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## **TECHNOLOGICAL EVOLUTION AND INVOLUTION; A PRELIMINARY COMPARISON OF EUROPE AND JAPAN.**

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This paper presents in a rough and preliminary way a few brief accounts of the disappearance of what would seem to us to be useful techniques. It considers the difference between an evolution towards the replacement of human labour by non-human power in western Europe, the basis of the later 'industrial revolution', and the situation in historical Japan where human power increasingly replaced other forms of power, the so-called 'industrious revolution'.<sup>1</sup> It attempts to show that even when blind variation is not so blind, and even when retention is very selective indeed, the outcome may still be a situation which, in terms of our post-industrial rationality, is a form of involution rather than evolution.<sup>2</sup>

### **The west European trajectory.**

Let us start at the European end. Mokyr notes that 'As Lynn White has remarked, medieval Europe was perhaps the first society to build an economy on nonhuman power rather than on the backs of slaves and coolies.'<sup>3</sup> What were these forms of nonhuman power? The first and most important was animal power. There was the traction power of oxen and then horses drawing the improved ploughs using the better harnesses from the ninth century. Animals used were also in other activities - threshing grain, pulling carts and providing proteins for humans. It has been estimated that by the late eleventh century, '70 percent of all energy consumed by English society came from animals, the rest coming from water mills.'<sup>4</sup>

This takes us to the other two major sources of energy, water and wind. To start with water driven power, the number of water mills was immense. 'In 1086, Domesday Book listed 5,624 watermills in England south of the Severn river, or roughly 1 for every 50 households. Unlike their Roman ancestors, medieval men and women were surrounded by water-driven machines doing the more arduous work for them.'<sup>5</sup> The water mills were used increasingly for a multitude of tasks. They were used for grinding grain and pumping water, pulping rags for paper, hammering and cutting iron, beating hides, spinning silk. For instance, 'The importance of water-power in relation to the iron industries cannot be over-estimated...'<sup>6</sup>

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<sup>1</sup> cf. Hayami, *Population Growth*, p.37

<sup>2</sup> See Campbell, *Blind Variation*

<sup>3</sup> Mokyr, *Lever*, p.35

<sup>4</sup> Mokyr, *Lever*, p.38

<sup>5</sup> Mokyr, *Lever*, p.34

<sup>6</sup> Mumford, *Technics*, p.115

The wheel was also increasingly driven by the wind. 'In power technology, the most important invention of the later Middle Ages was the windmill. The windmill combined the ideas of the water mill and the sail. It, too, may have been imported to Europe by Moslems (from central Asia) but in spite of its apparent advantages in arid climates, it was not used widely in the Islamic world. The first windmills that can be documented with certainty were in Yorkshire in 1185.<sup>7</sup> All of these technologies depended heavily on that most basic of inventions, the wheel - for carts, ploughs, wind and water mills and later other inventions such as the clock.

The importance of this development is well laid out by Birdsall. 'Perhaps 80 to 90 percent of the total energy consumed at any one time before the Industrial Revolution was derived from plants, animals and men... Once this is understood, we can appreciate the importance of the sailboat, the water mill, and the windmill - three energy converters which made it possible for pre-industrial man to exploit the inanimate energy of the wind and of water streams.'<sup>8</sup> It was this which made European development possible. 'Thanks to the menial services of wind and water, a large intelligentsia could come into existence, and great works of art and scholarship and science and engineering could be created without recourse to slavery...'<sup>9</sup>

This 'evolution' towards the increasing use of non-human power, appears, after the event, to be so 'natural' and obvious that it is difficult to realize how extraordinary it is. The exceptional nature of the escape from human labour is only brought out when we look at the 'normal' course of human history, as it is shown in most other agrarian civilizations where such developments did **not** happen. Whether we look at the ancient civilizations of Mesopotamia, Greece and Rome, the pre-Conquest states of the Incas and Aztecs; the Indian sub-continent or China, we find the same absence of this development of non-human energy. This is a huge subject and here all we can do is to look at limited examples in one civilization.

### **The decline in the use of domesticated animals in Japan.**

It was Isabella Bird, coming from animal-rich Britain in the later nineteenth century who most graphically described the absence of domesticated animals by that period. She was struck by the silence and emptiness of the countryside. 'As animals are not used for milk, draught, or food, and there are no pasture lands, both the country and the farm-yards have a singular silence and an inanimate look.'<sup>10</sup> There were, for example, very few horses: 'there is little traffic, and very few horses are kept, one, two, or three constituting the live stock of a large village.'<sup>11</sup> Horses were not used for ploughing, nor, even, were they used for carrying. 'Very few horses are kept here. Cows and coolies carry much of the merchandise, and women as well as men carry heavy loads.'<sup>12</sup> So rare were domestic animals even in the later nineteenth century, that they were exhibited like exotic species: '...monkey theatres and dog theatres, two mangy sheep and a lean pig

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<sup>7</sup> Mokyr, *Lever*, p.44-45

<sup>8</sup> Birdsall, *Technology*, p.86

<sup>9</sup> Mumford, *Technics*, p.118

<sup>10</sup> Bird, *Tracks*, p.49

<sup>11</sup> Bird, *Tracks*, p.128

<sup>12</sup> Bird, *Tracks*, p.131

attracting wondering crowds, for neither of these animals is known in this region of Japan.<sup>13</sup>

The situation two centuries earlier suggests that there were more animals, though they were still far from the level in Europe. In 1613, Saris had noted that pigs, goats and even cows could be purchased cheaply.<sup>14</sup> Kaempfer's account at the end of the eighteenth century shows that knowledge of the animals was not lacking. Of pigs, he wrote 'They have but few Swine, which were brought over from China, and are bred by the Country-people in Fisen, not indeed for their own Use, which would be contrary to their superstitious Notions, but to sell them to the Chinese, who come over for trade every year, and are great admirers of Pork, tho' otherwise the doctrine of Pythagoras, about the transmigration of Souls, hath found place likewise in China.'<sup>15</sup> Or again 'Sheep and Goats were kept formerly by the Dutch and Portuguese at Firando, where the kind still subsists. They might be bred in the Country to great advantage, if the natives were permitted to eat the flesh, or knew how to manage and manufacture the Wool.'<sup>16</sup> There were some horses, but not a great number. 'There are Horses in the Country: They are indeed little in the main, but some of them not inferior in shape, swiftness and dexterity to the Persian Breed. They serve for state, for riding, for carriage and ploughing.'<sup>17</sup> 'Oxen and Cows serve only for ploughing and carriage. Of milk and butter they know nothing.'<sup>18</sup> Thus in the most pastoral area of the mountains 'we saw no cattle grazing any where all day long, excepting a few cows and horses for carriage and plowing.'<sup>19</sup> 'They have a sort of large Buffles, of a monstrous size, with bunches on the back, like Camels, which serve for carriage and transport of goods only, in large Cities.'<sup>20</sup> A century later, Thunberg noted that **Sheep** and **Goats** are not to be found in the whole country; the latter do much mischief to a cultivated land, and wool may easily be dispensed with here, where cotton and silk abound.<sup>21</sup>

### **The declining use of the wheel in Japan.**

An even more mysterious reluctance lies in the decreasing use of the wheel. If we take the wheelbarrow, this device was traditionally enormously important in China. 'For adaptability to the worst road conditions no vehicle equals the wheelbarrow, progressing by one wheel and two feet. No vehicle is used more in China, if the carrying pole is excepted, and no wheelbarrow in the world permits so high an efficiency of human power as the Chinese...where nearly the whole load is balanced on the axle of a high, massive wheel with broad tire.'<sup>22</sup> Yet in Japan the wheelbarrow was not adopted, unlike most things Chinese. For the medieval period, we are told 'The wheelbarrow seems to have been unknown (whereas it was used in China) and earth was carried either in baskets, or thrown on to a screen made of straw or rushes drawn by hand and slid along

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<sup>13</sup> Bird, Tracks, p.176

<sup>14</sup> Purchas, Pilgrims, 147

<sup>15</sup> Kaempfer, History, 1, p.196

<sup>16</sup> Kaempfer, History, 1, p.195-6

<sup>17</sup> Kaempfer, History, 1, p.194

<sup>18</sup> Kaempfer, History, 1, p.194-5

<sup>19</sup> Kaempfer, History, 2, p.376

<sup>20</sup> Kaempfer, History, 1, p.195

<sup>21</sup> Thunberg, Travels, iv, 95

<sup>22</sup> King, Farmers, pp.237-99

the ground.<sup>23</sup> Towards the end of the nineteenth century, Chamberlain noted that 'Japanese rural economy knows nothing of wagons or wheelbarrows.'<sup>24</sup>

Moving up to larger wheeled devices, Kaempfer had noticed a rough cart being used for moving stone.<sup>25</sup> Yet there is very little evidence elsewhere in his work of much use of wheeled carts. A century after Kaempfer, Thunberg noted the virtual absence of wheeled conveyances. 'No post-coaches, or other kinds of wheel-carriages, are to be found in this country for the service of travellers...'<sup>26</sup> The only carts he saw were near the city of Kyoto (Miaco), and they were not only the exception, but showed, as Kaempfer noted, how primitive and undeveloped the technology was. 'This day, I saw several carts driving along the road, which were the first I had seen, and indeed were the only wheel-carriages used in and about the town of Miaco, there being otherwise none in the country. These carts were long and narrow with three wheels, viz the two usual wheels and one before. The wheels were made of an entire piece of wood sawed off a log...Nearer the town, and in it, these carts were larger and clumsier, sometimes with two wheels only, and drawn by an ox.' He noted that they tended to break up the roads, and were hence confined to one side of the street. Carts being 'only allowed on one side of the road - "which, on that account, seemed much broke up".'<sup>27</sup>

In the middle of the nineteenth century, a number of western commentators noticed the absence. Oliphant on the Elgin mission noted in almost identical words to Kaempfer and Thunberg, 'I also observed, for the first time, one or two carts of a very rude construction, and drawn by bullocks; but they are apparently very little used in Japan.'<sup>28</sup> Alcock quoted Veitch: 'There are no carts in this district. Everything is transported from and into the interior by horses and bullocks.'<sup>29</sup> Morse noted that 'I have seen no wheeled vehicles except the jinrikisha and there are very few of these,'<sup>30</sup> though he did note 'A very common sight to encounter in the streets is laborers dragging on a two-wheeled dray a fruit, or flowering, tree, such as camellia.'<sup>31</sup> Wheeled transport for carrying people came very late indeed. 'The rickshaw is thought to have been invented in Tokyo in 1869, though the origins are obscure. Japanese no longer had to rely on transport by water or on foot, and within a few years there were as many as 50,000 rickshaws in Tokyo.'<sup>32</sup>

How then was the immense traffic in goods and people in Japan carried? Apart from a very limited use of horses, and good water transport, the answer is basically on the human back and shoulders. Morse described a few of the techniques. The main method was by poles and racks. 'The farmers have long racks with which they lug grass or grain from the fields. They are longer than a man and are carried high on the back.'<sup>33</sup> For stones and dirt '...when a sufficient load is collected a pole is thrust through the loops and two men lug it off on their shoulders, the matting suspended from the pole like a hammock. Wheelbarrows are unknown in Japan and this device provides a good

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<sup>23</sup> Frederic, *Daily Life*, p.129

<sup>24</sup> Chamberlain, *Things*, p.20

<sup>25</sup> Kaempfer, *History*, 3, p.202

<sup>26</sup> Thunberg, *Travels*, iii, 108

<sup>27</sup> Thunberg, *Travels*, iii, 134

<sup>28</sup> Oliphant, *Mission*, p.139

<sup>29</sup> Alcock, *Tycoon*, 2, p.477

<sup>30</sup> Morse, *Day i*, p.425

<sup>31</sup> Morse, *Day i*, p.347

<sup>32</sup> Jansen and Rozman, *Transition*, p.463

<sup>33</sup> Morse, *Day i*, p.66

substitute.<sup>34</sup> Immense loads were carried. 'After leaving the market town we met scores of people struggling along with heavy loads hung from their carrying poles. Such loads! I have tried a number of times, without success, to lift them from the ground, and these people will travel miles with them.'<sup>35</sup> Even when there were carts to lighten the load, people were used to pull or push them rather than animals, as in the West.<sup>36</sup>

### **The outcome: intensive rice agriculture in Japan.**

Rice was grown in irrigated fields in Japan. This meant that an immensely complex system of water control had to be developed. A good deal of the water could be taken to the appropriate terrace by using gradients and an elaborate system of dams and sluices which were copied from China. Very often the water needed to be raised from irrigation channel to individual fields. An obvious way to do this is to use the current of the stream for power, driving a wheel to raise buckets. This was a method early invented by the Chinese, and it was used in parts of Japan. Morse described 'A curious device for irrigating the rice-fields'. 'On the banks of a swift-running river a water wheel was adjusted and was slowly turned by the current. On the sides of the wheel were fastened square wooden buckets; as they dipped into the stream they became filled with water, and as the wheel rotated the water was spilled from the buckets into a trough which conveyed it into the fields beyond.'<sup>37</sup>

While this device was 'not uncommon in the southern provinces', Morse found that it was 'rare about Tokyo and farther north.'<sup>38</sup> In central and northern areas, instead of letting the water take the strain, a much more labour-intensive, if flexible, system was used. The principle of lifting buckets on a wheel was the same, but instead of power being provided by water, it was produced by human muscle. Morse drew a figure showing a man coming down the road with the wheel and box carried in the usual manner. In the same sketch is a man treading the wheel and raising water from the ditch in the rice-field. 'The box is first fitted into the embankment, the wheel drops into appropriate sockets, a long pole is driven into the mud alongside the wheel, and holding onto this the man keeps his equilibrium and turns the wheel with his feet' to lift the water from the channel to the field.<sup>39</sup> Often more than one person provided power. 'It was interesting to see a tread wheel in which were two strong-looking samurai treading away patiently, supplying power for a certain portion of the machinery...'<sup>40</sup> A device which could have saved this effort was known and used elsewhere in the country yet people opted for this method.

The soil is usually baked hard and it is extremely difficult to turn over. This is one of the prime opportunities to apply non-human power, namely oxen or, even more powerfully, horses, as plough animals. It appears that in the sixteenth and seventeenth century and perhaps before, animal power was used quite extensively for ploughing. In the early seventeenth century it was noted of the Japanese that 'They plow both with Oxen and Horse as wee doe heere.'<sup>41</sup> Kaempfer had noted that 'On the road hither we

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<sup>34</sup> Morse, Day i, p.345-46

<sup>35</sup> Morse, Day i, p.46

<sup>36</sup> Morse, Day i, p.9

<sup>37</sup> Morse, Day ii, p.51

<sup>38</sup> Morse, Day ii, p.284

<sup>39</sup> Morse, Day i, pp.46-7

<sup>40</sup> Morse, Day ii, p.271

<sup>41</sup> Purchas, Pilgrims, 147

saw great numbers of calves, which are nurs'd up for ploughing, the country hereabouts being reckon'd the best in Japan for wheat and barley.<sup>42</sup> Thunberg described a mixture of hoeing and ploughing. 'In the beginning of April, the farmers began to turn over the ground that was intended for rice. The ground was turned up with a hoe, that was somewhat crooked, with a handle to it and was a foot in length, and of a hand's breadth. Such rice fields as lay low, and quite under the water, were ploughed with an ox or cow...'<sup>43</sup>

Alcock provided a picture of Japanese ploughing.<sup>44</sup> Morse describes 'a farmer going to his work carrying a plough on his shoulder. It is dragged by a single bull. The point is tipped with iron and the plough is typical of the region, for there are many types of ploughs in different parts of the country.'<sup>45</sup> He adds that 'In mountain regions bulls are used to drag ploughs, and cows are used in softer ground so that boys can do the work.'<sup>46</sup> It would appear that humans also pulled special ploughs; 'peculiar shovel made of wood tipped with iron, The shovel part was over three feet in length and the handle seven feet long. It is used through the western part of this province (Musashi) and seems to take the place of the plough.'<sup>47</sup>

In fact, what seems to have happened, is that the Japanese moved from the plough to the hoe as the population built up in the seventeenth century. We can deduce this from the absence of plough animals by the end of the eighteenth century. Horses were not used for ploughing and were in any case very few in number, 'The small number of **horses** to be met with in this country, is chiefly for the use of their Princes; some are employed as beasts of burden, and others serve travellers to ride on. Indeed I do not suppose that the sum total of all their horses amounts to the number of those made use of in one single town in Sweden.'<sup>48</sup> As for oxen and cows, 'they seem to have a still smaller number...the sole use they make of them is sometimes for drawing carts, and for ploughing such fields as lie almost constantly under water.'<sup>49</sup>

Hayami has provided a useful overview of what happened. 'Instead of a plow drawn by livestock, a hoe or spade using human labor became the main plowing tool. This means that the labor that had been carried out earlier by horse-power now came to be done by man-power.'<sup>50</sup> Whereas there had been considerable numbers of draft animals to the end of the seventeenth century, 'after that, their number obviously declined.'<sup>51</sup>

Numerous further stages then occur in rice cultivation, the constant weeding, the harvesting, and so on, but let us move on to the final stages. Once the grain had been brought back to the house, it has to be prepared for use. An immense amount of energy has to be used to de-husk grains and this was one of the areas where water mills became so useful in Europe and in many parts of the world. Given the numerous rushing streams

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<sup>42</sup> Kaempfer, History, 3, p.202

<sup>43</sup> Thunberg, Travels, iii, 137

<sup>44</sup> Alcock, Tycoon, i, 295

<sup>45</sup> Morse, day ii, 139

<sup>46</sup> Morse, Day ii, 332

<sup>47</sup> Morse, Day ii, 326

<sup>48</sup> Thunberg, Travels, iv, 94/5

<sup>49</sup> Thunberg, Travels, iv, 95

<sup>50</sup> Hayami, Population Growth, p.37

<sup>51</sup> idem

and heavy rainfall of Japan, we would have expected water mills to be widely used at this stage. The principle of water-driven machinery was widely known. Mills could not only help with rice, but also with the equally tedious and time-consuming work of grinding beans and other crops. Such machines were used in parts of China, as King noted in the early twentieth century. 'At several places on the rapid streams crossed, prototypes of the modern turbine water-wheel were installed, doing duty grinding beans or grain. As with native machinery everywhere in China, these wheels were reduced to the lowest terms and the principle put to work almost unclothed.'<sup>52</sup>

Strangely enough, however, I have come across little evidence of the widespread use of water (or wind) mills for grinding grain in Japan. Instead, much more labour-intensive methods were used. One was the quern where, with immense effort of arms and shoulders, grain is ground between two heavy stones. Morse describes how 'The mill for grinding grain is turned by hand, and strong arms are required to turn it.'<sup>53</sup> This would turn grain into flour, but it is no use in taking off the outer, inedible, husk. To do this the Japanese used several methods, one of these is similar to that found all over the world, for instance in Nepal, where a heavy weight is dropped repeatedly on the rice until the husk is pounded off. 'The rice is hulled by a sort of trip-hammer made of wood and weighted with stone. This is worked by a man stepping on the end of the beam, thus raising it and letting it drop. This device has endured in China for two thousand years.'<sup>54</sup> Even in the heart of cities, people were employed for hour after hour to step on and off this kind of tread-mill. 'One may see this rice-pounding going on even in the city of Tokyo. The man is naked and is concealed by a curtain consisting of strands of straw rope, a convenient device, for one may pass through this curtain without delay.'<sup>55</sup> A picture of rice pounders is provided by Regamey.<sup>56</sup>

It is not a particularly difficult task to devise a mechanism to allow water to raise and drop this weight. Thunberg at the end of the eighteenth century saw some water-driven machines of this kind. Writing of rice husking, he observed 'Sometimes it was beaten with blocks which had a conical hole in them. These blocks were placed in two rows, generally four on each side, and raised by water, in the same manner as the wheel of a mill. In their fall they beat the rice so that the grain separated from the chaff.'<sup>57</sup> Alongside this was the foot-driven machine. 'Sometimes, when there was no opportunity for erecting similar water-works, a machine of this kind was worked by a man's foot; who at the same time also stirred the rice with a bamboo.'<sup>58</sup>

### **The puzzle of the different trajectory of Europe and Japan.**

Given the different paths taken by Europe, particularly England, on the one hand, and Asia, and particularly Japan, on the other, it is obviously puzzling to know why so little use was made of non-human power, in particular animals and wheels, in Japan. The answer to this question would throw much light on the nature of invention and

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<sup>52</sup> King, *Farmers*, p.363

<sup>53</sup> Morse, *Day i*, p.55

<sup>54</sup> Morse, *Day i*, p.55

<sup>55</sup> Morse, *Day i*, pp.55-66

<sup>56</sup> Regamey, *Art and Industry*, p.185

<sup>57</sup> Thunberg, *Travels*, iii, 149; cf iv, 85

<sup>58</sup> Thunberg, *Travels*, iii, 149

innovation. Japan is an excellent comparative example. The knowledge was there. Earlier from China and later from the Portuguese and Dutch, the Japanese were perfectly aware of the possibility and mechanisms for using animals, wind and water power. For instance attempts had been made to introduce the water wheel from China in the ninth century, but had completely failed.<sup>59</sup> They were extremely ingenious and inventive in many ways. Morse commented that 'The Japanese are said to have no inventive faculties, but in my rambles around Tokyo I have noticed many mechanical appliances of a simple nature which our artisans might adopt.'<sup>60</sup> He described, for example how 'At one place in Kii I saw a curious implement used for weeding in rice-fields. It consisted of a long box without a bottom; inside the box were two shafts running from side to side, these shafts being studded with wooden pins; long arms or handles ran up from the box; and the machine was pushed through the rows of the rice-fields...It was invented by a man in the village where we saw it used.'<sup>61</sup> Yet it does not seem to have spread. Or again, Alcock noted early instances of colour lithochrome printing in Japan, which suggested that this was 'only one more instance in which by their own unaided genius and ingenuity they have anticipated by centuries some of the most recent inventions and discoveries of Europe.'<sup>62</sup> So it does not seem to have been either lack of knowledge, of technical ability, of ingenuity, of curiosity or of a practical desire to increase production that held the Japanese back.

The Japanese were particularly inventive as farmers. Kaempfer paid a tribute to their abilities. 'The Japanese are as good Husbandmen, as perhaps any People in the World. Nor indeed is it very surprizing, that they have made great improvements in Agriculture, considering not only the extream populousness of the Country, but chiefly that the Natives are denied all commerce and communication with Foreigners, and must necessarily support themselves by their own labour and industry.'<sup>63</sup> He noted more generally that 'Nature did not in vain so liberally bestow upon this nation, bodies fit for hard labour, and minds capable of ingenious inventions.'<sup>64</sup> Subsequent visitors also stressed the ingenuity and inventiveness. Thunberg stressed the practical and hard-working nature of the Japanese. 'In **mechanical ingenuity** and invention, this nation keeps chiefly to that which is necessary and useful; but in industry it excels most others.'<sup>65</sup> In the mid nineteenth century, the Elgin mission found '...for the investigation of their manufactures and appliances, at once so original and ingenious, proved a never-failing source of interest and amusement.'<sup>66</sup> How then are we to explain the apparent movement towards involution?

### **Possible reasons for the absence of domesticated animals in Japan.**

There are a number of possible explanations for the marked absence of large numbers of domestic animals. The ecological arguments would stem from the nature of the volcanic soil of Japan. Japan lacked the possibility of pastoralism except in certain areas

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<sup>59</sup>Farris, Population, pp.97-8, 115

<sup>60</sup> Morse, Day ii, p.344

<sup>61</sup> Morse, Day ii, pp.285-6

<sup>62</sup> Alcock, Tycoon, 2, p.283

<sup>63</sup> Kaempfer, History, 1, p.185

<sup>64</sup>Kaempfer, History, 3, p.314

<sup>65</sup>Thunberg, Travels, iii, 257

<sup>66</sup>Oliphant, Mission, 186

in the west and north. This argument is then supported by a second, namely that given the small area of cultivable land people could not afford to keep animals which would compete with grain production. The opportunity cost of giving up precious land to livestock was too high. It was necessary to use every piece of fertile ground to produce the basic grains on a very densely settled strip.

Many people have observed that raising animals is an expensive option - for instance, to feed grains to chickens may produce meat and eggs but many people in the world cannot afford the grain. The fairly desperate struggle to grow enough rice and other foodstuffs may have made animals a luxury the Japanese could not afford. Indeed, as population built up in the seventeenth century, the cereal rather than animal husbandry option may have become increasingly attractive. Thunberg at the end of the eighteenth century had noted the absence of pasturage and animals. 'Meadows are not to be met with in the whole country; on the contrary, every spot of ground is made use of either for corn-fields, or else for plantations of esculent rooted vegetables.'<sup>67</sup> He implied that it was the low number of grazing animals that led to the absence of pasturage. 'They have few Quadrupeds; for which reason there is no occasion to lay out the land in extensive meadows.'<sup>68</sup> As the agronomist King pointed out when he visited Japan in the early twentieth century, 'By devoting the soil to growing vegetation which man can directly digest they have saved 60 pounds per 100 of absolute waste by the animal...'<sup>69</sup> He calculated that '1000 bushels of grain has at least five times as much food value and will support five times as many people as will the meat or milk that can be made from it.'<sup>70</sup> The agricultural area of Japan, on this reckoning, could only have supported six million, if it had been based on pastoral agriculture rather than the thirty million actual inhabitants in 1800.

A similar theory was put forward by several anthropologists in the 1950s who described how 'Land shortage accounts particularly for the rarity of grazing animals. On arable land, crops grown for direct human consumption are much more efficient than natural vegetation or fodder crops for grazing animals.' There is not enough waste or spare grazing for larger animals.<sup>71</sup> This view is supported by the agricultural economist Boserup, who points out that 'Draft animals fed on produced fodder are not an efficient source of energy supply. The mechanical energy supplied by them is probably only some 3-5 per cent of the energy contained in the fodder they consume.'<sup>72</sup>

While all this is undoubtedly a powerful factor, there is clearly also a cultural or religious dimension. There is a mixture of ritual prohibition and a feeling of disgust which alone can explain why, even when chickens or cows were kept, they were not eaten by ordinary Japanese. This was an aversion that lasted into the middle of the twentieth century. For instance, an anthropologist describes how in a Japanese village in the 1930's 'Horses and cows are kept, but they are used only as beasts of burden. The animals are backed into their stables, where they spend all their time when not working. Milk is considered dirty and is only drunk on doctor's prescription.'<sup>73</sup>

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<sup>67</sup>Thunberg, Travels, iv, 81

<sup>68</sup>Thunberg, Travels, iv, 94

<sup>69</sup> King, Farmers, p.135

<sup>70</sup> King, Farmers, p.135

<sup>71</sup> Beardsley, Village, p.177

<sup>72</sup>Boserup, Population, p.49

<sup>73</sup> Embree, Suye Mura, p.31

There is evidence that some Japanese interpreted the Buddhist scriptures as putting a ban on consuming the products of four-footed creatures. Hence meat and milk would be banned. That Buddhism in Thailand, China or much of south-east Asia has not lessened the consumption of sheep, goats and other animals suggests that this can only be a partial explanation, but it does not make it an invalid one. There is obviously something more, however, which concerns the classification of what is 'good to eat'. Many were genuinely disgusted at the thought of eating meat or drinking milk, it was not merely a matter of religious prescription.

Of course, Japan is not quite the most extreme case of the avoidance of animals, and it may also have other roots, as Mokyr suggests. He notes that large domesticated animals 'were entirely lacking in pre-Columbian America and Africa, and scarce in most parts of Asia. This scarcity may have had deep historical roots: African and East Asian adults suffer from lactase deficiency and cannot digest large quantities of fresh milk (although they can digest milk in the form of cheese or butter).'<sup>74</sup> Whatever the reason, it is clear that, while knowing about most useful animals from at least the sixteenth century, the Japanese kept few domestic animals. This affected every branch of their life.

### **Theories to explain the declining use of the wheel.**

In accounting for the non-use of the wheel and plough in sub-Saharan Africa, Goody suggests that it was low population density which was a major factor.<sup>75</sup> This can hardly be the explanation in Japan. Again, in trying to explain the fact that the wheel faded out of use in Muslim societies, Bairoch suggested two major reasons. One was religious. 'At least throughout the Middle Ages, there seems to have been a sort of prohibition in the Muslim West outlawing the use of wheeled vehicles, a prohibition of which it would be worth finding a plausible explanation.'<sup>76</sup> Yet this cannot be the major explanation why the wheel had disappeared earlier. 'What makes the search for some sort of explanation all the more intriguing is the fact that carts or wagons and other wheeled vehicles were used in the Middle East for at least a few millenia before the advent of Islam. It appears, however, that the use of the wheel had already disappeared before the Arab conquest.'<sup>77</sup> Instead, it looks as if an alternative had been found, namely the camel. 'The most plausible explanation may be the introduction and eventual predominance of the camel as a beast of burden in Muslim societies. And it should be noted in this connection that, as Bulliet (1975) has clearly demonstrated, the replacement of the cart by the camel in traditional societies, especially in semidesert regions, constituted technological progress and not a step backward.'<sup>78</sup>

If we take this argument to Japan, and substitute the human being for the camel, we move into the most commonly advanced type of argument, which is also used to explain the situation in China, namely that as the population becomes very dense, the cost of human labour becomes so low that it is cheaper to use people. This, for example, is the

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<sup>74</sup> Mokyr, *Lever*, p.161

<sup>75</sup> Goody, *Technology*, p.26

<sup>76</sup> Bairoch, *Cities*, p.377

<sup>77</sup> Bairoch, *Cities*, p.377

<sup>78</sup> Bairoch, *Cities*, p.377

explanation given for the drying-up of labour-saving inventions in China by Fairbanks. As population built up 'the abundance of muscle power made labor-saving devices less needed. Kang Chao notes that the 77 inventions for use in agriculture (like the bucketed water wheel or **noria** for irrigation) listed in a 1313 handbook were not appreciably added to in later such works.<sup>79</sup> The Japanese were not averse to labour-saving devices. 'Everywhere in Japan may be seen the most successful efforts to economise labour.'<sup>80</sup> Alcock was aware that labour was very cheap, nevertheless savings were still worth while. He noted that the fields were carefully trodden down with bare feet, 'to keep the seed from being worked out', which gave '...equal evidence of the care of the husbandman and the cheapness of labour. Yet they are always economising it, cheap and plentiful as it may be, and instead of the feet they sometimes use a simple roller made out of a transverse section of a tree.'<sup>81</sup> Part of the solution lies in a remark of King's. He noted that 'Extensive as is the acreage of irrigated rice in China, Korea and Japan, nearly every spear is transplanted; the largest and best crop possible, rather than the least labor and trouble, as is so often the case with us, determining their methods and practices.'<sup>82</sup>

With a very dense population and, relatively, too little land, the really scarce resource is not human labour, but land. Hence, one criterion used to decide whether to use human or non-human labour is which is more efficient, not in terms of amount of human effort, but in total yield. If labour is very cheap, it becomes uneconomical to sink money into plant or animals. To build, maintain and operate a water mill to grind grain was more 'expensive' than doing it oneself. To pump water using one's legs, was less 'expensive' and much more flexible than constructing large machines for doing so, which would not easily be moved from tiny field to field. All this tends to support those famous arguments which suggest that one of the reasons for the development of industry and manufactures in England was the very high cost of human labour. It became economical to invest money to replace labour. Of course it is a circular situation. The low cost of human labour in Japan was one of the reasons why it was not practicable to use other sources of power. This tended to make escape from this form of the 'poverty trap' or 'high level equilibrium' more difficult. The exigencies of rice cultivation, particularly where there was extreme shortage of space to graze animals, to construct paths and tracks down which wheelbarrows and carts could proceed, to build mills on, did not help. It is no coincidence that it was not in the rice growing south of China that wheeled carts were to be found. 'It is only in northern China, and then in the more level portions, where there are few or no canals, that carts have been extensively used, but are more difficult to manage on bad roads.'<sup>83</sup>

In conclusion, we may suggest that a set of ecological, social structural and demographic pressures coincided to take the Japanese economy towards a form of Geertz's classic 'agricultural involution', which was the total opposite of the situation in Europe.<sup>84</sup> Very roughly, if there was a problem in Europe, one tried to get round it by applying more ingenious machinery. If there was a problem in Japan, one tried to apply more thought, social organization and human labour. One led to the 'industrious

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<sup>79</sup>Fairbank, Paradox, p. 172

<sup>80</sup> Alcock, Tycoon, 1, p.319

<sup>81</sup> Alcock, Tycoon, 1, p.296

<sup>82</sup> King, Farmers, p.284

<sup>83</sup> King, Farmers, p.239

<sup>84</sup> Geertz, Involution. Interestingly, in the Japanese case none of this could be blamed on colonialism.

revolution' in Japan. The other led to the 'industrial revolution' in Europe. Judged by the standards of the latter, the former was a trap in which alternatives to human labour were increasingly replaced. Only a very small part of the story has been told here, but it illustrates how complex the development of technology can be and the need to avoid certain ethnocentric assumptions based on the west European experience.

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Possible abbreviations.

Am. American  
Ed. Edited or editor  
Econ. Economic  
Hist. Historical  
Jnl. Journal  
n.d. no date  
n.s. new series  
no. number  
pt. part  
Proc. Proceedings  
Pub. Publications  
Rev. Review  
Soc. Society  
tr. translated by  
Trans. Transactions  
vol. volume

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