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Crowding Out during Britain's Industrial Revolution

ROBERT A. BLACK AND CLAIRE G. GILMORE

Contrary to earlier assertions, the historical data for Britain do confirm a (lagged) crowding-out effect during the Industrial Revolution. Heavy government borrowing after 1793 for the wars with France raised interest rates. These results are confirmed with nominal-interest-rate equations rather than with real-rate equations, which impose restrictive assumptions about the adjustment of nominal rates to inflation expectations. We see no reason to abandon the neoclassical, factor-allocation model of saving and investment in favor of a theory asserting that firms accumulate capital for investment independently of household saving decisions.

Recent interest in Britain's rate of economic growth during the "First Industrial Revolution" has led to a discussion of whether heavy borrowing to finance the French Wars of 1793 to 1815 crowded out private investment, limiting the country's capital formation and growth.[1] Using a neoclassical general-equilibrium model, Jeffrey Williamson concluded that "the rate of [capital] accumulation was suppressed by war well below what it would have been in peace."[2] But Carol Heim and

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[1] Whether borrowing by Britain to finance war efforts in the late eighteenth and early nineteenth centuries affected interest rates and private investment is by no means a recent issue. Mill is among the nineteenth-century writers who suggested that war debts could, under certain circumstances, displace private capital accumulation. See John Stuart Mill, *Principles of Political Economy* (1862; New York, 1909 printing of 5th edn.), pp. 873–75. The recent interest in historical crowding out is related to U.S. experience with high budget deficits in the 1980s. A number of studies have examined the potential for deficits, or government expenditure, to crowd out private investment. See, for example: Paul Evans, "Do Deficits Raise Interest Rates?" *Journal of Monetary Economics*, 20 (Sept. 1987), pp. 281–300; Gerald P. Dwyer, Jr., "Federal Deficits, Interest Rates and Monetary Policy," *Journal of Money, Credit, and Banking*, 17 (Nov. 1985, Part 2), pp. 655–81; Robert J. Barro, "Government Spending, Interest Rates, Prices, and Budget Deficits in the United Kingdom, 1701–1918," *Journal of Monetary Economics*, 20 (Sept. 1987), pp. 221–47; John A. Tatom, "Two Views of the Effects of Government Budget Deficits in the 1980's," Federal Reserve Bank of St. Louis *Review*, 67 (Oct. 1985), pp. 5–16; and Michael D. Bradley, "Government Spending or Deficit Financing: Which Causes Crowding Out?" *Journal of Economics and Business*, 38 (Aug. 1986), pp. 203–14. Bradley includes a brief summary of the results from 14 earlier studies of the link between deficits and interest rates.

[2] Jeffrey G. Williamson, "Why Was British Growth So Slow During the Industrial Revolution?" this JOURNAL, 44 (Sept. 1984), pp. 687–712, see especially p. 712. It is wartime borrowing that is at the heart of the argument. For a study of crowding out during the Civil War, World War I, and World War II in the United States, see Paul Evans, "Do Large Deficits Produce High Interest Rates?" *American Economic Review*, 75 (Mar. 1985), pp. 69–87. An interesting classical view on why the "want of parsimony" among sovereigns during peace gives rise to wartime borrowing in

Philip Mirowski (hereafter referred to as HM) found no evidence of crowding out in this period.[3] They broke the crowding-out argument into two parts: first, large government debts produce higher real interest rates; second, higher rates negatively influence investment decisions by the private sector. Based on data for the period 1782 to 1816, their empirical work focused on the first link, the effect of government borrowing on real interest rates.[4] HM's results showed no relation between real interest rates and real net receipts from borrowing but a strong relation between real interest rates and the change in real debt. They accepted the first result as evidence against crowding out and rejected the second as due to simultaneity bias.[5] In reviewing their evidence, however, Williamson noted the "need to do more work on just how price expectations are formed."[6]

Beyond the crowding-out question, another issue is at stake in the Williamson and HM exchanges: the appropriateness of the neoclassical model of saving and investment. In this model the principal source of investment funds is households, whose savings allocations are based on their intertemporal utility-maximizing decisions. Firms do not generate their own investment funds internally but must compete with government and others in capital markets. Distribution of scarce investment funds among competing borrowers is accomplished through the allocative mechanism of the price of funds, measured as the market rate of interest. But in the event that increased borrowing does not lead to rising interest rates or crowding out, is it necessary to assume, as HM apparently did, that the neoclassical model is inappropriate? Should it be replaced by a model in which investment funds come primarily from the firm's own accumulation of capital rather than from household savings?[7]

In this article we reexamine the empirical evidence regarding the effect of government borrowing on interest rates during the early British Industrial Revolution. We also address the issue of the connection between the empirical results and the viability of the neoclassical model

the first place is in Adam Smith, *The Wealth of Nations* (1776; New York, 1937), pp. 861–62. Smith also noted that "in the war which began in 1688 . . . the foundation of the . . . enormous debt of Great Britain was first laid" (see pp. 873–74).

[3] Carol E. Heim and Philip Mirowski, "Interest Rates and Crowding-Out During Britain's Industrial Revolution," this JOURNAL, 47 (Mar. 1987), pp. 117–39.

[4] Ibid., p. 118.

[5] Ibid., pp. 121–22.

[6] Jeffrey G. Williamson, "Debating the Industrial Revolution," *Explorations in Economic History*, 24 (July 1987), p. 288; see also Williamson's response to HM in "Has Crowding Out Really Been Given a Fair Test? A Comment," this JOURNAL, 47 (Mar. 1987), pp. 214–16. The same point regarding the inadequacy of the expectations variable was also made to the present authors by Thomas Chiang.

[7] HM hold to this concept of business investment. See "Interest Rates and Crowding Out," p. 137–38.

of saving and investment. Our estimates provide information about inflation expectations and lags in borrowing effects which are material to a correct understanding of the impact of wartime borrowing on interest rates. The estimates confirm that wartime borrowing in Britain did raise the nominal rate of interest, but with a lag. We then show that even the absence of interest-rate effects would not invalidate a crowding-out argument or the neoclassical model; a variety of intervening historical factors could have offset the effects of wartime borrowing. We conclude with anecdotal evidence that borrowing by Britain for the earlier Seven Years War had also raised interest rates and that this affected the availability of funds for private investment. In short, we find evidence of both crowding out and the applicability of the neoclassical model during wartime in the early stages of Britain's Industrial Revolution.

I. GOVERNMENT BORROWING, INTEREST RATES, AND INFLATION: SPECIFICATION OF AN APPROPRIATE MODEL

To test the first link in the crowding-out argument, HM estimated the following equation:

$$RY_t = a_0 + a_1 \cdot RGB_t \quad (1)$$

where RY_t equals real yield on debt and RGB_t equals real government borrowing. They used both a long-term and a short-term interest rate and three different price deflators.[8] Two real-borrowing variables were employed: real net receipts from borrowing and the change in real debt. The regression failed to support a crowding-out hypothesis when real net receipts from borrowing was the independent variable; these results were accepted. However, a regression using the change in real debt did support a crowding-out hypothesis; these results were dismissed due to possible simultaneity bias from the discounting of bonds and from the use of nominal rates to calculate the value of annuities.[9] The estimates

[8] Ibid., p. 121. HM chose the rate on the popular and liquid East India Company bonds to "reflect conditions in the short-term private bond market" (p. 121). They chose the real consol yield as a measure of conditions in the long-term debt market. On this issue, see Sidney Homer, *A History of Interest Rates* (2nd edn., New Brunswick, 1977), pp. 159–60. Because the choice of price index did not affect HM's results in any crucial way, we use only the Schumpeter-Gilboy consumer price index. The data are reported in "Interest Rates and Crowding Out," table 1 (p. 120) and table 3 (p. 124). To accommodate long lags in estimating inflation expectations, we took additional Schumpeter-Gilboy price data from B. R. Mitchell and P. Deane, *Abstract of British Historical Statistics* (Cambridge, 1962), p. 469.

[9] HM, "Interest Rates and Crowding Out," p. 126, 127, fn. 16. HM also cited a potential complication in the data on real government debt due to debt-conversion operations beginning in 1808 (p. 126). The real net receipts from borrowing series corrects for these defects, limiting results to the years 1782 to 1816 (see also p. 123). Since the interpretation of HM's empirical results depends on the assumption of simultaneity bias, we tested for its presence when change in real debt is the debt variable, using the procedure outlined in James B. Ramsey and Peter Schmidt, "Some Further Results on the Use of OLS and BLUS Residuals in Specification Error Tests," *Journal of*

themselves are based on two restrictive assumptions: real yields were calculated using a perfect-foresight model of inflation expectations, and government borrowing was assumed to affect interest rates without lag. Furthermore, no other explanatory variables were considered. These assumptions are not warranted and they distort the evidence regarding crowding out.

Testing for Perfect-Foresight Inflation Expectations

HM recognized the importance of selecting an appropriate model of inflation expectations, but in the absence of "a canonical neoclassical model which can claim widespread allegiance in this area, [they chose] to adopt a simple version [of expected inflation] widely employed in the economics literature . . . the actual ex post observed rate."[10] This perfect-foresight model assumes that expected inflation (the inflation premium included in nominal yields) can be approximated by actual inflation, in other words, that market forecasts of inflation in the period were quite accurate.

A test of the perfect-foresight inflation-expectations mechanism becomes possible by means of a simple transformation of equation 1. First, express real yields as follows:

$$RY_t = NY_t - PP_t^e - NY_t \cdot PP_t^e \tag{2}$$

where RY_t equals real yield on debt, PP_t^e equals expected percentage change in price, based on information available at time t minus 1, and NY_t equals nominal yield on debt. Average inflation for the period is quite low (as discussed below), so we can ignore the interaction term.[11] Assuming perfect foresight, the real yield can be written as the nominal yield less actual current inflation:

$$RY_t = NY_t - PP_t \tag{3}$$

where PP_t equals actual percentage change in price at time t. Since the real yield in equation 1 assumes perfect foresight, it can be expressed in nominal terms by adding current inflation (PP_t) to both sides:

$$NY_t = a_0 + a_1 \cdot RGB_t + a_2 \cdot PP_t. \tag{4}$$

Equation 4 allows for a direct test of the perfect-foresight model of real yields. Perfect foresight implies that the coefficient of adjustment,

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the American Statistical Association, 71 (1976), pp. 389–90. The results supported the hypothesis of simultaneity bias for change in real debt but not for real net receipts from borrowing.

[10] "Interest Rates and Crowding Out," p. 121.

[11] An anonymous referee noted a difficulty in estimating equation 2 with the interaction term: the nominal yield appears on both sides of the equation. Ignoring the interaction term could bias estimates of the coefficients, particularly a_2 in equation 4. Accounting for the interaction, however, introduces its own substantial bias. Furthermore, low coefficients on inflation expectations in the nominal-rate equations reported below suggest that, if bias is present, it is not very substantial.

TABLE 1
ESTIMATES OF EQUATION 4: 1782 TO 1816

Dependent Variable	Nominal India Bond Yield: Real Net Receipts from Borrowing	Nominal India Bond Yield: Change in Real Debt	Nominal Consol Yield: Real Net Receipts from Borrowing	Nominal Consol Yield: Change in Real Debt
Constant Term	4.42**	4.54**	4.29**	4.53**
	(30.55)	(43.40)	(29.12)	(42.50)
Real Government Borrowing	0.03	0.003	0.05**	0.01**
	(1.66)	(1.39)	(3.40)	(3.25)
Current Inflation	−0.007	0.006	0.003	0.034**
	(−0.70)	(0.49)	(0.33)	(2.63)
Adjusted R^2	0.028	0.004	0.23	0.213
Durbin-Watson	0.72	0.70	1.31	1.56
$F_{\text{regression}}$	1.49	1.07	6.12	5.61
	(2,32)	(2,32)	(2,32)	(2,32)

* Significant at the 5 percent level, one-tailed test.
** Significant at the 1 percent level, one-tailed test.
Notes: Figures in parentheses below coefficients are *t*-statistics; figures in parentheses below *F*-statistics are degrees of freedom.

a_2, is significant and equal to one. Table 1 presents estimates of equation 4 and offers evidence that actual inflation is not an adequate representation of expected inflation or the inflation premium. The coefficient is significantly different from zero only for the equation which uses change in real debt and nominal consol yield. Furthermore, it is much closer to zero than to one, no matter which nominal yield or which real-debt variable is used. A test for whether the coefficients are equal to one is rejected in all cases.

Another interesting feature of the results in Table 1 is that the equations for the two debt variables, change in real debt and real net receipts from borrowing, now look quite similar. In fact, the significance of the effect of government borrowing now depends not on the choice of a debt variable, but on the choice of a yield variable. As a result a crowding-out hypothesis is supported for the nominal consol yield, even when real net receipts from borrowing is the debt variable; furthermore, the hypothesis only narrowly fails for nominal India bond yields (at 5 percent significance for a one-tailed test), using both debt variables.

The estimates reported for nominal yields in Table 1 show the difficulty in estimating crowding-out effects using ex post real yields as in equation 1. But it is also inappropriate to accept these results for nominal yields without question. First, since estimates in Table 1 reject the perfect-foresight hypothesis regarding expected inflation, other expectations models need to be investigated. Second, the Durbin-Watson statistics indicate potentially serious trouble with first-order autocorrelation of the errors. An improved specification or an estimation approach which accounts for the serial correlation is needed.[12] We respecify the equation below by introducing a different model of inflation expectations and also by including lagged borrowing terms as well as lagged nominal yields and lagged money growth.

The Inflation Premium and Models of Inflation Expectations

Henry Thornton wrote in 1811 that the inflation during the Napoleonic wars had caused an inflation premium to be incorporated into British interest rates.[13] Can the inflation premium during the period be adequately represented by current inflation, a perfect-foresight approach? Hardly. To understand why not, consider the requirements of a perfect-foresight approach: most of the variation in inflation must be forecastable and markets must have used optimal—that is, nonbiased and efficient—forecasts of inflation. If unforecastable shocks dominate variations in measured inflation, then current inflation and forecast inflation will not be closely related and perfect foresight will not be appropriate.

A negative rate of inflation, or deflation, creates another technical difficulty with the perfect-foresight approach. Since no one will lend at negative interest rates, preferring to hold money instead, the nominal rate of interest will never be less than zero. By implication, a negative inflation premium or expected rate of deflation can never be greater in absolute value than the real rate of interest.[14] When prices fall more than the usual real rate, say 3 to 5 percent, perfect foresight is not a meaningful assumption.

Available evidence indicates that the general level of British prices during the late eighteenth and early nineteenth centuries was indeed quite volatile, with numerous instances of deflation.[15] This is illustrated by Figure 1, which also suggests that average inflation tended to be quite low over most of the period; average prices rose about 0.7 percent annually.[16] As a result of volatile prices, using actual inflation for expected inflation results in equally volatile and sometimes negative real interest rates.[17] The real consol rate, for example, changes

[12] While it is possible to correct for autocorrelation using one of several econometric procedures, the preferred approach to autocorrelated errors is first to review the theoretical specification. The reason is that serially correlated omitted variables can induce serial correlation in the error term, which captures the effects of omitted variables along with random shocks.

[13] Thomas M. Humphrey, "The Early History of the Real/Nominal Interest Rate Relationship," *Essays on Inflation* (5th edn., Richmond, 1986), p. 151.

[14] See the discussion of Irving Fisher's *Appreciation and Interest* (1896) in ibid., pp. 156–57.

[15] T. S. Ashton, in *An Economic History of England: The 18th Century* (1955; London, 1972), p. 199, notes that it was primarily agricultural prices which were volatile. Phyllis Deane and W. A. Cole show that the period of 1790 to 1825 exhibited especially severe short-run reversals in price movements; see *British Economic Growth, 1688–1959* (Cambridge, 1967), p. 351, fig. 7.

[16] The price trend was calculated using a five-year moving average, including the current rate of inflation and four lagged values.

[17] See HM, "Interest Rates and Crowding Out," p. 120, table 1.

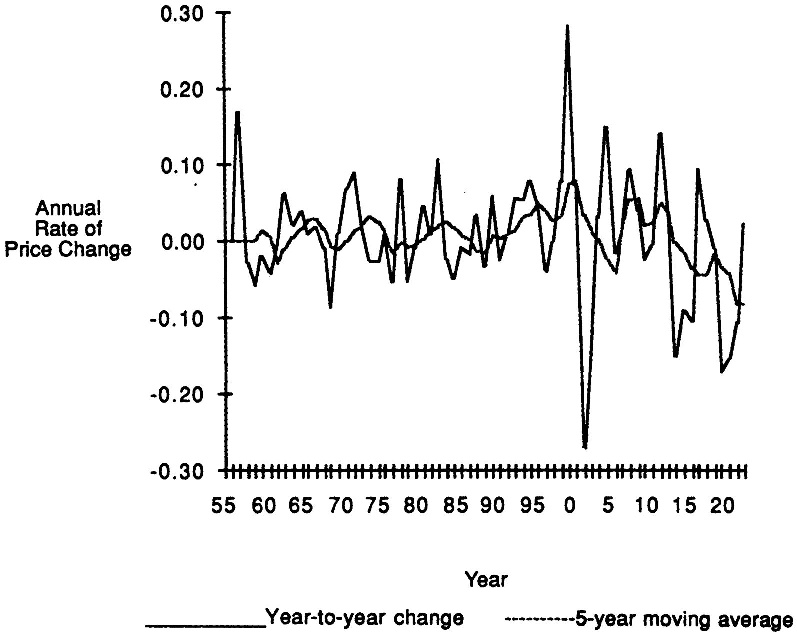

FIGURE 1

INFLATION AND ITS TREND IN BRITAIN, 1755 TO 1823: SCHUMPETER-GILBOY PRICE INDEX FOR CONSUMEER GOODS

Source: B. R. Mitchell and P. Deane, *Abstract of British Historical Statistics* (Cambridge, 1962), p. 469.

from about −28 percent to 27.5 percent between 1800 and 1802. The rate is back to −10 percent by 1805 and then up to 6.6 percent in the following year. When current inflation is so dominated by random shocks, an expectations mechanism based on perfect foresight is not adequate.

Two alternative approaches are used here. One is to duplicate the market's inflation forecasting model by estimating the best inflation equation given the available data and then incorporating the optimal forecasts as an explanatory variable in a nominal-yield equation. The second method is to assume that markets did not base risk premiums on the best forecast of inflation and that some other mechanism—such as adaptive expectations—served to calculate the premium.

We estimated an inflation equation which allowed for up to three lagged values of all the variables, including past inflation, past yields, and past government borrowing, to provide the best inflation equation possible. Separate equations were estimated for peacetime and wartime periods, but an *F*-test for the significance of a regime change showed that separate equations were not superior to a single equation for the entire period.[18] Equation 5 shows the result of fitting an inflation equation, with insignificant variables deleted (t-statistics less than one):

$$PP_t = \underset{(1.40)}{17.67} + \underset{(2.72)}{0.43} \cdot PP_{t-1} - \underset{(-3.23)^{**}}{0.50} \cdot PP_{t-2} + \underset{(1.30)}{0.56} \cdot RNRB_{t-1}$$

$$- \underset{(-2.53)}{1.58} \cdot RNRB_{t-2} + \underset{(2.59)}{1.45} \cdot RNRB_{t-3} - \underset{(-1.39)}{4.10} \cdot NCY_{t-3} \qquad (5)$$

$$R^2_{\text{adj}} = 0.370 \qquad \text{DW} = 2.38 \qquad \text{Sample: 1785–1816}$$

where PP_t equals percentage change in price using Schumpeter-Gilboy consumer prices, $RNRB_t$ equals real net receipts from borrowing, and NCY_t equals nominal consol yield. Predicted values from equation 5 serve as one expected-inflation variable in estimating the nominal-rate equations reported below.

Under an adaptive expectations model, a long distributed lag of past inflation values, rather than the best forecast of inflation, serves as the expectations variable. Such an approach to inflation expectations is by no means innovative, neither is the implied rejection of a perfect-foresight approach. In *The Theory of Interest,* Irving Fisher developed a model of real interest rates in which he tested and rejected the immediate adjustment of nominal interest rates to inflation.[19] He also found no statistical relation between nominal rates and *individual* values of lagged inflation; instead he found a strong relation between nominal rates and a distributed lag of inflation. Fisher concluded:

> By assuming a distribution of [the] effect of price changes over several years according to the form described above, the relationship between price changes and interest rates which was only faintly revealed by the first direct comparison is clearly revealed.[20]

[18] An anonymous referee suggested that inflation be explained using all the available information, including information on debt and nominal yields as well as information on past inflation. We also included the growth rate of money but this did not add to the significance of the regression, perhaps because debt and money are correlated. On the role of debt as money, see the discussion below in section 3. The same referee also suggested that the data on price included a possible regime change when the British economy went from peace to war in 1793. Estimating separate equations did show some changes in coefficients but an F-test for the significance of separate regressions showed that allowing for a regime change did not significantly increase the ability to explain inflation. In testing for crowding out, a peacetime/wartime inflation-expectations variable in unreported nominal-yield regressions did not change the results for the crucial borrowing variable.

[19] (New York, 1930), chap. 19. See especially pp. 416–25 for a study of the relation between inflation and nominal consol yields in Britain from 1820 to 1924. Fisher argued that realized, or ex post, real rates would be more volatile than nominal rates because "men are unable or unwilling to adjust at all accurately and promptly the money interest rates to changed price levels" (p. 415).

[20] Ibid., pp. 424–25.

Fisher's results imply that expectations about inflation adjust to actual inflation with a lag. If so, then some weighted average of past inflation rates may be appropriate for an expectations variable:

$$PP_t^e = \sum_{i=1}^{n} b_i \cdot PP_{t-i} \tag{6}$$

Fisher's estimates suggested that the length of the lag ran as many as 20 or 30 years for Britain in the mid-nineteenth century; he used an arithmetic lag distribution for statistical simplicity. Another approach to estimating the long lag distribution in equation 6 is with polynomial smoothing constraints to conserve degrees of freedom. It is important to see that using a long polynomial lag will not necessarily give the best forecasting equation for inflation. It does not matter, however, if the distributed lag is not the best forecast of inflation as long as it captures the mechanism generating the inflation premium in nominal interest rates.

To understand this better, consider the following simple nominal-India-bond-yield equation without borrowing effects:

$$NIBY_t = n_0 + n_1 \cdot NIBY_{t-1} + n_2 \cdot PP_t^e \tag{7}$$

In forecasting inflation, equation 5 outperforms a polynomial distributed lag.[21] But when one estimates equation 7 for the period from 1785 to 1816, first substituting the inflation forecast from equation 5 and then substituting a polynomial lag of inflation as alternative expected inflation variables, a reversal takes place. Now the lengthy distributed-lag variable gives more explanatory power and a higher adjusted R^2 than the optimal inflation forecast (0.587 compared with 0.514; equation 7 without *any* expectations variable has an adjusted R^2 of 0.529). In addition, the expectations coefficient for the distributed lag is larger and more significant than for the optimal forecast (n_2 equals 0.215 and t equals 2.02 compared with n_2 equals -0.003 and t equals -0.28). This result suggests quite clearly that the best inflation forecast may not be the best estimate of the inflation premium incorporated into nominal yields. Given the results, the nominal-rate equations were estimated using both the best forecast of inflation and a long distributed lag on inflation as the expectations variable. These estimates also accounted for the timing of borrowing effects on nominal yields.

[21] Estimating current inflation (PP_t rather than PP_t^e) as a 25-year distributed lag of past inflation for 1785 to 1816 will give an adjusted R^2 of only about 0.020. Comparing this result with equation 5 shows that the distributed lag approach is indeed inferior as an inflation forecasting equation. Even if information on government borrowing and nominal yields were not included in equation 5, its adjusted R^2 would only drop to 0.285, leaving it well above that for the distributed-lag equation.

TABLE 2
WARTIME REAL NET RECEIPTS FROM BORROWING AND NOMINAL CONSOL YIELDS: A SEARCH FOR LAGS

Year	Real Net Receipts from Borrowing (in £ millions)	Nominal Consol Yield (in percent)
1782 to 1792	£2.13[a]	4.29[b]%
1793	5.19	3.90
	(0.65)	(−0.61)
1794	9.12	4.44
	(1.49)	(1.49)
1795	15.51**	4.82
	(2.85)	(0.83)
1796	20.78**	4.34
	(3.97)	(0.08)
1797	19.12**	6.04*
	(3.62)	(2.73)
1798	10.34	6.09**
	(1.75)	(2.81)
1799	12.31*	5.55*
	(2.17)	(1.97)
1800	11.08*	4.72
	(1.91)	(0.67)

* Significant at the 5 percent level, one-tailed test.
** Significant at the 1 percent level, one-tailed test.
[a] Average borrowing for the period with n = 11. Standard deviation of real net receipts from borrowing is 4.69.
[b] Average yield for the period with n = 13. Standard deviation of the nominal consol yields is 0.64.

Lagged Borrowing and Nominal Yields

An important issue in any test for a "first link" between borrowing and interest rates is the potential for lagged effects of borrowing.[22] It is reasonable to assume that the full effects of borrowing on nominal interest rates may have developed over two or more years.[23]

A preliminary investigation of lagged borrowing effects supports, not a one-year lag, but a two-year lag between changes in government borrowing and changes in nominal yields. Wartime government borrowing and nominal interest rates were compared with their peacetime averages from before 1793. Table 2 provides evidence of a two-year lag in the statistical relation between real net receipts from borrowing and nominal consol yields. Obviously, this statistical relation does not prove

[22] HM's choice of the date on which to measure interest rates, the first Wednesday of April of each year, makes the issue of lags all the more important. Much of the government borrowing in 1782, for example, probably took place after the date in question, assuming a fairly even rate of borrowing. As a result one ought to allow not only for a contemporaneous effect but also for a one-year lagged effect of borrowing on interest rates. See HM, "Interest Rates and Crowding Out," p. 119.

[23] See, for example, the studies by Evans, "Do Large Deficits Produce High Interest Rates?" and "Do Deficits Raise Interest Rates?" which also assume lagged borrowing effects.

causality (nor for that matter does the regression analysis reported below), but it is consistent with a crowding-out theory.

The *t*-statistic for each observation in Table 2 tests the hypothesis that wartime values were drawn from the same distribution which generated the prewar averages. The *t*-statistics, therefore, show exactly when wartime borrowing and interest rates "broke out" of their prewar patterns. It appears that borrowing exceeded normal prewar limits two years before interest rates exceeded their prewar boundaries. This two-year lagged statistical relation seems to persist for all eight years considered in Table 2 (1793 to 1800).

The years covered in Table 2 contain one of the more notable highlights of British financial history, the suspension of specie payments in 1797. If the lagged effect of borrowing is ignored, it would seem that the suspension of specie payments early in that year might have had an immediate and clearly discernible impact on the nominal consol yield. If, however, one maintains a two-year lag in the effect of borrowing on nominal yields, then both the sharp increase in yields in 1797 and 1798 and the crisis which led to the suspension could possibly be attributed to the equally sharp rise in borrowing in 1795 and 1796.[24] Furthermore,

[24] An indication that borrowing could have a lagged effect on interest rates emerges from a report on the suspension of specie payment in 1797, an event that is closely related to the heavy wartime borrowing by the British government. In an anonymous tract, "Note on the Suspension of Cash Payments, at the Bank of England, in 1797," in John R. McCulloch, ed., *A Select Collection of Scarce and Valuable Tracts and Other Publications, on Paper Currency and Banking* (1857; New York, 1966), pp. 95–96, a contemporary writer highlighted the severity of the financial crisis leading to the suspension and outlined its probable causes, as well as the Bank of England's response:

> By far the most important crisis in the history of the paper currency of Great Britain took place in 1797. Owing partly to events connected with the war in which we were then engaged, to loans to the Emperor of Germany, to bills drawn on the treasury by the British agents abroad, and partly and chiefly, perhaps, to the large advances made by the Bank of England to Government, the exchange became unfavorable in 1795, and in that and the following year large quantities of specie were demanded from the Bank. No doubt, however, the ultimate crisis was wholly owing to political causes. Alarms with respect to invasion, and reports of descents, said to have been made on the coast, became exceedingly prevalent in the latter part of 1796, and the beginning of 1797. This produced a strong desire among many individuals, but chiefly among the small farmers and retail dealers, to convert as much as possible of their property into cash. . . . Demands for supplies of cash poured in upon the Bank of England from all parts of the country; and the stock of coin and bullion in her coffers, which amounted to £7,940,000 in March, 1795, was reduced on Saturday, the 25th of February, 1797, to £1,272,000 with every prospect of a violent run taking place on the following Monday. In this emergency, a meeting of the Privy Council was held, when it was resolved to suspend payments in cash at the Bank until the sense of Parliament could be taken on the matter.

The important point to observe from this account is an implied lag in the effect of governmental borrowing. Borrowing for the war with France, which began in 1793 and became quite heavy by 1795, was one underlying cause of the financial crisis in late 1796 and the subsequent suspension of specie payment early in 1797. The clear suggestion here is that the effect of wartime borrowing may have operated on the financial community, in particular on the nominal rate of interest, with a lag.

the subsequent fall in the yield in 1800 could be attributed to substantially lower borrowing two years earlier.

The implication is that the nominal rate may have generally responded to borrowing with a lag. This evidence, though, requires further support from a multiple regression test of the lagged effect. Moreover, since a two-year lag in estimating a nominal-yield equation presents some theoretical difficulties, a distributed lag of zero to two or more years should be estimated instead.[25] In addition, several other factors should be included in a nominal-yield equation. First, changes in the money supply could lead to changes in the yield. An increase in the money supply, for example, could work through its direct effect on liquidity, leading to lower yields, or through its effects on prices, leading to higher inflation premiums. Second, yields may have adjusted slowly to these factors, meaning that lagged yields may be important in explaining current yields.

Equation 8 takes account of the hypothesized lagged effect of government borrowing on nominal yields; it also allows for an inflation-expectations variable and lagged effects of changes in the money supply and nominal yields themselves.

$$NY_t = a_0 + \sum_{i=1}^{m} b_j \cdot NY_{t-j} + \sum_{j=0}^{n} c_j \cdot RGB_{t-j} + \sum_{k=1}^{q} d_j \cdot PM_{t-j} + e \cdot PP^e_{t-i} \quad (8)$$

where NY_t equals nominal yield on debt, RGB_t equals real government borrowing, PM_t equals percentage change in stock of Bank of England notes, and PP^e_t equals expected percentage change in price based on equation 5 or on a 25-year polynominal distributed lag on inflation.

Equation 8 was estimated with all lags except the one for real government borrowing (and for the inflation-distributed lag) set to a maximum of two years; pretesting showed that a lag of three years was

[25] An anonymous referee suggested that a long delay of two years in the effect of borrowing on rates "is inconsistent with the simplest principles of asset pricing [which] require that predictable changes in asset prices be smooth. Large predictable changes in interest rates due to information about government activity last year would imply forecastable profits." To avoid this difficulty, estimates of the yield equation reported below were first run with a smooth lag distribution running from zero to three years. Nevertheless, the coefficient on borrowing at a two-year lag was, for the nominal India bond yields, the first consistently significant one. In estimates for nominal consol yields, however, the one- and two-year lags were both significant; this finding *would* be consistent with asset pricing theory, given the choice of date for measuring the interest rate (see the discussion of this point earlier in this section). More evidence on the institutional aspects of financial markets is needed to reconcile the empirical data with a reasonable theoretical proposition.

TABLE 3
ESTIMATES OF EQUATION 8 USING INFLATION FORECASTS FROM EQUATION 5 AS EXPECTED INFLATION: 1785 TO 1816

Dependent Variable	Nominal India Bond Yield	Nominal Consol Yield
Constant Term	1.53**	4.56**
	(2.70)	(34.68)
Nominal Yield_{-1}[a]	0.64**	
	(4.67)	
Real Net Receipts_{-1}[a]		0.03
		(1.44)
Real Net Receipts_{-2}[a]	0.08**	0.07**
	(2.88)	(3.42)
Real Net Receipts_{-3}[a]	−0.04**	
	(−2.51)	
Money Growth_{-1}[a]	−0.01**	−0.01
	(−2.77)	(−1.62)
Expected Inflation (from equation 5)	0.01	0.02**
	(1.30)	(2.33)
Adjusted R^2	0.726	0.683
Durbin-Watson	2.04	2.13
$F_{\text{regression}}$	17.40**	17.71**
	(5,26)	(4,27)

* Significant at the 5 percent level, one-tailed test.
** Significant at the 1 percent level, one-tailed test.
[a] Negative subscripts indicate lag length.
Notes: Figures in parentheses below coefficients are t-statistics; figures in parentheses below F-statistic are degrees of freedom.

needed for borrowing (only with nominal India bond yields) but not for any of the other variables.

Table 3 shows a final estimate of equation 8, where the expectations variable was formed using the earlier forecasts of inflation from equation 5; insignificant lags on variables were deleted and the regressions recalculated each time to arrive at the final equation reported in the table.[26] Table 4 shows estimates of equation 8 where the expectations variable was formed using a 25-year polynomial-distributed lag on inflation; insignificant lags on variables were again deleted and the regressions recalculated each time. These equations confirm a lagged relation between borrowing and nominal yields, no matter which expectations variable is used.[27] The results hold whether consol yields or nominal India bond yields are used as the dependent variable. The coefficients for borrowing lagged two years are significant in all equa-

[26] The rule for respecification was to keep a variable if its coefficient had a t-statistic greater than one. This is approximately the rule used in several recently developed statistical criteria for model selection. See George G. Judge, et al., *The Theory and Practice of Econometrics* (New York, 1980), pp. 420–22. Given the available data on real net receipts from borrowing (1782 to 1816), a lag of three years on government borrowing left 1785 as the starting year for the sample.

[27] The results do not differ when change in real debt is substituted for real net receipts, the variable preferred by HM.

TABLE 4
ESTIMATES OF EQUATION 8 USING ADAPTIVE INFLATION EXPECTATIONS: 1785 TO 1816

Dependent Variable	Nominal India Bond Yield	Nominal Consol Yield
Constant Term	1.93**	4.03**
	(3.14)	(34.68)
Nominal Yield_{-1}[a]	0.49**	
	(3.08)	
Real Net Receipts_{-1}[a]		0.03
		(1.44)
Real Net Receipts_{-2}[a]	0.05**	0.05**
	(3.06)	(3.42)
Real Net Receipts_{-3}[a]	−0.02	
	(−1.11)	
Money Growth_{-1}[a]	−0.02**	−0.01
	(−3.05)	(−1.62)
Money Growth_{-2}[a]		−0.01
		(−1.05)
Expected Inflation (sum of distributed lag effects)[b]	0.19*	0.08
	(2.35)	(0.71)
Adjusted R^2	0.756	0.616
Durbin-Watson	1.90	1.91
$F_{\text{regression}}$	17.00**	8.12**
	(6,25)	(7,24)

* Significant at the 5-percent level, one-tailed test.
** Significant at the 1-percent level, one-tailed test.
[a] Negative subscripts indicate lag length.
[b] Sum of distributed lag coefficients and its t-statistic are reported. Estimation used a second-degree polynomial for India bond yields and a third-degree polynomial for consol yields, both with lag lengths of 25 years.
Notes: Figures in parentheses below coefficients are t-statistics; figures in parentheses below F-statistic are degrees of freedom.

tions. Thus the assumption of a lag in the effect of government borrowing is supported by the data although a contemporaneous relation is not.

The low coefficients on inflation expectations in Table 3 are not at all surprising. The market would not necessarily have adjusted long-term nominal rates to estimates of current inflation because current inflation was volatile and perhaps quite impossible to predict. Since the average yearly rate of inflation between 1760 and 1790 was only about 0.7 percent, people may reasonably have ignored the wild swings in current inflation. As a result the very low coefficients of adjustment in Table 3 along with the poor performance of the perfect-foresight, real-yield equations in Table 1 are quite understandable. In Table 4 the India-bond-yield equation showed the highest coefficient of adjustment, using the adaptive-expectations mechanism; nonetheless its value was only about 0.2, showing much less than complete adjustment of nominal yields even to this expectations variable.

The relation between government borrowing and interest rates which has been established in Table 3 does not seem to depend on any particular assumption about inflation expectations.[28] Instead, the results depend on relaxing the assumption that the nominal rate adjusts fully to the current rate of inflation (or even to its forecasts) and on relaxing the assumption that the relation between borrowing and interest rates is purely contemporaneous.

Summary of Estimation Results

The empirical evidence confirms a lagged relation between British interest rates and government borrowing during the early Industrial Revolution. Taking an average of the estimates in Tables 3 and 4, with other things constant, a sustained increase in the net receipts from borrowing of £12 million would have increased the nominal consol yield by about 1 percent after two years. This is approximately what is implied by the data in Table 2; in the first five years of the French war, average borrowing increased £11.8 million over prewar levels while, allowing for a two-year lag, average nominal consol yields increased 1.1 percent.

To what extent is the evidence on nominal consol yields and nominal India bond yields representative of the general effects of wartime borrowing on interest rates and private borrowing? According to Ricardo, the effects were indeed widespread and substantial:

> During the present war, Exchequer and Navy Bills have been frequently at so high a discount, as to afford the purchasers of them 7, 8 per cent., or a greater rate of interest for their money. Loans have been raised by Government at an interest exceeding 6 per cent., and individuals have been frequently obliged, by indirect means, to pay more than 10 per cent. for the interest of money.[29]

Our empirical estimates explain why Ricardo found that interest on government loans was in excess of 6 percent. Net receipts from borrowing exceeded the prewar average by £13.4 million in 1795 and £18.6 million in 1796; according to estimates in Tables 3 and 4, this rise in borrowing largely explains why consol yields rose above 6 percent—almost 2 percent higher than their prewar average—in 1797 and 1798.

Our estimates also confirm Williamson's suggestion that the formation of price expectations is central to understanding the impact of government borrowing on interest rates.[30] The estimates reject a perfect-foresight assumption about inflation expectations and suggest

[28] The results for lagged borrowing held up in tests with alternative expectations assumptions: an autoregressive expectations variable which only considered two lagged values of inflation; a perfect-foresight approach; and Fisher's distributed-lag approach, using polynomial lags of 5, 10, 15, 20, and 30 years.

[29] David Ricardo, *Principles of Political Economy and Taxation* (3rd edn., 1821; reprinted London, 1908), p. 281.

[30] "Debating the Industrial Revolution," p. 288, and "Has Crowding Out," pp. 214–16.

that nominal rates did not include much information about current inflation; therefore, accurate forecasts of current inflation were not crucial in modeling expected inflation. Markets apparently used information on long-term averages of inflation, gearing the inflation premium to that longer view and ignoring the volatile short-run information about current inflation. As a result our test of a crowding-out hypothesis focused on estimating nominal-rate equations rather than using an inflation-expectations variable to first calculate a real rate and then estimate a real-rate equation. The choice of an expectations model was not as critical in establishing a crowding-out hypothesis as the refusal to impose a model on the estimation procedure by calculating real rates of interest.

The estimates help resolve an apparent contradiction between those who have concluded that heavy wartime borrowing by the British government between 1793 and 1815 did not cause increases in interest rates and those who have concluded that it did. While the *realized* real rate of interest during the period may not be "a scarcity index for capital conceived as a factor of production," the nominal rate would appear to be such an index.[31]

II. INTEREST RATES, CROWDING OUT, AND THE NEOCLASSICAL MODEL: SOME HISTORICAL CONSIDERATIONS

The results above show that British data from the early Industrial Revolution support a "first link" in the crowding-out argument: wartime government borrowing raised nominal interest rates. What remains is to clarify the connection between crowding out and the neoclassical model. The model is compatible with the existence of alternative sources of additional investment funds. Consequently, the absence of evidence establishing an interest-rate effect of government borrowing would not justify the conclusion that the neoclassical factor-allocation model should be replaced by one in which firms generate their own investment funds. A number of factors were present in Britain after 1792 which could have ameliorated the effects of borrowing on interest rates.[32] First, a changing money supply could have offset the effects of changing government borrowing. Next, increased borrowing could have affected private saving behavior. Third, the availability of foreign capital might have increased in response to the heavy borrowing. Finally, the usury ceiling in force at the time could have distorted the

[31] HM, "Interest Rates and Crowding Out," p. 127.

[32] Evans, "Do Large Deficits Produce High Interest Rates?" pp. 72–73, for example, found no empirical connection between government deficits and interest rates for the United States during the Civil War period. His explanation of this result lists arguments which are similar to some of those to be discussed below.

TABLE 5
BANK OF ENGLAND NOTES IN CIRCULATION: 1780 TO 1825
(£ millions)

Year	Bank Notes in Circulation	Percentage Change from Five Years Earlier
1780	£7.4	
1785	6.2	−17.6%
1790	10.7	53.3
1795	12.4	14.7
1800	15.9	24.7
1805	17.1	7.3
1810	22.9	29.0
1815	27.3	17.5
1820	23.9	−13.3
1825	20.1	−17.3

Source: B. R. Mitchell and Phyllis Deane, *Abstract of British Historical Statistics* (Cambridge, 1962), pp. 442–43.

link between borrowing and interest rates when market rates were above the ceiling.

Variations in the Supply of Money

Textbook models of crowding out normally assume a fixed money supply. This is an implausible assumption for the period under study, however, for several reasons. First, the suspension of specie payment was followed by an excessive issue of notes by the Bank of England, at least according to Ricardo and other bullionists of the day.[33] The quantity of Bank of England notes in circulation for the years 1780 to 1825 and the percentage change from five years earlier are presented in Table 5. It can be seen that the five-year rate of change is quite variable. In addition, the estimates of equation 8 in Tables 3 and 4 give evidence that changes in money growth did have a negative, lagged impact on nominal yields; increased money growth and the accompanying increase in liquidity drove nominal interest rates down, at least in the short run.

Second, bonds themselves may have circulated as currency of a sort. T. S. Ashton noted that a number of short-term, and to some extent long-term, instruments served as media of exchange during the eighteenth century:

> Shortly before the eighteenth century opened the creation of the national debt had brought into being a mass of securities bearing more or less fixed interest rates. Some

[33] See David Ricardo, "The High Price of Bullion a Proof of the Depreciation of Bank Notes," *The Works and Correspondence of David Ricardo*, Piero Sraffa and M. H. Dobb, eds. (Cambridge, 1962), vol. 3, pp. 47–98; see also William Blake, "Observations on the Principles which Regulate the Course of Exchange: and on the Present Depreciated State of the Currency" (1810), in McCulloch, ed., *A Select Collection of Scarce and Valuable Tracts and Other Publications, on Paper Currency and Banking*, pp. 523–24.

of these, including exchequer bills, navy bills, and lottery tickets (as also the short-term obligations of the East India Company, the Bank of England, and the South Sea Company) could be used to settle accounts between individuals, and may perhaps, therefore, be thought of as falling within the somewhat shadowy boundaries of "money." Even the long-dated securities had some effect on purchasing power.[34]

Significant liquidity of government securities would tend to alter the interpretation of a test of the first link in the crowding-out hypothesis. If the debt instruments served as money, any increase in government debt during the period would not necessarily have caused a one-for-one reduction in the purchasing power of the public and investment might not have been impeded.

Taken together, the liquidity of government securities and the over-issue of Bank of England notes make it unreasonable to assume that the money supply was held constant while new war debt was accumulating. This means that the increased wartime government expenditure and borrowing, when accompanied by an increase in the issue of bank notes, could have left interest rates unchanged. New money, rather than diverted saving, would have financed the new debt until prices and expectations adjusted fully.[35]

Changes in the Rate of Saving

The impact of government borrowing on interest rates depends partly on the effect of that borrowing on private saving. Ricardo suggested that increased government borrowing could stimulate additional private saving to pay for the anticipated future tax liabilities resulting from that borrowing.[36] If households responded to increased government borrowing by supplying extra funds in the capital markets, the increased saving could accommodate the borrowing without a rise in interest rates and without a drop in private borrowing. The effect of borrowing would then be to crowd out consumption rather than investment. It is not necessary that consumption be completely crowded out by this equivalence effect. In fact, Williamson pointed out that Ricardo believed that in practice taxes and borrowing would not be treated equivalently.[37] But even an

[34] *An Economic History of England*, pp. 177–78.

[35] This could be illustrated by a rightward shift of both the IS and the LM curves so as to leave the nominal interest rate unchanged. Until inflation expectations began to catch up, the nominal rate would not adjust.

[36] See Ricardo, "Funding System," in *Works and Correspondence*, vol. 4, pp. 185–88. Robert J. Barro, in "Are Government Bonds Net Wealth?" *Journal of Political Economy*, 82 (Nov./Dec. 1974), pp. 1095–117, labeled this the Ricardian equivalence principle, whereby increased taxes or debt to finance increased government expenditure would have the same effects on the economy. For a helpful account of this and other issues regarding classical thought on government debt, see C. K. Rowley, "Classical Political Economy and the Debt Issue," in J. M. Buchanan, C. K. Rowley, and R. D. Tollison, eds., *Deficits* (Oxford, 1986), pp. 49–74, esp. 65–69. For a critical discussion of Ricardian equivalence, see James Tobin, *Asset Accumulation and Economic Activity: Reflections on Contemporary Macroeconomic Theory* (Chicago, 1980), chap. 3.

[37] Williamson, "Why Was British Growth So Slow," pp. 100–1.

incomplete adjustment of saving to government borrowing could reduce the response of interest rates to government borrowing.

All this would be irrelevant, though, if households had been generally unable or unwilling to save before and during the French war. But the evidence is that even poor laborers had occasion to save by joining "friendly societies," which, among other things, promoted thrift among their members. The number and influence of these societies was substantial even in the eighteenth century: over a thousand societies served several million members.[38] An Act of 1793 further "encouraged . . . the already numerous" societies.[39] Thus, thrift was becoming a habit even in the laboring classes by the end of the eighteenth century, leaving at least the potential for increased saving and crowding out of consumption during the French war.

Evidence that consumption was reduced during the war has been found by Brian Murphy, who cited lower industrial rates of growth for consumer-oriented leather and beer production for the period from 1795 to 1805 as compared with the previous ten years: for leather the decline was from 1.5 to 0.25 percent growth per year while for beer the decline was from 1.75 to 0 percent growth per year; soap and glass production growth rates also declined.[40] Further evidence suggests that the wartime borrowing may also have changed the mix of production, since pig-iron production growth rates remained high due to wartime demand for arms.[41]

Neither evidence about crowding out of consumption rather than investment nor evidence of a shift in the mix of production invalidate the neoclassical model in any way. The model can incorporate crowding out of investment *or* consumption and was formulated specifically for analyzing problems of allocation of means among competing ends. In fact, crowding out of consumption and the Ricardian-equivalence effect can be derived in the context of the saving and consumption decisions of utility-maximizing households.[42]

[38] E. Lipson, *The Growth of English Society* (New York, 1950), p. 357. Clapham is more conservative; he puts the "recognized membership" in the "year of Waterloo" at nearly a million but notes that this did not include members of informal secret orders. See J. H. Clapham, *An Economic History of Modern Britain* (Cambridge, 1930), p. 211.

[39] Paul Mantoux, *The Industrial Revolution of the Eighteenth Century* (revised edn., New York, 1961), p. 450.

[40] Cotton production, however, was in the midst of a period of great innovation, and the rate of growth of output increased. See Brian Murphy, *A History of the British Economy: 1088–1970* (London, 1973), p. 416, table II.5.

[41] Ibid. Murphy's evidence on pig-iron production supports HM's ("Interest Rates and Crowding Out," pp. 136–37) contention that the mix of output may have been changed by wartime expenditures. For a contrary view, see Williamson, "Why Was British Growth So Slow," p. 188.

[42] Paul Evans, "Are Consumers Ricardian? Evidence for the United States," *Journal of Political Economy*, 96 (Oct. 1988), pp. 983–1004.

Increased Foreign Lending

Crafts has suggested that the supply of investment funds may have been quite elastic during Britain's early Industrial Revolution due to the availability of foreign capital.[43] The effect would have been to reduce the response of interest rates to increased wartime government borrowing. As soon as British rates rose above rates in other financial markets, funds would have moved to Britain, especially with the turmoil on the Continent. The importance of foreign lending to the British government during this period, especially by the Dutch, was recognized by Ashton.[44] As Williamson observes, "while domestic savings may have been unresponsive to British rates of return, total savings could have been responsive to the extent that foreign capital markets were fairly well integrated."[45]

While the availability of foreign lending is evidence against a closed-economy model of crowding out, it should not be taken as evidence against the neoclassical model in general. The main reason is that there were presumably some limits even to the availability of foreign lending. The fact that the supply of capital was not perfectly elastic during the period is illustrated by the evidence presented above showing that wartime borrowing did indeed raise rates.

The Usury Ceiling

An additional factor that had at least the potential to affect the response of interest rates to wartime borrowing was the law against usury. Ashton noted that a usury ceiling of 5 percent was in effect on all private debt after 1714 in Britain.[46] Such a ceiling would have enhanced the ability of the government to sell bonds whenever the market rate, represented by the yield on consols, was pushed above the ceiling of 5 percent. This could reduce the effect of government borrowing on interest rates; it could also increase the wartime crowding out of private investment by diverting even more funds to the government when private borrowers could not pay the higher rates even if they wanted to.

The evidence on the actual effect of the ceiling is mixed and needs to be considered carefully. Interpretation hinges on whether market rates rose above the legal limit due to a totally ineffective ceiling or to a partially effective ceiling which caused rationing among private borrow-

[43] N. F. R. Crafts, "British Economic Growth, 1700–1850: Some Difficulties of Interpretation," *Explorations in Economic History*, 24 (July 1987), p. 247.

[44] *An Economic History of England*, p. 193.

[45] "Why Was British Growth So Slow," p. 290. HM, "Interest Rates and Crowding Out," pp. 133–34, also noted the role of the Dutch and other Europeans in lending to Great Britain, but they cited this as evidence against the neoclassical model rather than consistent with it. For a further discussion of financial integration, see Larry Neal, "Integration of International Capital Markets: Quantitative Evidence from the Eighteenth to Twentieth Centuries," this JOURNAL, 45 (June 1985), pp. 219–26.

[46] *An Economic History of England*, p. 27.

ers due to higher lending costs. On the one hand, the ceiling was not totally effective and rates did rise above legal rates as markets found ways to circumvent its restrictions. Ricardo, for example, noted the ineffectiveness of the ceiling by remarking that, while wartime interest rates were high, "during this same period the legal rate of interest has been uniformly [less than the market rate] at 5 per cent."[47] On the other hand, circumventing the ceiling was costly. As a result, J. R. McCulloch contended, the usury ceiling was itself responsible for high interest rates on private debt:

> When the rate fixed by law is less than the market or customary rate, lenders and borrowers are obliged to resort to circuitous devices to evade the law; and as these devices are always attended with more or less trouble and risk, the rate of interest is proportionately enhanced. During the late war it was not uncommon for persons to pay ten or twelve per cent for loans, which, had there been no usury laws, they might have got for six or seven per cent.[48]

McCulloch's assertion suggests that the usury ceiling may have indirectly increased funds available to the government during the war; while driving private rates up and quantity demanded down, the ceiling would have diverted funds to the government and moderated the rate the government paid.

One point is clear from reviewing all these factors which could have affected interest rates: it is possible to find no strong link between government borrowing and interest rates while still maintaining the stylized truth of the neoclassical model. In sum, the neoclassical model is able to incorporate or explain circumstances under which one-for-one or partial crowding out do not occur. Thus, finding no relation between interest rates and government borrowing would not by itself invalidate the factor-allocation view embodied in the model. Given the number of potentially strong intervening factors, it is all the more remarkable that government borrowing did apparently lead to increases in the interest rate on government debt, as our empirical findings have suggested.

III. CONCLUSIONS

This article has presented new econometric evidence regarding crowding out during the Industrial Revolution in Britain. Using different

[47] Ricardo, *Principles of Political Economy*, p. 281. See the quote in the conclusions to section I.

[48] J. R. McCulloch, *Principles of Political Economy* (2nd edn., Edinburgh, 1843), p. 520. Henry Dunning Macleod, *History of Economics* (London, 1896), p. 470, gives further evidence of the ceiling leading to high rates on various occasions: "The experience of several commercial crises had demonstrated that in consequence of the law attempting to prevent persons paying more than 5 per cent. for a loan of money, they often had to pay 50, 60, and 70 percent by the methods they were forced to adopt." No doubt such high rates had a chilling effect on private borrowing.

assumptions about inflation expectations and the timing of the crowding-out effect, we have found evidence of a strong effect of government borrowing on nominal interest rates. We have also argued that failure to find such an effect would not necessarily constitute evidence against crowding out, nor would it be sufficient to invalidate the neoclassical model of the economy.

The finding of a link between British wartime borrowing and interest rates is not new; the same conclusion was announced by Mill as part of his discussion of conditions under which government borrowing encroaches on private employment:

> When they do raise the rate of interest, as they did in a most extraordinary degree during the French war, this is positive proof that the government is a competitor for capital with the ordinary channels of productive investment, and is carrying off, not merely funds which would not, but funds which would, have found productive employment within the country. To the full extent, therefore, to which the loans of government, during the war, caused the rate of interest to exceed what it was before, and what it has been since, those loans are chargeable with all the evils which have been described.[49]

HM have suggested that more remains to be done in the area of a detailed study of the records of individual firms operating during the Industrial Revolution.[50] Our results simply suggest that more information is also available from the aggregate data itself, through an investigation of the timing of government-borrowing effects and the assumptions about real interest rates and expected inflation. But if one chooses to study effects of wartime government borrowing on individual firms, then perhaps the anecdotal evidence cited by Ashton is also appropriate. He tells of Jedediah Strutt and his brother-in-law, William Woollatt, who in 1757 were hoping to patent their Derby-rib stocking frame and to borrow money to promote the invention.

> Strutt's wife, Elizabeth, had previously been in service with the Rev. Dr. Benson who was, at this time, living in London. In the hope of inducing him to finance the new enterprise, she travelled from Derby to his home in Goodman's Fields; but in a letter dated "3 May 1757 6 o'clock in the morning" she had to inform her husband that her mission had failed:
>
> > Ye Dr. is pritty well again and I have acquainted him with our scheme which, so far as he understands it may do very well and he will do all he can for us, and wou[d] willingly supply us with ye money. Mr. William Cook at ye same time wanted to Borrow of him one thousand pound (and) in order to furnish boath of us he went to ye Bank to sell out but ye War makes ye Stocks run so very low y[t] he will loose a Hundred pound if he sells out now, and they will rise as much in proportion if there comes a peace.

[49] Mill, *Principles*, p. 874.
[50] "Interest Rates and Crowding Out," pp. 138–39.

In May 1757 the 3 per cent. annuities stood at 90. Dr. Benson was unwilling to forgo the chance of a recovery in the capital value of his holding. But he may also have reflected that the yield on investment in the annuities was now 3.3 per cent. and that the difference between this and the 4 per cent. offered by Strutt was small compensation for the additional risk.[51]

This information supports the notion of government crowding out of private investment, particularly during heavy wartime borrowing. It also supports the neoclassical view of the economy as "primarily a mechanism for allocating scarce factors . . . in which utility-maximizing household decisions figure prominently in the supply of saving to the rest of the economy."[52] The case of the Strutts and Woollatt would also seem to suggest that capital markets were becoming "somewhat integrated" during the period and that funds were at least potentially mobile between uses.[53]

[51] *An Economic History of England,* pp. 28–29. Ashton cites this story from R. S. Fitton and A. P. Wadsworth, *The Strutts and the Arkwrights, 1758–1830* (New York, 1958), p. 30.

[52] HM, "Interest Rates and Crowding Out," p. 117. Their point, though, was that the evidence did *not* support this view.

[53] For the contrary view, see ibid., p. 129.