Quantifying Egyptian Evidence for Transport
By Colin Adams

As we know, the papyri of Egypt offer the historian of the ancient economy valuable evidence for a wide range of issues. One such central issue is transport, and it is problematic – Peter Brunt described it as' the greatest failure of ancient technology'. The primitivist approach to the economy, advocated most vigorously by Finley, Jones, Duncan-Jones and others, holds that trade and transport was held back by two main factors: firstly, a lack of incentive to trade due to regions having the same needs and surpluses, and secondly, the high cost of transport – especially by land. Using the evidence of Roman agronomists and the costs of transport established by Diocletian's Edict of Maximal Prices, Jones stated that it was 'cheaper to ship grain from one end of the Mediterranean to the other than to cart it 75 miles'. The cost of transporting a mill 25 miles was 11% of its value, rising to 39% for 75 miles (Cato, Agr. 22. 3). Pliny's well-known letter (Ep. 10. 41) on transport in Nicomedia makes the higher cost of land transport over water seem clear. Any attempt to challenge these ideas was met with force: in Brunt's review, he criticizes Alison Burford's paper on the transport of bulky goods, saying: 'she merely showed what governments could do, regardless of cost, for defence, prestige or piety; it was no more possible for private entrepreneurs to emulate them than for IBM to put men on the moon'.

But the Egyptian evidence offers a rich picture of transport, which challenges strongly the pre-conceived ideas of Finley and his followers. The economic reality of transport was much more complex. Typically, though, the evidence at our disposal raises as many questions as answers (or partially-answers). Here, I set out some general bibliography on transport, and points of detail aspects of transport and the economy for which the papyri offer potentially quantifiable evidence. This might suggest ways in which we can answer some of the main questions we would like to ask, and serve to identify points where our evidence either falls short of an answer or where other complexities serve to obscure.

Land Transport

General

C. E. P. Adams, *Land Transport in Roman Egypt: A Study of Economics and Administration in a Roman Province* (Oxford, 2007).
P. A. Brunt, review of K. D. White, *Roman Farming* (London, 1970), JRS 62 (1972), 153-8.
H.-J. Drexhage, *Preise, Mieten/Pachten, Kosten und Löhne im römischen Ägypten (St Katherinen*, 1991).
A. C. Johnson, *Roman Egypt from Augustus to Diocletian*. T. Frank (ed.) An Economic Survey of Ancient Rome ii (Baltimore, 1936).

Transport capacity

i) Load-bearing capacity

B. Cotterell and J. Kaminga, *Mechanics of Pre-industrial Technology* (Cambridge, 1990).
W. Habermann, 'Statistiche Datenanalyse an den Zolldokumenten des Arsinoites aus römischer Zeit II', *MBAH* 9 (1990), 50-94.
O. M. Pearl, 'Varia Papyrologica', *TAPA* 71 (1940), 372-90.
P. J. Sijpesteijn, *Customs Duties in Graeco-Roman Egypt* (Zutphen, 1987).

Animal load-bearing capacity (according to no. attestations in P. Customs), after Habermann (1990), 60-1 (the figures are broadly similar if taken by numbers of animals of attested)

Animal	Artabas burden	No. of cases	%
Camel (35 cases)	5.33	1	2.86
	6	33	94.28
	10	1	2.86
Camel foal (25)	3	3	12
	4	22	88
Donkey (151)	1	3	1.99
	2	29	19.21
	2.5	2	1.32
	2.66	1	0.66
	3	68	45.03
	4	42	27.82
	4.33	1	0.66
	5	4	2.65

Animal loads according to village, after Habermann (1990), 63

Village	Artabas burden	No. of cases	%
Soknopaiou Nesos (32 cases)	2	10	31.25
	3	21	65.63
	4	1	3.12
Bacchias (59)	1	1	1.7
	2	13	22.03
	2.5	1	1.7
	2.66	1	1.7
	3	20	33.89
	4	23	38.98
Philadelphia (30)	1	2	6.68
	2	3	10
	2.5	1	3.33
	3	9	30
	4	10	33.33
	5	4	13.33
	6	1	3.33

Load-bearing capacity after Cotterell & Kamminga (1990), 194

Mode	Load (kg)	Velocity (km/h	Distance/day	Transportation per day (kg/km)
Man	60-100			
Horse	100-120	4	40	4000-4800
Mule	150-180	3-5	20-24	3600-3900
Donkey	80-100		24-30	2400
Camel (dromedary)	230		40	9200

Metrology

R. Duncan-Jones, 'The choinix, the artaba and the modius', *ZPE* 21 (1976), 43-51.
P. Mayerson, 'The sack (sakkos) is the artaba writ large', *ZPE* 122 (1998), 189-94.
P. Mayerson, 'Measures (metretai) and donkeyloads of oil in P. Wisc. II 80', *ZPE* 127 (1999), 189-92.
D. W. Rathbone, 'The weight and measurement of Egyptian grains', *ZPE* 53 (1983), 165-75.
J. Shelton, 'Artabs and choinices', *ZPE* 24 (1977), 55-67.
J. Shelton, 'Two notes on the artab', *ZPE* 42 (1981), 99-106.
E. Schilbach, *Byzantinische Metrologie* (Munich, 1970).

Animal tractive capacity, from Cotterell and Kaminga (1990), 207

Vehicle and mode	Load per animal (kg)	Useful load	Distance/day	Speed	Capacity (kg/km)
Horse/cart		680	43	4.3	29,000
Bullock/wagon		680	29	2.9	20,000
Donkey		170	43	4.3	7,000
Camel	1210	1000	38-48		43,000

ii) Transport capacity
1. Number of animals: impossible to establish beyond a notion of scale: Rathbone c. 1 million donkeys – as good as a guess as any.
2. Papyri offer a glimmer of evidence: *P. Oxy.* XVIII 2182 (AD 165?) – 'only' 411 donkeys from the Oxyrhynchite going to Arsinoite, but 156 remain, so the strategos asked to send a further 255 animals (?). Total of 666 donkeys available for service? We know from third century transport ostraca that Oxyrhynchite and Herakleopolite donkeys made up some 38% (Adams (2007), 176, with F. Reiter *ZPE* 134(2001), 191-207). If we assume 410 donkeys made 20% of animals used in the Arsinoite for state grain transport, then a notional total figure for *demosioi onoi* would be 2,050. On the basis that *demosioi onelatai* provided 3 donkeys each (but this was an ideal rather than a reality; see *BGU* I 15), we have 683 liturgists. Are there ways of testing these figures? Is there a way to establish the ratio between *demosioi onoi* and the total number of donkeys in a nome?
3. A transport account from c. AD 42 (*BGU* III 802) records a total of 322,154 art. of wheat, barley, lentils etc. On the basis of each donkey carrying 3 art. (which is not always the case, but is enough for our purposes), some 107, 384 loads are carried. Again, if we assume that 2,050 donkeys could be utilized, this would entail 52 loads per animal. Distances covered were short, so perhaps more than one journey could be made in a day. These

figures are obscured by different arrangements for transport existing for different categories of land and landowner, but represent a reasonable picture. *P. Oxy.* XXXIII 2670 (AD 127) is particularly important to our understanding of grain transport. It preserves a shipper's receipt for grain issued to the sitologoi of Paomis. The grain being delivered to the ships is from a previous harvest (125/6) and a little over 10,000 artabas are transported over a period of 9 days. We have a picture of frantic activity, grain being transported by convoys of donkeys over short distances. The grain is carried in *sakkoi*, each equaling 3 artabas. The number of convoys each day, the amount carried by each, along with the total amount of grain in artabas is recorded. The number of animals used in each convoy varies considerably, the largest being 48 donkeys. The transport operation increased in intensity until day 6, and then tailed off. The editor (n. ll. 16ff) invokes *P. Oxy.* XVIII 2182 as evidence, alongside the fluctuating numbers of animals in *P. Oxy.* XXXIII 2670, for 'this form of transport' being 'largely precarious and improvisatory'. This cannot be the case – **2182** suggests central direction, and **2670**, taken with the evidence of *P. Oxy.* XXII 2381 (AD 208) for patterns of granary clearance, further suggests an organized and structured approach to the use of transport resources.

4. A similar intensity of transport can be seen in *BGU* XIII 2272 (second century). In a seven-week period, donkeys transported grain from Berenikis Thesmophoru to a port for onward transport by river. 1734 loads are carried, and a total of 5202 art. – interesting in itself, as this is the 'normal' load. On the basis of one trip per day, this would keep 35 donkeys constantly busy in this period.

5. Capacity based on total wheat production? C. 6 million artabas = 2 million donkey loads?

6. As far as camels are concerned, it is clear that they are dominant in desert regions. The village of Soknopaiou Nesos offers the best evidence, but how typical is it? Is it possible to estimate camel numbers from the evidence of declaration/registration documents?

7. Is it possible to estimate the number of camels needed for state transport services? For the Eastern Desert, the *poreia* serving Mons Claudianus may have been made up of perhaps as many as 150 camels, and certainly no less than 75. Camel requisition was common – *P. Flor.* II 278 (AD 203) is a round-robin letter sent to the strategoi of 10 nomes concerning the requisition of camels. Is it possible to estimate the number of camels required for state service?

8. Kai Ruffing has estimated that some 2000 camel loads per month would have been required to supply Berenike. It is likely that only two journeys could be made in a month, so this would suggest 1000 camels.

Animal trade

A. Jördens, 'Sozialstrukturen im Arbeitstierhandel des kaiserlichen Ägypten', *Tyche* 10 (1995), 37-100.
D. W. Rathbone, 'Prices and Price Formation in Roman Egypt', in J. Andreau, P. Briant, and R. Descat (ed.) *Économie Antique: Prix et formation des prix dans les économies antiques* (St. Betrand de Comminges, 1997), 183-244.
Range and Average animal prices in dr. by century (interpreted broadly after Rathbone (AD7-97; 98-180; 197-267) (camel sales 136-82)

Animal	1st cent.	2nd cent.	3rd cent.
Donkey	72-120	48-340 (168)	300-800 (525)
Camel	440 (with equipment) – 1 case	448 – (600)	840 -

Animal maintenance

L. S. B. MacCoull, 'An account of fodder for pack-horses', *ZPE* 25 (1977), 155-58.
T. Reekmans, *A Sixth Century Account of Hay (P. Iand. Inv. 653)* (Brussels, 1962).
Animal Maintenance costs after Adams (2007), 83-8.

Animal	Fodder	Cost per art. in dr. (second century prices)	Monthly/Annual cost in dr.
Donkey	3-5 art. barley	5-6	15-25/180-300
Camel	12 bundles hay		c. 540

Figures do not include the cheaper *chortos* as fodder, or availability of pasturage, whether provided on one's own land or rented. For camels, browsing also important.

Ownership strategies: Adams (2007), 102-4. Sales of part-shares in animals: *P. Soterichos* 27; *P. Lond.* II 333 (p. 199); *SB* I 5679; *P. Kell.* Gr. 34.
Estimated animal earning capacity

Text	Animal/rate pd	Hire cost pa	Maintenance cost (max)	Earning capacity	Purchase price (3rd cent ave)
BGU I 14	Donkey/ 4dr	1460 dr	300 dr	1160 dr	525
(AD 255)	Camel/ 6dr	2190 dr	540 dr	1650 dr	?

River Transport

Ships and Shipping

L. Casson, *Ships and Seamanship in the Ancient World* (Princeton, 1971), esp. 331-41.
M. Merzagora, 'La navigazione in Egitto nell'età Greco-romano', *Aegyptus* 10 (1929), 105-48.
A. J. M. Meyer-Termeer, *Die Haftung der Schiffer im Griechischen und Römischen Recht* (Zutphen, 1978).
D. J. Thompson, 'Nile grain transport under the Ptolemies', in P. Garnsey, K. Hopkins and R. Whittaker (ed.), *Trade in the Ancient Economy* (Berkeley and Los Angeles, 1983), 64-75.
Ship Capacity – *P. Tebt.* III2 856 (c. 171 BC) – 22 ships, ranging from 9,000 art. (225 tons) to 18,000 art. (450 tons)

Kerkouroi	Burden (artabas)	Burden (tons)	Line ref.
2	9,000	225	129, 188
9	10,000	250	97, 116, 124, 126, 186, 191, 202, 205, 206
5	11,000	275	103, 107, 109, 114, 125
4	12,000	300	6, 99, 118, 187
1	16,000	400	127
1	18,000	450	112

NB. *Kerkouroi* not attested after first century BC (*BGU* VI 1303)

Ship types

see Casson (1971), esp. 340-43. Huge range of different vessels, the normal merchant vessels found throughout the Mediterranean in addition to local vessels. Often these were named after the types of cargo carried.

Ship capacity

Drexhage (1991), 330-33 – impossible to establish 'normal' cargo size: there was probably no such thing given variations is ship size. Upper limits seem to have been in the range of 5,000 artabas (although there were much bigger ships), (see *P. Oxy.* X 1259 where 8 ships carry 40,000 art. between them). *P. Giss.* 11 (AD 118) is instructive – a ship of 4,000 art. burden is owned by one Papeireis, who claimed to have at his disposal other ships with a total capacity of 80,000 art. by virtue of his being priest of a guild of *naukleroi*. Overloadig was probably common:
Ship Capacity – *P. Oxy.* XXIV 2415 (Late third century) col. ii and iii

Ship origin (nome)	Stated burden	Actual burden	% difference	Line ref.
Hypselite	3100	3490	12.5	ii. 23-4
Lykopolite	2600	2860	10	25-6
apo tou Megalou Choriou	2700	3000	11	27-8
Kynopolite	3300	3630	10	29-30
Oxyrhynchite	1000	1022	0.2	31-2
apo tou Methleitou ?	1800	1918	6.5	33-4
Oxyrhynchite	1500	1500	0	35
Lykopolite	1400	1556	11.6	36-7
Leontopolite	2200	2447	11.2	38-9
Lykopolite	1550	1705	10	40-1
Prosopite	850	945		iii. 43
tes Elearxias?	505	505	0	44-5
Herakleopolite	505	505	0	46-7
Apollonopolite	1100	1110	0.1	48-9
Arsinoite	1015	1015	0	50-1
Oxyrhynchite	1000	1000	0	52-3
Oxyrhynchite	1000	1137	11.3	54-5
Psthenite	402	402	0	56-7
Diospolite	502	502	0	58-9
Oxyrhynchite	1000	1016	0.16	60-1
Oxyrhynchite	1000	1016	0.16	62-3
?	500	500	0	64
?	600	600	0	65

Cost of transport by land

Generally, this is much more difficult to establish. A number of points:
1. It is very unusual for transport rates to be recorded
2. Transport rates are unlikely to have been established on distances to be travelled, but perhaps on day's duration.
3. Is it possible to suggest, as Drexhage does, that we can estimate transport costs based on animal hire rates per day? Would transport work in that way?
4. How does land transport fit into the bigger picture of a transport system involving the Nile and canals?
Costs suggested by Drexhage (1991), 349

Date	No. of Donkeys for 100 art.	Hire cost	Driver costs	Total
1st cent.	33	c. 33 dr	c. 6 dr	c. 39 dr
2nd cent.	33	c. 132 dr	c. 10 dr	c. 146 dr
3rd cent.	33	c. 264 dr	c. 24 dr	c. 284 dr

Is it possible to suggest transport costs on the basis of % value of market price?
Drexhage extrapolates from these figures by simple multiplication based on distance – 500km = 5 times cost suggested in table.