Supplementary Material

3
THE CONTRIBUTION OF ECONOMICS

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MONEY AND PRICES

Money has three functions: a means of making transactions, a unit of account, and a store of value. Good money performs all of these functions, but we regard things as money that perform only some of them. Modern money, for example, does not cease being money during inflation, even though it is no longer a good store of value.

Coins were used as money in the ancient world. Some historians have seen coins as symbols of imperial power or as art objects. Perhaps Roman emperors spread Roman coins widely to symbolize their suzerainty, but with coins came the practice of using money to value commodities and services. Actually, the practice of using silver as money preceded coins in the East and became more accurate and prevalent with coins. Uniform *sestertii* — linked to earlier *drachmae* in the East —encouraged the use of prices in transactions. Consistent valuations and ease of payment encouraged the growth of trade (Schaps 2004).

It is worth noting that economics and politics are inextricably mixed in the provision of money. Silver was weighed to be used as money before coins were introduced. Early traders cut up jewelry to make "hacksilber" to ease the problem of getting to an agreed amount of silver. Coins were issued by political entities, and the government stood behind the value of the coins. People were suspicious of coins at first, and they weighed coins as if they were hacksilber or other loose silver. Only after people became used to coins and confident of their consistent value, did they switch from weighing to counting coins. The practice of weighing coins continued in some circumstances into at least the fourth century. The government insisted that solidi be accepted at face value (counted) unless clipped. But there were supposed to be 72 *solidi* to a pound, and in the payment of taxes, "if 72 *solidi* did not make up a pound, they had to be supplemented (Jones 1974: 203)."

The use of coins issued by governments gave rise to the possibility of abuse. A government could acquire resources by devaluing coins—taxing people in effect. Governments learned to reduce the quantity of silver in coins or put a silver wash on base coins as metallurgical technology improved. If people did not realize the coins were debased, they spent them as before, and the government then could spend the silver it had saved to compete for purchases with other buyers. This of course is inflationary, and devaluations often were followed by inflation in medieval times. If people realized the coins were debased, they would know they were poorer and spend less as a result. Total purchases would not rise, and there would be no inflation.

Prices were used widely in Rome, and the letters and accounts of the time are full of references to them. Unhappily for the modern scholar, the prices almost always are for goods or services that are unique, ranging from dinner parties to monuments. The accounts reveal that people thought in terms of prices, but they do not provide a data set with which to examine prices. Prices for a uniform commodity are needed for that purpose. Wheat is the obvious candidate for such a price because wheat was both uniform and universal. Rathbone (1997) used the price of wheat in Roman Egypt to measure inflation. The coherence of prices across widely-spaced Mediterranean markets indicates widespread monetization, which facilitated trade by providing a standard unit of account. Just as the euro promotes European trade today, the wide use of *sestertii* and *drachmae* encouraged trade throughout the Roman Mediterranean. Kessler and Temin (2008) used wheat prices to measure the extent of monetization around the inland sea.

Price stability encourages trade as well, making the currency easy to deal with and credit easy to arrange. Ancient historians appear to agree that prices were largely stable in the late Roman Republic and early Roman Empire until the late second century. This is based on only fragmentary evidence, but prices from different time in these three centuries or so appear to be comparable. Price stability or very low rates of inflation are assumed in any exploration that requires such an assumption. Of course, there could be short-run events like the Tiberian credit crisis of 33 CE that affected prices in the short run (Duncan-Jones 1994: 23-25).

We do not know how the Romans kept prices stable, but we can use economics to frame the question more precisely. One relevant tool is known as the Cambridge equation. It states that the product of the amount of money and the velocity of its use equals the product of the price of transactions and their number: MV = PT. The velocity of money is the frequency with which any coin is used in the course of a year. This is not observed in modern economies; much less in ancient ones. Instead, economists assume that velocity stays stable or changes only in response to other economic variables.

Assume that V and P are constant, the former by convention and the latter as the phenomenon to be explained. As shown in the previous section, there is every reason to think that the Roman economy expanded at this time, so that T was increasing. That implies that M must have been increasing at more or less the same rate for P to remain roughly the same. Hollander (2007: ch. 6) used this framework to discuss the demand for money in the late Roman Republic.

When prices rose in the third century (Duncan-Jones 1990: ch. 9; Rathbone 1997), the equation suggests that the supply of money must have risen faster. Of course, if the rate of growth of the economy slowed and the volume of transactions grew more slowly, then an unchanged growth rate of money would have led to inflation. In other words, it is necessary to examine both sides of the Cambridge equation to understand how prices moved. This is the same as examining the supply and demand for money.

Of course, it is very hard to know the quantity of money in ancient times, and the problem is made more difficult by the Roman use of a bimetallic—or even a tri-metallic—currency. In later history, we know that when the ratios between, say, gold and silver coins was fixed, changing market prices for these metals meant that countries effectively were on a gold or silver standard. This appears to have been the case in the early Roman Empire when the silver denarius was the universal unit of account despite the existence of the gold *aureus*.

The relevant tool here is Gresham's Law, stating that "bad money drives out good." The reference is to a bimetallic currency where "bad" currency is worth more as coin than as metal and "good" currency is the reverse. In a bimetallic currency based on gold and silver, if the ratio of the prices of silver and gold on the market is 1:10 and the ratio of the value of silver and gold coins is 1:9, then gold will be the "good" money and silver "bad." It will be worthwhile for a person holding 10 silver coins to exchange 9 of them for a gold coin, melt down the gold coin and buy 10 silver coins' worth of silver to be coined. By this simple transaction, the person would have made a handsome profit in a very short time. Gold coins soon will soon be hard to find as "bad" money (silver coins) drives out "good" money (gold coins). People do not need to actually melt down gold coins for Gresham's Law to hold; they can instead hoard them as a store of value, taking them off the market and delaying planned expenditures into the future.

This argument depends on the existence of a market for the monetary metals outside the government and on the willingness of the government to buy metals at their stated value to make coins. Some numismatists and monetary historians assume that these conditions held in Roman times without a lot of evidence. Others have trouble even seeing coins as having monetary as opposed to ceremonial uses. Jones (1974: 201) was in the former camp, arguing that, "the Roman Empire [before Diocletian] was not on the gold standard: in it gold was a commodity whose prices expressed in the normal currency, the denarius, might vary like that of wheat."

Gresham's Law consequently complicates the use of the Cambridge equation. Is it proper to add the number of silver and gold coins to make the total stock of money if only one of them is used as a unit of account? Is it reasonable to use the presumed volume of coinage as an index of the stock if we believe that coins of one metal or the other may be melted down according to Gresham's Law? There are both theoretical and historical problems in the application of these tools to ancient economies.

The relationship between the supply of money and prices is far more complex in modern societies, where interest rates are an important part of the interconnection. There were loans and interest rates in the ancient world, but ancient financial systems were not complex enough for the interest rate to affect the relationship between economic activity and prices. The rate of inflation however could affect the use of interest rates in the ancient world. Economists distinguish between nominal and real interest rates, just as they distinguish between nominal and real wages. The real interest rate is the rate of return in terms of the goods that can be purchased with the money being loaned and repaid. The real interest rate is the nominal interest rate minus the rate of inflation. When prices are stable, the two rates are the same, and the distinction between them is not important. When prices rise, however, nominal interest rates need to rise in order to keep real interest rates stable. If lenders do not realize that prices are rising or if they do not understand the difference between nominal and real interest rates, they may lose purchasing power on each loan. Under those circumstances, credit will dry up and banks will disappear.

Ancient banks of course were not like modern ones. Their closest analog in current institutions is private banks, which were prevalent before industrialization but have grown increasingly scarce as joint-stock banks have grown. Ancient banks were individual or family affairs that performed the essential banking function of bringing together people who had resources (typically in the form of money) to loan and other people who wanted to borrow resources for consumption or production. They transferred money from place to place, from country estates to cities for landowners to spend, and from Asian properties to Roman investors. They also engaged in ancillary activities like financing auctions, exchanging currency, and holding endowments.

The money supply today consists of currency and bank deposits. Estimates of ancient money stocks typically only include currency in the form of coins. As a matter of logic, bank deposits also should be included. But since there are no data with which to estimate the amount of bank deposits, we can only infer that estimates based on coins alone must underestimate the money stock in times of stable prices (Harris 2006).

Just as coins facilitated trade by reducing the transaction costs of buying and selling goods, so bank credit facilitated both trade and production by reducing the difference between the return that people with money could get on their assets and the cost of capital to those people who wanted to spend more than their income. In both cases, these institutions promoted economic activity (Temin 2004; Rathbone and Temin 2008). The low rate of interest recorded during the late Republic may even have facilitated the transformation of Italian agriculture. I have discussed the role of trade, but there is also a question of financing a transition. Grape vines require years of cultivation before bearing fruit, while wheat is available much sooner. If the cost of resources is very high, farmers cannot wait for vines to mature. The availability of credit at low interest rates therefore aided the transformation of Italian agriculture from wheat to wine. Columella (3.3.7-11) included the cost of borrowed funds in his advice to wine growers.

TESTING HYPOTHESES

It is fun to formulate hypotheses; it is harder to find the data with which to test them. As noted already, there are not very many economic indicators like prices and quantities of production or consumption, and we must try to use the evidence we have intensively. The statistical technique known as regression analysis explicitly takes account of the scarcity of usable data. For example, it can be used to test the probability that the separate areas of the early Roman Empire were isolated in independent markets out of economic connection with Rome. The prices in these local markets would have been determined by local conditions, including the degree of monetization. There would have been no connection between the distance to Rome and the level of local prices.

We can evaluate the likelihood that there is a relation between the local price and the distance from Rome with a regression using some data gathered by Rickman (1980). We start by trying to draw a line that relates the price difference between the local price and the Roman price to the distance from Rome. We then adjust the line to make it the best description of the data in the sense that it minimizes the squared distance of the individual observations from the line. (We use the square of the distance to minimize the distance from points both above and below the line and to simplify the mathematics.) The resulting “least-squares” line is the regression line shown in Figure 3.7.

One value of regression analysis is that it generates tests of the hypotheses being tested. We can ask if an apparent relationship between the price discount and the distance from Rome is illusory, a result of observing only a few prices, rather than the result of a systematic process. This test tells us how unlikely it is for us to find a line like the one shown in Figure 3.7 by chance. Assume that the prices collected by Rickman were randomly drawn from an underlying distribution of price observations. In another world, different prices would have survived from this same distribution. Taking account of the random quality of the observations we actually have, how unlikely is it for us to find the line in Figure 3.7 by chance?

Regression analysis acknowledges that the slope of the line in Figure 7 is not known with certainty because the data used were selected randomly. It is the best line that can be drawn with the data at hand, but it is subject to errors deriving from the incomplete sampling of the underlying distribution. In the jargon of regression analysis, the slope of the line has a standard error. (The standard error is the name used for a standard deviation in this context.) If all the points in Figure 3.7 lay in a straight line, then the slope of the regression line would be clear, and the standard error of the slope would be close to zero. If the points are spread out as they are in Figure 3.7, the line is not known as clearly, and there is a chance that the line has no slope at all, that is, that there is no relationship between the distance from Rome and the price difference.

The test is to compare the size of the slope, the coefficient in the regression, with the size of its standard error. If the coefficient is large relative to the standard error, then it is unlikely that the line was a random finding without support in the price data. On the other hand, if the coefficient is small relative to its standard error, then it is possible that even though the regression line has a slope, there is no underlying relationship between the price and distance. Statisticians call this ratio a t-statistic, and they have calculated tables that can translate t-statistics into probabilities that the line is observed by chance.

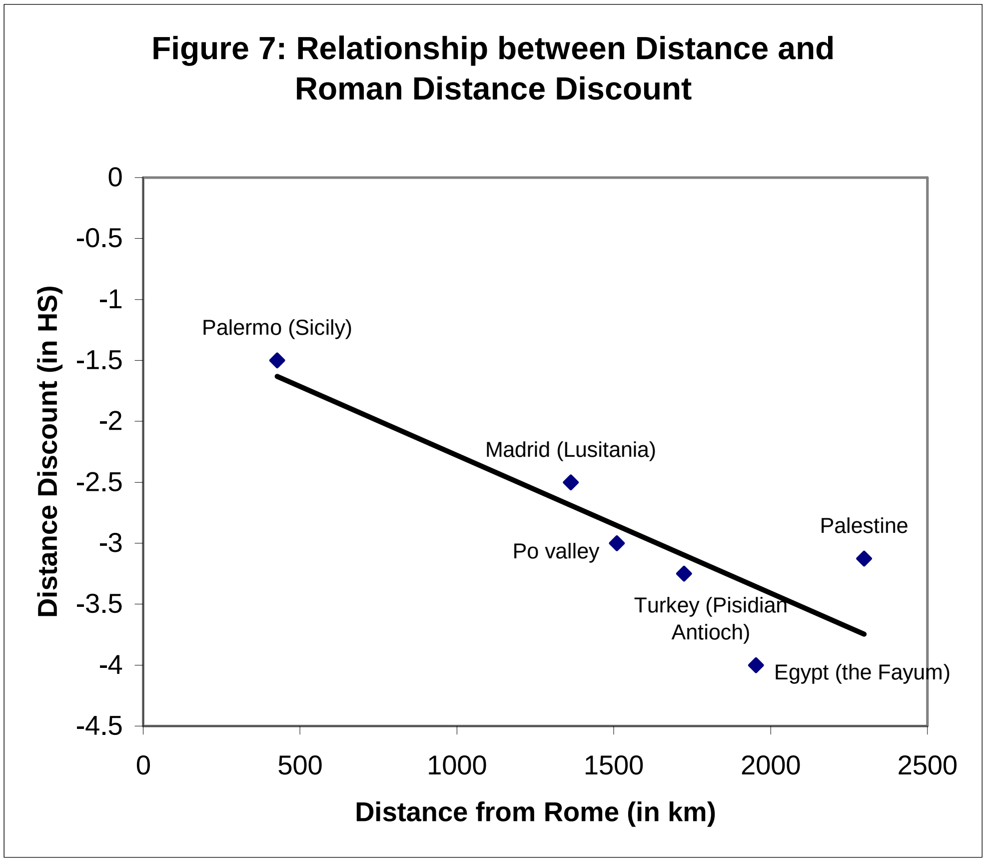
The tables take account of degrees of freedom, that is, the number of observations minus the number of coefficients. It takes two variables to define a line, its slope and its position (height in the figures). With six observations and two variables, there are four degrees of freedom. Omitting one observation with river transport reduces the number of observations by one and the degrees of freedom to three. The t-statistic has to be larger with such few degrees of freedom than with more degrees of freedom to show that a given regression line is unlikely to be the result of chance. A glance at the data in Figure 3.7 confirms that the regression line is a good description of Roman wheat prices around the Mediterranean.

One might think that the data — composed of only a few, badly observed values — are too poor for statistical analysis. Nothing could be further from the truth. Statistics are the best way of distinguishing signal from noise; they are particularly useful when there is a lot of noise in the system. They give us a precise sense of how unlikely it is that any putative pattern we think we observe would have been generated by random processes, that is, how unlikely it is that what looks like a pattern actually is noise. The value of statistics is that we can test a formal hypothesis, namely that wheat prices around the Mediterranean Sea were related in a simple way to those at Rome. We also can derive an explicit probability that this hypothesis is true, given the observations we have. Kessler and Temin (2008) provides a fuller discussion of this method, addressing several other questions about regression analysis with ancient data.

Another example of regression analysis is provided by an analysis of the spread of Christianity in its first two centuries by means of regressions. The dependent variable, Christianization, identified which cities had Christian churches by 180. The presence of such churches was explained in one regression as the result of having a Jewish community in the city, using Greek (Hellenism), and having been visited by Paul. The first two variables had significant explanatory power, but Paul's missions did not. In other words, once having described the nature of the towns, whether Paul had come did not make any difference (Stark 2006: Regression 5-4).

This example reveals a different use of regression analysis. In addition to informing us about hypotheses that appear to be valid, it also can help identify other plausible hypotheses that are not well founded. Paul's travels are well documented, and it is natural to regard them as a critical cause of Christianity's initial spread. Starks' regression, however, does not confirm that view. Instead, either Paul's ministries made no difference, or—more probably—he went to places conducive to the spread of Christianity. Stark did not explore this question, but his method would allow one to discriminate between these possibilities.

These examples show that there are enough data about the ancient world to test explicit hypotheses. Regression techniques are only one way of treating the data, and other methods may be more useful in particular circumstances. Ancient data are limited, but there are enough data sets around to be make progress. Hopkins (1978: 158-63) argued that the prices slaves paid for their freedom at Delphi rose in the late Roman Republic. Duncan-Jones (1990: ch. 3) reported data on the distribution of Roman oil lamps and suggested that they could reveal trading patterns. The prices in Duncan-Jones (1982) of buildings and monuments unhappily are not useful for this purpose because the items being priced are too varied to be compared easily. Economic theory is good at generating hypotheses, and we like as much as possible to check that these inferences are good history.



Source: Kessler and Temin 2008.

REFERENCES

Duncan-Jones, R. (1982) *The Economy of the Roman Empire: Quantitative Studies.* 2nd ed. Cambridge.

Duncan-Jones, R. (1990) *Structure and Scale in the Roman Empire.* Cambridge.

Duncan-Jones, R. (1994) *Money and Government in the Roman Empire.* Cambridge.

Hollander, D. B. (2007) *Money in the Late Roman Republic.* Leiden.

Jones, A. H. M. (1974) "Inflation under the Roman Empire," in *The Roman Economy: Studies in Ancient Economic and Administrative History,* ed. P. A. Brunt. Oxford: 187-227.

Kessler, D. and Temin, P. (2008) "Money and prices in the early Roman Empire," in *The Monetary Systems of the Greeks and Romans,* ed. W. V. Harris. Oxford: 137-59.

Rathbone, D. (1997) "Prices and price formation in Roman Egypt," in *Économie antique: Prix et formation des prix dans les économies antiques.* Saint-Bertrand-de-Comminges: 183-244.

Rathbone, D. and Temin, P. (2008) "Financial intermediation in 1st-century AD Rome and 18th-century England," in *Bankers, Loans and Archives in the Ancient World,* eds. K. Verboven, K. Vandorpe, and V. Chankowski. Leuven: 371-419.

Rickman, G. (1980) *The Corn Supply of Ancient Rome*. Oxford.

Schaps, D. M. (2004) *The Invention of Coinage and the Monetization of Ancient Greece*. Ann Arbor.

Stark, R. (2006) *Cities of God: The Real Story of How Christianity Became an Urban Movement and Conquered Rome*. New York.

Temin, P. (2004) "Financial intermediation in the early Roman Empire," *Journal of Economic History* 64: 705-33.