Natura non facit saltum in Alfred Marshall (and Charles Darwin)

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Abstract: The adage *Natura non facit saltum* was, as is well known, adopted by Alfred Marshall as the motto for his *Principles of Economics*, most probably as a borrowing from Charles Darwin's *Origin of Species*. This paper examines Marshall's use of the adage and argues that, on the whole, the 'Darwinian' promise implicit in its use was not realised: his intentions to the contrary, Marshall did not adequately succeed in his objective here. Two appendices provide, first, the original uses of *Natura* in Darwin, and, second, a history of its (and variant) uses, including the relevant passage from Linnæus.

Introduction

Few mottoes as this, on the frontispiece of Alfred Marshall's *Principles of Economics*, express at once so succinctly – 'Nature does not make a leap' – both the author's methodological position and his desire, given its apparent proximate source in Darwin, to be associated with the foremost intellectual revolution of his day. With what knowledge of its previous use Marshall deliberately chose to use it as the motto of his *Principles* is a question of interest in itself, and is dealt with further below. What is also of interest, is just what association – or as suggested above, claims to association – the motto, standing unambiguously on the frontispiece from the first edition onwards, would have suggested in an age when in the best tradition of Political Economy such texts were addressed as much to a wider public of literate persons from many disciplines as to specialist students and practitioners of the subject.

'That old canon in natural history' (Darwin)

The clearly most compelling proximate source of the motto is with Darwin's *Origin of Species, etc.* (1859) where it is employed (including in a chapter summary) seven times in all. *Natura* was used by both Darwin and Marshall from the first editions of their major works (*Origin* and *Principles* respectively); we may note here that Darwin came to use it less frequently, and Marshall more, as their respective works passed through later editions.[1] The relevant passages from the first edition of the *Origin* are given here in Appendix A; and, although pre-Darwinian uses of *Natura* (or related) are not the direct concern of this paper, Appendix B presents the best available synoptic account of its history, together with the relevant passage from Linnæus, not simply for the sake of interest, but in the hope that future quotation of *Natura*, by economists especially, will be more correctly done than in such recent instances which are cited there.

Marshall follows.....?

There does not appear to be, at least so far as an authority such as Groenewegen can tell us, any *direct* evidence of the source from which Marshall took his motto. What little we know (or can conjecture) is briefly stated:

> It [the First edition of the *Principles*] also contained a motto, *Natura non facit saltum,* adopted perhaps from Kant, perhaps from Darwin's *Origin of Species.* This concisely expressed the principle of continuity, applied throughout the book, which gave it 'the special character of its own' tentatively claimed for it by its author . . . Darwin associated the confirmation of this 'old canon' with the new knowledge produced by the theory of evolution, hence the use of the motto is partly designed to highlight the evolutionary spirit in which Marshall constructed his text (Groenewegen 1995, pp. 411 and 439, n. 52).

The earliest evidence of Marshall's reading of the *Origin* is in his 1867 paper 'The Law of Parsimony'[2]; the latest edition of the *Origin* available at that time was the fourth (1866). Marshall's personal copy of the book is no longer available[3], but as the substantive changes in the use of *Natura* had been made by the second (1859) edition[4], the question of just which edition Marshall had read would be of only marginal importance to this particular inquiry.[5]

The influence upon Marshall of the remarkable Henry Fawcett, his predecessor in the Cambridge chair, cannot be ignored. Fawcett, who had been present at the now-famous 1860 meeting of the British Association for the Advancement of Science, published shortly thereafter a cogent account of Darwin's theory (Fawcett 1860), and himself presented a paper at the 1861 meeting (Fawcett 1861). Fawcett's influence on the nine years younger Marshall was extensive (Groenewegen 1995 *passim*), and it is not unreasonable to suppose that he too played some part, albeit indirectly, in framing Marshall's thinking here, as elsewhere.[6] Nor should we neglect the time (1868, 1870-1), following his election to a fellowship (1865) and then appointment to a college lectureship (1868), which Marshall spent in Germany with exposure to the ideas of the emerging evolutionist thought in that country, with evidence of this later emerging in a footnote (*Principles*, p. 241 n. 1) where he specifically draws the reader's attention to works by two of the leading German evolutionists of the day, Ernst Häckel and Albert Schäffle.[7]

Marshall and *Natura*

The three instances in which *Natura* is to be found in the eighth edition of the *Principles* are now examined. Although effectively reversing the chronology of Marshall's presentation, it is more convenient for analytical purposes to consider them in the order presented here.

It was not until the fifth (1907) edition that Marshall apparently felt that he owed his readers some explanation for his use of *Natura* on the frontispiece:

> It [the *Principles*] avoids such special topics as currency and the organization of markets. And in regard to such matters as the structure of industry, employment, and the problem of wages, it deals mainly with normal conditions. Its motto, *Natura non facit saltum,* does not deny the existence of earthquakes and flashes of lightning. It is designed merely to indicate that those manifestations of nature which

> occur most frequently, and are so orderly that they can be closely watched and narrowly studied, form the foundations of economic as of all other scientific work; while those which are sudden, infrequent, and difficult of observation, are commonly reserved for special consideration at a later stage (Preface, 5th edition, Guillebaud 1961 (II), pp. 46-7).

This was subsequently modified in the next edition and then through all remaining editions to read:

> Those manifestations of nature which occur most frequently, and are so orderly that they can be closely watched and narrowly studied, are the basis of economic as of most other scientific work; while those which are spasmodic, infrequent, and difficult of observation, are commonly reserved for special examination at a later stage: and the motto *Natura non facit saltum* is specially appropriate to a volume on Economic Foundations (Preface, p. xiii, 6th-8th editions).

Whatever his reasons for using it, either originally or later, the justification which he subsequently offered was thoroughly *un-Darwinian* in nature. For Darwin, gradualism was characteristic of *all* change, and application of this principle served to distinguish scientific from non-scientific explanation. For Darwin, no phenomena were, on account of their apparently exceptional nature, 'reserved for *special* consideration at a later stage' (my emphasis), though there were many instances in the *Origin* where phenomena were conceded to lack as yet full explanation, but which he confidently believed would in time yield to the application of the principle of gradualism:

> Multiform difficulties will occur to everyone on this theory. Most can I think be satisfactorily answered. – 'Natura non facit saltum' answers some of the most obvious. – The slowness of the change, and only a very few undergoing change at any one time answers others. The extreme imperfections of our geological records answers others (Darwin 1990, p. 448).

Unlike the passage from the Preface just considered, elements of the following passage date from the first (1890) edition:

> For though institutions may be changed rapidly; yet if they are to endure they must be appropriate to man; they cannot retain their stability if they change very much faster than he does. Thus progress itself increases the urgency of the warning that in the economic world, *Natura non facit saltum* (*ibid*., p. 249).

This now stands as the penultimate paragraph of the chapter 'Industrial Organization' (IV.viii), a chapter which opens with Marshall's view on the debt which biology owed to economics (the Malthus-Darwin episode, of debatable significance, I happen to believe), and in which we see Marshall consciously borrowing the language of biology, as for example in 'This increased subdivision of functions, or "differentiation", as it is called, . . .' (p. 241). However, as the work passed through subsequent editions, a number of deletions and additions were made to the original passage proper, to the material leading up to it, and to the associated footnotes and Note XI of the Mathematical Appendix to which the reader has been referred just prior to the extract given here. This part of the *Principles* demonstrates that Marshall had, by the time of the fifth (1907) edition, absorbed some of the post-Darwinian developments and controversies in biology.

For reasons of space these developments and this aspect of Marshall's thought cannot be fully treated here, but two observations can nevertheless be made.

The first is that in this passage we find *Natura* being used to different effect from where, in the Preface (as just seen), it is used to state a methodological position – a principle, as Marshall believed, which formed 'the basis of economic as of most other scientific work.' Here, by contrast, it is being used at least partly in a sense closer to the Darwinian original, although Darwin, operating on a very different time-scale from Marshall, would not have allowed of any 'changes to man' sufficiently sensible to be of consequence or note as compared with the speed of change in industrial organisation to which Marshall refers (although some of the more optimistic Eugenicists, with whom Marshall deals earlier, might not have agreed).

My second observation concerns Note XI of the Mathematical Appendix, to which the reader of all editions from the third (1895) onwards is referred by a simple footnote, but which first appeared – at least in its original form – in large part as a long footnote. Here, Marshall tries his hand at what he appears to believe is Darwinian evolutionary biology.

Originally, the text read:

> The giraffe whose long neck enables it to survive by feeding on the shoots of trees when the grass is dried up, may possibly lengthen its neck yet further by constantly stretching it, and thus further increase its power of surviving; but this effect is not purposely sought. Again, the tendency for all peculiarities of this sort to increase their rate of growth as time goes on, within certain limits, is allowed to work itself out unopposed (unless by sexual selection) in the animal kingdom. The longer, within certain limits, the giraffe's neck is, and the more exclusively he feeds on the shoots of trees, the more will his chance of survival depend on the length of his neck; and the greater will be the force which the struggle for survival will exert in tending to accelerate that growth (see Note XI of the Mathematical Appendix) (Guillebaud 1961 (II), p. 326).

This does indeed at first sight appear to have an agreeably Darwinian flavour to it. Unfortunately, at no point which I have been able to find does Darwin use the giraffe's *neck* for any purpose of illustration, and the idea implicit in Marshall's little fable, of a form of Lamarckian inheritance of acquired characteristics, is the antithesis of Darwin's 'inheritance of favourable variations'.[8]

Whether he came to realise of his own accord that the 'giraffe's neck' was plainly silly or whether, as Groenewegen suggests, he was alerted to the Lamarckian implications of his line of argument by the biologist William Bateson (Groenewegen 1995, p. 484), it was replaced from the third (1895) edition by the 'webbed feet of aquatic birds':

> If members of any species of birds begin to adopt aquatic habits, every increase in the webs between the toes – whether coming about gradually through the operation of natural selection, or suddenly as a sport, – will cause them to find their advantage more in aquatic life, and will make their chance of having offspring depend more on the increase of the web (*Principles*, 8th edition, pp. 843-4).

Now we are on more solid Darwinian ground. But Marshall could not resist mathematising his argument, and the Note continues, as it had from the first edition, with 'web' now replacing 'neck':

> So that, if *f(t)* be the average area of the web at time *t*, then the rate of increase of the web increases (within certain limits) with every increase in the web, and therefore *f"(t)* is positive.

The usual form of Taylor's theorem is then given, leading to the observation that:

> There is more than a superficial connection between the advance made by the application of the differential calculus to physics at the end of the eighteenth century and the beginning of the nineteenth, and the rise of the theory of evolution. In sociology as well as in biology we are learning to watch the accumulated effects of forces which, though weak at first, get greater strength from the growth of their own effects; and the universal form, of which every such fact is a special embodiment, is Taylor's Theorem (*Principles*, 8th edition, p. 844).

On Marshall's use of Taylor's theorem here Levine writes:

> Now, one usually thinks of comparative statics as the appropriate universe of discourse of Taylor's Theorem. Still, the latter – or, more specifically, a Taylor expansion – may be resorted to, in the realm of dynamics, in order to approximate the form of a particular function, as Marshall set out to do in his Mathematical Note XI (Levine 1983, p. 283).

I believe that either Levine is giving too generous an interpretation to Marshall, or that Marshall himself was mistaken in his application of Taylor's theorem. As Levine correctly states, it is most usually employed in comparative-static applications to provide a linear approximation to a non-linear function, and hence allow testing for local stability; what it has never been claimed to do is to demonstrate the 'accumulated effects of forces,' not even in the most metaphorical of senses.

Finally, there is the matter of the frontispiece itself:

> *Natura non facit saltum* (Frontispiece, from first edition).

What, we must now ask, would the literate reader (who probably would not then have needed to be provided with a translation) have made of this, standing so clearly on the frontispiece? He (or, as is less likely then, she) would most likely have recognised it at once from Darwin's *Origin*, which, when the first edition of the *Principles* appeared in 1890, had just reached the thirteenth reprinting of the final (sixth) edition, making 39,500 copies printed (of all editions)[9]. It is less likely – especially in view of the use of *saltum* and not *saltus* – that it would have been seen as a reference to Linnæus, although echoes of either Kantian or Leibnizian gradualism and continuity may have been heard. Such indeed was the sub-text of the *Principles*, which Marshall tried in at least two cases, as we have seen, to make more explicit. In the end he had, however, to be content with the realisation that his great work, begun in a time of Darwinian orthodoxy, had lasted into (and in fact beyond) those developments in biology, some of which, at least at first, seemed to question the very foundations of that orthodoxy. By 1898 biology was even then moving so fast than Marshall could incorporate it only 'analogously', but not functionally, into his analysis:

> Again, with every spring the leaves of a tree grow, attain full strength, and after passing their zenith decay; while the tree itself is rising year by year to its zenith, after which it will also decay. But here we find a biological analogy to oscillations in the values of commodities or of services about their centres which are progressing, or are perhaps themselves oscillating in longer periods.

> The balance, or equilibrium, of demand and supply obtains ever more of this biological tone in the more advanced stages of economics. The Mecca of the economist is economic biology rather than economic dynamics (Marshall 1898, p. 43).

These sentiments were to appear in the next available edition (the fifth, in 1907) as:

> The Mecca of the economist lies in economic biology rather than in economic dynamics. But biological conceptions are more complex than those of mechanics; a volume on Foundations must therefore give a relatively large place to mechanical analogies; and frequent use is made of the term 'equilibrium,' which suggests something of statical analogy (Guillebaud 1961 (II), p. 47; subsequently *Principles*, 8th edition, p. xiv).

Conclusion

The 'old canon' served for most of its career – whether with Leibniz or Linnæus – as an expression of divinely-ordered progression, but never movement, in a fixed hierarchy of creation. Darwin, under cover of its ancient authority, used it to inject change into the system, thus ending stasis and, ultimately, the implicit ranking implied by the old hierarchical order of things. Marshall proved, despite perhaps his best intentions, and perhaps never quite grasping the full import of Darwin's work, to be not nearly so adventurous. The Darwinian reader of the *Principles* might well have come away disappointed, but at least he or she knew that here was an economist who was trying, in the best scientific tradition of humble inquiry, to look beyond the narrow confines of his own discipline to the broader world of contemporary scientific discourse. That his brave if ultimately unsuccessful attempt to bring Darwinian biology and economics together should now be being written out of the history of economic thought – as would appear by the complete omission of his name from a paper, the title of which, 'Darwinism in economics: from analogy to ontology' (Hodgson 2002), would suggest an obvious need for its inclusion – should not deter us from continuing to appreciate his efforts.

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APPENDIX A

[Numbers at end refer to page numbers, Darwin 1859 (First Edition)]

[1] - Means of transition – Cases of difficulty – Natura non facit saltum – Organs of small importance 171 [VI: DIFFICULTIES ON THEORY (Chapter summary heading)]

[2] Although in many cases it is most difficult to conjecture by what transitions an organ could have arrived at its present state; yet, considering that the proportion of living and known forms to the extinct and unknown is very small, I have been astonished how rarely an organ can be named, towards which no transitional grade is known to lead. The truth of this remark is indeed shown by that old canon in natural history of 'Natura non facit saltum.' 194 [VI: DIFFICULTIES ON THEORY]

[3] On the theory of natural selection we can clearly understand the full meaning of that old canon in natural history, 'Natura non facit saltum.' This canon, if we look only to the present inhabitants of the world, is not strictly correct, but if we include all those of past times, it must by my theory be strictly true. 206 [VI: DIFFICULTIES ON THEORY]

[4] The canon of 'Natura non facit saltum' applies with almost equal force to instincts as to bodily organs. 210 [VII: INSTINCT]

[5] I do not pretend that the facts given in this chapter strengthen in any great degree my theory; but none of the cases of difficulty, to the best of my judgment, annihilate it. On the other hand, the fact that instincts are not always perfect and are liable to mistakes; – that no instinct has been produced for the exclusive good of other animals, but that each animal takes advantage of the instincts of others; – that the canon in natural history 'natura non facit saltum' is applicable to instincts as well as to corporeal structure, and is plainly explicable on the foregoing views, but is otherwise inexplicable, – all tend to corroborate the theory of natural selection. 243 [VI: INSTINCT]

[6] It is, no doubt, extremely difficult even to conjecture by what gradations many structures have been perfected, more especially amongst broken and failing groups of organic beings; but we see so many strange gradations in nature, as is proclaimed by the canon, 'Natura non facit saltum,' that we ought to be extremely cautious in saying that any organ or instinct, or any whole being, could not have arrived at its present state by many graduated steps. 460 [XI: RECAPITULATION AND CONCLUSION]

[7] As natural selection acts only by accumulating slight, successive, favourable variations, it can produce no great or sudden modification; it can act only by very short and slow steps. Hence the canon of 'Natura non facit saltum,' which every fresh addition to our knowledge tends to make more strictly correct, is on this theory simply intelligible. We can plainly see why nature is prodigal in variety, but niggard in innovation. But why this should be a law of nature if each species has been independently created, no man can explain. 471 [XI: RECAPITULATION AND CONCLUSION]

APPENDIX B

> Natura in operationibus suis non facit saltum. Jacques Tissot, *Discours véritable de la Vie* etc. *du Geant Theutobocus*, Lyon 1613.. . . . *Nature in her operations does not proceed by leaps.* All is gradual, continuous, progressive . . . .Tissot is quoting an old and well-established axiom in physics. 'Operatur natura,' he says, 'quantum et quandiu potest, sans neant moins faire aucun sault ab extremis ad extrema. Natura enim in operationibus suis, *etc.*,' *ut supra*. His contemporary, Sir E. Coke, applies it to law: 'Natura non facit saltus, ita nec lex.' *Coke upon Littleton*, pp. 238b, 239. – *Law, like nature, does not proceed by leaps.* Leibnitz [*sic*] (Nouv. Essais, ed. E. Bontroux, Paris, 1886, p. 135) says, 'C'est une de mes grandes maximes et des plus vérifiées, que la nature ne fait jamais des sauts.' Linnæus (Philosoph. Botan., Stockholm, p. 27, Sect. 77) follows suit with 'Primum et ultimum hoc in botanicis desideratum est, *Natura non facit saltus.*' [King 1904, 209 (1614)]

Of all these, the closest to Darwin in terms of time and his own field of interest was Linnæus, the full text of whose Sect. 77 (from which King quotes) is:

> 77. METHODI NAT`URALIS Fragmenta studiose
>
> inquirenda sunt.
>
> Primum & ultimum hoc in Botanicis desideratum est.
>
> Natura non facit saltus.
>
> Plantæ omnes utrinque affinitatem monstrant, uti Territorium
>
> in Mappa geographica.
>
> [PRINCIPLES OF NATURAL METHODOLOGY Groups
>
> are to be diligently sought out.
>
> This is first and foremost what is required in Botany.
>
> Nature does not make leaps.
>
> All plants show an affinity with those around them, according to their geographical location.]

We note here the use of the plural *saltus* ('leaps') by Linnæus originally, put into the singular *saltum* by Darwin, and carried through as such by Marshall. Use of the singular or plural reveals whether the writer is familiar with the original, or knows of it only through hearsay. Thus, for example, Bruno Foa (Foa 1982, p. 15) writes of Marshall 'adopting as his own the motto affirmed long before his day by the great Linnaeus: *Natura non facit saltum.*' Others similarly try to give a patina of erudition to their theoretical work by quoting its supposed source: thus, Ignatius J. Horstmann and James R. Markusen (Horstmann and Markusen 1992, p. 109 n. 1) write that 'This quote is originally attributed to Carl von Linné Linnaeus (1707-1777) and in slightly different form to Tissot (1613)'. These authors appear to have trouble with both dates and Latin. Linnæus died in 1778, and had two forms of his name, not two surnames; and the 'slightly different form' is his, not Tissot's – see King above.

Notes

1 For confirmation of this from the respective *variorum* texts, see Peckham (1959) and Guillebaud (1961).
2 Groenewegen (1995, p. 119). In the following year Marshall was appointed to a Lectureship at St. John's College; he has been described as being at the time 'a young philosopher carrying a somewhat undigested load of German metaphysics, Utilitarianism, and Darwinism' (P.T. Homan, quoted by Guillebaud 1961, p. 3).
3 Personal communication from Peter Groenewegen.
4 The seven quotations of the 'canon' which appear in the first edition of the *Origin* did not all persist. From the second edition (referring to passage numbers in Appendix A here), [4] and [6] were deleted, [2], [5] and [7] changed slightly, and [1] and [3] remained unchanged. The relevant pages in the *variorum* text (Peckham 1959) are: [1] p. 321, [2] p. 361, [3] p. 378, [4] p. 383, [5] pp. 422-3, [6] p. 720, [7] pp. 735-6.
5 Seven years and four editions later, that it would have been the first is possible, but extremely unlikely.
6 See Fishburn (1995).
7 'See a brilliant paper by Häckel on *Arbeitstheilung in Menschen- und Thierleben* [sic 8th edn.] and Schäffle's *Bau und Leben des socialen Kõrpers*.'

Ernst Häckel (1834-1919), a zoologist, was the leading exponent and developer of Darwin's ideas in Germany. We owe to him the words *ecology*, *ontogeny* and *phylogeny*, but no longer his once-popular theory of 'recapitulation' (that the embryo shows in its development the evolutionary history of its species); his *General Morphology* (1866), but more so his more accessible *Natural History of Creation* (1868), established his name, and popular appreciation of Darwin, in Germany. Albert Schäffle (1831-1903) was an economist-sociologist, who could best be described as a 'Darwinian socialist.' His *Bau und Leben*, to which Marshall refers, was first published in four volumes in 1875-78 (revised edition 1896). Originally the footnote read: 'Besides the writings of Herbert Spencer on this subject, and Bagehot's *Physics and Politics*, see a brilliant paper by Häckel on *Arbeitstheilung in Menschen und Thierenleben*. Reference may also be made to Schäffle's *Bau und Leben des socialen Kõrpers*, and to Hearn's *Plutology*.' The present form appears from the sixth (1910) edition (Guillebaud 1961 (II), p. 323). I am indebted to an anonymous referee for reminding me that this aspect of the impact of Darwinian thinking on Marshall should not be ignored.
8 Thus Francis Hitching provocatively uses the 'giraffe's neck' in the title of his book (Hitching 1982), but gives no indication of where Darwin ever employed this case.
9 Peckham (1959, p. 24).

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