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A Search-Equilibrium Approach to the Roman Economy

There can now no longer be any doubt that the Roman economy – and by extension the Hellenistic and Punic economies the Romans inherited – was a market economy.[1] The evidence of significant specialization and exchange assembled by contributors to the *Cambridge Economic History of the Greco-Roman Economy* effectively puts to rest Finley's claim that the ancient economy was animated by values that promoted economic autarky and discouraged individual enterprise.[2] With the publication of Temin's *Roman Market Economy* the issue would seem to be effectively closed,[3] subject to Andreau's caveat that where non-specialists perceive similarities between ancient and modern economies, specialists see differences.[4]

The emerging consensus nevertheless leaves critical questions unresolved. If it was a market economy, what determined its expansion and contraction? When and where did it originate, and how did it end? The puzzle is not that the Roman economy was a market economy, but that it was part of a market economy that expanded for nearly a thousand years and then imploded. Resolving that conundrum requires more than simple identification of economic type. It requires a different way of thinking about how market economies work.

That the classical economy was a 'market economy' answers a question whose meaning is defined by the taxonomical approach to economic and social

[1] The bibliography bearing on this question is now massive. Illuminating examples include De Ligt (1993), Mattingly and Salmon (2001), Erdkamp (2005), Manning and Morris (2005), Morley (2007), Bang (2008) Andreau (2010, 2012), Holleran (2012).

[2] Scheidel et al (2007); Scheidel (2012) I reached the same conclusion in 1998 in a paper delivered to the American Economic History Associatio in 1998 entitled 'The Sherds of Trade.' After the talk, Temin came up to me and said, 'George, you scooped me.' As occasionally happens, the paper languished on an editor's desk until it was past its expiry date.

[3] Temin (2012)

[4] Andreau (2012: ix).

phenomena that characterized nineteenth-century historical economics.[5] Opposing the 'timeless' and culture-free affirmations of classical economic theory, which claimed to be true for all times and places on the grounds that men are much the same in all times and places, the historical school proposed a vision – one can hardly dignify it with the term model – of the economy as an ideal type distinguished not only by productivity and social organization, but by social purpose. The notion reflected a common sense observation that stable societies possess an underlying coherence evidenced by persistence through time suggesting the presence of a sustaining cause; and as societies evidently differ, so must the sustaining cause. Analytical implementation of this vision rested on the premise that social facts are to be understood in relation to the whole of which they are parts, engendering the conviction that the whole – nation, society, culture, civilization – is a self-sustaining entity ontologically prior to those parts. As an analytical structure, the typological vision was teleological, in which institutions, individual behaviour and sometimes even the means of production conceived as necessay conditions for existence and temporal persistence of the society as a whole.[6]

Implementation of that vision by economic historians took the form of an account of economic evolution as a succession of stages distinguished by complexity of social and economic organization, including the level of specialization and the extent of market exchange, technological achievement, particularly in industry, and values animating individual actions. This broad structure, which extended the notion of a temporal succession of 'modes of life' proposed by eighteenth-century thinkers like Montesquieu and Adam Smith,[7] provided an ample tent under which historians could shelter research on the economic organization of past societies without worrying too much about formal theory. It was generally assumed that people in earlier times were, if not less selfish than later generations, more constrained by their social milieu. Adam Smith himself noted that men commonly seek wealth not to increase personal consumption, but to better their social condition, implying that their actions are motivated not so much by what.they want *ab ovo* but by what they want other people to think of them.[8] The essential insight of the typological approach, then,

[5] Riha (1985); Tribe (1995); Perlman and McCann (1998). Though not officially of this school, Marx's dialectical rendering of economic change through a sequence of stages driven by Ricardo's economics and Hegel's logic makes him a family member.

[6] As Teggart (1925) pointed out, this vision founders on the problem of identifying efficient causes.

[7] Skinner (1976)

[8] 'An augmentation of fortune is the means by which the greater part of men propose and wish to better their condition. It is the means the most vulgar and the most obvious...' Smith (1937: 325)

is that economies differ in space and time because what people desire beyond the necessities reflects social contexts that differ in time and space.[9]

The stages theory seemed to capture changes then taking place in nineteenth-century Europe. Agriculture was becoming more commercialized, markets more geographically extensive and socially intensive, manufacturing more capital-intensive, industrial enterprises larger and more complex and people seemingly more obsessed with gaining wealth at the expense of religious and civic virtue. Ethnological accounts of Stone Age cultures nourished the intuition that European mankind had lifted itself from the stage of family and clan autarky to a capitalist economy transcending national and cultural frontiers. In the canonical sequence of stages, however, the Roman Economy was a troubling anomaly. It seemed to have been economically prosperous—indeed, in the first half of the eighteenth century it was widely believed that Roman agriculture was superior to contemporary English farming practice,[10] and to anyone exposed to classical education, which meant anyone truly educated, that the Ancients traded, lent funds at interest and remitted them across long distances was common knowledge. But the Roman economy did not evolve into a higher stage of economic development; instead it regressed to *Naturalwirtschaft*. As the Roman cultural achievement could hardly be denied, preserving the theory required inventing a new economic type to accommodate evidence of large-scale production and extensive trade in the Hellenistic and Roman eras, but lacking elements believed to have inspired European economic development since the turn of the second millennium. The analytical solution to this conundrum proposed a hybrid stage characterized by mass employment of slaves in agriculture and manufacturing as a way of explaining large-scale production using primitive technology. Although part of the output of these household economies writ large was commercialized, markets played a minor role in determining the kind and quantity of goods produced, long-distance trade serving mainly to distribute commodities not everywhere available for elite consumption.[11] The missing ingredient was capitalist or, more properly 'bourgeois' enterprise that extended the sphere of commercial activity as its means of existence and primary goal.[12] By contrast, commercial activity in

[9] Frank (2007)

[10] The early eighteenth-century agricultural innovator Jethro Tull castigated such admirers as 'Virgillian'. Fussell (1973).

[11] 'The Roman economy, in spite of its sophistication in some respects, was predominantly a subsistence economy. The monetary economy constituted a thin veneer of sophistication spread over and tied to the subsistence economy by the liens of taxes.' Hopkins (1980: 104)

[12] The origins of that mentality were usually dated to the municipal revolutions of the twelfth century, which were thought to have created legal and social space for the capitalist institutions and bourgeois virtues. On the early historiography, see Crossley (1993).

Roman antiquity was geared to maintaining self-sufficiency of elite families on a scale large enough to support their political and social ambitions. That vision is summed up by Finley in his celebrated account of the Roman failure to industrialize.

'Rostovtzeff and others following him have constructed a great theory about economic decentralization, the ruin of the bourgeoisie, the end of emergent capitalism, and the seeds of decline of the Roman Empire. I mean no offence, but this theory is an anachronistic burlesque of the affluent society. All that had happened was that a few minor trades over-reached the market, some hundreds of craftsmen in the western Empire in a few cities were displaced by some hundreds in a few other cities, and nothing else. They were no bourgeoisie to begin with, and imperial society was oblivious to, and unharmed by, the displacements.'[13]

1. Neoclassical economics

Superficially, nothing would seem to differ more from the typological vision of the stages theory than the economy depicted in neoclassical economics. Whereas the stages theory posits a community ontologically prior to the individuals it comprises, neoclassical economics is heir to a philosophical tradition which takes individual experience as the starting point of social construction. Only individuals matter and *de gustibus non est disputandum*. Apart from the anodyne premise that more is better than less, the propositions that procede from that philosophical foundation claim to be value free.[14] Markets are simply a means of coordinating tastes and talents of individuals in a manner compatible with peferences, resources, and the state of technology. How does one know whether an economy is a market economy? The conventional test is whether observed prices and quantities are consistent with predictions predicated on the assumption that they reflect market supply and demand. Where there is consistency, markets are presumed to be present.[15] This is not the only conceivable test. Where we have archaeological evidence of large-scale specialized production and extensive distribution of the output, even without price data it is reasonable to interpret the data as evidence of market exchange by analogy with similar patterns observed in better documented eras,

[13]Finley (1965:42)

[14] This premise, though plausible, is not as benign as it seems. Formally it is derived from the logic of revealed preference—i.e., that when people choose, their choice reveals what they prefer, which by definition makes them better off in their own eyes. This is a logical, not an empirical proposition, however, and in practice impossible to verify. Its employment as the foundation of economic reasoning is an act of faith. For trenchant expositions of the problems involved, see Little (1959) and Sen (1977)

[15] Temin 2013) performs several informal tests along these lines..

even though one has no way of observing the individual motivations or the precise institutional mechanisms.

The neoclassical and historical concepts of market economy nevertheless have more in common than meets the eye. One of the deep insights of theoretical economics is that prices and quantities in a closed economy are mutually determined by an accounting identity that makes the seller's income equal to the buyer's expenditure. That interdependence is abstractly captured by a system of simultaneous equations which set supply and demand of every good exchanged equal to each other combined with a 'no-profit' condition stipulating that prices equal the cost of production.[17] Since the number of independent equations equals the number of prices and quantities determined in equilibrium, the system's mathematical solution replicates outcomes a market economy would in principle realize if it were in full equilibrium. The model is called 'Walrasian' after the nineteenth-century economist who invented it.[18] Walras' supreme achievement was to show that (subject to certain qualifications) a general equilibrium logically exists.[19] A loose rendering of this proposition is that market economies tend towards the realization of a general equilibrium of prices and quantities. An corollary is that because the demand equations sum the utility-maximizing choices of individual agents, Walrasian general equilibrium thus maximizes economic welfare.[20] On this reading, a market economy exists to achieve the goal of maximizing welfare. Like the historical economic type, the neoclassical type is strictly functional.[21]

When economists like Temin speak of a 'market economy' this is the economy they are talking about. It is not a real economy; it is a toy economy built to facilitate mental manipulations thought to have a bearing on actual economies.[22] What makes the manipulation possible is a neat distinction between exogenous state variables and the endogenous outcomes generated by the equations. The state variables are the resource endowment (and its distribution among market participants), the technology, and the preferences of

[17] This condition holds for reproducible goods.

[18] Walras (1954)

[19] Modern theoretical economics is largely given over to such 'existence proofs', which have much in common with the existence proofs in scholastic philosophy.

[20] Since individuals are supposed to have independent subjective valuations of their consumption, work, and savings, the maximum condition is expressed as a state in which no one can improve her state (from her own point of view) without worsening the state of someone else (from his point of view).

[21] This functionalist attitude is particularly pronounced in the works of Douglass North, and more generally in the New Institutional Economics. See North (1981; 1990)

[22] 'The model provides a simplified description of events that can be repeated and discussed, and it allows economists to test *counterfactual* propositions….' Temin (2013: 5)

individuals with respect to goods, leisure, and saving; the outcomes are the prices and quantities ground out by the equations. Separation of exogenous causes and and endogenous effects supports an intellectually simple (though computationally complicated) causal analysis that relates equilibrium prices and quantities change to changes in state variables. Since attitudes and social values can also be considered state variables, the model is similar to the idealization of the stages theory: economic performance is ultimately explained by cultural *mentalités.*[23] The neoclassical market economy is thus also an ideal type, a static representation: that the Roman economy was a market economy therefore tells us nothing about how it came into being, expanded, and ultimately declined.

Explaining change within the Walrasian system involves identifying changes (and the causes of those changes) in state variables that drive the system. Analytically, the connection between the causes and the effects is secured by the presumption that resources are efficiently and fully employed—i.e., that the economy is operating at capacity given the stock of resources, technology and the preferences of its population with respect to work and saving. That presumption is commonly defended on the grounds that were the economy not operating efficiently, it would be possible for someone to profit by correcting the deficiencies, and since in the long run significant inefficiencies cannot be hidden, by the calculus of self-interest their persistence is logically impossible: a 50-euro note dropped on the sidewalk has a short half-life. The efficient markets hypothesis thus privileges supply side explanations of economic change.[24] When an economy is 'on its production frontier,' the only way to increase output is to increase the input or improve the technology. This proposition is defended on the grounds that changes in state variables in traditional economies occur so slowly that people have sufficient time to discover and eliminate obvious waste, leaving the supply of inputs and technology as the logically sole source of movement.[25] Although the model allows changes in demand to affect outcomes, demand-based explanations are usually dismissed as *ad hoc* on the grounds that unobservable changes in preferences can be adduced to explain anything and are therefore non-

[23] See Mokyr's (1992) remarks on Roman technological stagnation; Landes (1998) is a generic example. For a recent exercise of the same type see Acemoglu and Robinson (2012).

[24] For a vigorous conventional defence of this view, see Mokyr (1977).

[25] This was the burden of the claim by Schultz (1964), that peasant economies are generally efficient.

[28] Devries (2008) makes an ambitious and in my opinion successful identification of changes in tastes that affected whole economies.

scientific.[28] What matters are the factors governing the quantity and quality of inputs, the state of technology and institutional arrangements, to which may be added truly exogenous pandemic, tectonic and climatic events. To explain economic change is to identify when, where, and how these factors changed. For example, the common (and probably true) assertion that the extension of Roman control over the Mediterranean Basin during the late Republic gave a powerful boost to production and exchange identifies economic expansion with institutional change.

Neoclassical economics is especially helpful in interpreting the economic consequences of well-defined exogenous 'shocks' like pandemics,[29] and has been enthusiastically (if not always persuasively) used to interpret institutional arrangements as self-organizing responses to particular circumstances,.[30] By contrast, it is poorly suited to explain developments that endogenously arise in neoclassical equilibrium states in consequence of what Marxists call their 'internal contradictions.'[31] In this regard pre-modern economies pose a special problem for neoclassical explanations of economic change, because the technology and resource base evolved slowly, while population and output experienced wide swings. For lack of alternative explanations, economic historians have resorted to demographic and climatic change as ultimate causal forces. That such explanations withstand criticism is by no means evident.[32]

2. Search-Equilibrium Economics

While the strengths of the Walrasian framework are well-known, understanding its limitations requires exposure to its technical details. As is normally the case with economic models, its limitations are the price of its strengths. The strength is demonstrating the logical connection between factor and product markets in a market economy; the limitation is that a system of simultaneous equations requires everything to happen at the same time, which clearly does not the case in real economies. In particular, the equations tell us that in principle equilibrium exists, but not how it is attained. Walras' response to this difficulty was to imagine the economy as a general stock exchange in which buyers and sellers make bids and offers in response to prices 'cried out' by an auctioneer who raises the going price if demand exceeds supply and vice versa. No exchange takes place until all prices reach market-clearing levels, at

[29] Scheidel (2002)

[30] Hawkins (2007). See Olgivie (2011) for a trenchant criticism of the tendency to over-interpret institutional forms as optimizing adaptations to the structure of transaction cost. It is worth noting that the subtext of adaptation models of self-organization is that government intervention is superfluous, if not positively harmful.

[31] See Grantham (2013) for an airing of these issues.

[32] Grantham (1999)

which point the auction ceases and participants execute contracts agreed to in the price-making phase of the process. Walras' parable thus supplies a market process that in theory achieves general equilibrium. In fact, it is nothing a verbal computer algorithm for solving systems of simultaneous equations. Whether it takes a long or a short time for the auction to achieve equilibrium is irrelevant, as no actions are taken until equilibrium is attained; only the solution matters. The auction is hermetically sealed off from acts of production and consumption.[33] Walras claimed the real economy was 'like' his imagined one, but offered no evidence in support of that claim other than that prices tend to adjust to differences in supply and demand. The allegory is sometimes justified by the claim that market economies eventually converge to general equilibrium if you give them enough time, but Walras' great contemporary Alfred Marshall pointed out that the time required is so long as to be practically impossible.[34]

The Problem of Demand

Effective demand for a marketed good consists in market supply of the goods offered in exchange for it; every act of demand is thus simultaneously an act of supply. Where money is employed as medium of exchange, that connection is loosened in the degree demand for money fluctuates, as happens when financial crises cause people to hold their money for safe-keeping rather than spend it. In the long run, however, the relation between the stock of money and production of goods and services at a given price level is believed to be stable, which implies that the ultimate source of effective demand is marketed supply. That connection is formalized by an accounting identity known as Say's Law, which states that the market value of goods supplied necessarily equals the market value of goods demanded, a truism expressed by the maxim 'supply

[33] A particular difficulty is that production takes time, while the contracts for inputs and the sale of output must be simultaneously concluded as a condition of general equilibrium. Walras' solution is to imagine a market consisting of options to buy or sell ('*bons*'). Unlike real options markets, however, the options are valid only in equilibrium, so thee is no speculation on their price as the auction proceeds. This feature further stresses the 'timelessness' of the Walrasian economy.

[34] 'But in fact a theoretically perfect long period must give time enough to enable not only the factors of production of the commodity to be adjusted to the demand, but also the factors of production of those factors of production to be adjusted and so on; and this, when carried to its logical consequences, will be found to involve the supposition of a stationary state of industry, in which the requirements of a future age can be anticipated an indefinite time beforehand … Thus the uses of the statical method in problems relating to very long periods are dangerous; care and forethought and self-restraint are needed at every step. Marshall (1966 [1920]: 315)

creates its own demand.'[35] Increased aggregate demand for goods and services logically must originate in increased capacity to pay for them with by means of increased supply. Say's Law restates the Walrasian principle that economic change originates on the supply side.

The problem with that principle is that it is at variance with the facts. As will be discussed below, urban demand for produce was probably the most important factor determining the productivity of Roman agriculture;[36] its importance is well-established for medieval and early modern.[37] Similarly, high levels of specialization achieved in the major medieval cloth towns make no sense unless one posits a large (though geographically dispersed) demand for their products.[38] These well-attested facts raise the following question: where did the demand supporting that specialization come from? In the medieval case, demand for urban goods was originally thought to have been stimulated by growing agricultural surpluses made possible by agricultural innovation,[39] but this is now considered unlikely, as the alleged innovations were already present in classical antiquity, reopening the question what caused them to develop and diffuse in the central period of medieval economic growth.[40] In a somewhat comparable context Allen has proposed that agricultural innovation in early modern England was stimulated by growth in urban demand resulting from the growth of foreign trade.[41] But that plausible argument leaves open the question what supported growth in demand for London's commercial services?

Say's Law has no answer to such questions other than to posit technological change, increase in the resource endowment, or autonomous institutional changes enhancing economic efficiency.[42] It is a logically closed box, a perfect mousetrap: nothing gets out, but by the same token, nothing gets in. When a model ceases to explain significant facts, it is time to look for a new model.

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[35] Formally, Say's Law is the aggregate expression of the individual budget constraint that a person's purchasing power cannot exceed the market value of the goods and services he possesses.

[36] See especially Erdkamp (2005) and Kron (2008).

[37] Grantham (1989; 1999; Derville 1999)

[38] Perroy (1960). Fourteenth- and fifteenth-century Flemish militia lists reveal levels of specialization exceeding that of the Lancashire cotton towns in the nineteenth century. Prévenier (1983); Derville (1983).

[39] Duby (1962, 1973)

[40] Raepset (1995, 1997)

[41] Allen (2009)

[42] Cite North and Weingast here

Although auctions are found in contexts ranging from highly organized markets for financial instruments and homogeneous commodities to works of art and the sale of fish fresh off the boat,[43] market economies are not general auctions. Most exchange is bilateral: one goes to one's shop to buy bread or fish, one sells one's home to a particular buyer, a company sales rep deals with particular clients. Rather than being simultaneously and continuously coordinated, market transactions are strung out in real time at prices that vary from moment to moment and place to place. Students of retail pricing find that even within relatively confined urban districts, the price of common items like tissue paper varies significantly from shop to shop, presumably because the cost to consumers of seeking out the best price is more than it is worth and because the cost to retailers of calculating optimal prices for everything they sell is also more than it is worth. Individuals in a market economy are therefore more like particles in Brownian motion randomly bumping into each other than participants in a virtual auction. Although people usually shop at the same stores and firms tend to deal with clients they know, the matching parable comes closer to describing what happens in a market economy than the auction parable.

Peter Diamond has developed a formal model that captures this aspect of markets.[44] The model was invented to analyze fluctuations in the 'natural' rate of unemployment, but it is readily adapted to explaining fluctuations in the division of labour and the extent of the market.[45] Rather than conceiving the economy as a general auction in which buyers and sellers continuously interact with each other as they respond to prices called out by the auctioneer, Diamond proposes an exchange economy consisting of a ongeries of bilateral transactions matching particular buyers with particular sellers. To put that process in real time, he imagines exchange as a random process described by the probability that a seller achieves a successful match with a buyer within a given interval of time.[46] It is intuitively obvious that the greater the number of agents seeking matches the higher the probability of success. Price plays no role, because lowering the offer price or raising the bid price does not increase the probability of a making successful match. This captures the uncertainty of the market connection. If sales responded to prices, the market connection would already exist, and we would be in a Walrasian world. Diamond's matching model is as much a fiction as Walras' auction. The question is not whether one is nearer the truth than the other, but the kind of truth it seeks to uncover. The Walrasian

[43]Goldfarb (2000)
[44] Diamond (1984)
[45] Grantham (1999)
[46] The probability is the mean of a Poisson distribution. The function of this mathematical construction is to model transactions as occurring in real time.

model addresses questions that concern economic efficiency; the search-equilibrium model addresses the relation between the level of specialization and the extent of the market.

The crucial feature of the matching model is that it supports multiple steady states. This is because the probability of a successful market match is positively correlated with the number of agents seeking matches. At high levels of output, more agents are in the market than at low levels. Economies with the same population, technology, and institutional arrangements can therefore have different equilibrium levels of output and productivity depending on whether agents participate to a greater or lesser degree in market production. Because participation takes place continuously in real time, market equilibrium is defined by the condition that the depletion of sellers' inventories by successful matches is exactly replaced by new production.[47] Total output is constant. Unlike in Walrasian equilibrium, however, there can be more than one level of output that satisfies this condition. We now need to consider the decisions determining the level of output.

Decisions to undertake specialized production depend on how much it costs to produce. The costs that matter are irreversible costs that can only be recovered by achieving a successful match. The costs associated with specialization are the cost of acquiring specialized skill (you can't get your time and money back by promising to forget what you learned), investment in special-purpose facilities with no or limited alternative use, and time and money incurred in building up business reputation and knowledge of trading opportunities. For any agent contemplating production for market sale there is a maximum cost he is prepared to incur for the chance of making a sale. That decision depends on the likelihood of making that sale. At low probabilities, the odds are high that the irreversible sunk costs will not be recovered.[49] It follows that the greater the probability of making a sale, the higher the cut-off cost.

[47] In the formal model agents produce to inventory and then attempt to sell that inventory through a random match with a buyer. As in the Walrasian model, theoretical clarity is purchased at the price of unrealistic assumptions. The choice of an appropriate model depends on how the assumptions distort the reality one is attempting to model.

[49] For technical reasons, Diamond represents the schedule of costs as a cumulative probability distribution from which agents contemplating investment make random draws, some projects incurring higher cost than others. The agent makes a draw and then decides whether the project is worth pursuing. This technical apparatus insures that, as in the matching process, decisions to produce occur in real time.

Since projects with costs below the cut-off are accepted, a higher cut-off cost implies higher levels of aggregate output.[50]

Because individuals who invest in specialized skills and specialized facilities create hostages to fortune, the search-equilibrium approach is well adapted to modeling decisions to specialize. It captures the positive feedback between decisions to produce at higher cost (and thus at higher levels of output here interpreted as higher levels of specialization) and the probability that the sunk costs will be recovered, thus completing and formalizing Adam Smith's maxim that the division of labour depends on the extent of the market. Potential multiplicity of potential equilibrium states is driven by increasing returns in the number of persons engaged in production for the market and in the volume of transactions, but other factors reinforce that relation. In real economies market matching is coordinated by middlemen who invest considerable amounts of fixed capital warehouses and transport facilities, and human capital in building up trade connections, evaluating the reliability of suppliers and customers, and learning how to discern differences in the type and quality of goods.[51] As the volume and profitability of exchange increases, it becomes economically advantageous to invest in roads, bridges, and port facilities. Perhaps the outstanding example from classical antiquity is the port of Ostia, a port only by virtue of its proximity to Rome. Situated on a shallow bay silted up with sediment from the Tiber, the port was an artificial creation of Claudius.[52] When Rome decayed, the port was abandoned.

Diamond's search-equilibrium parable offers a way around the problem of explaining changes in demand without finding a corresponding exogenous shift in supply. Say's Law still holds, as logically it must, but we are not required to seek exogenous causes of change. The search-equilibrium model describes an economy in motion, in which significant elements bearing on productivity and the quantity of goods exchanged interact with each other endogenously to produce varying levels of specialization and aggregate demand without necessarily affecting the resource base or technology. An increase in specialization for whatever reason tends to produce a higher level of aggregate demand, which in turn supports even greater specialization. Supply creates its own demand, but the converse is just as true.

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[50] Since projects with costs below the cut-off point are accepted, a rise in the cut-off point increases the total number of projects undertaken.

[51] These matters comprise the greater part of the material in the older merchant manuals like *Le Partait négociant* (Savary des Bruslons, 1713).

[52] Rougé (1966 : 124-25)

Multiple Equilibria

That market economies with the properties described above can potentially operate at different levels of intensity raises the question how the actual level is selected. If among the feasible levels only one outcome can be selected, we are back in the conventional world of unique equilibrium that makes economic change a consequence of well-defined causes. Although this can happen, there are reasons to think that it is not generally the case, and that economies with multiple stable equilibria have intermediate unstable points of equilibrium, which means that rather than going back to the initial equilibrium following a modest shock, the economy diverges to a new one that is higher or lower than the starting point depending on whether the shock is positive or negative.

The Malthusian paradigm is an example of stable equilibrium. When living standards diverge from the 'subsistence' target, the demographic response to that divergence forces the productivity of labour to its steady-state value. If the technology is static, population and total production revert to the initial state; if it is improving, population and production grow at a rate that just keeps the standard of living constant. It takes a permanent change in an exogenous variable such as the target subsistence income permanently to change the equilibrium. By contrast, in economies with multiple equilibria generated by economies of scale, a temporary shock can produce a permanent change in equilibrium owing to the positive feedback between changes in the level of output and changes in the level of productivity. If the shock is positive it can expand to a new higher equilibrium point; if it is negative, the economy can implode.[54]

A crucial question is what factors set the upper bound to economic expansion. There are two logical possibilities: the first is that it is determined by the stock of resources and the state technology, which is the position held by Malthusianists; the second is that it is set by the institutional capacity to sustain the high volume of trade needed to sustain high levels of specialization. In effect this means mantaining high levels of effective demand. In pre-modern economies, the level of demand needed to sustain significant specialization was achieved through spatial extension of the market because the productivity of the dispersed agricultural population was low. This is the nugget of truth in the claim that the extension of Roman rule and Roman commercial law in the late Republic and the early Empire was a primary engine of economic growth, though one may dispute the claim that the transmission mechanisms was the

[54] A graphical exposition of this property is set out in the Appendix.

obligation to render tax and tribute to Rome.[55] It also suggests that monetary and fiscal stability, not to mention political stability, were essential to maintaining a market space supporting high levels of trade and specialization.

In brief, economies where processes analogous to matching are the primary means of effecting exchange—which would seem to cover all spatially extensive economies—are potentially unstable. Even where the fundamentals of technology, population, tastes, and resources stay the same they may experience wide swings in output and productivity in consequence of the internal dynamics of increasing return. The Great Depression of the 1930s and the current depression in Europe and the United States are modern examples of economies in which output fell without a corresponding regression in technology, population or institutional structure.

3. Understanding the Classical Market Economy

We now turn from these abstruse matters to the interpretation of the classical economy. The first issue is whether the necessary conditions for a search-equilibrium economy were present in Antiquity. One necessary condition is the existence of markets. This is now well established. That market connections over any significant distance involved high levels of uncertainty concerning not only price but also the possibility of sale is also well-established.[56] The proliferation of regional fairs and the clustering of retail shops selling similar types of goods are naturally explained as evolutionary adaptations to the cost of search making it advantageous to concentrate transactions in time and space.[57] It has recently been observed that a fruitful way of thinking about the Roman economy is in terms of variations in connectivity, which is better captured by the search-equilibrium parable than the Walrasian one.[58] The other conditions for a powerful positive feedback between the extent of the market and the division of labour are the presence of economies of scale in handicraft production and an agricultural supply function sufficiently elastic to prevent endogenous expansion from being shut down by the rising cost of food and organic raw materials. These two conditions are more problematic, especially the last one. The remainder of this paper is thus devoted to their investigation.

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[55] Hopkins (1980) This original and thought-provoking article is now showing signs of age.

[56] Morley (2007) Bang (2008).

[57] De Ligt (1993); Holleran (2012)

[58] '[T]his is not a question of either total disintegration with completely isolated communities or fully correlated markets moving in absolute unison; we are trying to look at differences between a group of highly complex pre-industrial societies with forces working on several levels to tie localities into wider networks.' Bang (2008:172)

[60] Wilson (2002)

Economies of Scale

Although the Ancients were more successful in harnessing the inanimate power of falling water than was once believed,[60] limited mechanization of industrial processes prior to the Industrial Revolution meant that with a few exceptions involving the harnessing of water power–notably milling grain, crushing ore, and sawing stone slabs—working up of raw materials into final goods was done by hand.[61] The limited exploitation of inanimate power has led historians to conclude that the productivity of Roman manufacturing was low, because it was necessarily carried out in households or small workshops.[62] Yet, as Adam Smith pointed out, the gains in productivity through specialization by task in the context of handicraft manufacture were often substantial, as he showed in the celebrated example of the pin factory, which demonstrated the principle at work under a single roof. The common pre-industrial instances involve many roofs.[63] The reasons for the positive correlation between productivity and specialization are well-known: improved motor skills, better control of heterogeneous materials, and higher rates of throughput in industries where different stages of production can be carried out simultaneously.[64] Xenophon's example of the division of labour in shoemaking in fourth-century Athens, some workers cutting the soles, some making the uppers, and still others stitching them together into a finished shoe is a celebrated case in point.[65] Labour productivity can also be increased by reserving difficult tasks to skilled workers and hiving the simpler ones off to less skilled ones.[66] None of this necessitates direction of production under a single management.[67]

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[61] See Schneider (2007) for a useful brief review of the classical technological achievement.

[62] Commenting on the appearance in the early Empire of mass-produced ceramics on the Roman frontier Fulford writes, 'Economy of scale has been suggested as another explanation for the 'marketing' success of these industries, but the labour-intensive nature of both production and distribution in particular argue against this as a significant factor.' Fulford (1992: 296)

[63] 'In those great manufactures, on the contrary, which are destined to supply the great wants of the great body of the people, every different branch of the work employs so great a number of workman, that it is impossible to collect them all into the same workhouse. We seldom see more, at one time, than those employed in one single branch.' Smith (1937: 4)

[64] The impossibility of achieving this division of labour in agriculture, where the sequence of operations is determined by the rotation of the seasons was the main reason why agricultural productivity was less responsive to increases in demand than industrial productivity. This does not mean that there was no responsiveness, but the mechanisms of that response differed. See Grantham (1989; 2010) for discussion of these issues.

[65] Hawkins (2012: 175)

[66] Sokoloff (1984)

[67] See the discussion of this point and evidence from Antiquity in Hawkins (2012)

Ceramics are a good place to start because the ceramic record provides the fullest record of expansion and contraction of specialized production of a non-agricultural commodity.[68] Unlike most manufactured goods pottery does not decompose, nor like glass and iron can it be re-melted or forged into new objects. . Pottery shards thus constitute the most ubiquitous surviving pre-industrial objects. Since pottery is fragile, the need to replace broken pieces implies a potentially huge market. That same fragility maked it costly to transport, so that in the absence of significant economies of scale in manufacture or significant reductions in transport cost, production and consumption of common types of pottery known as coarse ware were highly localized.[69] For ceramic articles to be extensively traded in quantities large enough to matter economically, they had to be produced cheaply enough to offset that transport cost.[70] In an age when pottery-making was ubiquitous, the only way to get the cost of commercial production low enough to compete with local producers was by exploiting economies of mass production, and mass-production required access to thick markets.

The primitive technology of pottery making is simple enough to be part of normal household work, as it still is today in remote parts of Africa and South America. Clay is extracted from local beds, dried in the sun, and broken down and sifted to remove extraneous matter. It is then mixed with water and left to cure for a day or so before being 'tempered' with stones or sand to protect the finished vessel from thermal shock. The fabric is then worked by coiling ribbons of clay into pots, jars and plates dried and then fired in a depression filled with brushwood.[71] At a slightly higher stage the work is done by part-time village potters who distribute their output locally. The archaeological record of that stage shows geographically scattered distribution of non-overlapping types that an earlier generation of prehistorians used as markers for 'cultures' or 'civilizations.'. Low entry costs in manufacturing the coarse ware ordinarily used by rural households together with high transport cost constituted a barrier to centralized production that which survived into the modern era.[72] The

[68] The interpretation of this record as an index of commercialized activity in general is a matter of some delicacy owing to imprecision in dating the material and distinguishing the effect of purely local factors from the general economic context. (Green, 2005; Cau et al, 2011)

[69] Such localization did not prevent widespread distribution of ceramic wares by persons who cooked with them whilst trading other commodities. Cf. Tomber (2000)

[70] It has been suggested that the fine wares produced in Tunisia might have been transported in ships that carried grain to Rome. (Carandini 1983; Bonifay, 2007).

[71] Peacock (1982: 13-14)

[72] Shortly before the American Revolution, an attempt to establish a commercial pottery in Philadelphia failed because it could not reproduce wares imported from Britain at the high end of the market and could not compete with the local potteries serving

common pottery used as household cooking vessels was inherently non-tradable or at most locally tradable.

In view of these features it is remarkable that mass-produced oil lamps and the dinner ware known as *terra sigillata* were the most widely traded manufactured commodities in Roman classical antiquity of which there is clear evidence.[73] Glossy red slip ware manufactured at Arezzo reached beyond the *limes* to Russia and India, and across the Sahara to the Fezzan.[74] That the trade was well organized can be inferred from a case discovered unopened in the ruins of Pompeii containing 90 red slip vases and 30 pottery lamps shipped from the Gallic pottery at La Graufesenque.[75] The industry that developed in the immediate hinterland of Roman Carthage in the first centuries AD was even more impressive.[76] *Terra sigillata africana* is so omnipresent that it is the principal means of dating late Roman and early medieval strata.

Given the difficulty of transporting ceramics in bulk, it is noteworthy that apart from North African ware, which was produced near enough to the North African coast to be shipped by sea, the principal districts of concentrated ceramic manufacture were in out-of-the way places. The Arretine industry was situated in the foothills of the Appenines 250 kilometres from Rome and 150 kilometres from the nearest seaport, while the great south Gallic pottery at La Graufesenque emerged in the remote highlands of the Causses and Cevennes. Relative isolation also characterizes the red slip industry in the Argonne, traversed by a single road connecting Metz and Rheims.[81] The location of these centres is not uniquely explained by privileged access to raw materials, for although the type of clay utilized in *terra sigillata* is not ubiquitous, it is widely distributed.[82] The emergence of large-scale production in out-of the way places seems therefore to reflect strongly increasing returns to agglomerated production seconded by investments facilitating the transportation and distribution of the final product.

Another indicator is the instability of sites of concentrated production. The spread of *terra sigillata* from Italy to southern Gaul and Tunisia has been long

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farmers in the back country at the low end. Peacock (1982:31, citing Olney, *Artisans for Revolution*, 31.

[73] Pucci (1983); Harris (1980)

[74] Carandini (1983:146)

[75] Coulon (1990:182)

[76] Bonifay (2004); Mackensen and Gerwulf (2002, 2006)

[81] Wightman (1985: 145-46)

[82] Peacock (1982: 119). This was also true even of fuel. Note the success of the Pantellerian pottery in an context of scarce fuel.

known,[83] but the displacement of primary centres of production within Tunisia over five centuries has only recently come to light[84] and the apparent ease with which a fine ware export industry emerged in the second century AD in northeast Gaul is underappreciated.[85] The instability of fine ware production sites (albeit over significant periods of time) indicates scale economies of agglomeration that could emerge in any number of places, and held in place by relative immobility of specialized labour and low transaction cost across short distances.[86] Positive feedback between productivity and volume of production propelling these centres, however, worked against them should they begin to decline. Although archaeological record does not tell us why production shifted from one place to another, the economics explains how it could happen A further sign is the displacement of locally produced ceramics, which could only happen if there was price advantage for mass-produced pottery. .[87] In Pannonia red slip ware produced in the Rhineland and southern Gaul utterly destroyed a local ceramic industry in the second century AD, although the local pottery has been judged by authorities to be technically equal to any contemporary product. The volume of trade was large enough for merchants exporting vessels from La Graufesenque to maintain a warehouse [88]

Production in the main centres was highly standardized.[89] There was a clear effort to identify brands by stamping articles with the name of the pottery and the employee who made them. Moreover, there is clear evidence of attempts to counterfeit the more widely traded wares using false stamps, suggesting that there was a market among consumers who like buyers of knock-off copies of branded goods today, appreciated but were not prepared to pay the price of the original.[90] The relatively modest quality of Gallic red slip ware, however, suggests it was primarily destined for a mass market spread over a wide area. The same was true of the less widely distributed burnished black ware that dominated the ordinary range of house wares in Britain between the second and

[83] Pucci (1983)

[84] Mackensen and Schneider (2002, 2006); Bonifay (2004, 2007).

[85] Huld-Zetche (1972); Wightman (1985); Polfer (2005)

[86] On the transactions costs see Hawkins (2012).

[87] Fulford (1977). A second-century inscription containing the words *negociatore cretarii Britanniciani* identifies a merchant specialized in importing continental ware to Britain. *Ibid*, 38. In fairness it should be noted that Fulford (1992) subsequently associated the wide distribution of red slip ware to the Roman military supply system.

[88] Bonis (1980)

[89] Wilson (2008)

[90] Some Gallic red slip vases imitate the Italian form and are stamped *arretinum verum* or 'genuine Arrezzo,'. Pucci (1983:110). Harris (1980:138-39) documents similar unauthorized use of 'brand names' in copies of terra cotta lamps, although he thinks that ceramic historians have exaggerated its extent..

the fourth centuries AD. Distribution was widespread, but production was concentrated in a handful of centres.[91]

Most of what we know about sources of increasing returns must unfortunately be inferred from the general characteristics of pottery-making and archaeological vestiges, since the industry has left virtually no literary remains. Nevertheless, with the exception of certain developments in the application of glazes, ceramic technology experienced no fundamental improvement from Roman times to the early eighteenth century, when Europeans successfully copied Chinese porcelain.[93] We thus know enough about ancient ceramic techniques to identify the sources of cost advantages in mass production.[94] The use of specialized equipment was crucial. In contrast to the traditional hand method of building pots from coils of clay, large-scale potters employed a weighted fly-wheel to build the clay rapidly into a cylinder Used in conjunction with a cylindrical mould with the design cut into interior wall a skilled potter could execute upwards of two hundred identical vessels per day.[96] There were also economies of scale in the preparatory operations. At Arezzo levigation tanks used to settle out heavier non-clay particles from the clay had a capacity of up to 10,000 gallons.[97] Kilns were built to fire large quantities at a time. Tunisian potters fired up to 2,000 pieces in hermetically sealed boxes,[98] Graffiti inscribed on shards at La Graufensenque as a means of recording production indicate that as many as 30,000 individual pieces could be fired in a single batch The same tally records 409,315 pieces produced by 34 workmen employed in a single establishment.[99]

The red ware industry collapsed between the fifth and seventh centuries. While the decline of the Arretine manufacture was probably due to competition from southern Gaul and North Africa (along with an ill-considered attempt to resite production at a seaside location near Pisa), the Gallic and North African decline surely reflects the general contraction of the Late Roman era and the correspondingly greater difficulty of marketing a product that was comparatively costly to distribute. The decline can be clearly seen in the

[91] Williams (1977)
[93] Berg (2010)
[94] Fülle's (1997) assertion that the evidence does not support large-scale production based on division of labour rests on an undemonstrated assumption that the market for Arretine wares was not extensive enough to support it. This is precisely the question at issue.
[96] Pucci (1983: 125-26)
[97]Peacock (1982: 122).
[98] Bonifay (2007)
[99] Peacock (1982: 125-26)

deterioration of the quality of the red slip ware produced at La Graufenseque and other potteries that begins in the later third century and accelerates through the fifth and sixth. Wheel-thrown pottery was displaced hand turned vessels; pots are made from coarser clays and fired at lower temperatures; slips less carefully applied and the decoration deteriorates.[100] In Italy the decline is clearly signalled by the abandonment of specialized production in the upper Volturno valley in the early sixth century, although wheel-thrown wares continued to be imported into areas closer to the Adriatic coast, whence manufactured wares from Africa could still be secured at low cost.[101] North of the Alps, centralized production seems to have largely disappeared by the end of the sixth century.[102] The overall pattern is one of reversion to local markets. When the extent of the market contracted, so did large-scale high-quality production.

The ancient iron industry is an example of an industry whose output went mainly into fabricating weapons and agricultural equipment rather than articles of popular consumption.[103] Unlike fine pottery, the techniques of ferrous metallurgy and ironworking were widely diffused through Europe and North Africa well before Roman annexation.[104] The technical mastery of Celtic smiths is well attested. By the end of the 7th century BC they had mastered the art of forging plough shares and by the beginning of the 3rd were fitting iron tires to wooden wheels, more proficient than their medieval successors who could only nail them.[105] Caesar admits to being impressed by the iron in the ships of the Venetii, noting that cross-pieces were fastened with nails 'as thick as a thumb[106] and archaeologists have recovered 24 tons of iron from the fort at Vindolanda. Iron was worked up in agglomerations like Michelsburg, Manching, and Alesia,[107] but the dispersion of the agricultural clientele that used them produced a sympathetic dispersion of smiths who forged and repaired the tools. That dispersion was renforced by the ubiquity of iron ore in quantities sufficient to supply the bowl furnaces used to reduce ore to iron in the first Iron Age. These

[100] Arthur (2007) The one exception to the general decline was the spread of lead glazed vessels.

[101] Hodges and Patterson (1986: 23)

[102] Hodges and Patterson (1986: 16-17)

[103] Manning (1985) for examples. Iron cooking vessels are an obvious exception. Perhaps the most sophisticated iron objects of popular consumption were the metal styli used to inscribe wax writing tablets, tweezers, and nail cleaners. A European inventory of these objects might provide useful insight into a metallic consumer industry. On their ubiquity in the Romano-British countryside, see Mattingly (2006: 461, 464-65). On their fabrication, see Sim (1997).

[104] Central Europe 700 to 400 BC. Balassa (1973,; Baranova (1989);

[105] Buchsenschutz (2007: 64); Piggott (1983: 164-67)

[106] Cited by Greene, 1986:22)

[107] Dehn (1962); Jacoby (1974); Mangin (1981)

factors supported widely distributed small-scale production oriented to the needs of local users.

Despite these constraints, archaeological investigations reveal numerous examples of iron smelting on a large scale.[108] The works at Populonia are the best known,[109] but the list of other centers of production is lengthening as investigators sift through sites where nineteenth-century ironworks exploited and largely destroyed iron-rich slag from Iron Age smelting.[110] The district of Saulieu in the Morvan region of Burgundy is a good example. In the 1980s a systematic survey of 400 km² uncovered more than 200 ancient metal working sites, almost all bloomeries.[111] Iron bars discovered near the bloomeries were flecked with gangue, indicating that the sponge was intended for export to other districts to be worked up into bars and tools.[112] Investigators also found a big increase in the number of smelting sites after the Roman conquest. Specialized industry almost always implied specialized farming,[113] and it is therefore not surprising that the areas producing food for nearby iron-workers was more densely populated in the first centuries AD than 1800 years later.[114] Production fell off sharply in the fifth century AD and the region seems to have abandoned iron-working until the thirteenth century. Even then, production never attained Roman levels, which no doubt explains why so many early sites survived to the twentieth century.[115]

Although the bloom produced by individual furnaces increased over time, restriction the size of furnaces resulting from the use of hand powered bellows meant that the growth in output was achieved by multiplying the number of furnaces. Archaeological excavation of ancient iron working sites in the Holy Cross mountains of southern Poland reveals batteries of 80 to 200 furnaces, and the remains at Populonia indicate a huge, though as yet underdetermined

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[108] Mangin (1989)

[109] Voss (1988) When French mining engineers surveyed the slag at Populonia in the 1850s by French mining engineers it extended 600 meters along the strand. The quantity of smelted ore estimated from that pile is 2 x 10^6 tons over the four to five centuries the works were in operation The abandoned site was the occasion for an elegiac reflection by Rutilius Namitanius (ca 420 AD) sailing past his way home in

Gaul. *Cernimus exemplis oppida posse mori.* Rutilius Namitanius, *De reditu suo sive Iter Gallicum.* Paris: Belles Lettres (2003)

[110] Radwan (1965); Kuna (1989); Mangin (1989)

[111] Mangin et al. (1992: 219)

[112] Mangin et al (1992: 235) Because small bowl furnaces did not reach temperatures high enough to fuse all the material in the ore, the sponge resulting from the smelting process was typically mixed with gangue that had to be removed by hammering.

[113] See in particular the remarkable surveys of central Auvergne. Trément (2004); Deberge (2007)

[114] Mangin et al. (1992:17)

[115] Mangin et al (1992 : :237)

concentration.[116] .Concentrating bowl furnaces on a single site afforded economies in preparing and stocking fuel, roasting, crushing, and screening ore prior to smelting. In small works pieces of broken ore were sorted by hand; in large operations the ore was screened.[117] The use of pits to collect molten slag also exhibits local economies of scale. Drawing off slag to an external pit saved fuel and permitted a longer smelt because the slag no longer extinguished the fire in the bowl. To economize the cost of digging pits, furnaces were arranged in circular batteries draining into a common sink. The consequence was an increase in output per smelt. The size of blooms increased from two to three kilograms in the 4th century BC to 10 kilograms in the early Empire.[118] That the change was induced by increased demand seems certain, as the bloom fell back to around 5 kilograms in the early Middle Ages.[119]

Other industries also afforded significant opportunities to exploit latent economies of scale in the division of labour,[122] but the most interesting case in view of its subsequent importance for European industrialization is the hardest to trace. More than any other pre-industrial manufacture, textiles offered the widest possibility for commercialization because of potentially massive aggregate demand for ordinary products, a high level of product differentiation for signaling status, and low transport costs resulting from their high value relative to weight and bulk. At the same time, the process of production supported high levels of specialization by task based on a succession of discrete operations transforming raw fiber into finished cloth, all of which could be simultaneously conducted in an on-going operation. In the later middle ages and early modern era, the sector supported a vast rural industry carried out in households and organized by merchants through by a 'putting out' system who supplied them with raw materials and marketed the output. Unfortunately, the evidence from classical antiquity is hard to come by. Literary references to places known for their textiles and to local breeds of sheep known for the quality of their wool indicate a manufacture resting in some measure on long-distance trade in raw materials and finished goods,[123] but apart from the well-known Igel monument,[124] the archaeological record has proven recalcitrant to generalization derived from physical evidence.[125] The most promising sign of

[116] Radwan (1965); Voss (1988)
[117] Ehrenreich (1985: 20-21)
[118] Tylecote (1973; 1980)
[119] Tylecote (1992)
[122] The most recent survey is by Wilson (2008).
[123] Jones (1960); Wild (2008)
[124] Drinkwater (1982; 2001)
[125] Gleba (2007), Gleba and Mannering (2012)

specialized manufacture to be recently recovered is the excavation a neighborhood in the Numidian city of Timgad that was given over to fulling (and possibly dying) woolen cloth for export.[126]

There is nevertheless one body of documentary evidence for specialized textile production that comes from inscriptions tax records from Ptolomeic andRoman Egypt that clearly indicate the existence of a local industry with significant division of labour.[127] A 3rd century payprus from Oxyrynchus records an advance payment to a tapestry weaver for two years service by the master of a workshop. Another papyrus from the same *fond* mentions the foreman of a workshop said to employ 'scores' of workers.[128] Doss-Krüpe's exhaustive analysis of the tax roles from the Theban districts of Oxyrynchus and Arsinoites reveals a well-developed industry that drew wool from specialized flocks in the Arsinoites, and a well-developed system of apprenticeship for training wool-combers, weavers, shearers, and tailors.[129] Although nomenclature of the specialized occupations is not perfectly clear, there is enough to indicate a high level of specialization by task.[130] The number of persons involved in that manufacture appears to have been substantial, though possibly not so large as implied by an estimate from 3rd-century tax rolls of an output of 100,000 pieces per year, which put Arsinoites on a par with the greatest textile towns of the Middle Ages.'[131] Dross-Krüpe estimates that the workers needed to produce the various kinds of cloaks recorded in the Oxyrnchos documents would have come to 21 percent of the local population.[132]

Across a wide spectrum of activities, then, the market economy of the Ancient World possessed latent economies of increasing return. As noted in the first part of this paper, such economies raise the possibility of that economy possessing multiple equilibrium states. Since technologies and resources

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[126] Wilson (2001)
[127] Ruffing (2008); Dross-Krüpe (2011)
[128] Aubert (2001: 104-105).
[129] Dross-Krüpe (2011:106-106).
[130] 'Diese schiere Vielzahl an Berufen und Spezialisierungen illustriert die Bedeutung dieses Wirtschaftssektors, in dem zweifelsohne eine grosse Zahl an Personnen ihr Auskommen fand.' P. 101
[131] Van Binnen (1986), cited by Dross-Krüpe (2011 : 79)
[132] Dross-Krüpe (2011 :85)
[140] Temin (2013: 193).

evolved slowly, rapid growth or decline could well have reflected movement from one state to another.

Agriculture, Population, and Diminishing Returns

Even if the division of labour and market pooling created a potential for increasing returns in the exchange and processing of raw materials, expansion could always be shut down by diminishing returns in agriculture. That this must have been the case is an article of faith among ancient historians old and new. Summing up the Roman economic experience, Temin writes, 'Rome did not have an industrial revolution. Without this momentous change, Rome was subject to Malthusian pressures that limited its economic growth.[140] Commenting on the ancient limits to urbanization, Kehoe observes, 'Since the growth of the urban economy was so closely linked to agricultural production, the possibilities for economic growth were limited.'[141] Frier sums up the conventional wisdom:

'Simply put, what I wish to observe is that the Roman empire was clearly exposed to the possibility of excess population growth, and that as a result some portions of the population could have approached the "Chinese" situation described by Wrigley and Schofield.'[142]

The notion that the Ancient economy was effectively constrained by a fixed land supply is a fixed point in reasoning about its expansion, stagnation, and decay. Yet, the proposition rests on its impeccable economic logic more than on empirical evidence-- impossible to assemble at scales of aggregation required for effective testing.[143] The correlation between rising wages and large negative population shocks is suggestive, but hardly probative in view of other factors affected by a sharp drop in population unattended by a similar drop in the stock of exchangeable wealth. On the doubtful assumption that they are generated by nationally integrated markets for labour and farm produce, wage and price data provide the best opportunity to demonstrate presence of Malthusian dynamics, but more than four decades of rigorous work with the extant time series on these data has failed to turn up unambiguous evidence of a Malthusian link between real wages and demographic changes in the pre-modern era.[144] What the data

[141] Kehoe (2007 : 546).
[142] Frier (2001: 150)
[143] The Malthusian paradigm models the behaviour of a closed economy subject to diminishing returns, which are plausibly (though as it turns out incorrectly) implied by a fixed land input. Unless one has information on total input and output, individual observations will be contaminated by the possibility of trade in the output, which means nothing can be legitimately inferred from them with respect to the Malthusian hypothesis.
[144]Weir (1991); Lee (1993)

show is that there seems to be a secular ceiling to real wages.[145] It does not explain what imposed that ceiling. There is also little evidence that population pressure in the past depressed living standards to the edge of famine.[146]

The Malthusian paradigm rests on the assumption of diminishing returns to labour in agricultural production.[147] I have elsewhere argued at excruciating length why I think that assumption does not necessarily hold for pre-modern economies.[148] The main reason is that traditional husbandry supported significant output response to changes in market demand. This usually required involved increasing the input of labour and capital, which for ecological and economic reasons often resulted in rising rather than falling productivity and land and labour.[149] The working out this effect took extended periods of time, because it was produced by gradual reorganization of the units of production and gradual accumulation of the capital (which assumed many forms, both physical and human) needed for more intensive specialized production. In the short term diminishing returns continued to hold; it was only over longer periods that adjustment market demand led to higher productivity. This process has recently been investigated for the region around Rome, which was particularly well situated owing to the enormous level of consumption of the capital's population. Erdkamp's study of the Roman grain trade at its height in the late Republic and early Empire shows the close connection between large and medium-sized landlords and farmers in the district and the markets they served. He estimates that in well-cultivated districts of Italy—well-cultivated because their farmers had an interest in cultivating them well—yield ratios were probably in the range of 8 to 10 to one, which at sowing rates of 2.5 to 3 hectolitres imply gross yields of 24 to 30 hectolitres per hectare, which is at the top of the range for pre-industrial yields.[150] Kron's review of the Latin agronomical treatises and the emerging picture of the Roman hinterland as a *pays* of prosperous modest farms gives confirming evidence of an agricultural system capable of producing significant surpluses when the occasion offered. The technological reason is that the technology underpinning classical farming was essentially the same as the agricultural technology of early modern and early industrial agriculture, so that, making due allowance for the climatic

[145] Clark (2007)

[146] Cohen (1995); O Grada (2007), but see Kelley and O Grada (2012)

[147] It also applies to the production of energy, which has recently acquired prominence as the critical limiting factor on pre-industrial economic growth (Wrigley (2010); Malanima (2006)

[148] Grantham (1989; 2010)

[149] The changes also include rearrangements in farm size and lay-out to save labour, and the specialization of traditional tools to specific tasks.

[150] Erdkamp (2005)

differences between central Italy and northern Europe, the productive response to local opportunity should have been similar.[151]

Average productivity in the Empire was undoubtedly low. In medieval and early modern Europe, where islands of high productivity are well-attested, everywhere else productivity was abysmal. At the beginning of the fourteenth century, when yields on some manors in southeast England approached 18 to 20 hectolitres per hectare, average yields in the country as a whole were probably around 10.[152] The most plausible explanation for that gap, which is reproduced at higher geographical scales, is that in most places it did not pay farmers to cultivate at levels of intensity producing high yields. The technology was there, but not the incentive.[153] In the pre-industrial era urban demand supplied the strongest and most stable incentives to reorganize agricultural production, which has led historians recently to connect the apparent prosperity of the Roman agricultural hinterland with the market at Rome. The evidence seems to confirm that hypothesis, but one should recall that additional output could sometimes be squeezed out by exploitative means – as apparently happened in Sicily—as by the positive intensive responses outlined above.[154] Productive responses to urban growth were not inevitable, as the experience of seventeenth- and eighteenth-century Naples clearly shows.[155] Yet, the balance of evidence suggests that in many parts of the Empire, the response was positive. It is reasonable to suppose then, that over large swathes of the territory incorporated by Roman administration or affected by the Roman economy, the agricultural response to non-agricultural specialization, much but by no means all indexed by urbanization, was sufficient to meet the additional demand for food and raw materials it generated. Agricultural elasticity was a permissive, not a causal factor in the elaboration of more specialized economies..

In an argument dealing with agricultural productivity in Roman antiquity, one inevitably must to say a few words about the vexed dispute between supporters of 'high' and 'low' counts of the population of Italy under Caesar

[151] '[T]he Romans incorporated most of the critical technical advances of seventeenth-century Dutch and nineteenth-century English farming into their already intensive traditional peasant agriculture.' Kron (2008: 73)

[152] Campbell (2000)

[153] Grantham (2007; 2011)

[154] 'More significantly, it cannot be automatically assumed that such a rise in the urban population was supported by increased productivity than, say, redistribution of the existing surplus production.' Morley (2011: 151)

[155] Marin (1996)

[160] Lo Cascio (1994)

Augustus. As is well known, Beloch adopted a low count based on his conviction that Italian agricultural productivity in the 1880s could not have been lower than in Roman times (although it might have been lower than during the Renaissance.[160] The finding that Italy's agricultural productivity in the late nineteenth-century was possibly only half what it was in 1300 suggests he was probably mistaken.[161] It is clear from the debate, however, that the dispute between the 'high counters' and the 'low counters' is unlikely statistically to be resolved by the kind of evidence that can be brought to bear on it. Deep ploughing of prime farm land in Italy has probably destroyed all possibility of recovering the density of rural settlement at different points of time in antiquity, and without that evidence it is impossible to set narrow bounds on the range of population estimates.[162] In the degree adherents of the low count base their ultimate defense on the proposition that agricultural productivity was too low to support a high count—as I believe is Scheidel's ultimate line of defense—the claim introduces facts not in evidence.[163] If anything, the evidence from agricultural productivity discussed above runs the other way. Anthropomorphic evidence bearing on the nutritional status of rural people can potentially throw light on this question, but as yet sample sizes are too small and too dispersed to support broad generalizations about the supply of foodstuffs.[164] My own view is that agriculture was sufficiently responsive to support fairly high levels of non-agricultural specialists, who were not uniquely located in cities. In the degree that population responded positively to income—or more precisely to opportunities for establishing independent households at customary living standards, low income and endogenous changes in output and specialization could go together. One does not exclude the other.

[161] Federico and Malanima (2004)
[162] Mattingly (2011)
[163] Scheidel (2008)
[164] Kron (2005) gives a possibly over-optimistic assessment of these data.

Growth and Decay

The Roman economy of the first century BC did not spring fully formed from a subsistence economy like Minerva from the head of Jupiter. The emergence of a spatially integrated economy stretching from the shores of the North Sea to the Euphrates occurred over eight to nine centuries during which trading connections between the eastern and western Mediterranean and between the Mediterranean and northwest Europe were intermittently knitted together.[169] Archeological evidence has confirmed and modified references to these developments in the ancient texts, although much remains obscure, particularly events in the fifth and fourth centuries that brought the Celts across the Alps into northern Italy and as far east as Galatia in Asia Minor.[170] One need not exaggerate the intensity of exchange to attest to its existence, which in terms of the search-equilibrium approach sketched out above is all that is needed to set the machine in motion. What seems clear from the record is that by the the beginning of the sixth century BC substantial communities having commercial connections with the outside world had established themselves in southwestern Iberia, Africa (modern Tunisia), Sicily and southern Italy, and Tuscany. The connecting of the eastern and western Mediterranean seems to have been provoked by rising demand for silver for means of payment in the Assyrian and Persian empires, that of the Mediterranean and Celtic Europe by the Celt's infatuation with wine and exotic articles of adornment, remarkably including articles made with Chinese silk.[171] The western connection was made possible by the improvements in ship construction and rigging in the Late Bronze Age Levant permitting long voyages involving significant stretches of sailing against

[169] Grantham (2006) This paper, which was submitted to the *Economic History Review* in the summer of 2006, sat on the referee's desk for three years before being rejected on the grounds that it does cite Scheidel et al (2007)!

[170] Les siècles appelés obscurs dans le monde grec, par lesquels nous allons aborder l'Âge de Fer, ne sont obscurs que pour nous.' Buchenschütz (2007 : 25)

[171] Champion and Champion (1986) Laubenheimer (1991); Schutz (1983 : 212)

the wind;[172] the penetration of the Celtic hinterland probably involved little more than traditional pack animals.[173] One should not exaggerate these early connections. It was not until well into the sixth century BC that signs of quickening development in Iberia, Italy and Tunisia become clearly evident. It is perhaps significant that the Greek colonies in southern Italy adopted coinage almost simultaneously with Greek cities in the homeland.[174]

The real upswing in trade and production between northern Europe and the Mediterranean, however, seems to begin after the middle of the fourth century BC. By the end of the third century, coins were being minted in Gaul. The following two centuries witnessed accelerated integration with the expanding Roman world. The evident quickening of exchange is associated with alteration in the size distribution of farms and the emergence of nucleated centers of artisanal production and distribution nodes.[175] In the first century BC these developments reach across the channel into southern Britain. Thus, by the time of the Pax Romana, the trading networks that would underpin the Roman economy at its peak were already largely in place. At present it is not yet possible to identify the shocks that set this process into motion, but it is becoming increasingly clear that the western European trading system was moving from a low to high-intensity equilibrium. That movement accelerated after the Roman conquest, plausibly owing to more rapid transfer of Mediterranean technologies and the imposition of a common law and a common peace.

The decline of the Roman economy was swifter than its rise. Setting aside the survival of a seemingly prosperous economy in North Africa and the eastern Empire through the fifth and into the sixth century, the collapse of the western economy after what now seems to have been a surprisingly prosperous fourth century is nevertheless surprising by its rapidity.[176] The collapse does not seem to have been caused by a structurally overburdened agriculture or to the inefficiencies of a supposedly 'dirigiste' state. The recovery of the fourth century belies the theory that it was triggered by the Antonine Plague. It was not caused by the invasion of 'hordes' of German barbarians, whose numbers we now know were small in relation to the settled Roman populations.[177] But collapse there was. The political chaos in the fifth century no doubt accounts for much of the decline, but its speed suggests that once the contraction began, the positive externalities that had powered growth in the expanding phase went into

[172] Wachsmann (1998)
[173] Laubenheimer (1991);
[174] Osborne (2007 :278); Von Reden (2007)
[175] Buchsenschutz (2007)
[176] On the prosperity of the fourth century, see Carrié (1994). The Romano-British economy was also at its peak around 350. (Mattingly (2006)
[177] Goffart (2009)

reverse with a vengeance. Search-equilibrium economics is a two-edged sword. When things are going well, it makes them even better; but when they start going poorly, the fixed costs that underpin increasing returns become more difficult to bear. Trade becomes more difficult and risky; the cost of maintaining connections takes up a higher proportion of the returns. As trade declines, the returns from trade decline. The first signs are the decay of the sites most directly connected with intense exchange: towns, cities, and specialized industrial establishments.

This is the briefest sketch of a possible dynamics of the classical economy. Most of the basic research needed to substantiate the claims made here still needs to be done. I believe that the necessary conditions for a search-equilibrium dynamics are well established. They include market exchange over significant distances, economies of scale in handicraft manufacture, and perhaps more contestably, elastic agricultural supply. Getting the chronology right is a more difficult enterprise. I believe a promising avenue is to construct inventories of agglomerated sites at 50-year intervals stretching from the fifth century BC to the sixth to seventh century AD. The growth of trade necessarily involved the creation of small centres that functioned as nodes in the trading network. The continued discovery of small towns from the Roman era whose populations probably ranged from 500 to 1000 persons suggests that this is exactly what happened.[178] Work by Frédérique Trément and his associates along these lines for Celtic and Roman developments in the Limagne in central France shows how this kind of inventory can be constructed for long periods of time.

As to the theoretical perspective, one must keep in mind that because neoclassical and search-equilibrium models address different questions they come up with different answers. The neoclassical model is concerned with the allocation or resources on the assumption that resources are scarce. The search-equilibrium model is concerned with the question whether and why resources may be underutilized. The claim of this paper is that much (though not all) of the variation in production and productivity in antiquity arose from endogenous variations in the intensity of resource utilization. Resources may always be scarce, but in the presence of increasing returns the resource constraints are conditional on the state of the economy. The search-equilibrium paradigm is a looser, but richer framework for investigating the economic evolution of antiquity.

[178] Burnham and Wacher (1990). Since the publication of this book, many more such centers have been discovered.

4. A Non-Mathematical Appendix[179]

Assume a barter economy in which goods are produced to inventory to be sold conditional on the seller finding a buyer. The variable of interest is the probability of meeting a buyer, who is simultaneously a seller of another good from inventory. Matching is a random process described by Poisson distribution the mean of which is the probability of an individual agent making a successful match in a fixed interval of time. It is assumed that this probability rises with the number of agents seeking matches. Equilibrium is defined by the condition of constant inventories – i.e.,sales are exactly replaced by new production.

Inventories are produced at costs described by a cumulative frequency distribution.[180] After making a sale, an agent makes a random draw from that distribution. Since individual draws have different costs attached to them, higher levels of production to inventory necessarily involve some draws that incur higher cost, analogous to an upward sloping supply curve. The difference is that in a standard supply functions producers compare the marginal cost of additional production with its expected price. Here, agents are presented with a project of predetermined cost, and decide whether to accept it on the basis whether or not they can find a buyer for the output. There is a maximum cost at which agents will accept the project and produce to inventory.

We can represent the steady states associated with different cut-off cost by a graph with the cost on the vertical access and inventories on the horizontal one. Following Diamond's notation we designate the inventories by the letter *e* and the cut-off cost by *c**. The graph sets out the steady state values of *e* (i.e. where inventories are constant) for different levels of *c**. The graph begins from a point above the origin because the least expensive draw has positive cost. The curve represents the minimum cut-off cost at which a given level of inventory is maintained in the steady state. Alternatively, it is the cost that must be met for production at that level to be sustained. The curve rises with inventories because higher levels of production require the acceptance of more costly projects.

The next step is modeling the cut-off cost for accepting a project to produce to inventory. An agent who sells her inventory makes a new draw from the distribution of possible projects to which trhere attaches a cost specific to that

[179] This appendix verbally reproduces the mathematical exposition in Diamond (1984).

[180] A cumulative distribution specifies the probability that a particular outcome has probability less than x, where the maximum value of x is 1. Thus, the probability that an outcome is less than 1 is 100 percent, while the probability of it being less than 0.5 percent will ordinarily be less than 100 percent. How much less depends on the shape of the function.

project. The cut-off cost is that cost at which she is indifferent between accepting or rejecting that project. Given the project's cost, the decision to accept depends on the probability of selling the inventory once it is produced—i.e., the probability of making a successful match within the matching time interval. Sales in that interval cover the cost of production, while failure to sell pushes the matching event forward in time, thereby imposing an additional interest cost. The cut-off cost thus rises with the probability of a successful match. Since that probability is positively correlated with aggregate inventories (i.e., the number of agents seeking matches), the higher the level of production to inventory the higher the cut-off cost. In ordinary language, production increases with the extent of the market, and the extent of the market increases with aggregate production.

The form of the curve relating the cut-off cost to inventories is thus upward sloping from the origin (if there are no inventories there can be no prospective sales and thus no incentive to produce to inventory). On the assumption that the marginal utility of consumption obtained from the goods purchased with the proceeds of the good sold from inventory diminishes with the level of output and consumption, the curve has an upper bound, and therefore concave.

Putting the two functions together yields the steady-state level of aggregate inventories. This is the level at which the maximum acceptable cost associated with that level of production is the same as the minimum cost that must be accepted to sustain it. This equilibrium is illustrated by figure 2.

The concave upward curve is defined by the condition that inventories are constant ($e = 0$). This is the minimum cost that must be accepted to maintain inventories at a given level as denoted by the *e* axis. The concave downward curve is the maximum cost that will be accepted at any given level of inventories. Recall that the level of inventories is positively associated with the probability of a successful match.

Figure 2 shows that under the posited assumptions there is more than one possible equilibrium level of inventories: the origin, where nothing is produced, an intermediate level, where the maximum acceptable cost curve intersects the minimum acceptable curve from below, and a high level where the maximum intersects the minimum from above. The shapes of the curves are merely illustrative. In practice they may both be wavy.

The important equilibrium is the intermediate one. It is unstable. If for any reason inventories fall below that level, the maximum cost which agents will accept at the new level of inventories is below the minimum that must be accepted to maintain that level. As a result production falls. As long as this condition holds it continues to fall. The end point is the origin. This condition characterizes economic implosion. As the extent of the market contracts, the incentive to produce for the market contracts, which further diminishes the

extent of the market. Conversely, deviations to the right of the intermediate equilibrium result in the minimum acceptable cost being below the maximum acceptable cost. Projects are accepted, inventories rise, which further increases the acceptable cost, creating a virtuous circle of expansion. That expansion is ultimately cut off by the rising marginal cost of additional projects, which can loosely be interpreted as reflecting the law of diminishing returns. The model thus has two stable equilibria. One in which there is no production, and one at which production is at a maximum.

The moral of the story is that an economy with positive costs of matching buyers and sellers is likely to have more than one stable equilibrium level of activity, which means that it can settle at a low level of output or a high level depending on which side of the unstable equilibrium it happens to land. Note that this account abstracts from feedbacks between the level of production and the menu of costs. Where there are economies of scale in production and distribution, a move to a higher equilibrium will cause the minimum cost of sustaining any given level of inventory to fall and the maximum price of undertaking new projects to rise. These reactions capture much of what Adam Smith had in mind when he asserted that the division of labour is limited by the extent of the market.

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