecessors with the 'mathematical symbols' of the 'fluxional calculus …. the branch of mathematics which most correctly applies to the subject' (Jevons 2001 [1871], pp. 198, 204). This implied that the calculus was simply a technique that enabled the formalisation and, therefore, clarification of the analysis but had no other ramifications for the theoretical representation of economic activity. That seems consistent with an argument made elsewhere in *TPE*: 'The symbols of mathematical books are not different in nature from language …. They do not make the mode of reasoning they embody; they merely facilitate its exhibition and comprehension' (*ibid.*, pp. 5-6). The fluxional or infinitesimal calculus was also important for another comment that indicated the rent theory played a more general role in the formulation of the marginalist project. In the preface to *TPE*, Jevons remarked that the rent theory had 'a distinctly mathematical character which seems to give a clue to the correct mode of treating the whole science' (*ibid.*, p. vi). The nature of the clue, however, was not explained.[5]

In presenting an explanation for the clue, which can cast some light on how Jevons produced his marginalist theory, this article argues that, contrary to Jevons's statements, his rent theory made an important analytical break with his predecessors. The break can then help explain the link Jevons made between the theory and the 'correct mode of treating the whole science', showing how the introduction of the calculus imposed a particular representation of economic activity. The analysis is presented in five sections. Two possible explanations that have been suggested for Jevons's elliptical remark about the rent theory are considered in sections 1 and 2. Those explanations are unsatisfactory in varying degrees because they either cannot, or are insufficient, to fully explain Jevons's remark. Section 3 turns to the rent theory in *TPE*, explaining the nature of Jevons's analytical break. Read in the context of the break, section 4 shows that his statement regarding the significance of the rent theory can help explain how he produced his marginalist analysis. Section 5 then considers how the use of the calculus imposed particular assumptions on Jevons's analysis.

1 The 'Sphere of Consumption'

The first explanation to be considered for Jevons's remark is that his rent analysis suggested the formulation of the marginal utility theory of behaviour. This follows from the claim that 'the 'marginalist revolution' …. consisted essentially of a generalisation of the principle of *intensive* diminishing returns …. (M)arginalism is an offspring of the theory of differential rent as it had been developed by authors such as Thomas Robert Malthus'. With the application of that principle to 'the *sphere of consumption*', the work of Jevons, Carl Menger and Leon Walras 'can hardly be said to have ushered in a new age of economics. Most of what they had to say had already been said by some earlier writers. There was no such thing as a proper 'revolution'' (Kurz 1999, pp. 144, 145).[6] If the problematic category of revolution (Steedman 1997) and the coupling of Menger with Jevons and Walras are put to one side, the argument is that Jevons's marginal utility theory was simply an extension by analogy of the concept of an intensive margin.[7] That could explain Jevons's comment in *TPE* (Rogin 1956, p. 463).

In considering this matter, it is important to note that the marginal utility theory in *TPE*[8] was not simply concerned with finished commodities as in the

market-period analysis of exchange (and hence supply and demand) presented in chapter 4. A further component of the theory was concerned with labour, explaining how a representative labourer would cease work at the point where the marginal disutility (pain) of labour was equal to the marginal utility (pleasure) of the commodity produced (Jevons 2001 [1871], pp. 165-74). Jevons used that analysis in chapter 5 to construct a long-period equilibrium position where the marginal utility ratio of the commodities exchanged was equal to their cost of production ratio (Jevons 1970, pp. 203-5). In that respect, he introduced an important analytical break by building his theory of market-period and long-period relative prices on the actions of a representative actor.

As Jevons's quotations and comments in *TPE* suggest, the key text for the formulation of the behavioural theory was Richard Jennings's *Natural Elements of Political Economy* (1855).[9] To produce his account, which Jevons reworked and extended with the calculus and geometry, Jennings drew on two principal theoretical resources. The first was the discourse of physiological psychology, published in Britain during the early 1850s, which explained a good deal of behaviour as reflex actions. Jennings combined that stimulus-response theory with the mechanics of William Whewell, so that behaviour was depicted as akin to a gravitational force (Jennings 1855, p. 141). With the body represented as a machine, the commodity marginal utility function in *TPE* was analogous to a gravitation function. Jennings also explained the shape of what became the marginal disutility function in *TPE* by referring to the muscular exertion necessary to hold a weight in the hand for different periods of time. This followed an argument used by Whewell to demonstrate how the concept of force could be felt and understood (Whewell 1847, pp. 186-8). Jevons also extended Jennings's argument by constructing an equilibrium condition for exchange based on that for a lever in static equilibrium. With exchange depicted as a balance of gravitational forces, political economy became, as Jevons noted in the second edition of *TPE*, a '*mechanics of utility and self-interest'* (Jevons 1970, p. 90).

Jennings's *Natural Elements* is relevant in two respects when considering the claim that the behavioural theory in *TPE* was simply an extension of the concept of an intensive margin. The first is that, by arbitrarily restricting the focus of the analysis to the demand for finished commodities, the claim erases any consideration of the complex basis for the resources that were used to produce the more general behavioural theory. An examination of Jennings's resources in the *Natural Elements* indicates that it was only possible to represent behaviour in a strict functional manner as a type of mechanics after the mid-nineteenth century. The second point is that Jennings constructed his explanation of behaviour without any reference to diminishing returns and a theory of rent. Rather than the rent theory suggesting the theory of behaviour, the available evidence indicates that Jevons was only able to construct the former after he had adopted the latter from Jennings.[10] It can thus be concluded that, when Jevons referred to the rent theory providing 'a clue to the correct mode of treating the whole science', he was not suggesting that the marginal utility theory was produced as an extension of the rent theory.

2 Interest on Capital

While Jevons's behavioural theory cannot be reduced to a reflection of the marginalist analysis of diminishing returns, the analysis does appear to have played

another role in *TPE*, a role which might explain Jevons's comment about the significance of his rent theory. As a number of commentators have suggested, the link in this case concerns the construction of the theory of interest on capital in chapter 7 of *TPE*. There was a clear similarity in the procedure used to explain rent and interest in a long period, where the basic theoretical approach was to assume two inputs, one fixed in amount and the other variable. All units of the variable input were homogeneous and recompensed, in equilibrium, at the same rate, which was equal to the marginal product of the last unit used. The marginal product would decline with each additional input, the fixed factor receiving the residual output. To 'roughly …. illustrate' his interest rate theory, Jevons used a diagram which depicted an 'industry' that employed 'a fixed number of labourers'. With an increase in the quantity of capital in each long period, the marginal product of capital would decline (Jevons 2001 [1871], pp. 244, 245).[11] The diagram was similar to that used for the rent theory (section 3 below).

The link to the rent theory was indicated in the 'Brief Account' where Jevons noted that when capital was invested in 'Buildings, tools, &c.', the return followed the 'laws' of rent, rather than those concerning the interest on capital (Jevons 1866, p. 286).[12] That cryptic reference was consistent with Jevons's discussion in *TPE* of how initial increments of capital in an industry could receive an 'indefinitely great return' until additional increments were supplied. A quasi-rent could exist before a long-period equilibrium was established.[13] Jevons did not mention rent in that context, drawing an analogy instead with the distinction between the total and marginal utility of a commodity (Jevons 2001 [1871], p. 242). In an 1873 letter on the subject to George Darwin, however, he made the analogy with the rent theory explicit. Referring to pages from the first edition of *TPE*, which contained the interest rate diagram mentioned above, Jevons argued that the 'earlier increments of investment may return any excess over the current rate, as fully explained on pp. 242-5 …. there is no reason why all increments of capital as used in industry should yield equal results. According to the accepted doctrine of rent, as stated by James Mill, this is certainly so (see p. 203)'.[14]

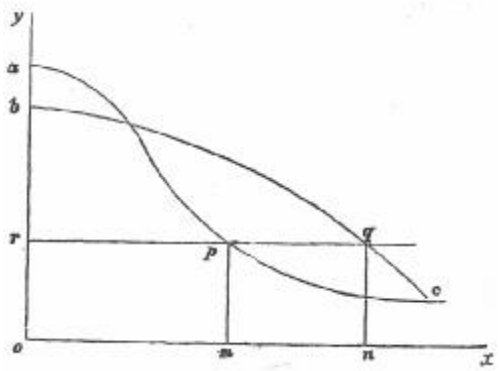
Jevons's marginalist representation of diminishing returns introduced a significant theoretical change in that, as he indicated, the analysis required that the fixed factor was fully employed at all levels of output. That assumption was imposed by the use of a partial derivative to explain rent and the interest rate. It should be noted, however, that the discussion of diminishing returns to labour played a less significant role in *TPE* than in subsequent distribution theories. When explaining the work decision referred to above, both Jennings and Jevons assumed that labour productivity was constant over the relevant range. (This reinforces the conclusion from section 1 that there is no evidence the diminishing returns analysis played a role in the formulation of the behavioural theory.) Jevons restricted the domain of diminishing returns for labour to explaining costs and prices in the raw materials sector because, like John Stuart Mill, he assumed that, for a given technology, wage rate and set of input prices in a long period, manufactured commodities were produced under conditions of constant costs. The mathematical representation of diminishing returns used for rent was adapted to depict a declining interest rate over series of long periods, a decline that Jevons regarded as confirmed by 'historical facts' (Jevons 2001 [1871], p. 239). The role of the rent theory in formulating the interest rate theory is, however, insufficient to explain Jevons's comment that the rent

theory provided a clue for 'the correct mode of treating the whole science'. It will now be argued that a more complete explanation turns on the recognition that Jevons had made a key analytical break with his predecessors' rent theory.

3 The Marginalist Analysis of Rent

To explain rent in a long period, Jevons assumed in chapter 6 of *TPE* that the amount of land was given and the quantity of labour variable. With different quantities of homogeneous labour applied to a piece of land, he used his discussion of the work decision from chapter 5, based on the device of a representative actor, to argue that work would cease at the point where the marginal disutility of labour was recompensed by the corresponding increment of output (Jevons 2001 [1871], pp. 205-7). All units of labour would be paid at the same rate that appears to correspond to Jevons's reference to the 'ordinary wages' of labour when describing the 'accepted Theory of Rent' (*ibid*., pp. 200, 204). With a declining marginal product of labour curve, rent was the surplus above the ordinary wage line up to the equilibrium point on the 'sterile land which it only just pays to take into cultivation' (*ibid*., p. 242). Figure 1 from *TPE* illustrates the analysis (*ibid*., p. 209).[15]

Figure 1



Units of labour effort are denoted along *ox*, with the marginal product of labour along *oy*.[16] The marginal product of labour curve for the first piece of land is *apc*. The marginal return to labour is given by *rq*. Work would cease at the point *p* with rent as the surplus of *rap*. Jevons extended that result to a second piece of land, with a marginal product of labour curve *bqc*. The actor would cease work at the point *q*, with rent of *rbq*, where the marginal product was equal to the marginal return in both cases (Jevons 2001 [1871], pp. 208-11). The analysis was consistent with the discussion of cost of production in the preceding chapter as Jevons had indicated when he noted that, in long-period equilibrium, '*articles will exchange in quantities inversely as the cost of production of the most costly portions, i.e. the last portions added*. This last point will prove of great importance in the theory of Rent' (*ibid*., p. 202). Rent was a price-determined surplus, which simply accrued to land ownership, equal to the difference between the price and cost of production at a long-period equilibrium point and the lower cost of production at intra-marginal levels of output.

It was this depiction of rent that Jevons described as the 'accepted' theory and with which he announced his agreement, citing the work of James Anderson,

J.R. McCulloch and James Mill (Jevons 2001 [1871[, pp. 198-204; cf. Anderson 1777, pp. 45n-50n; James Mill 1821, pp. 13-23; McCulloch 1839, pp. 444-53). At first sight, the reliance on texts by McCulloch and, especially, James Mill appears odd in that there was no mention of the work of David Ricardo (1951 [1819], chapter 2), Thomas Malthus (1989 [1820], chapter 3) or John Stuart Mill. Jevons's was a restricted account, exorcising Anderson's heresy[17] with no mention of John Stuart Mill's detailed discussion which argued that the rent theory did not have 'universal' applicability (Mill 1987 [1909], Book 2, chapters 5-7) and that some land would sell at a 'scarcity' value (*ibid*., Book 3, chapter 5).

If the account was restricted, Jevons had also made an important theoretical break with his predecessors. There was no capital in the analysis[18] and, in contrast with McCulloch and J.S. Mill, Jevons discussed transportation costs in the analysis of exchange in chapter 4 (Jevons 2001 [1871], pp. 103-5), so they played no role in explaining cost of production and, therefore, rent. The most significant difference, however, was that the theory was presented in strict marginalist terms. Jevons noted that his predecessors had provided two explanations for the origin of rent. The first referred to the cultivation of successive pieces of land with differential fertility. The resort to more inferior land was explained as the result of increasing population, although Jevons did not make that clear. The 'secondary' explanation (as Jevons put it) was that rent derived from the application of 'more or less labour and capital' to the same piece of land. He transformed the argument by assuming that population was a parameter in his value and distribution theory (*ibid*., pp. 200, 201, 255). With labour as the only variable input, the cultivation of an additional piece of land was thus undertaken by the same actor depending on the calculation of the marginal pain and pleasure. The differential fertility of the two pieces was represented by the different heights and particular shapes of the declining marginal product of labour curves. With population given, the 'secondary' component of the explanation for Jevons's predecessors now became the explanation.

The excision of population as an explanatory variable could explain why, as noted above, Jevons made no mention of the discussion of rent by Ricardo, Malthus or J.S. Mill, as population played a clear and explicit role in their accounts.[19] In contrast, Jevons bestowed high praise on James Mill's discussion in his *Elements* – 'a work which I never read without admiration of its brief, clear, and powerful style' (Jevons 1871 [2001], p. 202). James Mill's analysis of rent was closer to Jevons in that it made no mention of transportation costs and paid little explicit attention to the role of population.[20] The praise for the *Elements* in *TPE* might also go some way in explaining the ordering of Jevons's analysis in the 'Brief Account' of his theory. As was noted in the introduction to this paper, in 1862 Jevons first summarised his marginalist theory of work and then referred to rent before turning to exchange. Mill's *Elements* discussed production in chapter I, followed by rent in the first section of the following chapter which dealt with distribution. It may be that Jevons began his marginalist theory of value and distribution by following the exposition in Mill's *Elements*.[21]

In subsequent discussion of rent theory, it was argued that there was a 'parallelism' between the two explanations in that they were components of a unified marginalist analysis. Differential fertility was characterised as an 'extensive' margin, while the application of a variable factor to one piece of land constituted an 'intensive' margin (Hollander 1895, pp. 184-5). Textbooks today create the same impression when referring to 'diminishing returns' (Pindyck and

Rubinfeld 2001, pp. 185-7). As was explained by Wicksteed and Sraffa, however, that suggested unification is erroneous in a marginalist framework (Wicksteed 1914, pp. 17-20; Sraffa 1998 [1925], pp. 326-40; see also Bharadwaj 1978, pp. 44-54). In the 'intensive' margin case, where units of a homogenous factor (labour) are applied to a fixed factor (a unit of land), there is a functional relationship between the independent variable (labour) and the dependent variable (the marginal product of labour). Given the assumption that each additional unit of the variable input will produce a smaller increment of output, the marginal product of labour curve is explained by the technical relation between the two variables. The so-called 'extensive' margin case is quite different. Here, there are heterogenous units of land, so that a further behavioural assumption (profit maximisation) is required to explain the ranking of land from the most to the least productive. A (smoothed) curve drawn to depict the successive additions to output cannot, therefore, be explained by a functional or technical relationship between two variables. To call that 'descriptive' curve a marginal product (of land) function is, as Wicksteed argued, a 'spurious' characterisation.

The critique by Wicksteed and Sraffa clarified why references to a 'marginal' change have no precise analytical meaning apart from the particular theoretical framework in which the references occur.[22] Although 'it has often been pointed out that the Ricardian theory (of rent) was a form of marginal analysis' (Black 1970, p. 26), such attempts to depict Ricardo's analysis within the terms of the subsequent neoclassical framework depend on what is, for that framework, the analytically incoherent amalgam of the 'intensive' and 'extensive' margins cases.[23] Jevons's argument, however, was not subject to that critique.[24] Although he argued that his rent theory was not 'materially different' from that of earlier economists, he had produced a quite different explanation which, in omitting a key explanatory variable used by his predecessors, recast the explanation in the functional terms of the calculus. 'Diminishing returns' was now represented as a partial derivative. It would be misleading to suggest that Jevons 'concentrated' on an intensive (rather than an extensive) margin, as that would imply he simply modified the focus or emphasis of an existing theoretical framework. Rather, Jevons transformed the previous framework, subsuming the role of differential fertility within the terms of his marginalist analysis. It has been argued that Jevons's rent theory was 'an elegant restatement of Ricardian theory in calculus terms' (Black 1981, p. 7), thus constituting a theoretical bridge between early and late nineteenth-century political economy. As was shown above, however, the significance of theory in this regard is that it was actually symptomatic of the analytical distance between the postclassical framework in *TPE* and the work of Jevons's predecessors.

4 Explaining Jevons's Comment

It is now possible to consider Jevons's comment in *TPE* regarding the more general significance of the rent theory by linking it with the discussion of consumer demand used in his theory of exchange (chapter 4).

In Nassau Senior's *Outline* (1836), to which Jevons referred in *TPE*, consumption demand was explained as the result of two distinct 'desires'. The first and, as Senior made clear, the most important, was the 'desire for distinction', which depicted demand as interdependent, explained by reference to a hierarchy of consumption, where bundles of commodities were grouped in categories of necessaries, conveniences and luxuries. The second component of the explanation

was the diminishing want or desire for succeeding units of a commodity in each bundle, which Senior referred to as the 'desire for variety' (Senior 1951 [1836], pp. 11-13). Jevons transformed that analysis by representing the hierarchy of wants as marginal utility functions with different heights and shapes. Although he could refer to necessaries and conveniences in *TPE*, the hierarchy played no substantive role in the theoretical analysis since consumption demand was explained by the diminishing final degree of utility for a commodity. Indeed, Jevons made no mention of the desire for distinction in his discussion of Senior (Jevons 1871 [2001], pp. 48, 63-4). The theoretical dominance of the hierarchy in Senior's analysis, with its reliance on interdependent behaviour, was erased and replaced by the secondary factor of incremental desire, now represented in a functional manner with independent consumers.[25]

The same procedure was used in the theory of rent. While Jevons's predecessors had provided two principal explanatory factors for consumption and rent, he inverted the relative importance of the factors by reducing the previously dominant component of the explanation to a given, which was represented by the height and particular shape of a function. That component then played no further role in the theoretical explanation. The 'secondary' component of the explanation became the dominant one, represented in a functional form. By reducing a more complex explanation to a functional relation between two variables, Jevons's argument could appear to incorporate basic explanatory factors used by his predecessors (differential land fertility, the hierarchy of wants) while reducing them to givens that had no role in the core of the marginalist explanation of value and distribution. If Jevons had first used that analytical device when formulating the theory of rent and then extended it to the consumption theory, that could explain his comment that the 'mathematical character' of the rent theory provided 'a clue to the correct mode of treating the whole science'.

5 'Making a Mode of Reasoning'

It was argued above that Jevons's remark about the role of the rent theory can be explained, in large part, as one consequence of the analytical break he had introduced. The break was, however, obscured by two further comments in *TPE*. The first was the claim of theoretical continuity with the rent theory of his predecessors. The second was the suggestion that the calculus simply clarified the existing theory, making it more precise. Rather than making 'a mode of reasoning', the mathematics 'merely facilitates its exhibition and comprehension' (Jevons 1871 [2001], pp. 5-6). It is evident, however, that the calculus imposed a particular type of theoretical explanation. With rent explained as the area under the curve of a partial derivative, there was no role for a separate explanation of rent in terms of the differential fertility of land. Moreover, the use of a partial derivative to explain diminishing returns imposed the assumption that the fixed factor was fully utilised at all levels of production.

Consideration of the role of the calculus in that regard can cast further light on the production of the arguments in *TPE* by showing how it imposed other assumptions. As was indicated in section 1 above, the calculus was part of a theoretical package, making political economy a type of mechanics so that behaviour was represented as a functional relationship between two variables, modelled on a gravitation function. In an article Jevons cited in *The Coal Question* (Jevons 1866a, pp. xvi-xviii), John Tyndall noted that a gravitation function was

concerned only with quantity and not with quality: 'With gravity there is no selection; no particular atoms choose, by preference, other particular atoms as objects of attention; the attraction of gravitation is proportional to the *quantity* of the attracting matter, regardless of its quality' (Tyndall 1865, p. 133). That functional form imposed two assumptions on the theory in *TPE*.

The first concerned the homogeneity of commodities in a particular market. With the fundamental explanation for demand and supply given in terms of utility functions, the downward slope of a function depended on the assumption of a diminishing final degree of utility. Commodities, therefore, had to be homogeneous because differences in quality would introduce a further explanatory factor. Indeed, Jevons realised that he could not provide an explanation for the prices of heterogeneous commodities within the marginalist theory (White 2002). The second assumption was that of independent actions. While economists such as Adam Smith and Nassau Senior had made interdependent behaviour a key aspect of their work, Jevons was clear in *TPE* that each actor's behaviour was independent. In part this followed directly from the calculus. If the downward slope of the function depended only on the quantity of a commodity, there could be no further explanatory variables introduced without destroying the fundamental functional form. A further feature of the analysis reinforced the independence assumption. Jevons argued that while the behaviour required by the calculus, such as continuously adjusting purchases to a change in the relative price, was 'true' in theory, it would not necessarily occur in practice. Some consumers would act according to 'extraneous motives or …. caprice'. Jevons claimed, however, that aggregate behaviour was normally distributed according to 'the law of error', so that an average of actual behaviour would make the theory 'practically true' (Jevons 1871 (2001), pp. 21-3, 89-90). This entailed that all errors (deviant behaviours) were randomly distributed and, therefore, independent events. Using the calculus to explain a representative actor, coupled with the claim that average behaviour conformed to the theory, necessitated the assumption that each actor's behaviour was independent.

The calculus thus had definite theoretical effects which help to explain Jevons's use of particular assumptions that differentiated *TPE* from the work of his predecessors. Depicting economic activity as a mechanics in which the purpose of the analysis was to explain how utility was maximised by production and exchange, with a given set of resources (White 2004a) had two further effects. The first concerned the representative actor in the behavioural theory who balanced pain and pleasure at the margin of an equilibrium point. When Nassau Senior discussed the 'desire for distinction', he argued that it was 'with almost all men who are placed beyond the fear of actual want, the ruling principle of conduct. For this object they undergo toil which no pain or pleasure addressed to the senses would lead them to encounter; into which no slave could be bribed or lashed' (Senior 1951 [1836], p. 12).[26] As a strict Utilitarian, Jevons would, no doubt, have responded that all motives for behaviour could be subsumed under the utilitarian calculus (Jevons 1871 [2001], pp. 27-32). Even allowing for that argument, there was a marked theoretical distance between *TPE* and Senior's depiction of 'the ruling principle of conduct' which characterised behaviour in terms that would appear irrational in Jevons's fundamental model.

The second effect of the mechanics was that depicting economic analysis as a problem of maximisation under constraint meant that a change in population had no role as an explanatory variable. It has been noted in the secondary literature

that this was important for considering Jevons's explanation of wage rates. It should also be emphasised how important it was for changing the explanation of rent.

6 Conclusions

The significance of Jevons's rent theory is, in part, that it helps explain how he formulated a number of arguments in the marginalist project. The elliptical remark that the rent theory provided a 'clue to treating the whole science' in a mathematical manner can be explained by reference to two matters. The first was the use of the fixed and variable factor framework to explain distribution. The second was the way he had reduced the more complex explanatory framework of his predecessors to a functional relationship between two variables.

That explanation for Jevons's remark turns on the second aspect of the rent theory's significance. Although the analysis of rent in chapter 6 of *TPE* has often been depicted as a theoretical bridge between marginalism and the work of his predecessors, Jevons had introduced a clear analytical break. If his statement that he had adapted the 'accepted Theory of Rent …. (with) little or no alteration' (Jevons 1871 [2001], p. 204) appears odd, it is possible to partly explain it. Jevons argued, like his predecessors, that rent was a price-determined surplus explained by variations in costs of production at different levels of output. He also agreed that an explanation of rent should refer to both the differential fertility of land and the application of successive units of input(s) to a given piece of land. Although there was some congruence at this level of summary statements, their explanation was quite different in *TPE*. Diminishing returns was now depicted as a partial derivative, with differential fertility and population reduced to givens. Indeed, Jevons undermined his continuity claim by constructing a canon of 'the accepted theory' that omitted any mention of Ricardo, Malthus or J.S. Mill for whom population played a key theoretical role. To conclude, without qualification, that Jevons 'accepts the orthodox theory of rent' (Young 1912, p. 587; Steedman 1997, p. 55) erases the significance of Jevons's canon and his introduction of the new marginalist conceptualisation of diminishing returns.[27]

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* Economics Department, Monash University, Victoria 3800, Australia. Email: mike.white@buseco.monash.edu.au.

Notes

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2 For the 1860 diary entries, see Black (1973-81, volume 7, p. 120); White (1994a, p. 220. For the letters, see Black (1973-81, volume 2, pp. 410, 422). For the removal of the diary pages, see Grattan-Guinness (2002, pp. 687, 700-701).

3 For an explanation of the change in ordering, see White (2004a). In general, the secondary literature has followed J.M. Keynes in assuming that *TPE* 'follows very closely both the order and the substance of the abstract of nearly ten years before' (Keynes 1972 [1936], p. 130).

4 While the reference to rent in the 'Brief Account' was brief, there was a more detailed discussion in the unpublished version (Grattan-Guinness 2002, pp. 712-3).

5 In the opening paragraph to the rent chapter in *TPE*, Jevons also noted that the 'general correctness of the views put forth in preceding chapters derives great probability from their close resemblance to the Theory of Rent'. He then argued that this was simply due to the use of the calculus (Jevons 2001 [1871], p. 198).

6 The argument is buttressed by reading a number of earlier economists as precursors of marginal utility theory (Kurz 1999, p. 161n). All emphases in quotations here appear in the original material.

7 Although Kurz refers to Bharadwaj (1978) in support of his argument, that attribution is mistaken (cf. Bharadwaj 1978, pp. 46-8).

8 The term marginal utility is used here although Jevons used final degree of utility. See Marshall 1961, p. 838; Young 1912, p. 583.

9 Jevons (2001 [1871], pp. 65-8, 166-8. The following two paragraphs draw on White (1994a; 2004a; 2004b).

10 Heinz Kurz (1999, p .144) notes that both Knut Wicksell (1954 [1893], p. 40) and Piero Sraffa (1998 [1925]) referred to the formal similarity between the diminishing marginal utility and marginal productivity theories. Neither, however, made the historical claim that the former theory was derived from the latter. Indeed, for Sraffa, 'only *after* the studies of marginal utility had called attention to the relationship between price and quantity (consumed), did there emerge by analogy the symmetrical conception of a connection between cost and quantity produced' (Sraffa 1998 [1925], p. 325). A report of some notes made in the late 1920s also suggests that Sraffa saw a theoretical break in *TPE* which he traced to Jevons's reliance on the *Natural Elements* (Signorino 2001, p. 753).

11 Jevons did not use the terminology of marginal product but rather 'the amount of increased produce …. due to an increment of capital' (Jevons 2001 [1871], p. 244). His discussion of a long-period analysis in this case was different from that of Alfred Marshall, for whom all inputs were variable in a long period.

12 Here, Jevons referred to Francis Newman's *Lectures* and the work of 'other writers'. See Newman (1851, pp. 135, 145); Mill (1987 [1909], pp. 476-7).

13 This aspect of Jevons's analysis in *TPE* was, apparently, not widely recognised in the early twentieth century. When Jevons's reference to it in a manuscript (meant for the unfinished *Principles of Economics*) was published as an appendix to the fourth edition of *TPE* (1911), Allyn Young (1912, p. 587n) described it as a theoretical 'innovation' in Jevons's treatment of interest.

14 W.S. Jevons to George Darwin, 14 September 1873; Darwin papers, University of Cambridge, 251: 4556. (My thanks to Bert Mosselmans for a copy of this unpublished letter.) One reason why the diagram could not represent the interest theory 'with strict accuracy' (Jevons 2001 [1871], p. 245) is that it depicted only the quantity of capital. Jevons's explanation of the declining interest rate, however, depended on the distinction between the 'amount of capital invested' (the quantity of capital) and the 'amount of investment of capital' (the quantity of capital multiplied by the time for which it was invested) (Jevons 2001 [1871], pp. 221-5, 236-8; see Steedman 1972; Peach 1987, p. 1017). The simplified diagram could, however, indicate the way in which Jevons initially formulated his theory.

15 I have omitted part of the diagram for ease of exposition. That makes no difference to the substance of the argument here. Jevons's analysis shows it was not the case that F.Y. Edgeworth 'was the first to define the laws of diminishing returns in terms of the decline of the *marginal* product of a variable factor …. everyone before him defined it in terms of the *average* product' (Blaug 1986, p. 70).

16 Jevons called this the 'rate of production', consistent with his analysis in the preceding chapter (Jevons 2001 [1871], pp .206, 170-4).

17 It has been suggested that, given Jevons's references in the 'Brief Account' and *TPE*, 'it is strange that Anderson has received little attention in Jevons scholarship' (Grattan-Guinness 2002, p. 692). Jevons's references to and citation of Anderson followed the discussion in an editorial note by McCulloch published in his 1839 edition of Adam Smith's *Wealth of Nations* (McCulloch 1839, pp. 452-3). McCulloch did not mention that Anderson rejected the relevance of diminishing returns when considering the further application of capital to land already under cultivation (Cannan 1953 [1917], p. 293n). Anderson was not referred to in the corresponding note in McCulloch's 1828 edition of Smith's text (Smith 1828 [1776], pp. 100-25). That first note was written, in the main, by John Stuart Mill (Mill 1967, p. 162) and McCulloch changed a good deal of it for the 1839 edition.

18 In the second edition, following criticism by Walras, Jevons announced he was now assuming a constant capital to labour ratio (Jevons 1970, p. 220). There was, however, no return to capital represented in the theory.

19 In 1875 Jevons wrote to H.S. Foxwell that 'Ricardo has not the slightest claim to the (rent) theory, as it was quite as well stated by Malthus if not by Anderson long before' (Black 1973-81, volume 4, p. 147). If this could be read as a rationale for excluding any reference to Ricardo in *TPE*, it only makes the absence of Malthus appear more peculiar.

20 See, for example, Mill (1821, pp. 16-17). The quotation from Mill in *TPE* shows that Jevons used the first edition of the *Elements* (Jevons 2001 [1871], pp. 203-4; Mill 1821, p. 17).

21 The ordering of the 'Brief Account' was quite different from the *Elements* after the discussion of rent, due, in large part, to different explanations of wage rates.

22 See Sylos Labini (1988) for a more extended discussion of this point. Even within *TPE*, there were different meanings for a marginal or incremental change. At some points Jevons referred to discrete changes in a quantity (for example, a quarter of corn). In the specification of the equilibrium conditions, however, there were only infinitesimally small or imaginary changes (White 2004b).

23 For an example of the amalgam, see Kaldor (1955-6, pp. 84-6). See also Samuelson's representation of a 'canonical classical model' which he characterised as a 'rigorous (mathematical) analysis' (Samuelson 1978, pp. 1417-8, 1420). Two of Kaldor's colleagues were subsequently more careful in their treatment of this matter (Robinson and Eatwell 1973, pp. 77-88).

24 The critique is also relevant when assessing the reading of Keynes's *General Theory* in terms of a neoclassical labour market theory based on diminishing returns with homogeneous units of labour (an 'intensive' margin) and a fixed money wage to explain unemployment in the 'short run'. Keynes, however, assumed that diminishing returns to labour were explained by the heterogeneity of labour (Sardoni 1994, pp. 72-7), with employment, productivity and the real wage rate driven by changes in aggregate demand. The argument is analogous to the 'extensive' margin case, so there can be no neoclassical marginal product of (or demand for) labour function (Wells 1974). (While critical of the formulation of Wells's account, both Weintraub (1974) and Leijonhufvud (1974) acknowledged the validity of that basic point). It is, moreover, bizarre to use the neoclassical labour market model in a Keynesian context since that diminishing returns analysis entails that the fixed factor (capital) is always fully utilised. How can a Keynesian analysis be presented satisfactorily if there is no possibility of excess capacity in an economy?

25 This inversion and transformation dissolved the lexicographic consumption analysis in Senior's text (White 1992). Jevons also used that method in his analysis of

the work decision. Just as the demand analysis depicted different groups of commodities, Jevons referred to different work patterns by groups identified in terms of race and class. By comparison with 'professionals', for example, the 'lower races' and most of the British working class preferred leisure to work. This would correspond with different slopes and heights of the respective (average) marginal utility and disutility functions (White 1994b).

26 This could be related to, but was not the same as, Adam Smith's discussion of the 'over-weening conceit which the greater part of men have of their own abilities', coupled with an 'absurd presumption in their own good fortune' (Smith 1976 [1776], p. 124).

27 The analysis here has been restricted to the discussion of rent in chapter 6 of *TPE*. The Preface to the second edition (1879) abandoned the argument that rent was price-determined (Jevons 1970, pp. 68-71). That requires a more detailed discussion (White 2004c).

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