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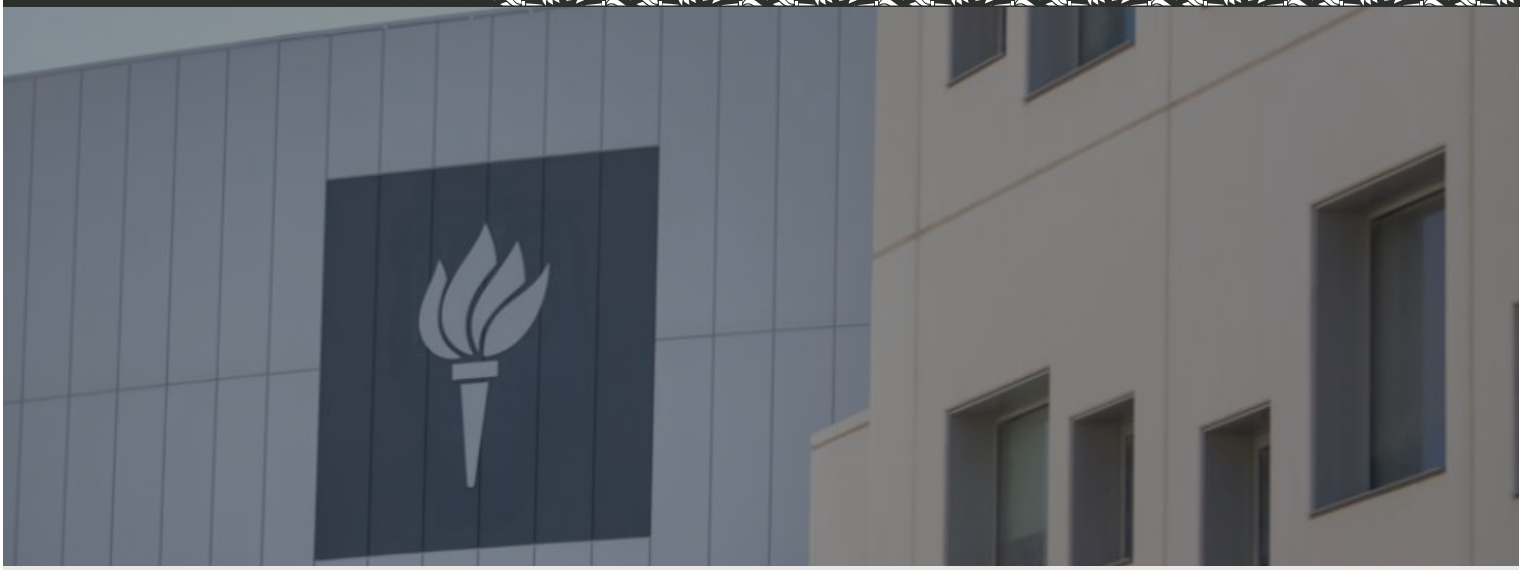

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Robert C. Allen

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Slavery in Arabia and east Africa, 1800-1913

by

Robert C. Allen

Global Distinguished Professor of Economic History
Faculty of Social Science
New York University Abu Dhabi
Abu Dhabi, United Arab Emirates

email: bob.allen@nyu.edu

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Abstract

Slavery in Arabia is usually regarded as benign in contrast to slavery in the Caribbean. The difference is often explained in terms of cultural values and stress is often laid on the role of Islam. This paper analyses this view primarily in terms of men employed in oasis agriculture and pearling in Arabia in the long nineteenth century, although some attention is also given to the situation of women. It is argued here that differences in the skill requirements of growing sugar in the Caribbean and dates in Arabia, as well as differences in the importance of self-supervision, explain the differences in the character of slavery. The centrality of market forces in explaining behaviour is developed by analysing the supply of slaves from Africa to Arabia and the demand for slaves derived from models of a date plantation and a pearling voyage. The economic return to organizing date gardens, so that the slaves have enough income to raise children is also discussed, and the interface between this source of supply and that of newly purchased is analysed. A geo-referenced data base of slave prices is developed and used to explore these issues. It is argued that Britain's efforts to suppress the slave trade, the division of east Africa among colonial powers, and state development in Ethiopia drove long run increases in the supply price of slaves. The opening of the Suez canal increased the demand price of dates after 1869, while rising incomes led to an increased demand for pearls later in the nineteenth century. The increased prices of these products increased the demand price of slaves. The evolution of demand and supply both contributed to a long run rise in the price of slaves.

JEL codes: J47, N35, N55

key words: slavery, Arabia, date cultivation, pearling

In recent decades, the growth of the oil industry in Arabia has led to a great increase in demand for labour. In the short run, the only way to meet this increase has been through international migration. In countries with small populations and large oil exports, as much as nine tenths of the population are foreigners. In countries with large populations, the percentage of foreigners is smaller, and the growth of the local population through natural increase is displacing them, as in Saudi Arabia today. Many of the foreign workers are in weak legal positions and receive low wages by international standards. Comparisons with slavery are often made.

While the legal position of contemporary guest workers is better than slavery, the comparison should be kept in mind in understanding the real slavery that existed in the past. Frequently, Arabian slavery is judged to be benign in comparison to the slavery that existed in the Caribbean in the seventeenth and eighteenth centuries. Indeed, the difference is great. In the sugar plantations of the Caribbean, the work force was largely male (so reproduction was impossible), the men were organized in centrally directed gangs and worked to death. Four million slaves were shipped to the British West Indies and yet only 400 thousand were present at emancipation in 1832 (Allen 2011, p. 70). In contrast, in Arabia many slaves (especially women but also men) were treated as members of the master's household. Males working in agriculture and other productive activities had wives and children. Many slaves were manumitted. These differences are often attributed to culture and the teachings of Islam.

While Islam offered many reasons for treating slaves well, appealing to Islam as an explanation is insufficient. People sort their cultural heritage and gradually abandoned parts that are inconvenient. It took a few centuries–but only a few centuries– for instance, for Christians to abandon prohibitions on loans at interest once the economy developed to the point where financial markets made an important contribution to its operation. Why have Islam's injunctions regarding slavery routinely been honoured? I will argue the reason is that they fit the economic needs of Arab slave owners in the past.

To see what those needs were and how they might have been fulfilled, we need to analyse the economic activities in which Arabs were engaged. I am here primarily interested in the employment of men in Arabia in productive activities like agriculture, although I would argue that similar incentives led to the similarly favourable treatment of male slaves employed as soldiers, guards, or trusted deputies and, indeed, even to women in many cases.

The main productive activity in which male slaves were employed from antiquity to the twentieth century was oasis agriculture. Plants require water, and in Arabia water was often found in oases. In some parts of Arabia, the water table was close to the surface and erupted in springs forming natural oases. Farming could be extended easily in the vicinity of springs since the water table could be reached with shallow wells, that could be dug by individuals. The pre-eminent example is the al-Hasa Oasis, located about 60 km inland from the Gulf near Qatar. With 2.5 million date palms, it is the largest in the world. Date palm oases were located in many other parts of Arabia, where the irrigation issues were often far more complex and expensive to resolve.

An important feature of date cultivation is that it is highly skilled work and requires considerable care for high yields of good fruit to be obtained. 'Skilled' in this context means that it requires both execution and conceptualization. Execution means that the worker is adept at a range of delicate tasks. Conceptualization means that the worker can organize the work and, in particular, the timing of tasks, whose successful completion varies from tree to tree and even from bunch to bunch depending on each tree's growth experience. This need posed two management challenges. The first was how to obtain skilled labour–indeed, any labour. The second was how to motivate that labour to work attentively and responsibly to increase production.

These requirements were most acute during an export boom of which there have been several in the history of Arabia. During a boom, date prices were high, and there were strong profit incentives to expand production. More date palms and the irrigation to sustain them were needed–how these investment requirements were met will not be comprehensively discussed here–and more labour, skilled labour in particular, was required for cultivation. Where would it come from? The best source was the natural increase of the existing agricultural population since the best way to learn how to cultivate dates was to grow up on a date farm and learn from one's father. While this source (if properly supported) might produce a steady growth in numbers, growth was slow and could not be accelerated in a short time frame. Attracting labour from other parts of Arabia was not a viable option either. Camel raising Bedouin were not inclined to take up farming. Settlement programs in recent years to get them to do so have been failures. Their hardiness, group solidarity, and military prowess meant that they "despise agriculture and [furthermore] know nothing about it." (Cole 1975, p. 160) The sheep herders were more flexible. In the north Arabian desert, they often planted millet and returned later to harvest it, so they had some knowledge of crops and more sympathy for them. "Within the space of a few decades, therefore, some villages in this area [of Syria] passed through several stages: deserted or used only as summer camping grounds until about 1870, then inhabited for a time by semi-sedentary tribesmen, and then taken over by a landlord and cultivated on his behalf by share-croppers." (Lewis 1987, p. 70) This progression, often interrupted by reversions to pure nomadism, effected a transfer of labour from the herding economy to the agricultural economy. Wilkinson (1977, pp. 190-1) describes analogous shifts in Oman. In both cases, however, the operative word is 'slow.' Generations might be involved. Furthermore, it could be dangerous to existing land owners. While a tribal group as a whole might slowly transition into an oasis if conditions were attractive, it might do so by expelling the existing owners and taking over the oasis for itself (Heard-Bey 1982, p. 198, Wilkinson 1977, pp. 189-99). This was not a source of labour to react to a commodity boom.

So the best source of more labour was international migration, just as it is today. The slave trade functioned as a system of involuntary migration. Another advantage of slavery was that it provided a labour supply that was free of tribal attachments and dependent on the new slave owner and no one else. This dependence could be turned to positive loyalty if the slave was well treated. Since a loyal, hardworking employee was the aim of the exercise, good treatment was in the slave owner's interest.

Even if loyalty could be cultivated, the new slaves were not trained. This entailed supervision costs that cannot easily be measured at today's remove. The best way to mitigate them, however, was to create slave families, so that the children of the slaves would provide a skilled work force as they grew up. Stable slave families were in the interest of the slave owner.

The final management issue was how to incentivize the slave to work conscientiously to maximize the value of production. This issue has been analysed on the theoretical plane by Fenoaltea (1984). Fenoaltea's model distinguishes tasks that are effort-intensive like digging holes or harvesting sugar cane from those that are capital and care intensive like tending animals, nurturing fruit trees, and gardening operations that require attention to the state of individual plants. Fenoaltea argued that the former were best accomplished by gangs of workers supervised by overseers and motivated by harsh physical punishments, while the latter were best motivated by the absence of pain and instead rewards for good performance–including eventual manumission. These considerations explain the difference between the

harsh treatment of slaves in sugar plantations, mining in both the classical world and the Americas and large wheat growing latifundia in the Roman Empire, on the one hand, and the benign treatment of slaves who were skilled craftsmen in Roman cities, slaves raising cattle on Roman farms and the disappearance of slavery on Roman farms cultivating grapes and olives.[1] Our argument is that the cultivation of dates was like the cultivation of grapes and olives and was the kind of activity that was most successfully accomplished when slaves were rewarded for their efforts rather than driven by the lash. In Arabia, share contracts provided the rewards. Since manumitted slaves remained dependent on the former owners and continued to work on the same farms on the same terms, manumitting the slaves was not a costly gift and might, indeed, secure more enthusiastic effort, which would benefit the former owner.[2]

Early history of slavery

These arguments will be developed in this essay by analysing slavery and the slave trade, mainly on the eastern side of Arabia in the 'long nineteenth century,' from 1800 to the First World War. More detailed information is available about slavery in this period than for earlier times, although the nineteenth century evidence is limited compared to that for slavery in other parts of the world at the same time. I begin, however, with two earlier, less well documented examples of slavery, since they reveal some long run tendencies and recurring patterns.

I concentrate on the coast from Bahrain to Oman. While the aridity of the climate implied a small population and that, in turn, meant that Arabia was never large enough to significantly affect neighbouring civilizations like Mesopotamia, the reverse was not true. Developments abroad created opportunities for trade that could lead to dramatic changes in population, economic activity, and society overall. The process was straight forward: The foreign demand for dates rose. As a result, the price in Arabia also rose, and there was a corresponding incentive to expand production. More production required more labour, more date palms, and more irrigation. Sometimes the need for capital could be met by local efforts and sometimes it led to state action. The need for labour led to a demand for slaves when the demand was so great that it could not be met by the local population. This pattern has been repeated at least three times.

We know the least about the earliest example, and so our account is highly

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[1]See Scheidel (2008) and Temin (2013, pp. 114-38) for discussions of this model in the context of ancient Rome and other societies.

[2]Dari-Mattiacci (2013) has proposed a similar model that emphasizes 'asymmetric information,' that is, the slave knows more about what he is doing and how hard he is working than does the master. This model leads to similar conclusions. This model comes into its own in the context of pearling where it will be discussed. Since the slave owner can observe the date harvest, however, which determines his income, I am not sure why it would be important to him to know what the slave did during the year. However, one issue that Dari-Mattiacci's does illuminate is the slave master's educating young slaves. Since the slave does not have the option of quitting, the slave owner realizes the return to educating the slave over the slaves's life, and that increases the incentive to provide education.

speculative, but suggestive of later instances. This example concerns the al-Hasa oasis in eastern Arabia and adjoining oases in neighbouring Qatar and Bahrain. This district has exported dates for centuries. The earliest remains of cultivated dates in eastern Arabia were found on Dalma Island in the UAE and dated to about 5000 BC. They have been cultivated ever since although locations are sketchy, and the nature of the agrarian system is the subject of considerable debate (Cleuziou and Costantini 1980, Charbonnier 2017, 2018). We posit that there was an increase in production that began in the seventh century in response to events in Iraq.

Southern Iraq has been a major date producer for millennia. Date palms were extensively planted in ancient times on the banks of rivers and canals in Mesopotamia. "The levees are optimal areas for the cultivation of a wide variety of crops, including date palms, in the shadow of which smaller fruit trees, cereals, legumes and vegetables can be grown. Date-palm shade creates a micro-climate of cooler than average temperature and higher than average humidity, and the rooting system of the date-palm stabilizes the soil, improving permeability and structure." (Potts 1997, p. 17) This production system was deranged by the great flood of 628 when the Tigris burst its banks and shifted its course, in the process inundating much of southern Iraq (Christensen 1990, pp. 73-5). Reclaiming land was a lengthy and expensive process. Al-Tabari reported fifteen thousand slaves clearing land in southern Iraq in the ninth century. Conditions were so deplorable that they led to a formidable rebellion that lasted years–the so called Revolt of the Zanj (Popovic 1976) The flooding most likely destroyed many date-palms, reducing date production in Iraq, and subsequent events like the civil wars of 861-70 and the Zanj Revolt (869-883) and continuing unrest prevented recovery. If so, prices would have risen, and this increase would have stimulated the expansion of date cultivation in al-Hasa and Bahrain.

The increase in date production required more labour and more date-palms. Because of the closeness of the water table to the surface, the extra water needed was obtainable with shallow wells, and massive state investment was not required as in other cases. The increased labour supply might have come from population growth (bound to be a slow process). African slaves were the only immediate source of supply. Indeed, the most specific piece of evidence of about this period is an eleventh century report by Nasir-I Khusraw in his book of travels. He reported "thirty thousand Zanzibari and Abyssinian slaves working in the fields and orchards" of the al-Hasa oasis. (Reilly 2005, pp. 58-9, 126-7, 130).

What became of the slaves? Much is unknown. The likely trajectory is that they became free and remained on their farms as sharecropping tenants. They intermarried with Arabs, so their descendants are today visually indistinguishable from other Arabs. However, they differ from most Arabs in that (a) they are Shiite muslims rather than Sunnis, and (b) they are not members of traditional tribes. Instead they constitute recognized groups–the Baharinah in Bahrain and the Hawaiyah in the al-Hasa oasis. Most significantly, however, (c) serological studies show the wide spread prevalence of the hemoglobin S gene and Duffy-negative antigen. Both confer immunity to malaria and are markers of African ancestry. They indicate that Africans were the forebearers of the Shiite population of eastern Arabia. (Reilly 2005, pp. 58-9, 126-7, 130).

We have more documentation about a second great boom, which occurred in Oman in the seventeenth and eighteenth centuries. It was preceded by a millennium of chaos in the region. Between 550 BC and 651AD, Oman was administered by the Achaemenid, Parthian, and Sassanian empires. Wilkinson (1977, pp. 122-36) has argued that most of the falaj irrigation in Oman was built by the Persians in this period, and dates would have been a

major crop grown on fields watered by them. Conversion to Islam in the mid-seventh century led to a revolt that drove out the Persians. During the eighth century, the Imamate was established in central Oman under which an imam was elected spiritual, political, and military leader. They provided direction but not administration, and Oman became a collection of feuding tribes. When Portugal expanded its possessions in the Indian Ocean in the early sixteenth century, it met little resistance in Oman and occupied all of the major ports, thus isolating the interior from the coast. The empire did not last long as it came under assault by the English and Dutch East Indies Companies as well as local nationalist groups. The fall of the Portugese fort in Hormuz in 1622 to a combined English-Persian force was a turning point (Steensgaard 1974). It was followed by the election of the first Yarubid Imam in 1624. This dynasty ruled the country until 1742. The Yarubids did what earlier Imams had failed to do. They gradually recaptured all of the cities and forts occupied by the Portugese and re-united the country under an administration that had enough capacity to end tribal strife and provide infrastructure.

The result was another boom in date production. It is unfortunate that records of the prices of dates and dibs–the sweet liquid that could be pressed from the fresh fruit–around the Indian Ocean have not survived in the early modern period. Prices would show whether demand was rising in India, for instance. It is clear, however, that demand was rising in the interior of Oman. Reuniting the country and establishing domestic order opened up foreign markets and cut transport costs to Suhar, the leading port for exports.

The rise in prices in the interior made it profitable to plant date palms and construct the presses to produce dibs in places as far inland as the Buraimi Oasis in al-Ain (Power and Sheehan 2012). Expansion took place across Oman. In 1696, John Ovington (1696, p. 423) reported that "the Staple Commodity of the Country is Dates, of which there are whole Orchards for some Miles together. They have so much plenty of this Fruit, for which they have so ready a vent in *India*, that several Ships are sent thither loaded from hence without any other Cargo." The Yarubid government played a pivotal role, for it financed the construction (or re-construction according to Wilkinson 1977, p. 126) of falaj irrigation schemes across the country.

> [The Imām Sayf b. Sultān al-Yaʿrubī] improved a large portion of Oman by making water-courses and planting date and other trees… he had acquired one-third of all the date-trees in Oman [over the course of his reign, c. 1692-1711]… he repaired the al-Sāyighy canal at al-Rastāk, the al-Yazīly in the Zāhira, the al-Kūthir at al-Hazm, and the also the Barazamān and al-Misfāh canals… [He] planted at Naʿmān Barkah 30,000 young date-trees and 6,000 cocoa-nut trees, besides which he planted at Biʾr al-Nashwa, al-Rāssa and al-Mandzarīya. (Power 2018, p. 230, who annotated it.)

Building the falaj systems represented a major investment. "For falaj systems to be introduced it is argued that first: there should be sufficient demand for crops to warrant the expenditure upon the construction, and second: there should be enough capital available, either from the government, shareholders or individual landlords to fund construction." (Costa and Wilkinson 1987, p. 78). The return on the investment came through a rise in the value of oasis properties, and a significant share accrued to the Imam as a property owner. The gains were distributed somewhat more widely including relatives of the Imam, as well as merchant groups, who also bought oasis real estate. Land values were pushed upwards and

protected as new crops were introduced to cultivators, and villagers were encouraged to undertake the falaj maintenance work (Wilkinson 1977, p. 126).

The investment and subsequent increase in production required a bigger work force. Population growth in response to higher labour incomes was one possible source, but it would be a long time coming since it took close to two decades to produce another worker. A reallocation of labour from herding to agriculture was another possibility, but it was bound to be slow as well.

Slavery was the solution to the labour supply problem since slaves were available in elastic supply at a low price in east Africa. Zanzibar had been a Portugese possession since the early sixteenth century, and it was the major export point for slaves. After the Omanis expelled the Portugese, they expanded their own possessions in the Indian ocean and in 1698 conquered Zanzibar and Mombasa, thus internalizing the slave trade. In 1811, it was estimated that 6 - 10 thousand slaves a year were exported from Zanzibar. Around 1840 another estimate has it that one third of Oman's population were black slaves (Power 2018, p. 231), and in 1902 that all of the work in the date gardens in the Buraimi Oasis was done by black slaves who amounted to half of the population (Zwemer 1902, p. 62).

nineteenth century globalization

The third example concerns the impact of globalization on the Gulf and Oman during the long nineteenth century (1800-1913). We have more information, particularly numerical information, on some (but not all) of the key issues, so it warrants research.

The Gulf includes two important industries in which slaves were employed. One was date farming as in our previous examples. There were important oases in Oman, al-Ain in the UAE, Bahrain, and al-Hasa. Dates were consumed locally and many were exported to India. The second industry was pearling. Pearls were harvested in the oyster banks off the present UAE, Qatar, and Bahrain as well as on the Persian side of the Gulf. The pearls were sent first to Bombay, and from there they might be shipped anywhere. Slaves formed an important part of the labour force of both industries, although they were not employed to the same extent in all districts.

Understanding slavery requires us to pay attention to both the demand for slaves and their supply. The demand for slaves derived from demand for the commodities that they produced, so I study the prices of those commodities and how the technology of production and the prices of related items affected what producers found it profitable to pay for slaves. The supply of slaves included new slaves imported from Africa as well as the children of slaves already present in Arabia. In the next section I begin with supply.

The International Slave Trade

There were two main branches of the slave trade between Africa and Arabia. The first was the so-called Swahili coast. The second was Ethiopia.

The Swahili coast was a long standing source of slaves. Africans captured other Africans in the territory of present day Kenya, Tanzania, and Mozambique as well as in Madagascar. The slaves were then marched or shipped to export ports. Zanzibar was the biggest, but others like Mombasa and Kilwa were important (Vernet 2009).

There was an extensive trade between Oman and Zanzibar. Dhows left the Gulf in September or October loaded with dates, which they carried to ports along the south Arabian

coast and east Africa. In Zanzibar they sold their remaining cargo and purchased, timber (poles cut in mangrove swamps), ivory and slaves. In April or May when the winds shifted, they returned to Oman with a month's sail and arrived at Gulf ports a few weeks later (Agius 2005, pp. 113-4, 126).

Ethiopia was the second major source of slaves. In the eighteenth and much of the nineteenth century, the country was divided into an array of small kingdoms and polities, and the Emperor was a mere figure head. For much of the time, the country was cut off from the sea. Beginning in the nineteenth century, several leaders expanded their territorial control, but they process proceeded slowly with many setbacks. In 1889, Menelik II, who had been king of Shewa, which includes Addis Ababa, the city he founded 1886, became Emperor and united much of central and northern Ethiopia. Thereafter, he expanded his control over the southern part of the country.

Menelik's wars in the 1880s and 1890s generated many captives who were sold as slaves. Raiders from his more organized state took many more captives in the less organized South, who joined the long march to export ports where they were shipped to Arabia. The ports included Massawa (Mitsiwa) in the north that serviced Jeddah, Assab across the Red Sea from Mocha, Tadjoura in what is now Djibouti, and Berbera in Somalia on the Gulf of Aden that was the main shipping point to Muscat.

The purchasers of slaves in Arabia drew a number of distinctions that were reflected in prices. In the first instance, prices depended on age. Children were in demand, especially for domestic roles, but peak prices were realized on slaves in their mid teens since they could work as adults and had longer lives ahead of them than older slaves. Adult males who had been reared as slaves in the owners' household were often educated and placed in roles requiring trust. Men were purchased as agricultural workers. Eunuchs commanded very high prices. Women were divided into two groups. Many were assigned menial domestic roles and fetched relatively low prices. Attractive women became concubines or wives and commanded very high prices. This was especially true if they were Gallas–a pejorative term indicating Oromo slaves from southern Ethiopia. Gallas were light skinned and considered particularly attractive.[3] They were also regarded as especially hard working and trustworthy.

The west to east direction of the slave trade suggests that slave prices would have been higher the further east they are observed since greater transport costs would have been incurred in shipping the slaves there. This expectation is, indeed, confirmed by data. Several historians have studied the slave trade and compiled lists of slave prices from Zanzibar and Ethiopia to the Gulf. I have combined these to form a larger data set. In many cases, the original sources have been consulted to clarify the information recorded. This has been a valuable exercise since in many cases more information is available than has been previously transcribed. The prices are not derived from the statistical analysis of samples of prices, but are rather someone's impression of the ruling price in the market. Examining the sources makes the variation in data quality abundantly clear. British naval officers surveyed the coasts of Arabia and wrote systematic and detailed reports that evince considerable numeracy. Some European travellers and explorers shared the same outlook. Others were casual in the treatment of their numbers. Where a choice can be made I prefer the report of the naval officer to that of the idle wanderer who lacked a head for numbers. Despite these caveats, the

[3]Testimonials to the beauty and character of Galla women include Beke, (1852 p. 22) and Southworth (1875, pp. 349-50).

data as a whole present a coherent picture.

Since, as noted, slaves sold at very different prices depending on gender, age, and other attributes, the data are broken down in these terms. The data have also been divided by time period. There is no apparent time trend in prices before the 1870s. Afterwards they rose in part because of the depreciation of silver and in part for other reasons we will discuss. (Prices were quoted in Maria Theresa dollars or rupees, which were silver coins.) By the late nineteenth century prices had more than doubled. I distinguish two time periods in the analysis–one before 1870 with most observations in the 1830s and 1840s and one from the 1890s to the First World War. Many categories lack enough observations for analysis.

Figures 1 to 3 map prices for young adult men, young adult women purchased as domestic servants, and young adult women purchased as concubines or wives. The figures for men show the main geographical patterns. In Figure 1, the price was low in Zanzibar. This was the main source of slaves for Oman and the Gulf where prices were higher. Unfortunately, we have no prices for slaves in the hinterland of Zanzibar. We can, however, observe the price structure across the whole supply chain for Ethiopian slaves. Prices were lowest in southwestern Ethiopia in what are today the Oromia Region and the Southern Nations, Nationalities, and Peoples Region. These were the areas to the south of the consolidated empire that Menelik II put together in the 1880s. The Southern and the Oromia Regions were at war with Amharic armies and raided by slave traders through much of the nineteenth century. It was a major source of slaves, and prices were lowest there. Prices were higher in central Ethiopia where captives were first taken and then higher still in the direction of export at Berbera on the Gulf of Aden, Massawa on the Red Sea, and Khartoum on the Nile. Prices were highest on the eastern shore of the Red Sea at Jeddah and Mocha. The prices of female domestic servants (Figure 2) had the same pattern, although the prices were higher in Khartoum, Mecca, and the Gulf than they were for men. We lack prices for concubines (Figure 3) in southwestern Ethiopia, but otherwise the data show the increase in price with distance from that region and even higher prices in Mecca and the Gulf than those realized for female domestics.

Figures 4-6 repeat these comparisons for the late nineteenth/early twentieth century. All show the same increase in prices from the source. What is most striking is the overall increase in prices compared to the 1840s. So far as eastern Arabia is concerned, prices in Muscat were five times higher than in the 1840s and in the Gulf almost ten times higher. In Zanzibar, the main port supplying this region, prices had risen more than three fold. In Ethiopia, the cheapest price observed in the southwest region ($10) was two and a half times greater than the cheapest price in the 1840s. Many prices in central and northern Ethiopia were similarly inflated, and prices in Jeddah and Khartoum were much higher. Prices of female slaves were also inflated, but the data are not as abundant as for men. Moreover, the impression is that the geographical price structure was not as uniform as it was in the 1830s and 1840s.

We can learn more by analysing the price patterns statistically. The strategy is to measure the distances that would have been travelled from the source of the slaves to the places where prices are quoted. Regressions of destination price on distance are then estimated. Regressions of price on land and sea distance have been estimated, but the specification is not very revealing for the sea voyages for which the data are very sparse and irregular. Sea voyages will, therefore, be separated from land journeys. The investigation of

overland costs is thus confined to Ethiopia with occasional observations for the Sudan.[4]

Overland distances between points are ascertained in two ways. Some distances between major cities in Ethiopia, Somalia, and Eritrea were taken from the distances of modern major driving routes. These were checked against descriptions of caravan routes (e.g. Beke 1844), which were often somewhat obscure, to make sure that the modern route followed the old route. In many cases, this procedure was not possible, and distances were worked out from road maps. To do this, all data were entered in QGIS. A shapefile of modern, local roads in Ethiopia was added.[5] I assume that modern local roads followed ancient routes since in both cases the roads traverse the same geography and were probably built as inexpensively as possible. In addition, modern roads probably connected settlements that were established in accord with older roads. The distance measuring tool in QGIS was used to measure the distance along a path of local roads connecting the settlements in question.

I begin with male slaves, for whom the data are most extensive. Table 1 shows regressions of pre-1870 and post-1890 prices on distance from the point of capture in southwest Ethiopia. A simple linear regression fits the data quite well with a very high R^2 (.83) in the early sample and a lower R^2 (.59) in the later. In the third regression the samples are combined and the intercept and distance variables are interacted with a dummy variable distinguishing the periods in order to test the significance of differences in the slope and intercept. The intercept is significantly higher in the later period than in the first, while the hypothesis that the slope coefficients are the same cannot be rejected. The implication of the regressions is that the cost of shipping male slaves over land was about 2 cents per kilometre throughout the nineteenth century. The larger value for the intercept after 1890 indicates that slaves were more expensive to capture in southwest Ethiopia than they had been in the middle of the nineteenth century, and this raised their price of slaves all along the route to the Red Sea and Sudan by the same amount.

Table 2 reports the results of the same specifications for the price of concubines. The value of the intercept, which equals the price where they were captured, is badly estimated in all cases. This is probably due to the fact that only one observation is in the southwest part of Ethiopia, so the intercept is an extrapolation from distant prices. What is most surprising, however, is the comparatively large size of the coefficient on distance, which indicates that concubines cost about 10 cents per kilometre to transport to the coast. The explanation may be that they received special treatment, so that they arrived in Arabia in pristine condition. This included being treated as a wife of the chief slaver, a dubious distinction, and getting better food, her own hut each night, and the chance to ride a mule rather than walk for the many months journey (Beke 1844, pp. 20-1). All of this cost money. While the result is not statistically significant, the regressions do suggest that female slaves, like their male relatives, were more expensive to capture at the end of the nineteenth century than they were earlier.

We can also say something about the cost of sea voyages, but there are not enough observations to model the relevant variables in a regression framework. Instead, we report the results of dividing the increase in price over the route (eg the price at Muscat minus the

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[4]A couple of observations on the upper Nile led to attempts to estimate cost per kilometre on rivers, but the data were too few to reveal any pattern.

[5]The ‘roads’ file on https://mapcruzin.com/free-ethiopia-arcgis-maps-shapefiles.htm

price at Zanzibar) by the sailing distance between the ports.[6]

Table 3 shows the results. Several points stand out. I begin with the 1830s and 1840s and consider men, for whom we have the fullest information. First, the cheapest routes by far were those from Zanzibar to Muscat or the Gulf. The cost per kilometer ($.002) is about one tenth that of overland transport in Ethiopia ($.02–see Table 1). Second, the rate per kilometer on the route from Berbera on the Somali coast to Muscat and the rate from Muscat to Gulf destinations ($.01) was five times higher than the Zanzibar routes. Why this was so is a mystery. These were long routes, although not as long as Zanzibar-Muscat. Third, the most expensive routes were those in the Red Sea between Ethiopia and Arabia. They were in the range of $.04-.06 per kilometre. These were shorter than the others, which may have contributed to higher costs, and sailing conditions in the Red Sea may have been less auspicious. They rates for concubines were notably higher than the rates for men, as in the case of land transport, perhaps for the same reasons.

Unlike land transportation, the cost of sea transportation was far higher at the end of the nineteenth century than it had been in the 1830s and 1840s. Rates per kilometre for male slaves shipped from Zanzibar and Mogadishu were almost ten times greater around 1900 than they had been half a century earlier. The rate from Muscat to the Gulf was fifteen times higher. Rates on Red Sea shipments had also advanced but to a lesser extent.

Shipping rates like any prices set in competitive markets depend on both supply and demand. In this case, however, supply factors look like the principal determinants. Three political factors lay behind the increased shipping costs. First, Menelik II consolidated his control over southern Ethiopia, so the wars ended, and he decided to suppress slave raiding there. This may have been due to British pressure but also reflected the view that a productive agriculture would emerge if the people had peace and security, and taxes on agriculture would generate more revenue than taxes on slaving (Fernyhough 1989). The policy was not well enforced, so slave captures continued (Pankhurst 1968, pp 99-107), but the price of newly captured slaves rose–hence, the rise in the intercept in Table 1. Slavery itself, moreover, was not suppressed, so there was no marked increase in the rate per kilometre of moving slaves across Ethiopia. Second, the occupation of the east African coast by European powers after the Congress of Berlin in 1884-5 led to the suppression of slaving on land. The result was the sharp rise in the price of slaves in Zanzibar, still controlled by Oman. Third, the efforts of the Royal Navy to suppress the slave trade in the Indian Ocean, Arabian (Persian) Gulf, and the Gulf of Aden was the probable cause of the rise in shipping rates by sea shown in Table 3. "Great Britain's Slave Trade Agreements with the Sultan of Muscat and Trucial Chiefs of 1845, 1856 and 1873, followed by considerable British Naval activities, practically put a stop to imports from overseas and to open slave markets in local ports, but they have not succeeded in suppressing local slave usage." (Thomas 1931, p. 237). The effectiveness of the Navy's efforts have been debated by historians.[7] While the evidence points in contradictory directions, the apparent dramatic rise in shipping costs suggests that flying the flag may have been enough to reduce shipping and raise costs.

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[6]Sailing distance was normally taken from www.sea-distances.org.

[7]Reilley (2015) surveys the debate and argues that the price history indicates that naval patrols were ineffective.

A Model of a Date Growing Village

While we have argued that the price at which slaves were supplied to eastern Arabia depended mainly on the costs of capturing and transporting them from the interior of Africa, someone had to be willing to pay the delivered price for the trade to operate. Who was willing to pay the prices for men in Figures 1 and 4 and why? The answer depends on the price of dates (and pearls) since that is what the slaves produced. Date prices rose sharply in the 1870s, and that unleashed a date boom that led to Africans being imported for oasis work. The demand pressure from dates lapsed thereafter, and pearling then became the activity that generated the high demand for slaves, as we shall see.

Date prices rose in the 1870s because of the opening of the Suez canal in 1869. Before then trade between eastern Arabia and Europe or America was limited and involved only a few ships (mostly American) every year (Hopper 2015, pp. 51-60). With the opening of the canal, the shipping distance to the north Atlantic was cut and with it the cost of transport. The price of dates doubled in the Gulf. The prices of all varieties moved together, and Figure 7 shows the history of the price of Sayr dates in Basra. This was the best selling variety. Unfortunately the data are patchy with 1873 being the only year in that decade represented. Nevertheless, its price and those in the 1880s were double most in the 1860s. The highest price in the pre-Suez period was in 1866. It is as high as the later prices, but it is the exception that proves the rule, for 1866 was a year of exceedingly low production: "When the dates were about the size of currants, swarms of locusts made their appearance in this district and destroyed such quantities of the fruit that the total yield was less than 30,000 tons–about half that of ordinary years." (Basra consular report 1867-8, p. 34) In a normal year production was much larger and prices were lower than after the opening of the Canal.

Higher date prices led to greater exports and production. Before the Suez Canal was opened, 57 thousand tons of dates were produced in Iraq of which half (28 thousand tons) were exported (Bussorah report, 1867, p. 256). Exports topped 57 thousand tons in 1887 and hit 75 thousand tons in 1913 (Basra reports). Total production in the early twentieth century was on the order of 139 thousand tons.[8] A two and a half fold increase in production would have led to a correspondingly great increase in the demand for labour in the date gardens. In addition, complementary investments in date palms were occurring, although their magnitude is hard to quantify. In Oman in 1884 "the American date trade is rising in importance and yearly increasing...The particular sort of date required for the American market is the 'fard,' and the demand for it raised the value to such an extent that the Arabs are now beginning to plant this kind in their gardens to the exclusion of others." (*Persian Gulf Residency and Muscat Political Agency Administration Report* 1883-4, p. 148).

Who would do that work? In particular, was it worthwhile buying slaves for work in date gardens either before or after the Suez canal was completed? We can make some rough calculations to answer that question with a model of a date plantation. These calculations are not definitive since we must assume values for some variables about which we have little information, but they are suggestive of the incentives in play.

Date gardens required a substantial supply of water. Sometimes that came from natural springs or shallow wells when the water table was near the surface. The outstanding example is the al-Hasa oasis. Often, however, more substantial irrigation was required. The

[8]Lorimer (1915, p. 2298) reports 3.48 million date palms in Iraq. At 40 kg of dates per tree, production would have been 139 thousand tons.

Buraimi oasis at al-Ain on the UAE-Oman border is watered by at least nineteen aflaj that bring water from the surrounding mountains. The aflaj are many kilometers long and required substantial investment to construct (Power and Sheehan 2012, pp. 292-3).

There is a debate amongst archaeologists as to when and where the falaj (or its cousin the qanat) was invented. Wilkinson (1977, pp. 122-136) argued for invention in Persia, where qanats are widespread, and their introduction into eastern Arabia during the centuries of Persian domination. Other archaeologists argue that invention was in Arabia with diffusion to Persia.[9] There is also a related debate as to when the aflaj were constructed with Wilkinson arguing that all aflaj in eastern Arabia were built by the Persians since the Persian empires were the only institutions that had the resources to build them. After the Persians were driven out in the seventh century CE, many irrigation systems were abandoned. The subsequent appearance of a falaj indicated the refurbishment of a Persian original rather than something built from scratch. This view has been disputed in the case of the Buraimi oasis by Sheehan and Power (2012, pp. 297-303) who contend that the aflaj of that oasis were new constructions in the seventeenth century. Similar arguments were made for Balad Seet, Oman by Nagiev et al (2004) and Siebert (2005, pp. 156, 171,175).

In the absence of general statistics that might guide us in developing a model of date production in Arabia, I have based analysis on detailed surveys of oases in Oman conducted as part of the German-Omani project "Transformation processes in oasis settlements of Oman"[10] as well as an agricultural census of the al-Hasa oasis in Saudi Arabi (Abu-Bakr 1976). A particular focus is the oasis in Balad Seet, Oman, whose history has been studied in detail by Nagieb (2004), Nagieb et al (2004), and Siebert (2005). This was not a large oasis. At its peak in the 17th to 19th centuries, it had 7.6 hectares of land planted with date palms. They were the primary beneficiaries of the village's aflaj. A further seven hectares were cultivated with wheat and alfalfa. This land was irrigated with run off water from the date palms during the winter when water levels were highest. The date trees were intercropped with fruits and vegetables. In the absence of any specific information, I assume they were tomatoes, cabbage, cucumber, egg plant, and onions. For our nutritional analysis, it makes little difference exactly what vegetables or fruits were grown.

Table 4 summarizes the land use and cropping pattern.[11] In addition to crops, sheep and cows were also kept by the villagers (Wilkinson 1977, pp. 27-8). I assumed that there were about half as many cows as households. The sheep flock was the number that could be fed after deducting the feed consumed by the cows. The animals generated milk every year as well as occasional meat as superannuated animals were slaughtered. The sheep also gave wool, which was made into the village's clothing.[12]

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[9]In addition to Wilkinson (1977), the debate includes English (1968), Goblot (1979), al-Tikriti (2002), and Boucharlat (2001, 2003).

[10]http://www.oases-of-oman.org/sites/project.htm

[11]The starting point for this reconstruction was the similar reconstruction of Balad Seet by Siebert (2005, pp. 161-2) and Nagiev et al (2004).

[12]The 74 sheep would have produced about 74 kg of wool each year, and that, in turn, would have made perhaps 222 metres of cloth. Divided by the population of 174, the village wool supplied 1.3 metres per person. This was a scanty supply of cloth, but it should be born

The table also shows the disposition of the farm production. The alfalfa was fed to the animals, 10% of the wheat was saved for seed the following year, and half of the dates were paid as rent. We have little information about land ownership and tenure arrangements in Balad Seet, so this share is based on the usual generalizations. In most date palm oases the land and the trees were the property of absentee landowners. They were often Bedouin tribes but could also be the ruler, or his relatives, or merchants. The land was usually let on share contracts with the rent being half of the production of the date crop–the most valuable product of the oasis. The cultivators could have been either slaves or nominally free. Rent extraction was the same in either case. The rest of the production was the village's food supply. (Reilly 2015, p. 89, 134, Heard-Bey 1982, pp. 223-5).

To assess how adequate the food supply was as well as to estimate the value of a slave labourer to a landowner, we need to work out the population and the work force of the village. One approach is demographic–how many people could the village sustain? The second is technological–how much labour was required to cultivate the land? As it happens, the two approach lead to similar conclusions. I begin with the demographic.

The population in the village that could be sustained by its agriculture equals the gross production minus the seed and fodder consumed in producing it and the rent paid to landowners, whom we assume were outside the village economy. Rent was typically half of the date harvest and is shown in Table 4. How many people could that support? There are two steps to answering that question. The first is to chose a reference standard of living, and I assume that the village population was at subsistence. There are two reasons for this assumption. One is that the villagers were either slaves or were free but could not move elsewhere because they were still dependent on their former owners. It was in the owners' interest that the population be as poor as possible subject to the condition that it would reproduce, so there would always be a trained work force. This interest implies that the rent share be set to leave the cultivators with a subsistence income–subsistence in the classical sense that the population had enough to reproduce itself. There is no indication that the rent share varied from place to place or over time, so it looks like a rule of thumb. The second factor that would have ensured that the population was at subsistence was demographic. If the population dynamics were Malthusian–that is the population expanded or contracted if income was above or below subsistence–then the population would settle at the size such that its income was at subsistence whatever rent share had been set.

How much food constitutes 'subsistence'? I focus in the first instance on calories. The World Health Organization and Food and Agricultural Organization have developed a procedure to determine the minimum average calorie requirement of a group of people in order for them to survive (FAO 2001, FAO 2008b). These calculations are the basis of the 'food insecurity lines' that are computed for poor countries. Values range from about 1600 calories to 2000 per day (FAO 2008, p. 8) depending on the age structure of the population and the vigorousness of its physical activities.[13] In the appendix, I summarize this model and compute the calorie requirement with assumptions that look appropriate for nineteenth century Arabia. The model indicates that 1803 calories per person per day were necessary for

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in mind that very little of this went to the children.

[13]The US Department of Agriculture computes food security lines for many countries using a uniform standard of 2100 calories (USDA, 2018, p. 1).

survival. This is an average across both sexes and all ages, so it allows working age men, for instance, to consume 2416 calories per day while three year old girls have 913. Based on these calculations, I take 1800 calories to have been 'subsistence.'

Table 5 works out the nutritional implications of this calculation. They are dire. Except for calories where the required standard of 1800 is reached by choosing the appropriate size for the population, the diet fails to supply the requirements for protein, fat, or any of the vitamins and minerals required to prevent anaemia, pellagra, beri-beri, or scurvy. The reason is that dates were the main stay of the diet but supplied little beyond calories. One hopes that the people were successful hunters since some game would have alleviated some of these deficiencies, including, in particular, those of protein and fat. Many people in many parts of the world, however, have subsisted, if not flourished, on diets this bad.

The population calculation also has important implications for economic organization. Leaving aside boys and men too old to climb trees, about one quarter of the population would have been adult male cultivators. Consequently, there would have been 43 farmers and farms. If the agricultural land was divided equally among them, the average farm would have been 0.34 hectares with 35 date palms. These farms were small, but not unusually so. The modal farm size class in the al-Hasa oasis in 1973-4 was 0.2 to 0.5 hectares and included 40% of the farms (Abu-Bakr 1976, p. 46).

Why was the rent share at 50%? Fairness usually commends a 50/50 split, and possibly that was a consideration. A profit oriented owner of the land and slaves, however, would have set the rent at the level that fully utilized the family's labour in order to maximize income from the land and the slaves. Although the agronomic data are not very strong, they are consistent with the claim that a farm family could have cultivated about 35 date palms. We reason as follows Date cultivation was the main activity in an oasis, and it involved a series of tasks that were performed by adult males. The most important were fertilizing the female plants, thinning and pruning, and harvesting the fruit. The harvest was the most labour intensive and, given the time in which it had to be done, it was the bottle neck that limited the size of the farm; that is to say, if the farm had enough labour to harvest its date palms, it had enough labour to do all of the other tasks in dating growing, cultivating its other crops, and caring for the animals.

How many trees could a farmer harvest? That number equals the duration of the harvest multiplied by the number of trees per day that a farmer could deal with. Trees had to be climbed multiple times in the harvest period since the dates did not ripen simultaneously. Hence, the number of trees per day that a farmer could deal with equalled the number of trees he could climb and harvest in one day divided by the number of times he had to climb each tree in the harvest period. A range of values were possible for all of these parameters:

duration of the harvest period–In the date business, three different degrees of ripeness are distinguished–Khalal, Rutab, and Tamar. The first are fresh and ready to eat but do not last, while the last have been left on the tree the longest, so that they have dried out and keep indefinitely. This would have been the predominant type harvested in Arabia in the nineteenth century, for dates comprised the staple food over the whole year. The time frame for harvesting tamar dates is variously stated as 2-4 weeks (Lobo et al 2014, p. 66), 2 weeks (Morton 1987, p. 7), and "The crop is harvested over a some week period at the September." (Aboonajmi 2004, p. 2). I will work with a four week time period on the grounds that farmers in the nineteenth century kept a lot of the crop themselves and did not have to meet marketing demands.

number of trees a farmer could climb and harvest in a day–One study found that in the USA harvesters not using machinery could climb and harvest eight trees per day (Akyurt et al 2002, p. 481). These trees, however, had ladders permanently attached to their upper reaches, which would have made the work easier and more secure than it was in Arabia, where bare foot men climbed the palms with a single rope looped around their waist and the tree for security. I assume that an Arabian cultivator climbed and harvested 4-6 trees per day.

number of times each tree had to be climbed and harvested--Morton (1981, p. 6) reports that 6-8 ascents were required. Other sources indicate fewer. Akyurt (2002, p. 481) indicates that in California only 2-5 ascents were made. I assume that each tree was climbed 3-5 times.

If we assume that the cultivator made 3-5 ascents of each tree during the tamar harvest and could climb and harvest 4-6 trees per day, he could manage 22-56 trees in a four week period. More extreme values broaden the range even more. These calculations do not narrow the possibilities as much as we would like, but certainly include the 35 date palms that the demographic calculations implied. A cultivator who made five ascents per day and harvested each tree four times would finish exactly 35 trees in four weeks. These calculations accord reasonably with Wilkinson's (1977, p. 92) view that "40 to 50 palms support a family-group of five persons."

The Value of a Slave

The input-output relationships in Tables 4 and 5 can be turned into an economic model of production by treating them as fixed coefficients and valuing them with prices. The resulting equation is the profit function of the oasis. In fact, to analyse slavery, the only product price we need is the price of dates: This is because the only revenue accruing to the slave owner is the value of the rent, which is paid in dates. One further assumption will be necessary, however.

The value of a slave to his owner is the value of the rent that his labour makes possible and which is what the owner gets out of the farm. To complicate matters, however, the rent also includes the value of the land in the farm since land and labour were used together in fixed proportions (by assumption) in production. If we knew the rental value of the land alone, we could subtract it and get the value of the labour, but we do not know that. Wilkinson reports that Oman was littered with abandoned aflaj (in his view constructed by the Persians) that could be restore for much less expense than a new system would have cost. Burdened by the precariousness of the assumption, we proceed on the basis that three quarters of the rent per farm was a return to labour and the remaining quarter was a return to land (including trees and water).

Table 6 shows the implications of the production model for the value of slaves in Oman and the Gulf at different points in the long nineteenth century. The figures labelled the 1840s are broadly representative of the situation before the opening of the Suez Canal. The figures labelled 'coast' are coastal locations like Bahrain and the Batina–Oman's coastal strip along the Gulf of Oman. The price in these districts is presumed to have been the same as the price in Basra. The price at 'inland' sites like valleys in the Hajar mountains and the al-Hasa oasis are set equal to 75% of the coastal price to allow for transport costs to the coast. In both districts, the date rent of our stylized village (30400 kg in line 1 of Table 4) is set equal to the value in Table 6. This is valued at the price of dates in sterling (line 2) and converted to

Maria Theresa dollars (lines 3 and 4) and finally divided by the number of households to get rent per household (line 5). This is the income the slave generated for his owner. Deducting 25% as the return to land (line 6) gives the labour portion of that rent (line 7). This is the annual return to the slave owner from the labour of his slave. Dividing this income by the rate of return to capital gives the present value of the slave, which is the most that a prospective slave owner would be willing to pay for the slave. The table uses interest rates of 9%, 5%, and 7% depending on the year. Why those values are used will be clear shortly. A greater interest rate implies a lower present value and vice versa.

Date growing and the supply of dependent labour

Date oases not only demanded slaves, but they were also suppliers of dependent labour–in a particular way. Slaves were not sold by Arabian owners (although thousands were 'leased' to the pearling fleets in the late nineteenth century by sending them to the Gulf where they earned their share of the catch, which was remitted to their owners.) Indeed, one of the distinguishing features of Arabian slavery was its 'benign' nature in contrast to the slavery practised in places like the sugar colonies of the Caribbean. In the sugar colonies, much of the work was organized in gangs that were closely supervised. Procreation was discouraged, and the slaves were worked to death. Constant purchases of new slaves kept the work force stable. "From 1708 to 1735 Barbadian planters purchased eight-five thousand slaves, but mortality rates were so high that the island's slave population increased by just four thousand." (Thompson 2009, p. 580) In Arabia, on the other hand, the slaves had their own holdings in the oases. Families were the norm. While children of slaves remained slaves, there was a tendency to manumit slaves and over time, the enslaved population became 'free.' But it was a limited sort of freedom since the freed slaves owed his master many things including work. A slave had no bargaining power since, in practice, it was impossible for a slave to leave his village (Domar 1970). And where would he or she go if they did? Not back to Africa. Reilly (2015, pp. 92-3) recounts the story of Griga, an African slave in Algeria, who was manumitted. He could not cross the Sahara to return to his ancestral village since he was not a member of a tribe that would have protected him and so would have been subject to capture by slave traders on his journey and re-sold into slavery (Mercadier 1971).

What Arabian slavery did, however, was establish a self-reproducing demographic system and labour supply for the date gardens. "The institution [of slavery] has continued by slave begetting slave" (Thomas 1931, p. 237). Why was a different model followed in Arabia than in the Caribbean? The usual explanation for the Caribbean system is the low price of slaves brought to the Caribbean. To be precise, the price of a sixteen year old slave brought from Africa (for instance) was less than the costs that would have been incurred in raising a sixteen year old on the plantation. Those costs included the lost production and work time of the mother while pregnant and nursing, the cost of the food etc in raising the child, the augmentation of those costs implied by high infant mortality that implied that more than one birth was necessary to yield one adult, and, finally, the interest on the funds tied up in the investment to produce the child raised on the estate.[14]

[14]Hall (1962) reproduces and discusses several contemporary estimates of these costs made by planters. There is little consistency in the estimates, which highlights the needs to

These costs have been calculated for slavery in the USA for the period between the abolition of slave imports in 1807 and the start of the Civil War in 1861. American slavery was certainly harsher than Arabian slavery, but it was less harsh than Caribbean slavery. In the USA plantations, production was also organized in large gangs, but slave procreation was encouraged by giving slaves their own plots, houses, and families. The usual explanation is that the abolition of the slave trade raised the price of new imported slaves (who were rare and had to be smuggled into the country) above the cost of allowing the slaves to reproduce, so plantations were organized to allow that to happen.[15]

We can carry out calculations along these lines to explore whether the 'mild' slavery of Arabia was also cost effective.[16] However, these calculations must be performed in tandem with the calculations of the demand for servile labour in order that the rates of return be the same in the two cases as well as the implied price of slaves. Capital markets were notably absent from nineteenth century Arabia, so that rate of return differences between activities could not easily be arbitraged away resulting in big differences in profit rates between industries. However, it was the same slave owners who were using the slaves and organizing arrangements so that they could successfully reproduce. 'Arbitrage' occurred in his head. Modern finance was not necessary to equate the two rates of return.

Table 7 outlines the calculations of the cost of raising a 16 year old male slave or dependent worker in the oasis. The table is based on the demographic model in Appendix 1. The first column indicates the age of the slave. The second allows for infant mortality by indicating the number of individuals who would have been alive at each age so that one was still living at age 16. Column 3 shows the calorie consumption of people of that age relative to the average person. Column 4 is the cost of the calories of someone at each age, i.e. column 3 multiplied by the average cost of calories in a date diet of 1800 calories. Column 5 allows for the effect of interest by showing the 'future value' of expenditure for each age (ie increased using a specified interest rate) up to age 16. Column 6 shows the cumulated cost to age sixteen of expenditure at each age: column 2 times column 4 times column 5. The sum of the values are the cost of raising a 16 year old slave in the oasis–MT$55.30 at prices of the 1840s.

The cost of raising the sixteen year old depends on the interest rate used to calculate line 5: the greater the interest rate, the higher the cost. This table uses the same interest rates as those shown in Table 6 where the demand price of the slave was calculated. The reader will note that the cost of producing the slave in Table 6 closely approximates the demand prices in Table 7. Fine tuning the calculations by using more decimal places in the interest

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consider the question comprehensively.

[15]This logic was first recognized by Yasuba (1961), who specified it was the test for the 'viability' of plantation slavery in the antebellum USA. 'Viability' was contrasted with 'profitability,' which was the rate of return to buying a slave (Conrad and Meyer 1958). The rate of return calculations in Table 6 are examples of 'profitability' calculations. We are now investigating 'viability.'

[16]These questions are pursued in the shadow of the great slavery debate of the 1970s that involved most of the leading American cliometricians of the time. Two pivotal books were Fogel and Engerman (1974) and David et al (1976), but there were many other excellent works.

rate would bring closer alignment. Any other interest rate would create a great divergence between the cost of producing a slave and the demand price.[17] This interest rate shows the financial equilibrium in the village economy.

The village equilibrium and the market for slaves

The equilibrium values of the interest rate and the price of slaves in Tables 6 and 7 have important implications.

It should be noted that the interest rates are relatively low. They are not markedly different from rates of return in Europe or North America at that time. Normally we think of the middle east as a capital scarce region, which implies high interest rates. As we will see, interest rates in the pearling industry were much higher, as were urban rates. If the calculations can be believed, they highlight the significance of the lack of financial institutions and instruments in Arabia–there was no easy mechanism to arbitrage across different capital markets and bring rates of return into alignment. Evidently, investment in the agricultural sector was not a high profit activity, but capital was not drawn out of it into other activities like pearling.

The demand prices for slaves in Table 6 are often greater than the market prices of slaves in Oman and the Gulf shown in Figures 1 and 4, although the premium varies. In the 1840s it was about double, in the 1870s it was 5-10 fold, in the 1900s it was non-existent in the Gulf and one and a half or two fold in Oman.. The difference in the demand price and the market price in the 1840s was not large enough to induce the large scale purchase of new slaves. Thomas (1931, p. 237) reported that "The Oman slave market is said to be satiated before the operation of these treaties [signed in 1845, 1856, and 1873]." In the 1900s there were few slaves bought for work in the date gardens. That only happened around the 1870s.

If Arabian slavery had been a question of moment by moment comparisons of the price of slaves in the market and the cost of rearing slaves on the estate, then the decision at most times and places would have been to free slaves, expel them from the village, and replace them with newly purchased male slaves. This could not readily be accomplished, however, since, first, the slave population was the village population and would have resisted any such action, and, second, the newly purchased work force would not have known how to cultivate dates and its management would have entailed substantially higher costs for additional teaching and supervision. It was only when date cultivation was expanding, which was the case in the decades after the opening of the Suez canal that new African slaves were purchased to cultivate the enlarged date gardens.

But there are two other considerations in play that tipped the balance the other way. They were farming knowledge and incentives. They work together. Date growing required skilled workers as can be seen by considering that tasks involved. There were three key episodes in the annual cycle. There are male and female date trees, and the first important task was fertilization of the female plants. Since only female plants produce fruit, most date palms in a garden are females. As a result, pollen from the stamin must be taken from the few male trees and manually applied to all of the pistols in each bunch on the female date palms.

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[17] The interest rate values in Tables 6 and 7 were determined by trying alternative values in the models until the price of a slave converged.

> The most common technique of pollination is to cut the strands of male flowers from a freshly opened male spathe and place two to three of these strands, lengthwise and in an inverted position, between the strands of the female inflorescence. This should be done after some pollen has been shaken over the female inflorescence...In order to keep the male strands in place and also to avoid the entanglement of the female cluster's strands during their rapid growth, it is recommended to use a twine (a strip torn from a palm leaflet or a string) to tie the pollinated female cluster 5 to 7 cm from the outer end. (Zaid 2002, chapter VIII)

This requires some skill and also judgement regarding timing since it must be accomplished at the correct point in the reproduction cycle of the tree. In addition, the work must be done while climbing to the top of the tree, which adds to the seriousness of the task.

The second key task is thinning. A properly thinned tree gives more fruit of higher quality. Both the number of bunches and the size of each bunch can be reduced. The optimal approach depends on the variety of date and characteristics of each tree. Sometimes thinning is done at the same time as pollination. "However, and generally speaking for most varieties, it is recommended to wait 6 or 8 weeks after pollination in order to apply the adequate thinning method." Usually, "not less than one-half and not more than three-quarters of the total number of fruits" should be removed. "In fact, if the number of fruit bunches per palm is not reduced to an appropriate level, the next year's production will be low, and consequently an alternancy phenomenon is established." Whole bunches should be removed from the tree in order to maintain the optimal ratio of eight to nine leaves per fruit bunch. Since the leaves of a date palm are arranged on thirteen vertical columns, it is only necessary to count the leaves on one column, multiply by thirteen, and then divided by the optimal ratio to determine the number of bunches to aim for–basic numeracy is an advantage. "A grower is advised to take into account the variety, the state of his palms and existing cultural conditions before determining which leaf-bunch ratio to adopt." In addition, the thinning operation must be accompanied by operations like installing covers on every bunch to protect against insects and birds, as necessary. (Zaid 2002, chapter VIII)

The final task is harvesting. It too required care, precision, and attention to the development of the fruit on each tree. "Harvesting the fruit entails the use of experienced workers" since they must climb the tree and know what they are doing. The date could be harvested at any of three stages of maturity: Khalal, Rutab, and Tamar. The first gives fresh fruit, the third has dried on the tree and will last the whole year. However, "Experience in most date producing countries showed that a well matured Rutab, handled with care...gives the grower the highest rate of return. However, Rutab has three serious setbacks: it is produced in comparatively short periods with the tendency of production peaks; it is highly perishable; and it is delicate, which makes handling and transport difficult and expensive." (Zaid 2002, chapter IX) Since bunches mature at different rates, each tree must be climbed several times over the harvesting season so that each bunch is harvested at the time of greatest value.

The type of work has several implications for slavery in Arabia. First, it should be emphasized that the newly landed slave from Zanzibar would not have known how to perform the tasks just described in date production. Much supervision and training would be need to turn him into an effective date producer. The contrast is with a boy who grew up in an experienced date farming family. The boy would have learned how to grow dates by

watching his father. This important factor was omitted when we compared the cost of a boy raised on in a date garden with the cost of the newly imported slave. It made sense for a slave owner to pay more for a trained slave than for an untrained slave. One of the benefits to the owner of the date garden from having it organized as family farms is that it solved the labour training problem that otherwise would have emerged.

Comparing the tasks in date cultivation with the tasks on sugar plantations in the Caribbean brings home the importance of this consideration. While there were some skilled slaves like carpenters on every plantation, most of the slaves on a sugar plantation worked in gangs under the supervision of overseers and performed menial tasks. Some plantations have left records showing the number of days of labour spent on each activity (Roberts 2006, Thompson 2009). Most time was devoted to digging holes in which to plant cane, turning manure and spreading it on the cane fields, cutting the cane with a machete and so forth. There was no attention to the development process of each sugar plant (as there was with each date palm), so all conceptual aspects of the work were done by the supervisor who laid out the field for planting and designated the location of the whole, decided when and how much manure to apply, and when to harvest the cane. What the slave did was hard, unskilled work. The difference with date cultivation was stark. That is why sugar plantations could make use of new slaves from Africa, while date farms could not so easily do so.

One implication of the skill level in date cultivation is that training is required. Skill has a second implication. One feature of the skill of date growing is planning the timing of the activities. This cannot be done centrally by an overseer as in sugar production since timing depends on the growth pattern of each tree and, indeed, each bunch. Each operator must make the decisions. This creates an incentive problem: why should the date cultivator apply himself to making the best decisions and executing them as perfectly as possible? This problem was solved under the Arabian system by employing all growers–whether slave or free–on share contracts. Half of the date output went to the owner in most cases and half to the cultivator. If the cultivator applied himself effectively to growing dates and increased the quantity and quality of the harvest, he realized half of the rise in income.

Demand for slaves in pearl diving

Pearls have been harvested from the Gulf for millennia (Carter 2005, 2012). European travellers in the eighteenth and nineteenth centuries described a well established industry. It was not an industry that employed a slave labour force, however. It looks like all of the divers were Arabs (Whitelock 1836). It was not a question of individuals leaving their tribes, pitching up in a port, and taking a job as a pearl diver. Instead, tribal groups began to spend the summer on the coast where they manned small boats and went diving (Heard-Bey 1982, p. 198-9). For these Arabs, pearling was their main source of income.

The situation changed dramatically in the second half of the nineteenth century, for global economic development increased the price of pearls in the Gulf even more dramatically than it did the price of dates. It is difficult to pin down the magnitude, for pearls were exceptionally heterogenous. In the major market in Bombay in 1906, pearls were divided into 26 categories and the price range for each category was specified according to the weight of the pearl expressed in terms of Bombay Chaus (Lorimer 1915, pp. 2235-40, 2281-3.) The price schedule in force in 1852/3 had doubled by 1877/8 and then more than doubled again by the time of Lorimer's survey (1904-7). (Lorimer 1915, p. 2239). This is usually taken to mean that the price level of pearls rose more than four fold, although we do not know how the distribution of pearls across the 26 categories may have shifted. Prices

continued to rise: In 1909-10 they jumped up 30% (Carter 2005, p. 157n15.) The price rise from 1850 was more than twice that of dates with important implications.

The price increases experienced by the pearl industry dramatically raised the value of slaves in pearling. We can calculate the impact by modelling the cost structure. The calculations for pearling are simpler than the date calculations (a) because the industry ran largely on a share contracts and (b) because Lorimer (1915, pp. 2220-2293) reported in detail on the working of the industry in the first decade of the twentieth century. We present parallel calculations for the 1870s and 1850 that embody the same logic but use less reliable numerical data. I focus on Bahrain since it was the largest component of the Gulf industry and it has the longest run of comparable data. Rough calculations suggest that the Bahrain fleet was the most productive in the Gulf, perhaps because it fished the best banks.

Table 8 shows the calculations. The starting point is the value of pearls harvested each year. This is available annually from 1873/4 onwards. The total value of the catch is divided by the number of boats to obtain revenue per boat (line 1). The owner of the boat was usually also its captain. The pearling season lasted for about 168 days in the early twentieth century but fewer earlier, and during that period, the crew lived on the vessel since it was stationed on the pearl banks. The crew had to be fed while on board, and provisioning the ship was expensive since so much food was required. Buying the food was usually financed with a loan from a *musaqqam* who received 15-25% interest on the loan. This range is considerably more than the rates of return in date farming that were computed earlier–thus attesting to the lack of a capital market that bridged the industries–but compares to rates in Cairo in the 1840s. Wilkinson (1847, p. 143) reports that the interest rate on unsecured loans was 60%. It dropped to 24% on loans 'with security' and 12% on loans secured with jewels. Paying off the loan to the *musaqqam* was the first charge on the ship's harvest.

The second charge on the ship's revenue was the cost of the food itself. This was estimated from Lorimer's (1915, p 2230, 2231) description of the routine on board the ship."The divers, before they commence operations for the day, are allowed a light meal of half a pound of dates and a few cups of coffee each." At mid-day, they have a "a few cups of coffee, and an hour's rest." After evening prayers, "the divers take a substantial meal of fish, rice and dates, and then, after a little smoking and coffee drinking, retire for the rest of the night." Or they socialized. "The Nakhudas and their crews visit friendly boats to enjoy coffee, wafer cakes, and tobacco." One imagines that all of the nicotine and caffeine made the hard work of diving bearable.

Table 9 converts this description into costs by assigning specific values to the quantities consumed and valuing them with prices. Lorimer reported that divers had a half pound of dates for breakfast, and I assume that their evening ration was the same. I assume that their substantial portion of rice at dinner amounted to half a kilo, and that the cakes they received required 100 grams of flour per day. I assume they ate 250 grams of fish at dinner, but this does not affect the cost calculation, as it was caught on board and not purchased in advance. The diet provides 3468 calories per day. While the quantities are arbitrary, it is difficult to see how pearl diving could have been carried on for months on end with fewer calories. In addition, I allow them 5 grams of tobacco per day–the equivalent of five cigarettes. At pre-Suez canal prices, a season's provision for one man came to 11.4 rupees. By the 1870s, this had risen to 12.8 rupees because the Canal had boosted the price of dates in the Gulf, and by the early twentieth century the decline in value of silver currencies like the rupee and the Maria Theresa dollar had pushed the cost up to 38.3 rupees (line 3).

The third charge against revenue was the profit that went to the owner of the ship as a

return on his investment (line 4). This equalled 20% of the income in line 1 net of the charges in lines 2 and 3.

Once profit to the shipowner is deducted, the remaining income in line 5 is divided among the crew of the vessel. Vessels and their crews got bigger over time. In the 1830s the average crew was 9 people per dhow (one captain, four divers, and four haulers), and that the crew increased to 12 in the 1870s (one captain, five divers, fiver haulers, and one deck hand).[18] According to Lorimer (1915, pp. 2227-8), the crew was larger in the early twentieth century (one captain, 7 divers, 9 haulers, and 2 deck hands). The captain and the divers each got 3 shares, the haulers 2, and the deck hands 1. In the 1840s, there were 23 shares among the 9 members of the crew, and each share was worth the net income of the ship (line 5) divided by 23 shares giving a value of 20.34 rupees per share (line 6). Multiplying the value of a share by the number of shares yields the income of each job category (lines 7-10).

The incomes we have computed have some interesting implications. In the early twentieth century, pearling was highly profitable. Lorimer (1915, p. 2228) reports that "a pearl boat of the largest dimensions, to carry 40 men, costs Rs. 30,000 or more to construct and fit out." I assume (with some reservations) that 750 rupees per man (30000/40) was the cost of a ship for pearling. Dividing the profits per vessel by the cost of an average vessel at that rate implies a rate of return of 15% on the investment. This is a plausible number since investors charged 10 - 25% on their loans for provisioning pearling ships.

We can also compute the rate of return to buying slaves for diving. If a diver was not a slave, he received the income in line 8 as a wage. On the other hand, if the diver was a slave, the line 8 income legally went to his owner, and the owner had to support the slave and his family throughout the year. As late as the 1920s, thousands of slaves were rented by their owners in Oman, where they probably grew dates, to pearl boats in the Gulf. Tribal agents escorted the slaves to the ports and contracted with *nakhuda* to take them on their ships for the season. In exchange, the *nakhuda* gave the agents an advance and at the end of the season returned the slave and the balance of his earnings (Thomas, 1931, p. 238, LeBaron Bowen 1951, p. 169). The question is: how was that income divided between the slave and his owner? Lorimer does not discuss this, but there are hints that it must have been a reward system rather than a punishment system. The pearling boats did not carry overseers to monitor slaves or coerce them to work hard. On the contrary, tight bonds of mutual support prevailed among the crew. Furthermore, the work required conscious effort on the part of the diver to maximize output. Lorimer (1915, p. 2228) explained

> The efficiency of a diver depends more on his skill and daring than on the strength of his constitution,–the last being a point on which undue stress has sometimes been laid by writers on pearling; and a slave diver who is not afraid to enter deep and muddy water containing weeds is ordinarily valued at considerably over Rs. 1000.

Rs. 1000 was almost MT$750 when Lorimer wrote. This was, indeed, a great sum compared to the other prices in Figure 4.

Dari-Mattiacci (2013) has reformulated and extended Fenoaltea's theory of save management to include what he called 'asymetric infomation,' which, in this case, refers to

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[18]Whitelock (1836, p. 42).

the near impossibility of the owner's monitoring what the slave did under water–especially when that water was deep and muddy so the slave could not be seen. When the slave resurfaced without any oysters and reported that there were none on the bottom, was that the truth or was he afraid to swim amongst the weeds? Only the slave knew. Dari-Mattiacci's model shows that threats are useless in these circumstances, and a system of rewards is need to motivate the slave. "On a continuum from simple to complex activities, the model predicts that we should observe sticks at the simple end of the spectrum (informative signals), small carrots in the intermediate region and greater carrots–including the concession of freedom–at the complex end (uninformative signals)." (Dari-Mattiacci 2013, p. 87). Acting with bold cunning in dangerous water lies at the complex end of the spectrum, and the 'signal' was less informative the murkier it got.

There were a variety of arrangements that met this requirement. The slaves sent each year from Oman to the pearl banks may otherwise have been employed in date farming, so perhaps the same terms obtained–that is, a 50/50 split of the earnings. Alternatively, some slave divers lived with their masters as members of his household, giving him their earnings while sharing in the household consumption (Heard-Bey 1982, pp. 211). How this worked in practice was no doubt variable, but presumably it motivated the slave enough to produce a satisfactory income.

To explore the economics of slaves' diving, I work with the 50/50 split and so assume that the slave and the master each got half of the slave's earnings in line 8. The rest of the table works out the implications of these figures.

In the 1840s, the price of pearls was so low that slavery was a bad deal for everyone. The rate of return to capital invested in boats and equipment was a derisory 3% (line 11). The profit on the slave owner's investment in the slave was only a little better at 10% (line 12). However, this is much below 20%, which I regard as the target rate of profit in pearling since the musaqqam who outfitted pearl boats expected a return of 10-25%. The return on buying a slave in the 1840s just touched the bottom of that range. Observers of the industry in the 1840s describe only Arab divers and no slaves. Finally, what the slave could consume with his half of his earnings got him only 60% (line 14) of a subsistence standard of living[19] (line 13). A single individual could have lived on that amount, but a family would have been very hard pressed to survive (Allen 2020). There was no scope for the slave owner to increase his share at the slave's expense without threatening his ability to survive.

The income of the industry rose in the 1870s after the price of pearls had doubled. The return on investing in boats and rigging grew to 6% (still exceptionally low), but the return to buying a slave jumped to 33%, and the slave's welfare ration increased to 70% of subsistence–still not good. The situation was much better by the twentieth century when prices had doubled again. The return on ship's capital rose to 15%, the return to owning a slave was 25%, and the welfare ratio of a diver jumped to two and a half times subsistence. This put the diver on the same level as a skilled craftsman like a mason.[20] This was high enough to elicit some willing participating.

The remainder of the table arranges the figures regarding the profitability of slave

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[19]This is defined in Appendix III.

[20]The diver earned 3.4 rupees per day over his 168 day pearling season. The mason earned "3 rs. per diem. minimum rate" (Bahrain report xx 1911-12, p. 11)

investment in terms of present value. Using a discount rate of 20%, the capitalized value of a slave was $38 in the 1840s, $67 in the 1870s and $1047 in the early twentieth century. Reference to Figure 1 shows that these values were less than the price of male slaves in the Gulf in the 1840s and 1870s but much higher than the value in the 1900s. On the demand side, the rise in the price of slaves was driven by the rise in the profitability of pearling.

There are three reasons for the rise in profitability. The first was the jump in the price of pearls. The great demand for pearls, in turn, was due to the industrialization of the West which generated high incomes for the middle and upper classes. The bourgeoisie decorated its women in pearls.

The second and third reasons are less well known but are revealed by Table 9. Between the 1870s and the early twentieth century, revenue per pearling boat increased by a factor of 7.7. One reason is that the boats were bigger in the early twentieth century–crew size had increased from 12 to 19, that is by a factor of 1.58. Dividing 7.7 by 1.58 implies that revenue per worker rose by a factor of 4.88. Since the price of pearls doubled over this period, the productivity of workers in pearling increased by a factor of 2.44. Or, to be precise, Lorimer (2015, p. 2239) says that the price of pearls had "more than doubled," which implies a lower rate of productivity growth–probably nearer to 2. One cause of this growth was a lengthening of the diving season from 98 days in the 1830s to 138 days in the 1870s to 168 days in the 1900s. There was always a long summer diving. A spring diving season was added by the 1870s and a fall season was tacked on by the twentieth century (Whitelock 1836, Lorimer 1915, pp. 2228-9, Carter 2005 , p. 142, LeBaron Bowen 1951, p. 170). The lengthening of the diving season in the late nineteenth century would have pushed up output per worker by 22% if nothing else had changed. The remaining productivity growth was down to more efficient methods and procedures–perhaps to scale economies arising from the increase in the size of dhows. Nevertheless, in the case of slaves, the rise in output per worker and the higher slave prices that followed from it was down, in part, to a higher rate of exploitation–even if that also gave them greater consumption.

conclusion

Slavery developed in Arabia in the way it did because it performed certain functions that were economically important. The first is that it was a source of mobile labour that could be re-allocated to high value tasks. Arabia itself was not a good source of labour for export oriented industries, for many Arabs herded sheep or camels on common land. The result was tribes that provided their members with mutual assistance and protection and, in return, demanded allegiance and participation. These arrangements provided considerable security, so people did not readily leave them Slavery brought people into Arabia from outside this system, so they were not bound by its obligations and instead were at the mercy of their owners who could elicit loyalty and commitment to their purposes with properly structured rewards.

Second, the tasks assigned to slaves in date growing and pearling were complex and required the slave to show initiative to maintain a high level of production. In the case of pearling, the slave's effort was unobservable and impossible to evaluate. These features of the work meant that punishment was a counterproductive way to motivate slaves. Rewards for good performance were more effective, and so the slave's life was not as harsh as it was on a Caribbean sugar, or American cotton, plantation.

Manumission might even follow as a reward. This gift was not as great as it sounds,

for freedom for a slave was not real freedom–the freed slave remained a dependent of the former owner, had little scope to go elsewhere, and so had little more, if any, bargaining power than a slave. Consequently, the slave owner or former owner usually got most of the surplus no matter what the legal status of his dependents. Furthermore, the children of the slave were brought up by their parents as masters of their craft, and that was important as the activities of slaves in Arabia demanded more skill than those of slaves in the Caribbean. The third function of slavery was to produce a permanently dependent yet motivated and skilled labour force that could be kept at a subsistence standard of living.

For these reasons and in these ways, slavery in Arabia was ‘benign’ in comparison to slavery in many parts of the Americas. Humane treatment could always be justified with reference to God’s word. Obeying it was easier when good behaviour paid in this world as well as the next.

Table 1

Regressions of male slave prices on distance.
(T-ratios in parentheses)

Sample	Early	Late	Combined
distance	.0184 (7.84)	.0225 (3.61)	.0184 (4.53)
distance*late			.0078 (1.075)
late			16.77 (3.038)
intercept	2.89	15.95	2.89
R^2	.83	.59	.71
observations	15	11	26

Table 2

Regressions of female concubine prices on distance.
(T-ratios in parentheses)

Sample	Early	Late	Combined
distance	.1059 (3.22)	.0961 (2.39)	.1059 (2.18
distance*late			-.0098 (-.165)
late			42.16 (.7125)
intercept	-13.91	4.258	-37.91
R^2	.60	.36	.43
observations	9	12	21

Table 3

‘Cost’ per kilometre of shipping slaves across the sea
(Maria Theresa dollars per kilometre)

	1840 domestics	1840 concubines	1840 men	1900 men
Zanzibar-Gulf	0.0039			
Zanzibar-Muscat			0.0024	0.0205
Mogadishu-Muscat				0.0204
Berbera-Muscat	0.0102	0.0233	0.0122	
Muscat-Gulf		0.051	0.0102	0.1531
Berbera-Mokha		0.0532	0.0399	
Massawa-Jeddah			0.06	0.0862

Table 4

Agricultural Production and Utilization

		trees/ha	kg/tree	gross	uses of production =>			
	hectares	or % of animals	or kg/ha or kg/animal	production kg	rent kg	seed kg	animal feed kg	village food kg
dates	7.6	200	40	60800	30400			30400
crop land –								
wheat	4.9		1400	6860		686		6174
alfalfa	2.1		15000	31500			31500	
tomatoes	1		3000	3000				3000
cabbage	1		3000	3000				3000
cucumber	1		1200	1200				1200
egg plant	1		1200	1200				1200
onions	1		1500	1500				1500
	animals	% slaughtered						
sheep meat	74.17	25%	16.53	306.50				306.50
sheep milk	74.17	100%	100	7416.72				7416.72
cows meat	17	15%	130	331.5				331.5
cows milk	17	100%	420	7140				7140

Table 5
Nutritional Analysis of Average Village Diet

	total human consumption kg/yr	per capita human consumption kg/year	Nutritional Analysis nutrient	consumption per day		percent of daily requirement
dates	30400	175.51	calorie	1802	calorie/day	100%
wheat	4008.93	23.15	protein	25.67	grams/day	51%
tomatoes	3000	17.32	fat	21.85	grams/day	64%
cabbage	3000	17.32	iron	8.41	mg/day	44%
cucumber	1200	6.93	B12	1.28	micro g/day	146%
egg plant	1200	6.93	folate	0.16	mg/day	89%
onions	1500	8.66	B1 (thiamin)	0.66	mg/day	59%
sheep meat	306.50	1.77	niacin	12.10	mg/day	82%
sheep milk	7416.72	42.82	C	26.62	mg/day	65%
cows milk	7140	41.22				
cows meat	331.5	1.91				
butter	866.03	5.00				
annual food consumption		348.54				

Table 6

Value of male slave in date cultivation

line		1840s coast	1840s interior	1870s coast	1870s interior	1900s coast	interior
1	oasis rent, kg of dates	30400	30400	30400	30400	30400	30400
2	price of dates £/kg	0.00242	0.00182	0.00529	0.00396	0.00529	0.00396
3	MT$/£	5	5	5	5	7.93	7.93
4	oasis rent in MT$	368.28	276.21	803.52	602.64	1275.01	956.26
5	rent/household MT$	8.51	6.38	18.56	13.92	29.45	22.08
6	land share of rent	25%	25%	25%	25%	25%	25%
7	slave rent MT$	6.38	4.78	13.92	10.44	22.08	16.56
8	cost of slave, Oman, MT$	30	30	30	30	150	150
9	rate of return (line 7/line 8)	21%	16%	46%	35%	15%	11%
10	cost of slave, Bahrain, MT$	40	40	40	40	300	300
11	rate of return (line 7/line 10)	16%	12%	35%	26%	7%	6%
10	discount rate =	9%	9%	5%	5%	7%	7%
11	present value of slave	73.32	54.99	272.89	204.67	315.48	236.61

Table 7

Cost of Raising a Male Slave to Age 16

Part A Calculation for 1840s, inland location, interest rate = 8.7%

age at start of year	required people for one fifteen year old	fraction of 1800 calorie diet	1840s cost of diet MT$ per year	interest on outlay	1840s cost MT$ per year
0	2.05	0.39	1.79	3.49	6.26
1	1.43	0.44	1.38	3.22	4.44
2	1.35	0.50	1.49	2.96	4.40
3	1.27	0.53	1.50	2.72	4.08
4	1.19	0.58	1.52	2.50	3.81
5	1.12	0.62	1.54	2.30	3.55
6	1.10	0.68	1.65	2.12	3.50
7	1.09	0.74	1.78	1.95	3.46
8	1.08	0.80	1.91	1.79	3.43
9	1.06	0.87	2.06	1.65	3.39
10	1.05	0.72	1.68	1.52	2.55
11	1.04	0.79	1.81	1.40	2.53
12	1.03	0.86	1.95	1.28	2.51
13	1.02	0.94	2.11	1.18	2.49
14	1.01	1.02	2.27	1.09	2.47
15	1.00	1.10	2.42	1.00	2.42
cumulative cost =				MT$	55.30

Part B Comparison of Costs and Prices over time

	1840s	1870s	1900s
interest rate	8.7%	5.1%	7.0%
coast	$73.73	$271.81	$314.88
interior	$55.30	$203.86	$236.16
Slave prices			
Muscat	$30	$30	$150
Bahrain	$40	$40	$300

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Table 8

Revenues, Costs, Profits, and Rates of Return
of Pearling in Bahrain, 1840s, 1870s, 1907
(rupees except for the last line which is Maria Theresa dollars)

line		1840s per boat	1870s per boat	1907 per boat
1	revenue per boat	875	1750	13522.36
	division of revenue			
2	return to financier (musaqqam)	153.13	306.25	2366.41
3	provisions for voyage	136.99	216.58	683.01
4	return to boat owner	116.98	245.43	2094.59
5	earnings of crew	467.91	981.74	8378.35
	division of crew's earnings			
6	earnings per share	20.34	33.85	190.42
7	earnings of captain	61.03	101.56	571.25
8	earnings of one diver (Ghais)	61.03	101.56	571.25
9	earnings of one hauler (Saib)	40.69	67.71	380.83
10	earnings of extra hand (Radhif)	0.00	33.85	190.42
11	rate of return to ship investment	3%	5%	15%
12	rate of return to slave investment	10%	28%	26%
	WR of the slave & net profit of his owner			
13	annual living cost of family	51.16	73.66	107.32
14	family welfare ratio	0.60	0.69	2.42
15	net profit per slave	15.26	25.39	285.63
16	discount rate	20%	20%	20%
17	prevent value of slave (rupees)	76.29	126.95	1428.13
18	prevent value of slave (MT$)	38.14	63.47	1057.87

Figure 1

Price of young adult male slaves in 1830s and 1840s
(Maria Theresa Dollars per slave)

Figure 2

Price of young female adult domestic servants in 1830s and 1840s
(Maria Theresa Dollars per slave)

Figure 3

Price of young adult female concubines in 1830s and 1840s
(Maria Theresa Dollars per slave)

Figure 4

Price of young adult male slaves, 1890-1913
(Maria Theresa Dollars per slave)

Figure 5

Price of young adult female domestic servants, 1890-1913
(Maria Theresa Dollars per slave)

Figure 6

Price of adult female concubine, 1890-1913
(Maria Theresa Dollars per slave)

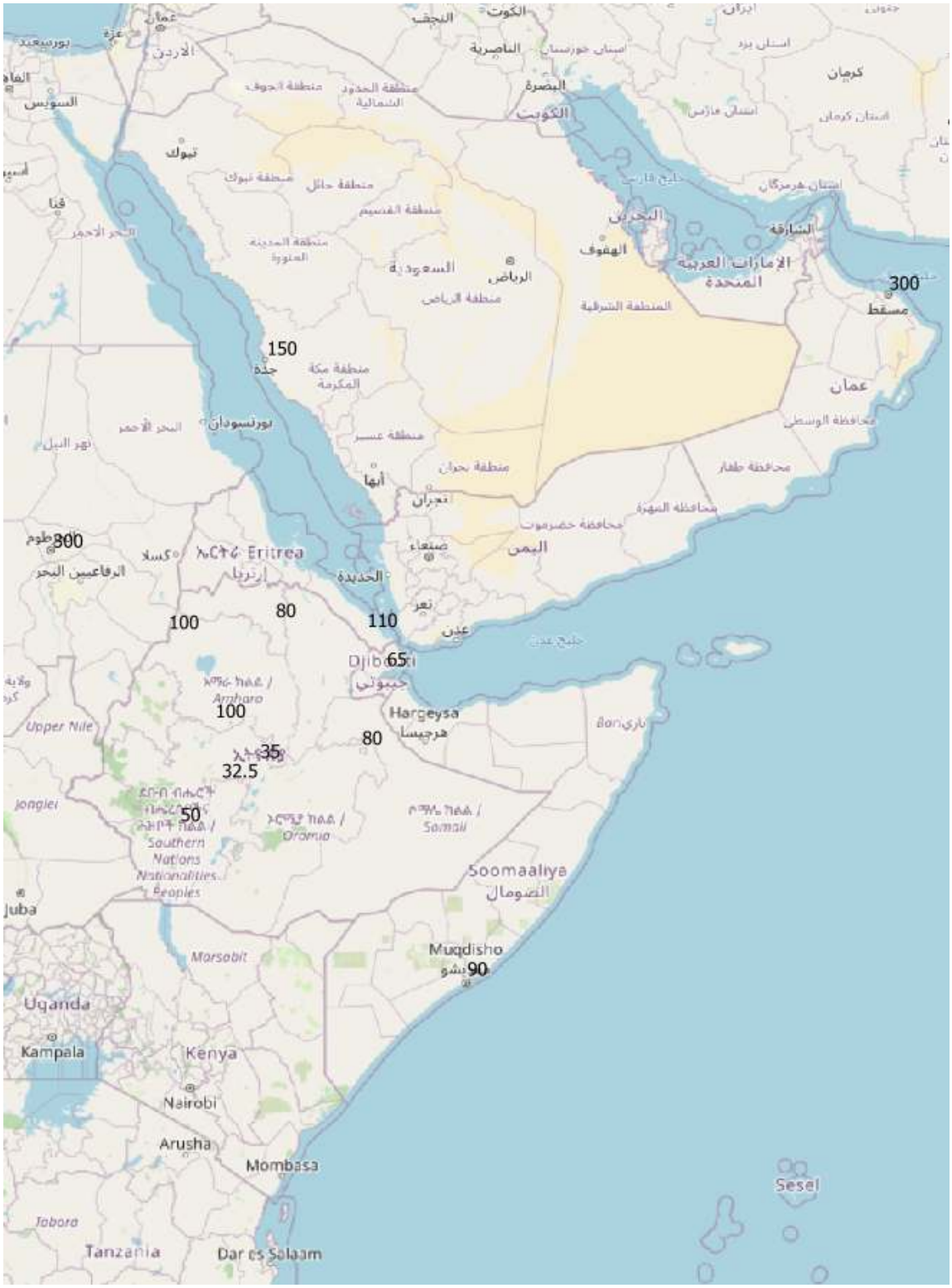
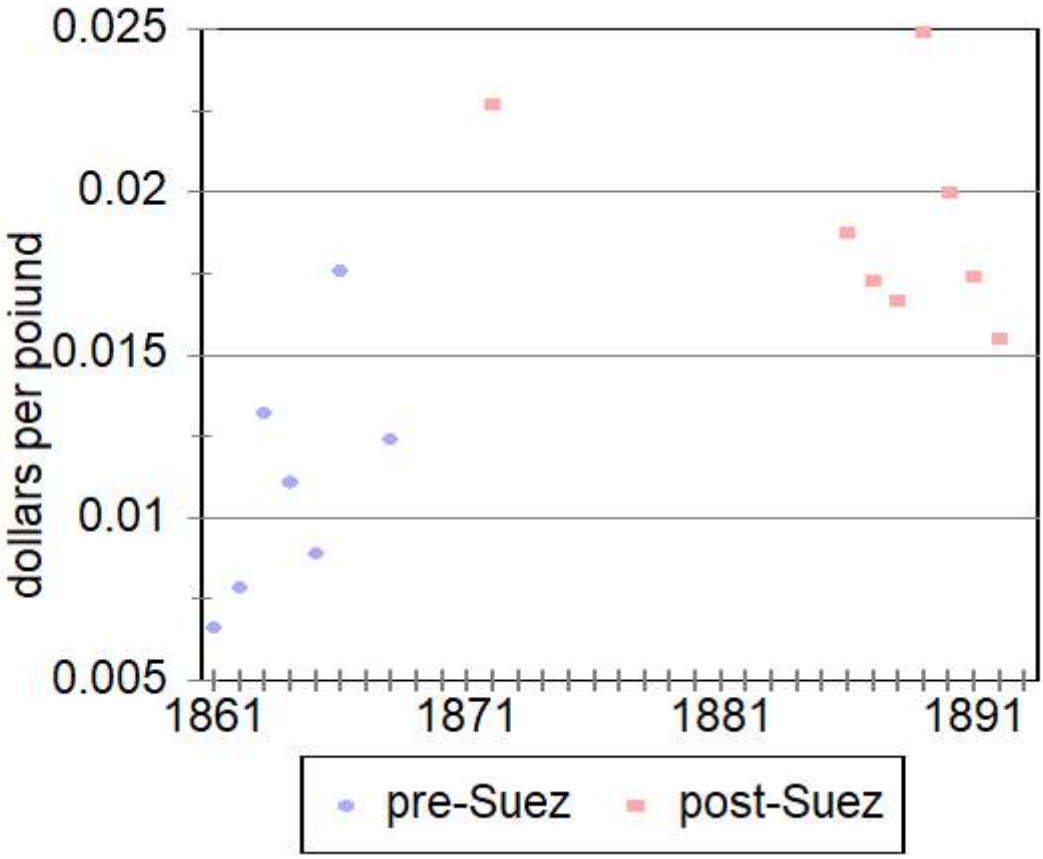


Figure 7

Price of Sayr Dates in Basra



source: j:/REFdata/basrah redo 2020.wb3

Appendix I

Source of Slave Prices

The following sources were consulted for the places indicated. In many case, the original sources were consulted in works like those by Abir, Fernyhough, Pankhurst, Reilly and others that had compiled collections of prices. This was done to establish the context of the price quotation and further information that was collected but not reported.

place	source
Wolamo	Fernyhough, p. 104
Agabja	Pankhurst, p. 84
Sodo	Pankhurst, p. 84
Ankobar	Pankhurst, p. 84
Jimma	Pankhurst, p. 85, Borelli, pp. 288, 332
Walaga	Fernyhough, p. 104, Pankhurst, p. 85
Gore	Pankhurst, p. 85
Shanqella	Pankhurst, p. 85
Roggi	Abir, Ph.D., pp. 419-420, Cecchi, p. 490
Qabana	Pankhurst, p. 85, Cecchi
Debre Berhan	Fernyhough, p. 104
Aliu Amba	Pankhurst, p. 85
Addis Ababa	Pankhurst, p. 85
Harar	Abir, Ph.D., p. 293, Pankhurst, p. 85
Gederu	Beke, p. 23
Gibe	Abir, Ph.D., p.159, Cecchi
Baso	Abir, Ph.D., p. 98-9 and Ahmad, p. 95, Beke, p. 22
Gondar	Abir, Ph.D., pp 43-4
Tigre	Pankhurst, p. 86
Antalo	Pankhurst, p. 86
Wallo	Pankhurst, p. 86
Tajura	Abir, Ph.D., p. 243
Berbera	Abir, Ph.D., pp. 243, 341, Wellsted II, p. 366
Mokka	Abir, Ph.D., p. 243
Massawa	Pankhurst, p. 86
Assab	Pankhurst, p. 86
Galabat	Ahmad p. 97, Baker, p. 350
Jeddah	Abir, Era of Princes, p 65, Combes & Tamisier, IV, pp. 92-5
Alexandria	Pankhurst, p. 87
Cairo	Wilkinson, 1835, p 286
Gulf	Abir p. 341, UK National Archives FO/84/486-2, Hopper, p. 308, Reilly, pp. 111-12
Mecca	Keane, p 76
Muscat	Fernyhough, p. 104, UK National Archives FO/84/486-2, Lorimer, II, p. 2499, Reilly, pp. 111-12
Khartoum	Southworth, p. 212
Shendi	Bjorkelo, p. 79
Berber	Bjorkelo, p. 79
Khordofan	Bjorkelo, p. 79
Zanzibar	Sheriff, pp68-9, Cooper, various
Mogadishu	Declich, p 54

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Appendix II

Energy Required for Subsistence Food Consumption

While the oasis farmers grew most of their own food, neither they nor the herders were self-sufficient: The exchange of food between both groups bound them together. The farmers of the oases produced dates and grain that they ate themselves and traded to the herders for whom it was their main source of calories. "On their journeys, the Bedouins live almost wholly upon unleavened bread baked in the ashes, and mixed with butter." (Burckhardt, Notes, I p. 240) However, "in the Hedjaz the usual dish of the Arabs is India rice, mixed with lentils and without any bread; this they find cheaper than corn and equally nutritious; but wherever dates grow, that excellent fruit constitutes their chief diet." So the food of the Bedouin was either imported into Arabia (Indian rice) or the product of oasis agriculture–wheat flour and dates. Butter they made themselves from the milk of their animals. They consumed it lavishly–"In Nedjd, Hedjaz, and Yemen, the Bedouin use butter to excess." (Burckhardt, p. 241)–and traded the surplus to oasis farmers for wheat and dates. Without this butter, the diet of the farming population was seriously deficient in fat since it consisted overwhelmingly of dates, grain, and such vegetables as they planted among the date palms. They had livestock but not enough to meet their needs for protein and fat. They also purchased wool from the Bedouin to make their clothing.

The WHO/FAO model of energy requirements computes the average energy required
--by the population from the following information:
--the distribution of the population by sex and age
--the mean height of males and females at each age
--a target body-mass index (BMI)
--activity levels at each age

The calculations are shown in Appendix Table II-A for males and II-B for females. The first column in both cases is the age or age interval. The second is the average height in centimetres. These are adapted from the sample tables in FAO (2008b, pp. 20-21) using lower attained heights for the adults. The third column is the BMI for each age from the previous source. Note how low these values are. The fourth column is the weight implied by columns 2 and 3. Column 5 computes calories per day for basal metabolism from the weight and the equations in FAO (2008b, p. 18). Note that in the equation given in FAO (2008b, p. 18) for women aged 18-29 is clearly wrong. The correct equation was back out of the example. Equations 6 show weight gain per day for those growing. Equation 7 shows the calories required for that weight gain, and equation 8 shows the implied total calories for weight gain. For those under age 18 the daily energy requirement in column 10 is the sum of columns 5 and 8. For adults age 18 and over, column 9 indicates the presumed activity, which is 'high'. In their case column 10 equals column 5 multiplied by column 9. Column 11 shows the fraction of the population in each age group. Half of the population are assumed to be male and half female. These population fractions are calculated from the smoothed age distribution of the Roman population (column 15) implied by the grouped ages in column 14. A Roman life table is used since it implies a very high infant mortality rate, which is appropriate for Arabia. Column 12 equals column 10 multiplied by column 11 and indicates the daily energy requirement of the people in each age group. The sum at the foot of the column (982.0217 for men) is the total of all men. Adding the corresponding value for women produces the total energy requirement of the population (1802.597 calories per day).

Appendix Table II-A

calculation of male energy requirement and total requirement

	attained height cm	BMI	weight kg for height	basel metabolisı calories	growth weight gain g/day	energy kcal/kg of weight gain	calories for weight gain	PAL Physical Activity Level	lower limit energy requir't kcal/per/d	population proportion age distribution	energy requirement for age group	Roman life table interval age distributioı %people	smoothed age distribution %people
0	66.5	17.3	7.650493	578.4336	16.16	4.1	132.512		710.9456	0.01605	11.41068	3.21	3.21
1	71.94118	16.1	8.332608	762.0358	6.58	2	26.32		788.3558	0.011913	9.391289	9.53	2.3825
2	77.38235	15.8	9.461085	885.545	6.3	2	12.6		898.145	0.011913	10.69915		2.3825
3	82.82353	15.4	10.564	949.5506	5.75	2	11.5		961.0506	0.011913	11.44852		2.3825
4	88.26471	15.3	11.91971	1027.351	5.48	2	10.96		1038.311	0.011913	12.36887		2.3825
5	93.70588	15.26	13.39949	1111.167	5.48	2	10.96		1122.127	0.01053	11.816	10.53	2.106
6	99.14706	15.38	15.11875	1207.101	6.03	2	12.06		1219.161	0.01053	12.83777		2.106
7	104.5882	15.6	17.06437	1313.791	6.58	2	13.16		1326.951	0.01053	13.97279		2.106
8	110.0294	15.89	19.23718	1430.585	7.67	2	15.34		1445.925	0.01053	15.2256		2.106
9	115.4706	16.23	21.6402	1556.862	9.04	2	18.08		1574.942	0.01053	16.58414		2.106
10	120.9118	14.29	20.89149	1290.167	6.3	2	12.6		1302.767	0.01	13.02767	10	2
11	126.3529	14.67	23.42075	1401.199	8.22	2	16.44		1417.639	0.01	14.17639		2
12	131.7941	15.14	26.29771	1524.018	10.41	2	20.82		1544.838	0.01	15.44838		2
13	137.2353	15.69	29.5498	1658.395	13.25	2	26.5		1684.895	0.01	16.84895		2
14	142.6765	16.27	33.12015	1800.478	14.25	2	28.5		1828.978	0.01	18.28978		2
15	148.1176	16.82	36.90112	1944.729	13.42	2	26.84		1971.569	0.00946	18.65104	9.46	1.892
16	153.5588	17.32	40.8411	2088.245	10.68	2	21.36		2109.605	0.00946	19.95686		1.892
17	159	17.75	44.87378	2227.951	6.58	2	13.16		2241.111	0.00946	21.20091		1.892
18	160	18.1	46.336	1389.881				1.7	2362.798	0.00946	22.35207		1.892
19	160	17.8	45.568	1378.317				1.7	2343.14	0.00946	22.1661		1.892
20-24.9	160	18.66	47.7696	1411.467				1.7	2399.494	0.04405	105.6977	8.81	8.81
25-29.9	160	18.66	47.7696	1411.467				1.7	2399.494	0.0405	97.17949	8.1	8.1
30-34.9	160	18.66	47.7696	1421.113				1.7	2415.892	0.0368	88.90482	7.36	7.36
35-39.9	160	18.66	47.7696	1421.113				1.7	2415.892	0.0331	79.96602	6.62	6.62
40-44.9	160	18.66	47.7696	1421.113				1.7	2415.892	0.02955	71.3896	5.91	5.91
45-49.9	160	18.66	47.7696	1421.113				1.7	2415.892	0.0261	63.05478	5.22	5.22
50-54.9	160	18.66	47.7696	1421.113				1.7	2415.892	0.0226	54.59916	4.52	4.52
55-59.9	160	18.66	47.7696	1421.113				1.7	2415.892	0.01875	45.29797	3.75	3.75
60-64.9	160	18.66	47.7696	1147.13				1.7	1950.121	0.01455	28.37426	2.91	2.91
65-69.9	160	18.66	47.7696	1147.13				1.7	1950.121	0.01015	19.79372	2.03	2.03
70-74.9	160	18.66	47.7696	1147.13				1.7	1950.121	0.00615	11.99324	1.23	1.23
75-79.9	160	18.66	47.7696	1147.13				1.7	1950.121	0.0029	5.65535	0.58	0.58
80-84.9	160	18.66	47.7696	1147.13				1.7	1950.121	0.00095	1.852615	0.19	0.19
85-89.9	160	18.66	47.7696	1147.13				1.7	1950.121	0.0002	0.390024	0.04	0.04
										0.5	982.0217		
									calories/person =		1802.597		

Appendix Table II-B

calculation of female energy requirement

	attained height cm	BMI	weight kg for height	basel metabolisr calories	growth weight gain g/day	energy kcal/kg of weight gain	calories for weight gain	PAL Physical Activity Level	lower limit energy requir't kcal/per/day	pop ratio	energy requirement for age group
0	61.5	16.9	6.392003	466.9314	15.07	4.4	132.616		599.5474	0.01605	9.622736
1	71.5	15.7	8.026233	705.1875	6.58	2	26.32		731.5075	0.011913	8.714083
2	77.28462	15.5	9.258013	829.0356	6.3	2	12.6		841.6356	0.011913	10.02598
3	83.06923	15.3	10.55776	902.2161	5.21	2	10.42		912.6361	0.011913	10.87178
4	88.85385	15.3	12.07936	985.9386	4.66	2	9.32		995.2586	0.011913	11.85602
5	94.63846	15.25	13.65857	1070.608	4.93	2	9.86		1080.468	0.01053	11.37733
6	100.4231	15.32	15.4499	1163.909	6.3	2	12.6		1176.509	0.01053	12.38864
7	106.2077	15.52	17.50667	1267.442	8.22	2	16.44		1283.882	0.01053	13.51928
8	111.9923	15.87	19.90459	1383.298	10.14	2	20.28		1403.578	0.01053	14.77968
9	117.7769	16.34	22.66587	1510.243	10.96	2	21.92		1532.163	0.01053	16.13367
10	123.5615	14.13	21.57291	1241.7	7.95	2	15.9		1257.6	0.01	12.576
11	129.3462	14.62	24.45989	1350.657	8.77	2	17.54		1368.197	0.01	13.68197
12	135.1308	15.19	27.73743	1466.558	9.86	2	19.72		1486.278	0.01	14.86278
13	140.9154	15.77	31.31472	1583.595	9.86	2	19.72		1603.315	0.01	16.03315
14	146.7	16.28	35.03601	1694.863	8.77	2	17.54		1712.403	0.01	17.12403
15	147.6	16.67	36.31686	1730.688	6.58	2	13.16		1743.848	0.00946	16.49681
16	148.5	16.94	37.35651	1758.836	3.84	2	7.68		1766.516	0.00946	16.71124
17	149.4	17.1	38.16782	1780.222	1.64	2	3.28		1783.502	0.00946	16.87193
18	150	17.19	38.6775	1057.499				1.7	1797.748	0.00946	17.0067
19	150	16.87	37.9575	1046.218				1.7	1778.571	0.00946	16.82528
20-24.9	150	17.38	39.105	1064.197				1.7	1809.135	0.04405	79.6924
25-29.9	150	17.38	39.105	1064.197				1.7	1809.135	0.0405	73.26997
30-34.9	150	17.38	39.105	1163.054				1.7	1977.192	0.0368	72.76068
35-39.9	150	17.38	39.105	1163.054				1.7	1977.192	0.0331	65.44507
40-44.9	150	17.38	39.105	1163.054				1.7	1977.192	0.02955	58.42604
45-49.9	150	17.38	39.105	1163.054				1.7	1977.192	0.0261	51.60472
50-54.9	150	17.38	39.105	1163.054				1.7	1977.192	0.0226	44.68455
55-59.9	150	17.38	39.105	1163.054				1.7	1977.192	0.01875	37.07236
60-64.9	150	17.38	39.105	1013.652				1.7	1723.208	0.01455	25.07267
65-69.9	150	17.38	39.105	1013.652				1.7	1723.208	0.01015	17.49056
70-74.9	150	17.38	39.105	1013.652				1.7	1723.208	0.00615	10.59773
75-79.9	150	17.38	39.105	1013.652				1.7	1723.208	0.0029	4.997302
80-84.9	150	17.38	39.105	1013.652				1.7	1723.208	0.00095	1.637047
85-89.9	150	17.38	39.105	1013.652				1.7	1723.208	0.0002	0.344642
										0.5	820.5749

note: columns 13-15 are the same as those in the male table.

Appendix III

The Cost of Subsistence

I have defined a subsistence basket using the method of Allen, Bassino, Ma, Moll-Murata, and van Zanden (2011) and Allen (2017b, pp. 29-30) rather than the preferred linear programming approach in Allen (2017a) since we have only minimal prices for Arabia in the period. Subsistence baskets give very similar results to the LP approach so long as they are based on cheapest source of calories in the regions which is also where the LP usually ends up.

Prices indicate that dates were generally the cheapest source of calories in Arabia, and they were also the core of the diet where they were available. At the end of the seventeenth century, Ovington (1696, p. 427) observed of Oman that "The soil affords abundance of Wheat, which might be properly made use of for their Bread, but the Dates are so plentiful, so pleasant and admir'd, that they mix them with all their Food, and eat them instead of Bread, through all these parts of Arabia, both with their Fish and Flesh." Early in the nineteenth century, Burkhardt (1831, Vol. I, p. 240) reported that "On their journeys, the Bedouins live almost wholly upon unleavened bread baked in the ashes, and mixed with butter." (Burckhardt, Notes, I p. 240) However, "in the Hedjaz the usual dish of the Arabs is India rice, mixed with lentils and without any bread; this they find cheaper than corn and equally nutritious; but wherever dates grow, that excellent fruit constitutes their chief diet."

With these observations in mind, the subsistence basket (showing annual consumption for the average person per year) was specified as follows:

	basket quantities	units	rupees/ lb or yd	pre-Suez rupees/ kg or m	pre-Suez rupees/ year	1870s rupee/kg	1870s cost	rupees/ lb or yd	20cent rupees/ kg or m	20cent rupees/ year
dates	183	kg	0.01	0.03	4.88	0.06	10.64	0.04	0.08	14.51
flour	31	kg	0.06	0.13	4.17	0.13	4.17	0.11	0.24	7.47
dal	5	kg	0.02	0.05	0.23	0.05	0.23	0.13	0.28	1.38
mutton/fish	5	kg	0.09	0.20	1.01	0.20	1.01	0.13	0.28	1.38
ghee	3	kg	0.15	0.34	1.01	0.34	1.01	1.00	2.20	6.61
cost of food					11.30		17.07			31.34
soap	1.3	kg	0.24	0.52	0.67	0.52	0.67		0.63	0.82
cloth	5	metre	0.21	0.23	1.13	0.23	1.13		0.22	1.10
cost of non-foods					1.80		1.80			1.92
10% for fuel, light, rent					1.31		1.89			3.33
annual cost per person					14.41		20.76			36.59

sources:
quantities were inspired by quotes above and are in line with subsistence baskets specified for other countries.
Prices
dates–Basra export prices from Basra consular reports, various years.
other prices pre-Suez and 1870s–Bussorah consular report1867, pp 262-3
other food prices 1900s–British consul Bahrain report 1911/12, p. 10

soap and cloth 1900s–based on British soap exported at £2 per cwt and cloth at 3d/yard.

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