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Toward a Factor Proportions Approach to Economic History: Population, Precious Metals, and Prices from the Black Death to the Price Revolution

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In the history of economic doctrine the name of Bertil Ohlin is inseparable from that of Eli Heckscher. The origin of the famous Heckscher-Ohlin theorem is the pathbreaking article by Heckscher (1919) in the special 1919 David Davidson *Festschrift* issue of *Ekonomisk Tidskrift*, later developed by Ohlin in his doctoral dissertation (1924) and his monumental *Interregional and International Trade* (1933). Together, these three works established the factor proportions approach to international trade.

Heckscher, History, and Theory

When it came to economic history, Ohlin and Heckscher differed completely. There are historical examples in both *Handelns teori* and *Interregional and International Trade*, but Ohlin was mainly concerned with theory and contemporary economic problems in his work. Heckscher was different. Despite his original contributions to trade theory and his numerous pieces on the empirical economic problems of his day he was first and foremost an economic historian—"the sole creator of economic history in Sweden as an institutionalized field" (Henriksson 1991:142)—with such works as *Mercantilism* (1931a) and a four-volume (uncompleted) economic history of Sweden from the early sixteenth century to 1815 (1935–49) to his credit. It was the writing of the latter that he conceived of as his "real task" (Henriksson 1991:148).

Even so, it would be unfair not to conclude that Heckscher had one foot in history and another in economic theory. What is more, he was a pioneer when it came to linking the two. Heckscher dealt with

the principles of connection between economic theory and economic history on at least nine occasions: 1904, 1920, 1922, 1929, 1930 (1933, 1936), 1937 (1944), 1942, 1947, and 1951. The main credo was laid down already in the first of these (1904), when the inductive method was rejected and the use of deductive economic theory was (implicitly) held out as the method to be applied in the gathering and interpretation of historical facts. This part of Heckscher's research program was to stay with him for the rest of his life. Both the early 1904 article and his subsequent publications on method foreshadow the development of the modern analytical approach by the New Economic History movement that began in the late 1950s. This is true not least of his 1920 article and 1922 book chapter (which overlap to some extent). The latter headed a volume intended to demonstrate the connection between the study of economics and of history, the importance of knowledge of general economic relations and of insight into the historical development for understanding economic relations (Heckscher 1922:9).

For Heckscher, the fundamental characteristic of economics is that it deals with problems of scarcity, and since scarcity is a feature that has accompanied mankind since the beginning of history, "the economic problem must be *fundamentally* the same in all ages" (Heckscher 1929:527). It then follows that economic theory should have some contribution to make not only when we deal with recent times but also to the study of more remote historical periods (Heckscher 1922:29, 1929:526). Already in 1904, quoting the dedication to Gustav Schmoller of a book of essays by William J. Ashley (1900:v), he wrote that for the economic historian it was "an imperative duty" to "be an economist without ceasing to be an historian" (Heckscher 1904:198). To be sure, Heckscher never argued that all of history could be explained by economic factors (Heckscher 1944), and he was also quite adamant in his opinion that the use of economic theory had its limitations. Theory was useful in the analysis of events during a given period or epoch with more or less given characteristics, but when it came to questions such as how one epoch evolved into another he argued that economic theory had little to offer (Heckscher 1920:20). The causes had to be sought elsewhere, "since the changes in the conditions of economic life have sprung mainly from other areas of society and hence must be considered as inaccessible for economic theory" (Heckscher 1951:54; cf. Henriksson 1991:165).

Heckscher was also cautious to point out that in the historical perspective the institutional framework matters (Heckscher 1922:24–25):

> [I]t is very dangerous to regard economic history only from the point of view of material for comparison with the theories that aim to explain present-day economic relations, since to a large extent, the kind of theory required to explain the circumstances of earlier times must be one that *differs* from the one valid for today. The economic theory that has been developed above all during the last century and a half takes as its point of departure a host of assumptions both with respect to the organization of society—rule of law, regular transportation possibilities, market organization, etc.—and with respect to the state of mind—the ability to calculate, procure information, take care of one's interests, etc., which in no way have always been present in previous times or, for that matter, today.

Still he argued that "for most periods of known Economic History the changes necessary in the usual theory are not fundamental, however" (Heckscher 1929:528). Furthermore Heckscher (1922:29) claims:

> [N]othing could bear more witness of less insight into the ways of science than believing that a theory would be completely useless because something, no matter what, in the surrounding reality has changed.... Sometimes, it seems the reasoning criticized here more or less explicitly takes as its point of departure the notion that it is impossible to apply modern economic theory to times when it did not exist. The absurd character of such an idea, however, immediately stands out.

What was fundamental for Heckscher was that when it came to the "*choice* of facts and the *explanation* of them" (Heckscher 1929:529, cf. 1951:45–54), the use of economic theory was indispensable, since "only when the pure theory of economic relations has been made clear has a heuristic principle has been found, and insight obtained about the questions to be posed in the area of economic history" (Heckscher 1936:10). At the end of the day, the "plea for theory" had to be made, "since central parts of the course of economic history cannot be studied successfully without access to or, rather, familiarity with the body of ideas of the economic science" (Heckscher 1951:45).

Strangely, however, in his empirical historical work Heckscher does not appear to have made much use of the basic theoretical construct he himself originated: the factor proportions approach. His 1919 paper receives a passing mention in a footnote in *Mercantilism* (Heckscher 1931a, vol. 2:110), and in the discussion of labor as a

factor of production in the mercantilist system, he notes that the policy of keeping labor costs down would lead to increased exports of labor-intensive goods (Heckscher 1931a:135). No use of the approach is made either in his work on the history of industrialism (Heckscher 1931b), or in his two major surveys of Swedish economic history (Heckscher 1942:1935–49).

What was it then that inspired Heckscher to produce his 1919 theoretical breakthrough? If we are to believe the introduction of Flam and Flanders (1991) to their translations of Heckscher's 1919 article and Ohlin's 1924 dissertation, it was his desire to defend free trade from the charge by Knut Wicksell, that it might induce extensive emigration, as happened in Sweden at the end of the nineteenth century under the stimulus of cheap grain imports from across the Atlantic. If it was possible, even if not empirically likely, that trade alone could equalize factor prices, then it would not be necessary for any adjustment through factor movements to occur at all.

In this chapter we will attempt to demonstrate the power of the factor proportions approach not just as a pure theoretical construct but as a tool of economic history. To some extent the point has already been made by the literature that emanated from the "sector-specific" version of the factor proportions model of Ronald Jones (1971). The connection of this theoretical contribution with the explicitly historical concerns of Habbakuk (1967), Temin (1966, 1971), and Fogel (1967) is examined in Findlay (1998).

A major historical episode, to which the factor proportions approach must be applicable if indeed it is applicable at all, is the Black Death, the catastrophic plague epidemic that reduced the population of Europe in the middle of the fourteenth century by a third, possibly even more. We will propose in what follows a suitably extended factor proportions model that can account for the most important facts of this momentous event.

An Extended Factor Proportions Model

The model that we are going to sketch is an extended version of the Jones model with sector-specific inputs. One sector produces "goods," considered as a generalized commodity à la Solow, with a specific factor "capital" that is a stock of the same "stuff" as the output that it produces together with labor. The only other sector of the

economy produces a commodity, "silver," with inputs of a specific stock of natural resources (which we can think of as an essentially limitless deposit of silver), obtainable with the input of labor but with diminishing returns at the margin. Thus far the model has exactly the same structure as the original Jones (1971) article.

The relevant equations are

$$G = G(L_g, K), \tag{1}$$

$$S = S(L_s, \bar{N}), \tag{2}$$

$$L_g + L_s = L, \tag{3}$$

where G and S are the flow outputs of goods and silver, L_g and L_s the labor allocated to each sector, K the specific input to G, and N the specific input to S. The labor allocations to each sector add up to the total labor force L available. Both production functions have constant returns to scale and positive but diminishing marginal products for all the inputs. Of the three inputs only natural resources, the specific input N to the silver sector, are fixed as in the original Jones model.

The supply of labor is determined endogenously by a Malthusian mechanism of the type proposed by the economic demographer Ronald Lee (1973). Denoting the real wage in terms of goods as w, we have fertility f and mortality m as increasing and decreasing functions respectively of the real wage, as stated in equations (4) and (5) and figure 22.1:

$$f = f(w), \quad f'(w) > 0, \tag{4}$$

$$m = m(w), \quad m'(w) < 0. \tag{5}$$

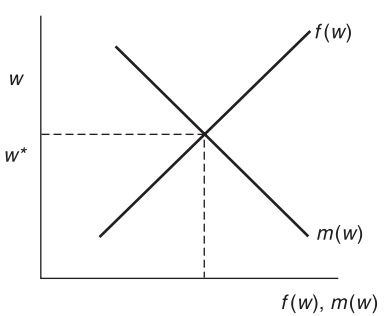

Figure 22.1
The Malthusian mechanism

Population is stationary at a real wage w^* in terms of goods where

$$f(w^*) = m(w^*). \tag{6}$$

The *size* of the population and labor force at this equilibrium real wage w^* will depend upon the endowment of capital and natural resources that the economy has. Assuming, for the moment, that the capital stock K and the relative price of goods and silver is given, the equilibrium level of employment in goods and silver, and thus the size of the total labor force, will be given by

$$\frac{\partial S}{\partial L_s}\left(\frac{\bar{N}}{L_s}\right) = pw^* = p\left(\frac{\partial G}{\partial L_g}\right)\left(\frac{K}{L_g}\right), \tag{7}$$

where $p = P_g/P_s$ is the price of a unit of goods in terms of silver. The equilibrium allocations L_s and L_g are determined from the values specified for p and K by equating the marginal value products of labor in the two sectors.

Suppose now that the Black Death occurs, carrying off a third of the labor force. With fixed stocks of natural resources and capital, and holding the relative prices constant, the effect will be a substantial rise in the real wage, a fall in the outputs of both sectors, and reduced total incomes of the specific factors. This follows directly from Jones (1971).

With higher real wages and per capita incomes, the Malthusian mechanism will lead to a fall in natural mortality after the "one-shot" decline in population due to the plague and a rise in fertility. Population and the labor force will therefore slowly recover, driving down real wages and per capita income until the economy gradually returns to its initial position with the equilibrium values of all variables unchanged. This initial drop in population, and the sharp rise in real wages, followed by a population recovery and a long slow fall in real wages is broadly consistent with European experience over the century and a half after the Black Death.

We now turn to the full extension of the model endogenizing the relative price of goods in terms of silver and the capital stock. If we take silver as the unit of account, so that one "ducat" has a silver content of one ounce in a system of commodity money such as we are going to specify, the national income in the model can be expressed as

$$Y = pG + S. \tag{8}$$

Since p is defined as P_g/P_s, where P_g and P_s are the "nominal" prices of goods and silver in terms of "ducats," it can be thought of not only as the relative price of goods in terms of silver but also as the price level of goods in terms of silver. With silver and goods transformable into one another at increasing marginal cost, a price level of, say, five "ducats" per unit of goods will also be equal to a relative price and a marginal rate of transformation of five ounces of silver for one unit of goods.

The flow supplies of goods and silver are functions of p so that we have

$$G = G(p), \quad G'(p) > 0, \tag{9}$$

$$S = S(p), \quad S'(p) < 0. \tag{10}$$

As the reader can readily verify, we also have

$$Y'(p) > 0, \quad Y'\left(\frac{1}{p}\right) < 0. \tag{11}$$

The national income in terms of silver is an increasing function of the relative price of goods in terms of silver, and a decreasing function of its reciprocal, the relative price of silver in terms of goods.

For any given values of the capital stock K, the natural resource N, and the total labor force L the production possibility frontier showing the trade-off between the flow supplies of goods and silver, will be determined as depicted in figure 22.2. Changing the slope of the tangent to the production possibility frontier, that is, the relative

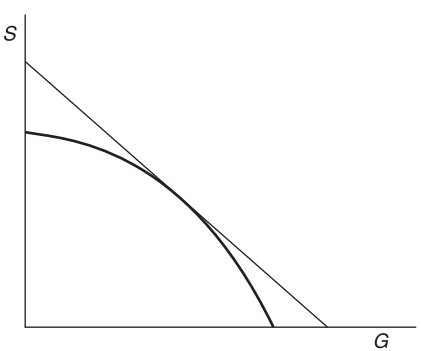

Figure 22.2
The production possibility frontier

price of the two goods, depicts the effects on national income Y of these changes in terms of the vertical intercept, the axis for silver in figure 22.2.

It also follows from the familiar properties of the specific-factor model that the real wage w and the real return to capital r in the goods sector are determined as

$$w = w(p), \quad w'(p) < 0, \tag{12}$$

$$r = r(p), \quad r'(p) > 0. \tag{13}$$

Raising the relative price of goods in terms of silver increases employment in the goods sector with K unchanged and so reduces the marginal physical product of labor in this sector and hence also the "real wage" w in terms of goods, while raising the marginal physical product of capital and hence the real return on capital r in terms of goods. In the silver sector the marginal product of labor increases and the marginal product of the natural resource decreases. The wage in terms of goods and the wage in terms of silver thus move in opposite directions in response to a relative price change, the familiar "neoclassical ambiguity" in the specific-factor model, as opposed to the Stolper-Samuelson or Heckscher-Ohlin-Samuelson model where the real wage changes in the same direction in both sectors when there is a shift in relative product prices.

We now turn to the monetary side of the model. Paper or "fiat" money has become universal only since the twentieth century. In the medieval and early modern periods of western history, and for the Middle East and Asia up to quite recently, movements of the precious metals and their impact on price levels have been of utmost significance. While commodity money is mostly ignored in current modern works on monetary theory it was the focus of detailed attention by the early writers of the subject, from Hume and Ricardo to Wicksell, Marshall, and Irving Fisher. It is an indispensable feature of the story we wish to tell here.[1]

The money supply in our model consists, at any moment, of a stock of coins with a given silver content. For convenience we maintain the convention that each coin has a "face value" of one ducat and a silver content of one ounce, that is, we do not consider debasement and other related issues although these could be analyzed as comparative static exercises within the context of the model. The commodity silver can be costlessly minted into coins. The coins in

circulation "depreciate" at a given rate due to "wear and tear," so that we assume that a fraction μ of the coins simply disappears per unit of time.

The demand for money in our model for transactions purposes is given by the familiar Fisher quantity theory in its Marshallian or "Cambridge" version

$$M_{\mathrm{d}} = \alpha Y\left(\frac{1}{p}; K, L\right) \tag{14}$$

where α, the Cambridge "k," is the reciprocal of the income-velocity of circulation of money. Thus M_{d} is a "stock" demand, related to the flow of national income, Y, through the desired ratio, α.

Denoting the supply of money at any moment by M, and requiring demand and supply to be balanced at every moment, we obtain the "momentary" equilibrium condition

$$M = \alpha Y\left(\frac{1}{p}; K, L\right) \tag{15}$$

Taking K and L, together with M, as state variables initially given by history, (15) is one equation in one unknown, the reciprocal of the price level of goods in terms of silver $1/p$. Figure 22.3 depicts the momentary equilibrium specified in (15) by showing how the value of $1/p$ that prevails will equate M to M_{d} when M, K, and L are given. The demand for money curve is negatively sloped because Y varies inversely with $1/p$, as specified in (11), and M is vertical because it is determined by past history at any given point in time.

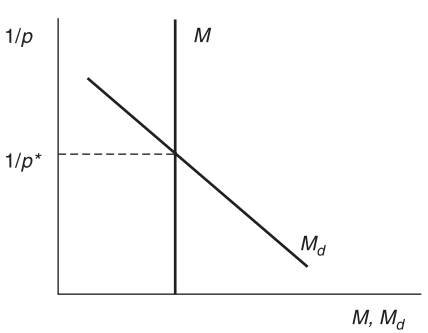

Figure 22.3
Money market equilibrium

With the relative price of goods and silver determined at any instant by equating the stock demand for money to the given stock of money in circulation, the relative price $1/p$ thus emerges as an "asset price" instead of in its more familiar role as equating the flow demands to flow supplies in standard Walrasian general equilibrium fashion of which the specific-factor model is a particular case. What we therefore have is an instance of what André Burgstaller (1994) calls the "asset market approach to the theory of value."

The relative price p determined by (15) determines the flow supplies of goods and silver as specified in (9) and (10). These flow supplies have now to be reconciled with flow demands, which will be specified below.

The consumer budget constraint is given by the national income Y, which is determined at any moment by the historically determined values of M, K, and L, which also determine p through (15). With this income consumers can either purchase domestically produced goods or what we will term "Eastern luxuries," such as spices, silk, and other exotic wares that were not produced within Europe at all. We assume, with historical justification, that all these goods had to be paid for in silver. We also assume that the prices of all these goods are fixed in terms of silver irrespective of the level of Western demand. Thus, by suitable choice of units, we can set the price of a "bundle" of these Eastern luxuries at one unit of silver so that p, the relative price of a unit of goods in terms of silver, is also the relative price of a unit of goods in terms of Eastern luxuries, and its reciprocal is the relative price of Eastern luxuries in terms of goods.

Additional flow demands for silver and goods will be the "depreciation" of the stock of silver coins, equal to μM, and the depreciation of the capital stock, δK, where δ is also a constant.

The budget constraint can be written as

$$Y = pG + S = p(G_c + \delta K) + (E + \mu M), \tag{16}$$

where

$$G_c = G_c(p, Y), \quad \frac{\partial G_c}{\partial p} < 0, \quad \frac{\partial G_c}{\partial Y} > 0 \tag{17}$$

and

$$E = E\left(\frac{1}{p}, Y\right), \quad \frac{\partial E}{\partial (1/p)} < 0, \quad \frac{\partial E}{\partial Y} > 0 \tag{18}$$

are the consumption demands for goods and Eastern luxuries, respectively. The total flow demands for goods and silver are obtained by adding the depreciation of the capital stock δK and of the money supply μM to the respective consumption demands. There is no guarantee that flow demand will equal flow supply, since

$$G_d \equiv G_c + \delta K \gtreqless G, \tag{19}$$

$$S_d \equiv E + \mu M \gtreqless S. \tag{20}$$

Walras's law and equation (16), however, imply that

$$(S_d - S) \equiv p(G - G_d), \tag{21}$$

that is, the excess flow demand for silver equals the value of the excess flow supply of goods. Our model implies that the excess flow demand (supply) reduces (increases) the corresponding stock of either money or goods, so that we have

$$\dot{K} = (G - G_d), \tag{22}$$

$$\dot{M} = (S - S_d). \tag{23}$$

From (21) it follows that $\dot{K}$ and $\dot{M}$ are either both equal to zero, when flow demands equal flow supplies, or of opposite sign. For the economy to be in a long-run steady state equilibrium it is of course necessary for all the state variables, L, K, and M, to be constant, that is,

$$\dot{L} = \dot{K} = \dot{M} = 0. \tag{24}$$

We now turn to the determination of this long-run steady state equilibrium of the model. For population and the labor force to be stationary, we know from (6) that the real wage in the goods sector must be equal to w^*. From (7) this determines uniquely the ratio of capital K to employment L_g in the goods sector that makes the marginal physical product of labor in this sector equal to w^*. Also from (7) it follows that for each value of p there is a unique employment level L_s in the silver sector that equates the marginal physical product of labor in that sector to pw^*, the wage in terms of silver. The lower is p, the higher is $1/p$, the greater is L_s and hence the output of silver $S(1/p)$, which equates the marginal physical product of labor in the silver sector to the lower wage in terms of that commodity. Thus, given the size of the stock of natural resource deposits N,

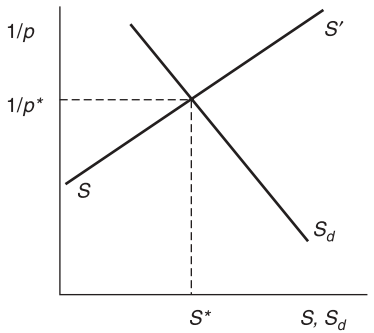

Figure 22.4
Flow equilibrium in the silver market

equation (7) determines the long-run steady state flow supply curve of silver

$$S = S\left(\frac{1}{p}; w^*, \overline{N}\right), \tag{25}$$

which is depicted in figure 22.4 as the positively sloped curve SS'. The long-run flow demand for silver, S_d in figure 22.4, at each price $1/p$ will depend only on K, since L_s is determined by $1/p$. L_g is proportional to K, as determined by w^*, and so the labor force L and national income Y are determined for each value of K. By (14) the stock demand for money M_d is determined by $1/p$ and Y, and so the money supply M and its "depreciation" μM are determined as well. The expenditure on Eastern luxuries E is also determined by $1/p$ and Y from (18). The total flow demand for silver, equal to E plus μM, is thus an increasing function of Y, and hence K, for each value of $1/p$. By (20) we can therefore find the unique value of K, and hence L, Y, and M, that equates the flow demand S_d for silver to the flow supply $S(1/p)$ for each value of $1/p$, as illustrated in figure 22.4. It also follows that steady state L, K, and M are all increasing functions of $1/p$.

We therefore see that there is a continuum of steady state equilibria (L, K, M), each corresponding to a particular value of $1/p$ and varying positively with changes in this relative price.

To determine a unique steady state, we now introduce the final behavioral equation of the model. This is a long-run "portfolio balance" equation that makes the desired ratio of physical capital K to the money supply M an increasing function of the relative rate of

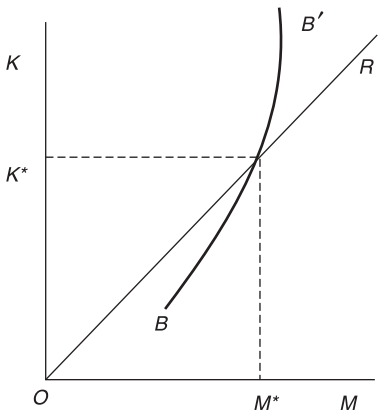

Figure 22.5
The portfolio balance

return to holding capital instead of commodity money as an asset, so that we have

$$\frac{K}{M} = h(\rho), \quad h'(\rho) > 0, \tag{26}$$

where

$$\rho \equiv (r - \delta) + \mu. \tag{27}$$

The higher the net rate of return $(r - \delta)$ on capital itself, the more attractive it clearly is to hold capital. Commodity money "depreciates" at the rate μ, so holding capital instead of commodity money as an asset brings an additional return of μ, as stated in (27).

In every steady state the real wage must be equal to w^*, and hence the marginal product of capital must be equal to $r(w^*)$ by the "factor-price frontier" in the goods sector. Whatever the price level p may be in the steady state, its future values are stationary at that level, so there is no Fisherian "capital gain" component to add to the relative rate of return ρ as defined in (27). Thus ρ is uniquely determined by w^*, and consequently the *ratio* of K to M in all steady states is a ray through the origin OR as in figure 22.5.

The other curve BB' in figure 22.5 shows the *values* of K and M corresponding to each other in a segment of the continuum of steady states (L, K, M), one value for each value of $1/p$, as determined above.

We assume that "diminishing returns" in the natural resource-based silver sector are so strong that the curve BB' cuts OR from below. In other words, the capital accumulation proceeds faster than the increase of the money stock as $1/p$ increases. The intersection of BB' and OR determines K^* and M^*, and consequently L^* and $1/p^*$, as the unique long-run steady state equilibrium of the model.

Economic Consequences of the Black Death

To model the impact and consequences of the Black Death, we assume that the European economy of the midfourteenth century was initially in the long-run demographic, monetary, and economic equilibrium corresponding to the steady state depicted in the last section. The Black Death itself is conceived of as a one-time, instantaneous shock that reduces population and the labor force substantially. (The exact proportion does not matter since our analysis will be qualitative rather than using or providing numerical estimates.) We begin by deducing the consequences from the model in the first section below. The second section briefly examines the historical record to check whether the analytical consequences derived from the model broadly conform to the facts established in the voluminous historical literature on this demographic catastrophe.

Model Analysis

The instantaneous decline of the labor force has some obvious immediate consequences. Wage rates rise in terms of both goods and silver, and the output of both commodities falls. Silver deposits and the capital stock (at first) are unchanged but the decline in the labor force means that the production possibility frontier shifts inward. The outputs of both sectors decline, if relative prices are held constant, because each sector will employ less labor due to the rise in the real wage.

The relative price of goods and silver, as we have seen, is determined in the asset market; that is, it depends on what happens to the stock demand for money since the stock of silver coins is at its initial level. The stock demand for money falls, since national income declines because of the reduction in the labor force. The result is an instantaneous fall in the relative price of silver in terms of goods,

that is, a jump in the price level of goods in terms of silver. All of this follows from quantity theory reasoning. In terms of the famous Fisher equation, MV is constant and Q falls, so p must rise.

This shift in relative prices implies that the fall in the output of silver induced by the reduction of the labor force is accentuated by the fact that goods production is now relatively more attractive. The flow supply curve of silver has shifted to the left, so production falls at constant relative prices, and the fall in the relative price induces a movement down the supply curve as well. In the goods sector, on the other hand, the rise in relative prices moves production up the supply curve, mitigating the reduction in output caused by the decline in the labor force.

Real wealth and income per capita of the surviving population are both considerably higher than before the catastrophe. The demand for Eastern luxuries, in particular, will then rise. The combination of the reduction of the population and the shift in relative prices that this creates on impact thus produces an excess demand for silver and an excess supply of goods. The stock of silver coins in circulation therefore starts to shrink, while the capital stock increases. The rise in the real wage makes fertility exceed mortality, so population begins to increase slowly from its level in the immediate aftermath of the Black Death. With labor and capital both increasing the production possibility frontier begins to expand, making it possible for production in both sectors to recover. The increase in national income means that the stock demand for money also starts shifting back toward its original level. Together with the ongoing decline in the money supply (silver in circulation) due to depreciation and purchases of Eastern luxuries, this makes the relative price of silver rise again; that is, the jump in the price level of goods that was the consequence of the negative population shock begins to be reversed. This encourages the recovery in the production of silver relative to that of goods.

The picture we have of the postcatastrophe scenario is that population and production are expanding from the depressed levels in the immediate aftermath of the arrival of the plague, while the price level and real wages decline from their initially inflated levels. Real wages fall as population recovers, although they remain well above their pre-plague level for a long time. The price level of goods in terms of silver continues to fall since production is recovering while

the stock of silver is shrinking, because the output of silver is insufficient to cover "depreciation" and the expenditure on Eastern luxuries induced by the rise in per capita wealth and income.

However, the deflation of the price level itself stimulates the output of silver. Together with falling real wealth and per capita incomes due to the rise in population, it also reduces the demand for Eastern luxuries while at the same time the "depreciation" component of the flow demand for silver itself shrinks since its base is reduced. Eventually the excess demand for silver must therefore reverse itself into an excess supply, and the amount of silver in circulation begins to rise again. The mirror image of the excess demand for silver, the excess supply of goods, must also be reversed and the capital stock, which is above its pre-plague level, is reduced.

The relative price of silver l/p must continue to rise as long as the money supply is contracting, since the stock demand for money must be rising because of the increasing labor force and capital stock. If the money supply continues to fall when the price of silver rises to its initial pre-plague level $1/p$ will "overshoot" its initial level; that is, the price of goods in terms of silver must fall below the pre-plague level. Eventually, however, the excess flow demand for silver that is contracting the money supply must be reversed and the money supply will begin to increase again. The relative price of silver $1/p$ will continue to rise if the demand for money rises faster than the supply. The long deflation of the price level must, however, eventually be reversed to an inflation as the labor force and the capital stock converge back towards their initial levels. The initial pre-plague price level is returned to from below rather than from above. The price level of goods in terms of silver will thus display an initial upward spike on the impact of the plague, followed by a long deflationary phase that takes the price level below its initial value (i.e., "overshooting"), followed by a gradual inflation as the supply of money increases faster than demand, converging asymptotically back to the pre-plague level when the full adjustment is completed and the values of all variables have returned to their initial levels.

It is conceivable, however, that the money supply will begin to expand before the rise in the relative price of silver $1/p$ has reached its initial pre-plague level. At this turning point the demand for money always increases faster than the rising supply. Otherwise, $1/p$ would fall and the system would not get back to the initial equilibrium. Then the possibility arises that $1/p$ continues to rise until the

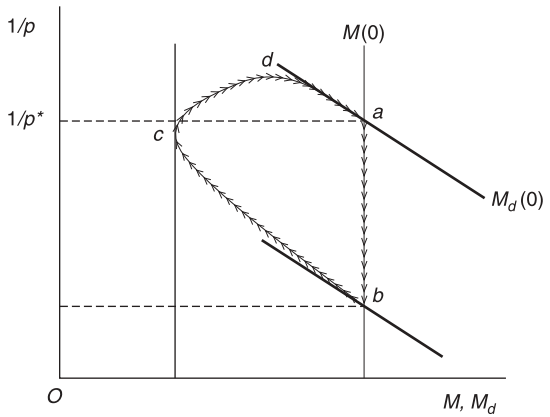

Figure 22.6
The long swing in the price level due to the Black Death

initial level is attained and the labor force and capital stock will converge to their long-run steady state values, without any "overshooting" of the price level. The initial inflationary spike is followed by slow deflation back to the original pre-plague level. It is, however, also possible for $1/p$ to rise above the initial level before the long-run equilibrium is attained; that is, there is "overshooting." In this case, again, the deflation of the price level must eventually be reversed and followed by an inflationary phase as the initial pre-plague price level is approached from below rather than above.

Thus "overshooting" will not occur in one of the three cases considered. However, the two cases in which it does occur both appear to be more consistent with the historical record, as we will argue below.

The process that we have described is depicted graphically in figure 22.6. The initial position is that of point a, with money supply $M(0)$, money demand $M_d(0)$, and the price of silver in terms of goods at $1/p^*$. The Black Death instantaneously shifts the money demand function downward on the vertical supply curve $M(0)$ to point b, producing a fall in the relative price of silver in terms of goods $1/p$. In quantity theory terms, MV is constant while Q falls, so p must rise; that is, $1/p$ must fall. For the reasons that we have given above, there is now an excess flow demand for silver, which means that the money supply shrinks, shifting the vertical supply curve of the money stock leftward. The recovery of population and the labor

force, and the increase of the capital stock due to the excess flow supply of goods, means that the stock demand curve for money starts to shift back upward again. The relative price of silver $1/p$ therefore starts to rise above the level to which it initially fell at point b, since the demand for the money stock of silver is rising while the supply is falling.

Eventually, however, the excess flow demand for silver that is draining the stock must be reversed as the rising price of silver and the falling real wage in terms of goods increase the flow supply while the demand for Eastern luxuries is reduced and the "depreciation" component μM is also falling as M itself declines. At point c in figure 22.6, the money supply stops contracting and begins to increase back toward its initial level. (As noted above, point c could be above point a, without affecting the essentials of the process described here.)

The stock demand for money continues to rise because of the increasing labor force. Despite the beginnings of the increase of the money supply, the increase in the demand for money keeps on raising $1/p$, the relative price of silver. The rise in $1/p$ can "overshoot" the original level of $1/p$, corresponding to point a, if the increase in the stock demand for money at that price is larger than the increase in the amount of silver in circulation. The price of silver $1/p$ then rises to point d in figure 22.6, after which the increase in money demand, which is being dampened as the original size of the labor force and capital stock are being approached, falls short of the increase in money supply, causing $1/p$ to fall thereafter toward the original level at point a. At this point the recovery from the effects of the Black Death is complete. With all parameters, technology and behavioral relations unchanged the system returns to the original position.

The time path of the price level p over the entire sequence is depicted in figure 22.7 for the "overshooting" case. At the onset of the Black Death, at time $T(0)$, the price level jumps instantaneously from p^* to p' and then descends slowly from that level, falling below p^* itself and reaching a floor at p'' at time T. After that it rises back toward the original equilibrium level p^*, with all other variables unchanged as well.

The next section examines the historical record to assess the extent to which the predictions of the model are consistent with historical facts and interpretations.

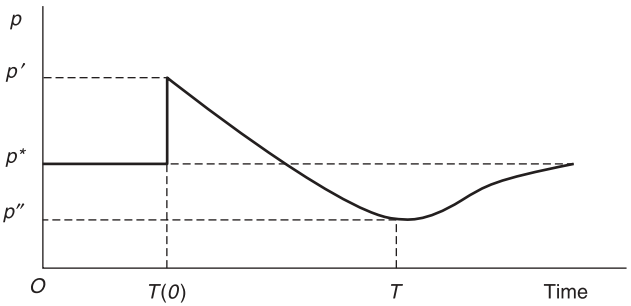

Figure 22.7
The price level pattern following the Black Death

History

The bubonic plague, *Yersinia pestis*, that struck Europe in 1347 was, ironically, a consequence of the increased trade and commercial activity between East and West stimulated by the unification of the Eurasian continent under the Pax Mongolica. According to McNeill (1977) the plague bacillus was transmitted to Central Asia by Mongol troops who were infected by it on a punitive expedition to the Burma-Yunnan border in 1253. It crossed Central Asia to the port of Caffa on the Black Sea, a major Genoese trading station. From there it was apparently carried by Genoese vessels to Messina in Sicily and eventually to the whole of Europe. The death rate during the initial outbreak was devastating. Cipolla (1964:131) gives an estimate of 25 million killed out of a total population of approximately 80 million between 1348 and 1351. The plague recurred in several waves of diminishing average intensity, before disappearing from Europe by the end of the seventeenth century. There has been a prolonged debate on the extent of the mortality but no disagreement on the fact that it was substantial.

The way we have modeled this demographic disaster, as an instantaneous one-shot catastrophe, is thus not strictly accurate but it corresponds quite well to the estimates of Cipolla for the 1348 to 1351 period. Our treatment of the plague as an exogenous shock is also supported by demographic evidence. Livi-Bacci (1997:53) says: "The plague constitutes a population check largely exogenous, or external, to the sociodemographic system." He also notes the tendency of endogenous economic and social forces to reduce mortality

and increase fertility, just as in the present model. A reduction in the age of females at marriage is an important adjustment stressed by many demographers and historians, which can plausibly be explained by the better economic circumstances of the surviving population. Under the influence of the induced effects on fertility and mortality the population of Europe seems to have regained its pre-plague level by the end of the sixteenth century. It took over two centuries for the shock that we give to our model to peter out and long-run Malthusian equilibrium to be restored.

There is also considerable scattered evidence on the consequent rise in real wages. England provides the best data, partly because of the famous index of real wages calculated for a period of seven centuries by Phelps-Brown and Hopkins (1956). This index is effectively combined by Hatcher (1977:71, fig. 2) with estimates of population from 1250 to 1750. Population falls from a peak of close to 6 million around 1300 to about 3 million in 1350, continuing to decline to barely 2 million around 1450. It then slowly climbs back to reach the 1300 level of 6 million only as late as 1750. The real wage index (of building craftsmen) rises from a level of 60 in 1300 to 105 in 1450, that is, 75 percent. The 1450 to 1460 decade sees the trough of the population curve coinciding with the peak of the real wage index. Real wages decline after the 1450 peak to a trough with the index at 40 in the first half of the seventeenth century. It then rises slowly back to the 1300 level of 60 only as late as 1750. In other words, real wages were unchanged at the beginning and end of half a millennium! The 1460 peak of 105 was not attained until the second half of the *nineteenth* century. The swing in real wages that our model predicts is thus dramatically borne out by the English data. Goldthwaite (1980:334) presents evidence on the construction industry in Florence, showing that real wages were about 50 percent higher than the 1360 level in the period from 1420 to 1470, after which they fall back to pre-plague levels by 1600.

Economic historians have conducted an intense debate about whether the two centuries after the Black Death, which coincide with the conventional periodization of the Renaissance, could be characterized as a boom or a depression. Lopez (1953) tries to account for the paradox of cultural efflorescence during an economic contraction by arguing that "hard times" with low rates of return on investment induce rational businessmen and bankers such as the Medici to "invest in culture" instead. Cipolla (1964) criticizes this and a related

paper by Lopez and Miskimin (1962), pointing to evidence of prosperity. The controversy can be reconciled by distinguishing between total and per capita magnitudes. Total production and trade would fall in response to the decline in numbers but much less than proportionately, so per capita wealth and incomes go up. The point is made with a macabre sense of humor by Bridbury (1962:91) when he remarks that the Black Death corresponded to a "sort of Marshall Plan on a stupendous scale."

From simple two-sector general equilibrium reasoning we can expect that labor-intensive goods would decline in production while land-intensive or capital-intensive goods would expand, if relative product prices are held constant (the Rybczynski 1955 theorem). Furthermore, since per capita income is now higher, the relative prices of labor-intensive goods would rise and the prices of land or capital-intensive goods would fall. There is considerable evidence of this sort of shift in the composition of total production, with livestock-raising and viticulture expanding relative to food crops, for example. Luxury consumption of all kinds would also rise because of the higher per capita incomes. Examples abound. Indeed the primacy of Italy during the Renaissance can partly be explained by her comparative advantage within Europe in luxury products, such as silk-weaving and other high-quality textiles, expensive arms and armor, and especially the Venetian and Genoese grip on the supply of Eastern spices and other goods.

One sector of production to which we have paid particular attention in our theoretical analysis is the mining of precious metals, "silver" as we have called it. A strong prediction was that this sector would be particularly hard hit, since it would suffer not only from the general labor shortage and rise in wages but also because the sharp fall in the demand for money would lower the price of silver relative to goods in general. This prediction is strongly confirmed in the historical record. Nef (1987:721) states that in the aftermath of the Black Death "the production of gold and silver in Europe as a whole actually declined," and he also speaks (1987:722) of a "long slump which lasted for several generations." Recovery only came with the revival of population and total real incomes.

Combining this reduction in the supply of silver with the rise in demand for Eastern luxuries, also amply documented in the historical record, makes for an excess demand for silver that must result in a contraction of the stock of silver coins in circulation. This is exactly

what happened, for so long and to such an extent that it led the monetary historian John Day to speak of "The Great Bullion Famine of the Fifteenth Century" (Day 1987:ch.1). The shortage of silver and the precious metals generally in Europe in the century or so after the Black Death is well attested and analyzed in this work and other authoritative treatments, such as Miskimin (1975) and Spufford (1988:ch.14–16).

Our model predicts first a rise in the relative price of goods in terms of silver, when real income drops and the money supply is constant, followed by a fall in this relative price as the demand for money begins to rise back to its initial position and the money supply contracts. The scanty data on industrial and agricultural prices expressed in terms of silver exhibit exactly this pattern. Day (1987:100) presents two industrial price indexes rising from 100 to 125 and 100 to 133–200 from 1330 to 1370, and falling from 125 to 72 in 1410 and 43 in 1470, and from 133–200 in 1370 to 83–100 in 1410, and 104–125 in 1470. Indexes of agricultural prices in Northern France go from 100 for the 1331 to 1340 decade to 107 in 1361 to 1370, then fall to 78 in 1401 to 1410 and 42 in 1461 to 1470. In England the pattern for the same periods is from 100 to 127, then falling to 102 and 69. Some other evidence and discussion is also provided in the recent book on price history by Fischer (1996).

The demand for Eastern luxuries, to which we have assigned major weight in connection with the reduction in silver output as the cause of "the great bullion famine," is extensively documented, although numerical estimates are relatively scarce. We should first note that "Eastern" does not necessarily mean "Southern," the familiar exotic products of the Islamic world, the East Indies, and China. Russia, Finland, and the eastern shores of the Baltic also provided a major luxury import for Western Europe, namely the rich furs of ermine, sable, and marten, so familiar to us from the Renaissance portraits not only of nobility but also of the merchant princes of the age. Miskimin (1975:138) reports that 450,000 furs were shipped from Riga to Bruges in one year, 1405, alone, and Riga was not the sole outlet for the fur supply. This fur trade particularly enriched the merchants of the Hanseatic League. Wax for candles was also a luxury import of a rather morbid kind, since one of the main sources of demand was the lighting of candles at the masses for the dead.

More than matching the drain of silver to the northeast through the Baltic for furs, wax, and amber was the drain to the southeast

through Italy, especially Venice and Genoa, and then to Egypt, where the spices and silks of Asia were acquired by European merchants. A particularly fascinating account of the drain of silver eastward in exchange for luxuries is given in an article by Lopez, Miskimin, and Udovich (1970). The article has three sections, one by each author. The first, by Miskimin, tells how silver was drained out of England and France to Italy, in exchange for luxuries of various kinds. The next section, by Lopez on Italy, explains how all this northern silver did not stay in Italy but was transferred to Cairo and Alexandria by Venetian and Genoese merchants in exchange for spices, silks, and other Eastern luxuries. The third section, by Udovich on Egypt, explains how all this Italian silver did not remain in Egypt but was drained eastward to the region of the Caspian Sea for slaves and furs and through the Red Sea to India and the East Indies for spices and silks. All three regions meanwhile were devastated about equally by the plague. The authors report that they were looking for expert co-authors on India and China to explain what finally happened to the silver but could not find anyone suitable in time for the conference at which they had to present the paper.

Our model predicts that this persistent drain of silver was destined to end and be reversed. This again is exactly what happened. From about 1460 the stock of silver in circulation appears to start rising again, the excess (flow) demand for silver now being converted into an excess supply. On the demand side the "depreciation" as a constant fraction of a declining stock was becoming a smaller proportion of a rising flow supply in response to the rising relative prices of silver in terms of goods. Per capita wealth and income were shrinking as population rose, reducing the demand for Eastern luxuries. The rising relative price of silver encouraged the re-opening of old mines, stimulated the search for new ones and also the search for better methods of extracting metal from the ore. Nef (1987:735) speaks of a "boom in mining and metallurgy" from 1460 to 1530, reporting that: "[b]etween 1460 and 1530 the annual output of silver in Central Europe increased several times over, perhaps more than fivefold," reaching a maximum during the 1526 to 1535 decade.

It is vitally important to note that all the events that we are describing have nothing to do as yet with the voyages of discovery in the last decade of the fifteenth century. As we will see in the next section the fact that prices in terms of silver were rising in Europe *before* the great influx of silver from the New World in the middle of

the sixteenth century has been taken in some quarters to refute the monetary view of the Price Revolution of the sixteenth century, and even the quantity theory itself.

American Silver and the Price Revolution

Few ideas have been more famous or controversial in economic history than the celebrated thesis of Earl Hamilton (1934) about the impact of the influx of silver from the New World on European prices in the sixteenth century and its implications for the future course of economic development. Despite an enormous outpouring of theoretical, statistical, and historical research, the subject does not appear to have found a resolution, more than sixty-five years later. While a full discussion of even the most basic of the issues involved will require more space than is available for the present chapter, it may be useful to put the model presented here through the paces of another exercise. As we will see, the results could be illuminating, particularly if taken in conjunction with those of our analysis of the consequences of the Black Death. For other interesting approaches to this problem of American silver and the Price Revolution, the reader is referred to Niehans (1993) and Flynn (1996).

As in the previous exercise we assume that the system begins in full long-run equilibrium with population, money supply, and capital stock all stationary. The "discovery of America," for purposes of the model, will simply be an exogenous increase in the stock of silver deposits available. The initial effect is therefore to shift out the production possibility frontier on the silver axis. The rise in real income that this represents shifts the demand for money function to the right, with the initial supply of money (stock of silver coins in circulation) remaining constant. The immediate impact of the discovery is therefore to raise the relative price of silver in terms of goods; that is, there is a *deflationary* spike in the price level of goods in terms of silver at the moment of the discovery. The flow supply curve shifts to the right, so the flow output will increase because the relative price of silver in terms of goods has risen as well. Although the demand for Eastern luxuries will rise because of the higher real income, this increased expenditure will be less than the increase in the flow supply of silver. There is then an excess supply of silver leading to an increase in the stock of silver coins in circulation. Thus the fabled influx of "American treasure" into Europe begins.

The rise in real income and the increase in silver output pull labor out of the goods sector, raising the real wage in terms of goods. This, under the demographic regime that we have postulated, leads to an increase in population and the labor force. That in turn shifts out the production possibility frontier even further for both commodities and implies increasing real income, shifting the demand for money outward as well. On the basis of the historical evidence, it is clear, however, that the increase in the net supply of new silver, added to the money stock, must have exceeded the increase in the demand for money due to the higher real income. The discovery of American silver led to huge additions to world silver stocks, about 50 percent during the sixteenth century and 85 percent during the seventeenth. Out of these additions 74 and 71 percent respectively reached Europe, and 40 percent was passed on to Asia. Production in the Americas amounted to 74 percent of world output from 1493 to 1600 and 85 percent from 1601 to 1700 (Barrett 1990). When the addition to the money stock exceeds the increase in the transactions demand for money, the price of silver in terms of goods will fall; that is, there will be inflation of the price level of goods in terms of silver. It is this outcome and its continuation that constitutes the celebrated Price Revolution of the sixteenth century.

The falling relative price of silver in terms of goods will tend increasingly to reduce the flow supply of silver, despite the increases in the labor force induced by a real wage above the Malthusian equilibrium level. The "depreciation" component of the flow demand will rise steadily, proportionately to the increasing base of the total stock of silver in circulation. The expansion of real incomes also means that the expenditure on Eastern luxuries is rising. Thus, eventually, the rate of growth of the money supply will slow down, below the rate of expansion of the demand for money, caused by increasing real incomes, and the relative price of silver $1/p$ will begin to rise. Deflation will follow inflation, creating another "long wave" in the price level. In the end the excess flow supply of silver must turn into an excess flow demand, so the stock of silver in circulation within the extended European economy will start to shrink. The falling real wage will also eventually lead to a stationary population.

The final long-run equilibrium will therefore have the same real wage that preceded the discovery of the silver deposits of the New World that set the whole "long wave" in motion. Population will be stationary, but at a higher level than previously, because of the

augmented stock of silver deposits. The capital stock first declines because there must be an excess demand for goods corresponding to the excess flow supply of silver during the inflationary phase of the "long wave." It begins to increase when the money supply starts to shrink because of the logic of the model. The final capital stock will be larger, supporting the increased population and augmented natural resources created by the discovery. This, in turn, means that the price level must "overshoot." To the increase of the capital stock through the excess supply of goods corresponds an excess flow demand for silver and a reduction of the monetary stock. Deflation must follow inflation and lower the price level of goods in terms of silver back toward its initial value.

The final long-run steady state to which the system tends can now be briefly described. The three state variables, the labor force L the capital stock K, and the supply of money M, will all increase in proportion to the increase in the stock of natural resource deposits N due to the "discovery of America." The real wage w^* and price level p^* will remain constant at their original levels. Thus the stock demand and supply of money in figure 22.3 will both shift proportionately to the right leaving the relative prices of silver, $1/p^*$, and hence the price level, p^*, unchanged. In figure 22.4 the flow supply and demand for silver will also be shifted to the right at unchanged $1/p^*$, in proportion to the increase in N. In figure 22.5 the desired proportion of capital stock to money stock remains unchanged, since $r(w^*)$ is unaffected by the increase in natural resource depicts. The BB' curve shifts to the right as a result of the increase in N, leading to an increase in the same proportion of K and M at the point where the new BB' curve intersects the ray OR from the origin.

The transition to the new equilibrium and the time path of the price level are depicted in figures 22.8 and 22.9.

We begin in figure 22.8 at the initial steady state equilibrium at point a. The discovery of the additional natural resource deposits shifts out the production possibility frontier and raises real income and the stock demand for money. With the initial money supply given, this implies a jump in the relative price of silver $1/p$ from point a to point e. The additional resource deposits and the higher relative price stimulate the output of silver, leading to an excess flow supply and hence an expansion of the money supply. The demand curve for money shifts steadily to the right, because the higher real wage induced by the expansion in silver production stimulates the

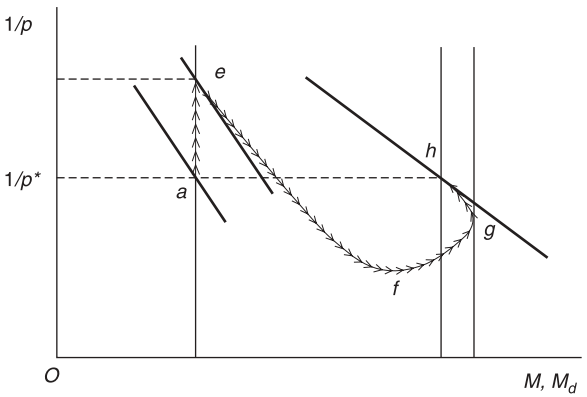

Figure 22.8
The long swing in the price level due to American silver

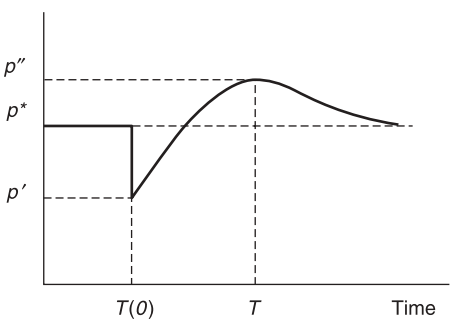

Figure 22.9
The price level pattern following the silver discoveries

growth of population and the labor force. The rate of expansion of the money supply exceeds the growth of money demand, leading to a falling relative price of silver $1/p$ or an inflation of the price level of goods in terms of silver.

The fall in $1/p$ continues to point f, falling below the initial relative price $1/p^*$. The growth of the money supply begins to slow down and is exceeded by the expansion of money demand, leading to a rising relative price $1/p$ from point f to point g. At point g the excess flow supply of silver finally becomes zero, after which it turns negative; that is, the money supply starts to contract while the relative price $1/p$ continues to rise in response to the continuing rise in money demand. Equilibrium is finally restored at point h, where $1/p$

returns to the original level $1/p^*$ the real wage falls back to w^*, and the capital stock, labor force, and the money supply all have increased in the same proportion as the increase in the natural resource deposits. Since the money supply is contracting from g to h, the capital stock now rises, recovering its losses in the transition from e to g and increasing in proportion to the money supply and the labor force.

Figure 22.9 plots the time path of the price level p that is a reciprocal of the movement of $1/p$ in figure 22.8. At $T(0)$ there is an initial deflationary spike from p^* to p', after which there is a long inflationary phase from $T(0)$ to a peak of p'' at T, followed by an asymptotic decline of the price level back toward p^*.

To confront the implications of our model with the actual historical experience is a task that we will not attempt here. There is no doubt that the price level of goods throughout Europe rose in terms of silver throughout the sixteenth century, although there is much disagreement about the extent and pattern of the rise. The causes, however, continue to be fiercely debated. Hamilton's quantity theory explanation was criticized by historians on many grounds. Some are mutually contradictory, such as the assertion that the Fisher formula is "only a truism" and that it is "based on unrealistic assumptions." Stronger than these criticisms of the internal logic of the "monetarist" explanation was the contention, pointedly made in an influential article by Ingrid Hammarström (1957), that prices had been rising well before the influx of American silver ever reached the shores of Europe.

This is where our consideration of the long-run adjustment to the shock of the Black Death can be useful. That shock was deflationary for a long time, during the "bullion famine" of the fifteenth century, but was eventually self-correcting since the rise in the relative price of silver would stimulate an expansion of silver output. This rise in European silver output has been well established by the work of Nef (1987) on the 1460 to 1530 mining boom. The two "thought experiments" that we conduct for our model, on the Black Death and the discovery of New World silver, are not fully separated in historical time. The *Niña*, *Pinta*, and *Santa María* sailed before the full adjustment to the Black Death, a century and a half earlier, had been worked out. The American silver started to arrive at Seville before the inflationary final phase of the Black Death "long wave" had ended. Thus it is no valid criticism of Hamilton's thesis to say that inflation was already occurring in Europe. The inflation was undoubtedly greatly amplified and prolonged by the American silver.

In their disillusionment with "monetary" explanations several historians have looked for "real" explanations, with population changes as the most favored among these. Much of the underlying logic of these arguments appears spurious and exasperating to economists. The pressure of population on scarce land, making food more expensive and thereby causing "inflation," is only one of the more egregious examples. Nevertheless, the controversies between "Monetarists" and "Malthusians" among economic historians (e.g., see the exchange between Robinson 1959 and Postan 1959) have the merit of trying to do justice to what is undoubtedly two fundamental factors involved in all these episodes, factors that economists have for the most part kept in separate compartments. Our model, however, embraces both population and commodity money as endogenous variables along with production in a general equilibrium framework. In this model the price level of goods in terms of silver is a *relative* price of goods and silver, and so the distinction between "real" and "monetary" factors loses its relevance.

The model requires the Price Revolution to recede and be followed by a deflationary phase. Here again it conforms to reality. While the sixteenth century was a booming inflationary period with an initial rise in real wages and expanding population under the stimulus of the discoveries, the seventeenth century was a century of stagnation and falling prices, as emphasized in a famous article by Eric Hobsbawm (1954) on the "seventeenth-century crisis," which is still the subject of a debate that shows no signs of ending. In that century real wages had fallen toward the Malthusian equilibrium level, making population stagnate, while the drain of silver to the East through the activities of the Dutch and English East India Companies lowered the price level. The model thus has the merit of pointing to a necessary connection between two historical episodes that have been considered as quite distinct. The explanation for the "seventeenth-century crisis" has been sought in such exogenous factors as for example, climatic change, when a good part of the story can be traced to the consequences of the preceding epoch.

Concluding Observations

We began this essay by invoking Heckscher on the relation between theory and history. Our intention was to respond to his "plea for theory" in the practice of economic history. In 1929 his plea was a cry in the wilderness, not heeded until about a generation later, by

the emergence of the New Economic History school. The main emphasis of that school, however, on the application of econometric techniques to historical data and less on theory per se. Almost as a by-product of this work a number of contributions emerged that specifically applied or developed appropriate economic models to investigate historical problems. Whenever possible it is sufficient to simply take a well-known model or conceptual tool "off the shelf," as it were, and apply it directly to economic history. Frequently, however, the historical circumstances are such that no standard model applies directly. One then needs to be sufficiently resourceful and opportunistic to "do it yourself." What we have presented here is just such a do-it-yourself model.

The core of our model is the Jones (1971) specific-factors construct, which was itself inspired by the historical problem of Anglo-American productivity differences in the nineteenth century. What we have added is the endogenization of the labor supply by appending a neo-Malthusian demographic regime, combined with a model of commodity money, requiring stock-flow adjustments through the application of the asset market approach. The best modern treatment of commodity money is Barro (1979). His paper also uses the stock-flow adjustment mechanism but takes real national income and the flow supply curve of "gold" as exogenously given. In our system real national income and the flow supply of silver are both endogenously determined along with the supplies of labor, capital, and money in a full general equilibrium framework. What we have done therefore is to start with one of the standard variants of the "factor proportions" approach, endogenizing the supplies of factors and money, in the spirit of the Findlay (1995) Ohlin Lectures. It is interesting to note that Heckscher himself briefly considered the implications of making factor supplies respond positively to increases in their own real rewards in his 1919 article.

The application of this analytical apparatus to history takes the form of "thought experiments," investigating the effect on the long-run equilibrium of the model and the transition to that state of some "shock" that corresponds to a significant historical event. The two experiments that we have conducted are the Black Death, in which one-third of the population and labor force disappears practically overnight, and the effect of the discovering of rich silver deposits in the New World. The first is a demographic shock that has subtle and complex monetary consequences, since we show that the phenomena

associated with the great bullion famine of the fifteenth century can be derived as consequences of the demographic disaster of the previous century. The other is a monetary shock that has demographic consequences. Together, the two experiments show that it would be misguided to take an exclusively "Malthusian" or "Monetarist" view of history, for the demographic and monetary regimes are both embedded in a wider system of general interdependence.

We also saw that despite his plea for the application of theory to the analysis of historical epochs, Heckscher did not consider it applicable to shifts from one epoch to another, since the determinants of such shifts generally lie outside the realm of economics. Thus the plague outbreak in Europe in the midfourteenth century and the discovery of silver mines in the New World are both examples of Heckscher's point. Each of these events had momentous economic consequences but were largely, though not entirely, brought about by circumstances independent of economic conditions.

The spirit of our model is entirely "classical." What we call long-run equilibrium is nothing but the "stationary state" of Malthus, Ricardo, and Mill. (Why else did Paul Samuelson 1971 talk about the Ricardo-Viner model?) The system returns to its original state, as in the case of the adjustment to the Black Death. But can it really be that the Europe of, say, 1547, was the same as the Europe of 1347 even if population, real wages, money supply, and so on, were all the same? Not really. What is missing is "hysteresis," the alteration to the underlying parameters of the system when it is subjected to a shock, so that it does not return to the original starting point but to some other position determined by the changes during the transition.

This is the idea underlying the brilliant little book by the late Harvard medievalist David Herlihy (1997) entitled *The Black Death and the Transformation of the West*. Herlihy argues persuasively that the experience of affluence in the aftermath of the Black Death fundamentally altered cultural and social values in a direction conducive to material advancement and economic growth. To take but one example, the age at marriage of females could have increased, shifting the fertility curve of our figure 22.1 to the left, resulting in a higher equilibrium wage and per capita income, with a smaller equilibrium population. Such changes could ultimately have led to the Industrial Revolution, in which the "Unbound Prometheus" of technological change altered the world forever and made our "pre-industrial" classical model no longer applicable.

Notes

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1. We are grateful to David Laidler for drawing our attention to the exposition by Marshall in a volume of his early writings edited by Whitaker (1975), in which the money commodity is the shells of an extinct fish that can be dredged for at increasing marginal cost in terms of goods.

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