

Development of Harbour Infrastructure on the Tyrrhenian Coast and the Decline of Maritime Transport Costs

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Introduction

The purpose of this paper is to reinforce my own argument of the decline of transport costs across the Roman Mediterranean in the late Republic and the early Empire,¹ supported by archaeological evidence and recent discussions based on it.

My argument is that the transport costs (as the whole expense incurred in moving goods from the production place to the consumption place) across the Mediterranean would have declined in the passage of time roughly between the second century B.C. and the second century A.D. The primary reason for this view is that the greater security for shipping in the so-called *mare nostrum*, as the consequence of political and economic unification of the Mediterranean basin, would have decreased maritime transport costs. The security for shipping was realised by the suppression of piracy (including a sort of ‘privateering’ such as the pirates used by Romans to attack Carthaginians in the Punic Wars).² The maritime peace would have decreased maritime transport costs, by reducing its three components, namely, (a) the cost of

¹ M. Ikeguchi, ‘Settlement Patterns in Italy and Transport Costs in the Mediterranean’, *Kodai* 13/14 (2004), 239-249; Id., *The Dynamics of Agricultural Locations in Roman Italy*, Ph.D. thesis (University of Cambridge), 2008, Ch.2; Id., ‘The Decline of transport costs of agricultural produce and the change in agricultural locations in the early Imperial period’, *Rekishigaku Kenkyu (Journal of Historical Studies)* 781 (2003), 152-159 (in Japanese).

² The major Roman efforts to eradicate pirates included the campaign by Marcus Antonius in 102 B.C., a law for terminating piracy in 100 B.C. and another famous campaign by Pompey the Great in 67 B.C. Then the suppression of piracy was maintained by the improvement of the Imperial navy by Augustus and later emperors. In 150, there were large fleets in Forum Julii, Misenum and Ravenna, and the fleet of Misenum had detachments at Ostia, Puteoli and Centumcellae. There were also important fleets at Alexandria and Seleucia and Caesarea. So we have an impression that the trade across the Mediterranean would have been protected effectively against pirate attacks in this period. C. G. Starr believed that piracy was eradicated from the commercial routes of the Mediterranean in the period from Augustus and Septimius Severus, since ‘there is not one contemporary reference to a Mediterranean pirate in this period’ (C. G. Starr, *The Roman Imperial Navy 31 B.C. - A.D. 324*, Ithaca, 1941, 172f.). Ancient writers often witnesses to the maritime peace in the early Empire. Strabo (*Geography*, 3.144) says, ‘all piracy has been broken up, and hence the sailors feel wholly at ease’. The famous passage by Suetonius (Aug., 98) describes how the passengers and crew on an Alexandrian ship at Puteoli thanked Augustus for the maritime peace and their safe shipping.

maintenance or the replacement of the ships, (b) the maintenance of or the payment to the crews, and (c) the maritime insurance costs.³

In the seventeenth century, the Atlantic ocean shipping between England and America, suffered not only from piracy but also from privateering. However, when the share of each country in the northern and middle America was somewhat determined, and the commerce between those countries and their colonies became important, pirates and privateers began to be discouraged or suppressed. According to G. W. Walton, total costs per voyage declined between late 17th and late 18th century, mainly due to the reductions of crews and armaments as a result of the decline of piracy and privateering, which also reduced insurance rates to some extent. D. North also emphasises the influence of piracy and privateering in shipping, suggesting that their decline accounts for the decreasing freight rates in the 17th, 18th and the former half of the 19th century.⁴

【1】 Harbours and Their Network along the Tyrrhenian Coast

W. Scheidel argues that the imperial state formation was the most important as the determinant of the productivity of maritime commerce in the Roman period, also referring to the Atlantic ocean shipping freight rates as comparative evidence.⁵ I agree, as my argument above would be incorporated in such a notion. However, the

³ The explanation about ships and crews is rather simple, as the lost or damaged ships had to be replaced or repaired, and that is also the case for crews. It may also have been important for merchant ships to keep armaments to protect themselves with. When maritime transport became safer and such replacement or preparation became unnecessary, the freight rates did not have to cover such costs anymore and would have sunk. Maritime insurance is believed to have been born in the Middle Ages, but maritime loans (such as *pecunia traiectica* and *pecunia nauticum*) lent at the interest called *fenus nauticum*, had already functioned as insurance in the Roman world. In the contracts covering those loans, the owner of a ship or a cargo did not have to return the borrowed money, if the ship or cargo was prevented from reaching its destination, by an accident or by an attack. It would have been especially necessary for a ship or cargo owner, to insure himself against loss of property when voyage was unsafe; but when shipping became safer, the importance of maritime loans would have declined, and the rate of interest they carried, would have decreased.

⁴ G. M. Walton, 'Sources of productivity change in American colonial shipping, 1675-1775', *The Economic History Review*, 2nd ser., 20 (1967), 77; D. C. North, 'Sources of productivity change in oceanic shipping, 1600-1850', *Journal of Political Economy* 76 (1968), 954; 959-960.

⁵ W. Scheidel, 'A comparative perspective on the determinants of the scale and productivity of Roman maritime trade in the Mediterranean', in W. V. Harris and K. Iara, *Maritime Technology in the Ancient Economy: Ship-Design and Navigation* (JRA Suppl. 84), Portsmouth, 2011, 21-37.

development of infrastructure, especially harbours and their facilities, would also have played a significant role in enhancing water transport.

The construction of Portus initiated by Claudius in AD 42, and that of the inner hexagonal basin by Trajan by 112, would have facilitated water transport from the Provinces to Rome, probably reducing transport costs by providing safe mooring space for many vessels, even for considerably large ones (Fig. 1).⁶ Transported goods such as grain were often stored in warehouses near the harbours before they were transshipped to barges and moved along the Tiber to the city of Rome, and the capacity of warehouses would have greatly influenced the efficiency of handling cargoes in such processes, affecting the transport costs in general. The Portus Project led by the University of Southampton has been revealing important features of Portus and Ostia. A large area of warehouses have been discovered around the hexagonal basin,⁷ and at least three warehouses have been found by recent geophysical surveys in the southern part of Isola Sacra, which was actually within the newly found city wall of Ostia. These newly found warehouses in Isola Sacra are dated between the 1st century A.D. and the early 2nd century A.D. by circumstantial evidence (e.g. the layout of one of the warehouses has similarities to that of *Grandi Horrea* in Ostia. Fig. 2).⁸

⁶ The Oxford Roman Economy Project database of shipwrecks suggests that 85% of shipwrecks were less than 200 tonnes burden. A. Willson, 'The economic influence of developments in maritime technology in antiquity', in W. V. Harris and K. Iara, op. cit., 212-215. See also P. Bang and M. Ikeguchi, 'Afterword' (for K. Hopkins, 'Models, ships and staples'), in K. Hopkins (edited by C. Kelly), *Sociological Studies in Roman History*, Cambridge, 2018, 310f.

⁷ S. Keay, 'Portus in its Mediterranean Context', in K. Höghammar, *Ancient Ports: The Geography of Connections*, Uppsala, 2016, 298-301. See also S. Keay, et al., *Portus: An Archaeological Survey of the Port of Imperial Rome* (Archaeological Monographs of the British School at Rome 15), London, 2005.

⁸ P. Germoni, et al., 'Ostia beyond the Tiber : recent archaeological discoveries in the Isola Sacra' in M. Gervasoni et al., *Ricerche su Ostia e il Suo Territorio : Atti del Terzo Seminario Ostiense*, Nouvelle édition [en ligne], DOI : 10.4000/books.efr.3637.

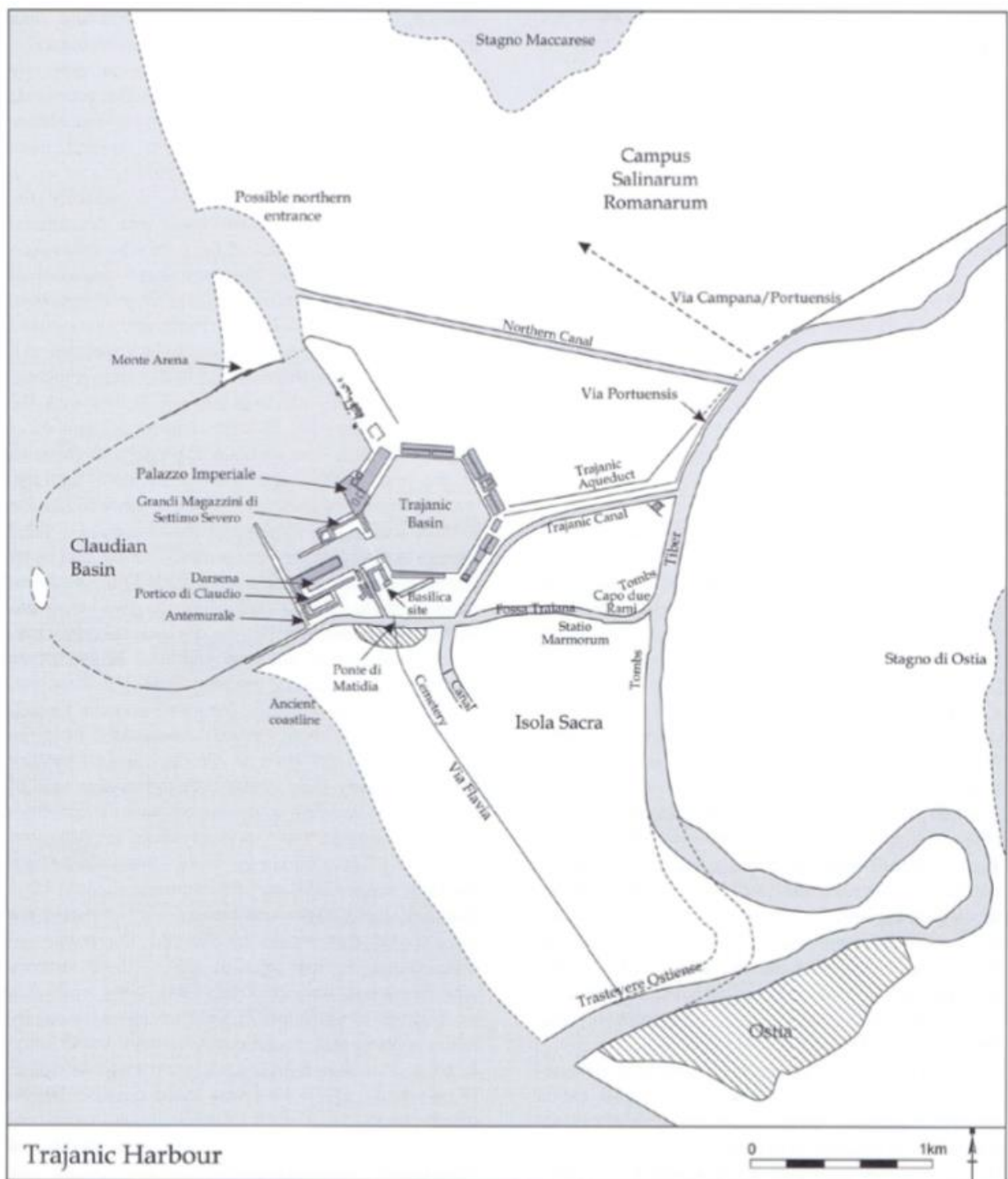


Fig.1 Portus in the Trajanic period⁹

⁹ S. Keay and L. Paroli (eds.), *Portus and Its Hinterland: Recent Archaeological Research* (Archaeological Monographs of the British School at Rome 18), London, 2011, Fig.1.3 (by courtesy of S. Keay and the British School at Rome)



Fig.2 Grandi horrea, Ostia (M. Ikeguchi)

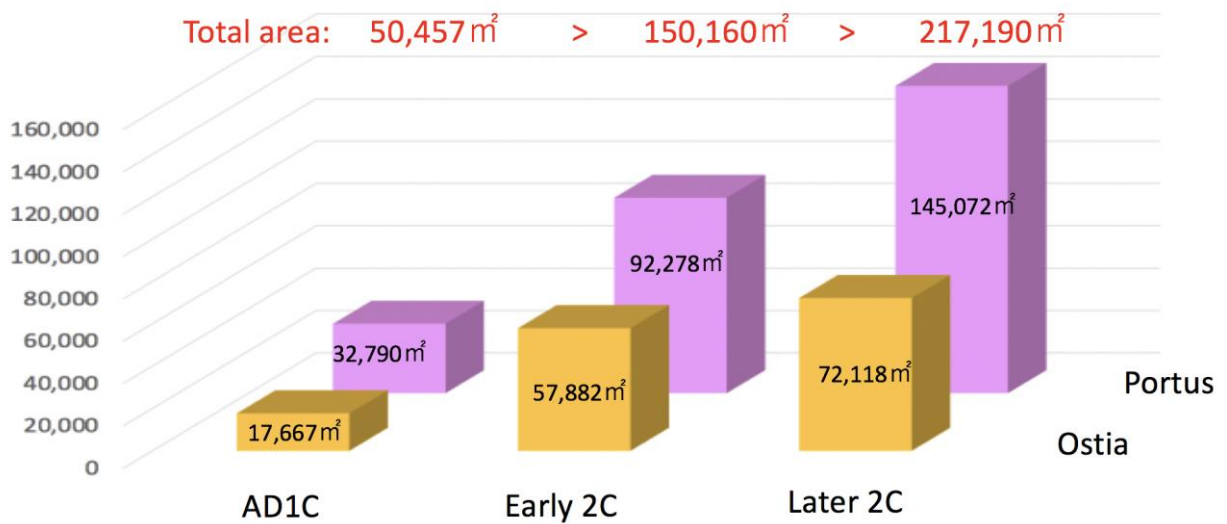


Fig.3 Warehouse areas at Ostia and Portus¹⁰

¹⁰ The data is based on S. Keay et al., *Portus: An Archaeological Survey of the Port of Imperial Rome* (London, 2005) and P. Germoni, et al., 'Ostia beyond the Tiber : Recent archaeological discoveries in the Isola Sacra' (in M. Gervasoni et al., *Ricerche su Ostia e il suo territorio : Atti del Terzo Seminario Ostiense*, Nouvelle édition [en ligne], DOI : 10.4000/books.efr.3637). The area of recently found

It seems that there was continuous enlargement of warehouses in both Ostia and Portus in the early Imperial period (Fig. 3). The warehouse capacity of Portus surpassed that of Ostia by the late 1st century at the latest, and the significant further enlargement of warehouses in Portus by the later 2nd century would particularly have facilitated the transport for Rome. The aggregate area of warehouses of both Portus and Ostia in the later 2nd century is now 217,190 sq.m. We may have to further raise the estimate to some extent in the future, especially as the evidence of additional warehouses have been revealed by geophysical survey in Ostia.¹¹ For the moment, let us use the figure of 220,000 sq.m as the area of warehouses, which could roughly store 220,000 tonnes of grain. If we accept the common view that the inhabitants of around one million of the city of Rome in the second century consumed 400,000 tonnes of grain per year, the maximum capacity of grain in Portus and Ostia amounts to 55% of it.

However, as is often pointed out, (i) a part of those warehouses had to be used for the local consumption in Ostia and Portus themselves; (ii) the proportion of the warehouses used for grain is unknown (as *suspensurae* (Fig. 4) for reducing humidity and slopes for moving bulky goods to the upper floors are almost the only evidence for it); moreover, (iii) some of the buildings considered to have been warehouses may not have been so. Rome itself had warehouses near the river ports and they have to be taken into consideration, but the aggregate capacity of grain in Portus, Ostia and Rome would not have been enough for the total annual consumption in those three cities.

warehouses in Isola Sacra is added to that of Ostia temporarily in the early 2nd century, which is proposed as the latest construction period, and the later 2nd century

¹¹ M. Heinzelmann, 'Bauboom und urbanistische Defizite. Zur städtebaulichen Entwicklung Ostias im 2. Jh.', in C. Bruun, A. G. Zevi (eds.), *Ostia e Portus nelle Loro Relazioni con Porto* (Acta Instituti Romani Finlandiae, 27), Rome, 2002, Taf. IV.2



Fig. 4 *Suspensura* of Grandi Horrea, Ostia (M. Ikeguchi)

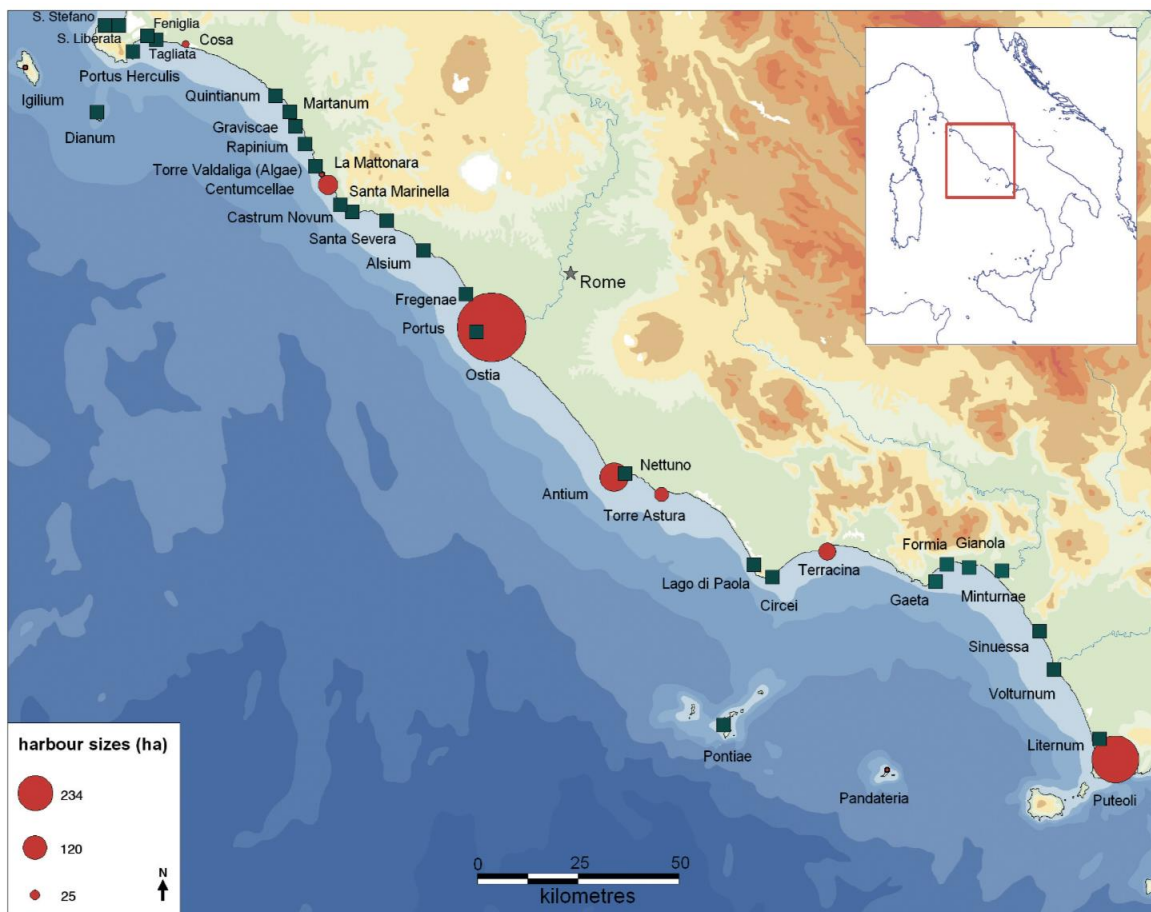


Fig. 5 Harbours on the Tyrrhenian coast and harbour sizes (by courtesy of K. Schörle)

Portus (total)	234ha
Puteoli (total)	67.9ha
Antium	25-30ha
Centumcellae	14ha
Tarracina	11ha
Torre Astura	7.8ha
Cosa	2.5ha

Fig.6: Harbour sizes (based on Schörle (2011))

That was probably one of the main reasons why Rome had to be supported by the so-called ‘port system’ involving other harbours.¹² K. Schörle considers that the size of a harbour represents its importance in the port hierarchy (Figs. 5 and 6).¹³

Portus is by far the largest and is more than 230 ha (Figs. 7 and 8), more or less the same size as Portus Magnus (over 226 ha) of Alexandria. The harbour of Puteoli, 68 ha, played the most important role in storing and transshipping the Egyptian grain for Rome before Portus was constructed, and it probably fulfilled the same function to some extent until early third century as suggested by the active construction of public buildings there.¹⁴ The harbour of Centumcellae (mod. Civitavecchia: Figs. 9 and 10), constructed by Trajan by AD 110, was 14ha and was much smaller than Portus, but had outer and inner basins like Portus, providing safe moorage. The harbour of Tarracina (mod. Terracina), constructed by Trajan and later repaired by Antonius Pius, was 11ha in size, which was similar to that of Centumcellae. Indeed, those harbours are correctly

¹² S. Keay, 'The port system of Imperial Rome', in id. (ed.), *Rome, Portus and the Mediterranean* (Archaeological Monographs of the British School at Rome, 21), London, 2012, 33-67.

¹³ K. Schörle, 'Constructing port hierarchies: harbours of the central Tyrrhenian coast', in D. Robinson and A. I. Wilson (eds), *Maritime Archaeology and Ancient Trade in the Mediterranean*. Oxford, 2011, 93-106.

¹⁴ S. Keay, 'Portus and the Alexandrian grain trade revisited', in S. Keay and G. Boetto (eds.), *Portus, Ostia and the Ports of the Roman Mediterranean*, *Bolletino di Archeologia on Line, Volume speciale* (2010), 11-22.

considered to have been ‘satellite harbours’ of Portus.¹⁵ They would have assisted Portus (and Ostia) by storing a proportion of staples or other materials transported from Provinces when the warehouses of Portus and Ostia were full and could not accept any more. The harbour of Antium (Figs. 11 and 12), constructed by Nero, was 25-30 ha, which is roughly double the size of those of Centumcellae and Tarracina. Although its importance in the port hierarchy is often discredited (since Nero constructed the harbour adjacent to his villa), Schörle suggests that its role in the Mediterranean trade should be reconsidered.¹⁶ Other harbours on the Tyrrhenian coast between Cosa and Naples included those of Alsium, Torre Astura, Gaeta, Formiae, Minturnae, Sinuessa and Cuma. Such harbours would also have been involved in the harbour network, though it is often impossible to know their sizes and therefore their importance. Given the smaller amount of its trade (mainly export), the function of villa harbours would have been secondary, but still, they were involved in the harbour network.¹⁷



Fig.7 The inner basin of Portus and *Grandi Magazzini di Settimio Severo* (M. Ikeguchi)

¹⁵ L. Quilici, 'Il porto di civitavecchia-l'antica Centumcellae', in R. T. Scott and A. R. Scott (eds.), *Eius Virtutis Studiosi: Classical and Postclassical Studies in Memory of Frank Edward Brown (1908-1988)*, Hanover, 1993, 63.

¹⁶ K. Schörle, op. cit., 98.

¹⁷ Ibid., 100-103.



Fig.8 *Grandi Magazzini di Settimio Severo* by the inner basin of Portus (M. Ikeguchi)



Fig.9 Entrance to the inner basin of the port of Civitavecchia (M. Ikeguchi)

Maritime transport costs would have decreased as a result of the construction and improvement of harbours in the first and the second century. The harbours, especially the inner basins of Portus and Centumcellae, would have protected the ships berthing inside, and consequently, made it less frequent to replace the ships that sank due to high waves while waiting or transshipping offshore. The warehouses constructed

around the harbours would also have facilitated handling of cargoes and contributed to the reduction of transport costs in general (Fig. 8 and Fig. 10). The construction of canals and roads to connect the harbours to neighbouring cities, typically seen around Portus, would have enabled smoother flow of goods, reducing the time and costs of transport, too.¹⁸



Fig.10 Warehouses by the port of Centumcellae

¹⁸ Technological developments such as that in shipbuilding (W. V. Harris and K. Iara (eds.), op. cit.) would also have contributed to the decline of transport costs to some extent. Another (non-archaeological) reason for assuming the decline of transport costs in the early Empire is the support from the state related to *annona*. Claudius granted privileges to people who built ships of 10,000 modii and used them in service for *annona* (Gai., *Inst.* 32c; Suet., *Claud.* 18-19). In the second century, the exemptions from liturgies were offered to those who made a ship of 50,000 modii or several ships of 10,000 modii (*Dig.*, 50.5.3). G. W. Houston, 'Ports in perspective: some comparative materials on Roman merchant ships and ports', *American Journal of Archaeology* 92-4 (1988), 558f.



Fig. 11 The remains of a mole of the harbour of Antium



Fig. 12 The Neronian villa by the harbour of Antium

【2】 Data Suggesting the Low Costs and High Activity of Maritime Transport

ORBIS (<http://orbis.stanford.edu/>) built up by W. Scheidel provides the data of time and costs of water and land transport as of A.D. 200 (Fig. 13). The cartograms showing the distances between cities in terms of transport prices are particularly interesting. A cartogram which presents such distances between Rome and other cities shows that cost-distances of water transport are much more shrunk than those of land transport, and the places connected with Rome by water routes, such as Tarraco, Carthage and even Alexandria, are quite close (Fig. 14). The data of transport costs provided by ORBIS are presented as those at the time of A.D. 200, when the maritime transport costs were probably lowest, and we cannot compare this cartogram with those at other times. However, it gives us a rough idea how the cost-distances in the maritime network would have shrunk as the sea transport costs declined between the late Republic and the early Empire.

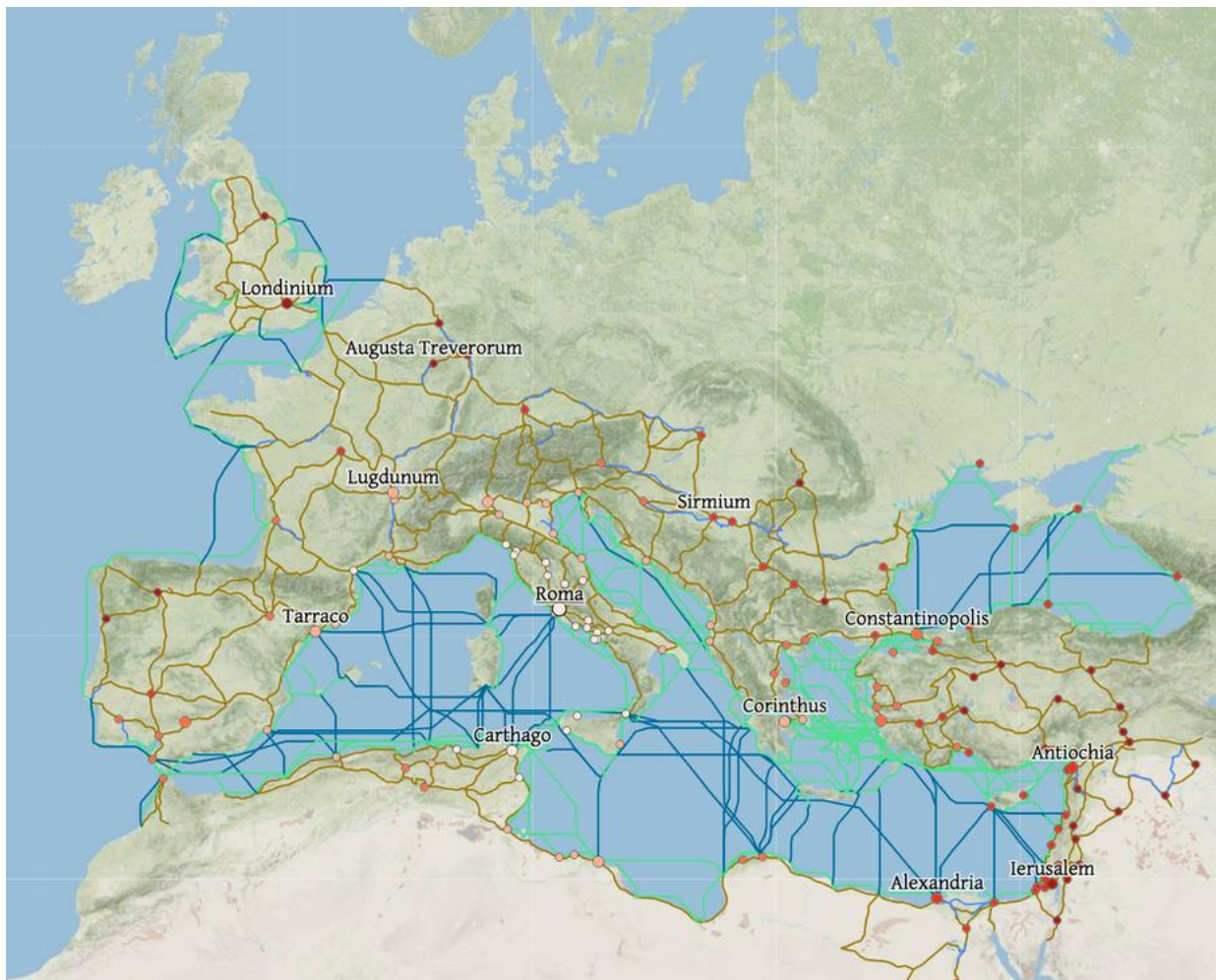


Fig. 13 Transport network in the Roman Empire as of A.D. 200 (ORBIS)



Fig. 14 Cartogram based on transport prices (bound for Rome in summer) as of A.D. 200 (ORBIS)

The number of the Mediterranean shipwrecks is often considered to indicate how sea transport was active (though this evidence has its own difficulties in interpretation). A. J. Parker published his Mediterranean shipwreck database in 1992,¹⁹ and then under the Oxford Roman Economy Project, J. Strauss has recently been updating the database, collecting data published after that (Fig. 15). The total number of shipwrecks dated up to 16th century is now approaching 1,800. It is well known that most of those ships sank in Roman times, probably indicating the active Mediterranean transport in that period compared to that in the former and the later periods. It is important for us that the number of shipwrecks rapidly increased in the 2nd and the 1st centuries B.C. and

¹⁹ A. J. Parker, *Ancient Shipwrecks of the Mediterranean and the Roman Provinces*, BAR 580, Oxford, 1992.

reached its peak in the 1st century A.D., because the security of maritime transport would have been improved by this very period. The sharp decrease between the 1st and the 2nd century, which was not known when Parker published his database, is difficult to explain. A. Wilson points to the fact that other archaeological evidence for this period such as harbour constructions and tableware exports contradicts this decline in the number of shipwrecks, and suggests the possibility that amphorae as containers were more and more replaced by barrels from this period and many shipwrecks were lost, because barrels do not prevent the ship's timbers from being rotted or scattered as amphorae do. He also suggests that the number of north African shipwrecks may be underrepresented because of the lack of modern underwater survey work there.²⁰

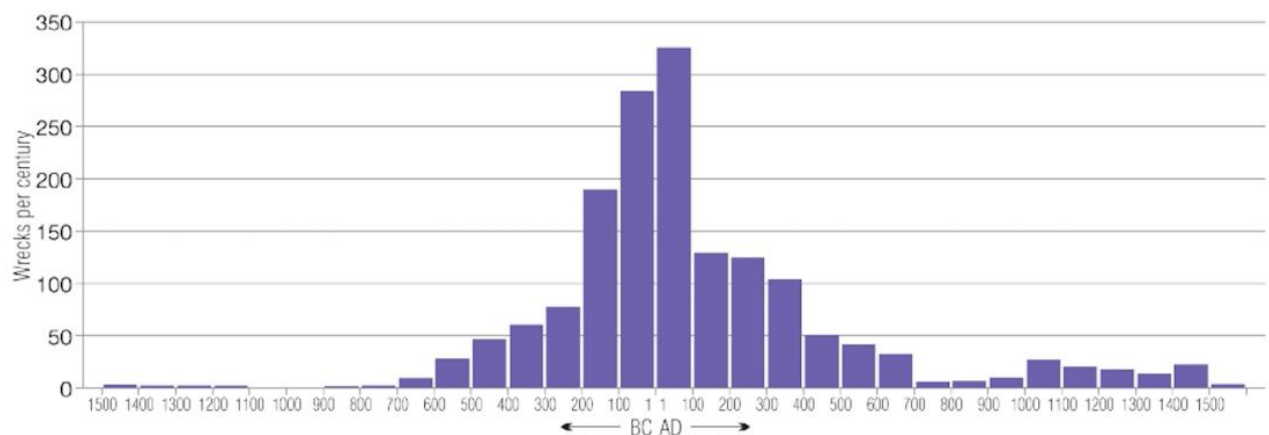


Fig. 15 Mediterranean shipwrecks provided by the Oxford Roman Economy Project (by courtesy of A. I. Wilson)

Concerning my argument, the important data is the number of shipwrecks on the route between Italy and the provinces. Strauss' database contains the information about the origins and/or the destinations for 320 shipwrecks.²¹ Fig. 16 shows how I counted such shipwrecks. Most of the shipwrecks are often dated for a long period, and we do not know the exact year or century when a ship sank within the time range. So I divided the value 1 by the number of centuries and allocated the decimal fractions to

²⁰ A. I. Wilson, 'Developments in Mediterranean shipping and maritime trade from the Hellenistic period to AD 1000', in D. Robinson and A. I. Wilson (eds.), *Maritime Archaeology and Ancient Trade in the Mediterranean*, Oxford, 2011, 33–59.

²¹ Although the data often seems not to be very certain (for those presented with question marks), I included even those data in counting the number of shipwrecks which sank on the way to or from Italy.

each century within the suggested period.²² The number of shipwrecks in each direction between the Provinces and Italy is shown on Fig. 17 with that of shipwrecks from the Provinces to Rome paid special attention to. The number of shipwrecks which were on the way from Italy to the provinces and those from the provinces to Italy both seem to have increased in the late Republic. However, the number of those on the way from Italy to the Provinces reached its peak in the first century BC and started to decline in the next century, whereas that of shipwrecks on the route from the Provinces to Italy kept increasing until the 1st century AD. That is also the case for the number of shipwrecks with amphorae. So these graphs may support the idea that, in the early Empire, Italian products were not competitive compared to provincial products. The decline between the 1st and the 2nd century is seen for both the shipwrecks containing Italian products and those containing Provincial products, and that needs cautious interpretation, but it is also interesting that the provincial products for Italy seem to have increased between the 2nd and the 3rd century again. This increase in the Provincial products for Italy actually happened for those heading for Rome as the graph shows, and a large proportion of such products would have been wine and olive oil, for all the shipwrecks heading for Rome contained amphorae. So if the warehouses in Portus and Ostia were partly used for wine and olive oil, their expansion continuing until later 2nd century (Fig. 3) may have been relevant with the increase in the import of Provincial (rather than Italian) wine and oil for Rome (Fig. 17).

²² For example, Wreck 8646, which is dated between AD175 and 225, is counted as 0.5 for the 2nd century and another 0.5 for the 3rd century. Wreck 105, which is dated between 50 B.C. and A.D. 150, is counted as 0.25 for the 1st century B.C., 0.5 for 1st century A.D. and another 0.25 for the 2nd century A.D. I did the same counting for the shipwrecks which was on the routes from the Provinces to Italy to draw Fig.17.

Wreck ID	Earliest date	Latest date	V	IV	III	II	I	1	2	3	4	5
8646	175	225							0.50	0.50		
46	-200	-150				1.00						
105	-50	150					0.25	0.50	0.25			
208	-150	-100				1.00						
207	-200	-180				1.00						
206	-250	-150			0.50	0.50						
7324	75	100						1.00				
9043	75	100						1.00				
51	-100	-1					1.00					
97	-100	-1					1.00					
65	-75	-25					1.00					
64	-150	400				0.09	0.18	0.18	0.18	0.18	0.18	

Fig. 16 Counting shipwrecks on the route from Italy to the Provinces²³

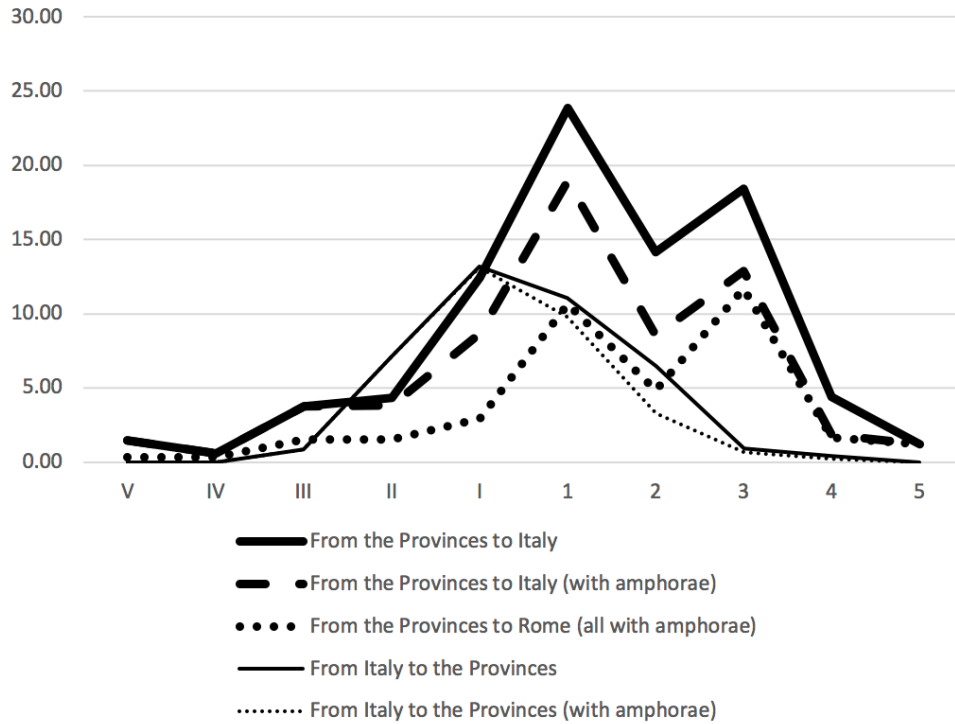


Fig. 17 Shipwrecks on the routes between the Provinces and Italy²⁴

²³ Based on Strauss, J. (2013), Shipwrecks Database. Version 1.0. (accessed 15th January 2019): oxrep.classics.ox.ac.uk/databases/shipwrecks_database/

²⁴ The data are the same as that of n.23.

Conclusion

The decline of maritime transport costs, brought about by the suppression of piracy in the late Republic and the development of the navy in the early Empire, was accelerated by the construction and the enlargement of ports and the port facilities such as warehouses on the Tyrrhenian coast, and contributed to the shrinking cost distances in the Mediterranean and the increasing amount of transport there. The data of shipwrecks on the route between Italy and the provinces suggest that there was an increase in the amount of transport in both the directions in the late Republic, but in the early Empire, the Italian products seem to have lost a part of their market in the provinces, whereas the provincial products are likely to have found expanding market in Italy until the first century A.D. and the amount of their transport appears to have kept a certain level until the third century (though there may have been a drop in the second century).

I have omitted land transport in this paper, as it was much more expensive per unit amount and unit distance compared to water transport. Land transport for long distance was impracticable, and was important only for short- (or up to middle-) distance trade. However, long-distance transport between the production and the consumption places was almost always the combination of land and water transport, so the development of land transport, especially the extension and refurbishment of public roads, would have expanded the influence of the changing maritime transport costs into inland areas, causing the transformation of agriculture there.