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Does inflation reduce productivity?

A review of regulatory mechanisms to control the volatility of prices

Index for 1994

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What would be the long-run economic benefit of reducing the rate of inflation? Conversely, what would be the cost of allowing inflation to rise above the current rate? The authors find that the cyclical relationship between inflation and productivity appears to be driven by the state of the economy and the actions of monetary policy, while the estimated long-run effects of inflation on productivity are highly sensitive to the identification scheme used to distinguish inflation from productivity shocks.

Regulatory proposals to control price volatility in the futures market generally recommend one of three approaches: margin setting, price limits, or transaction taxes. This article reviews the evidence for each of these mechanisms.

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Does inflation reduce productivity?

Argia Sbordone and Kenneth Kuttner

What would be the long-run economic benefit of reducing the rate of inflation, or eliminating it entirely? Conversely, what would be the cost of allowing inflation to rise above its current rate? Answering these key monetary policy questions requires an assessment of inflation's real effects. The case for zero inflation rests on the presumption that the real costs of inflation are substantial, while arguments for de-emphasizing the zero-inflation goal presume the opposite.

Many economists have argued that high rates of inflation create distortions that lead to inefficient resource allocation and hence lower productivity. Feldstein (1982), for example, has contended that given the existing tax structure, inflation lowers the real return on capital, discouraging capital formation. Other often-cited efficiency losses are associated with the unproductive activities required to cope with ever-rising prices. These include the costs of changing posted or printed prices, and the "shoe-leather" costs associated with holding less cash.[1]

The empirical evidence on the inflation-productivity relationship has been inconclusive. While many studies have sought a link between average inflation and real growth rates across countries, the results are mixed and tend to be sensitive to the inclusion of additional variables as determinants of productivity growth.[2] A recent paper by Rudebusch and Wilcox (1994) documented a strong inverse relationship between inflation and productivity in the U.S. More importantly, it added a causal interpretation and policy conclusion: Reducing inflation, it argued, would increase productivity. These results and conclusion received a great deal of attention in the business press and were cited by Federal Reserve Chairman Alan Greenspan in congressional testimony in May.

Our article examines the postwar evidence on the relationship between inflation and productivity in the U.S., paying particular attention to two questions that the existing literature has not resolved. One is whether the negative correlation documented by Rudebusch and Wilcox is a long-run phenomenon or simply reflects cyclical co-movements. The second question is what assumptions are required to interpret the correlation as a causal relationship and conclude that a permanent decrease in inflation would bring about a permanent increase in productivity.

In the first section we describe the statistical properties of inflation and productivity and corroborate the negative correlation at cyclical and long-run horizons. We then take up the interpretation of this correlation. Simple "Granger causality" tests suggest a causal link between inflation and productivity when only those two variables are included in the analysis. Controlling for other factors—monetary policy, in particular—destroys that relationship, however. In a four-variable vector autoregression (VAR) model, increases in the federal funds rate cause productivity to fall, while inflation lacks any predictive power.

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The next section takes up the long-run relationship between inflation and productivity, using a bivariate time-series model to estimate the ultimate effect on productivity of a permanent shock to inflation. An important conclusion of this analysis is that the size and sign of the estimated effect depend heavily on the identifying assumptions used to distinguish inflation shocks from productivity shocks. This result illustrates the dangers in drawing policy conclusions from bivariate correlations. In addition, robustness checks show that the strength of the long-run effects depends on the inclusion of the oil-shock episodes.

The article also discusses the economics that may underlie the strong negative cyclical relationship between inflation and productivity observed in the data. A box sketches the elements of a model that would exhibit this property. In such a model, a monetary policy rule that raises short-term interest rates in anticipation of future inflation can generate a negative correlation at cyclical frequencies. This argument relies on procyclical productivity behavior, and a lag between economic activity and changes in the rate of inflation. Immediately after a monetary contraction, therefore, inflation remains high while output contracts; meanwhile, labor hours fall less than output because of labor hoarding. The fact that labor productivity falls while inflation remains high generates the negative correlation in the data, rather than any causal link from inflation to productivity.

A look at the data

Figure 1 plots the quarterly series of inflation and productivity used in this article. Inflation is the annualized growth rate (approximated by the change in the logarithm) of the gross domestic product (GDP) deflator for the non-farm business sector. The productivity index is the output-to-labor ratio, or average labor productivity, in the non-farm business sector.[3]

Figure 2 displays the trend and cyclical components of inflation and productivity growth, obtained by passing the series through a band-pass filter that allows respectively only the low-frequency components (panel A) and the business cycle frequencies (panel B).[4] Panel A shows that inflation and productivity both exhibit a great deal of low-frequency variation. This also appears in the descriptive statistics reported in table 1, which shows that productivity was generally lower and inflation higher in the two decades following the 1973 oil shock. In addition, inflation and productivity appear to be strongly negatively related; the correlation coefficient is –0.36 in the unfiltered data and –0.47 for the cyclical components (not reported in the table).

Causality tests

The negative correlation between inflation and productivity apparent in figure 2 and documented in table 1 is quite robust—so much so that it is tempting to jump immediately to the conclusion that inflation causes productivity to fall. But since correlation does not imply causality, such a conclusion might be premature. Low productivity growth might cause inflation to increase, for example, rather than the other way around. Alternatively, the correlation might represent a common response to some third factor rather than an underlying structural relationship between inflation and productivity.

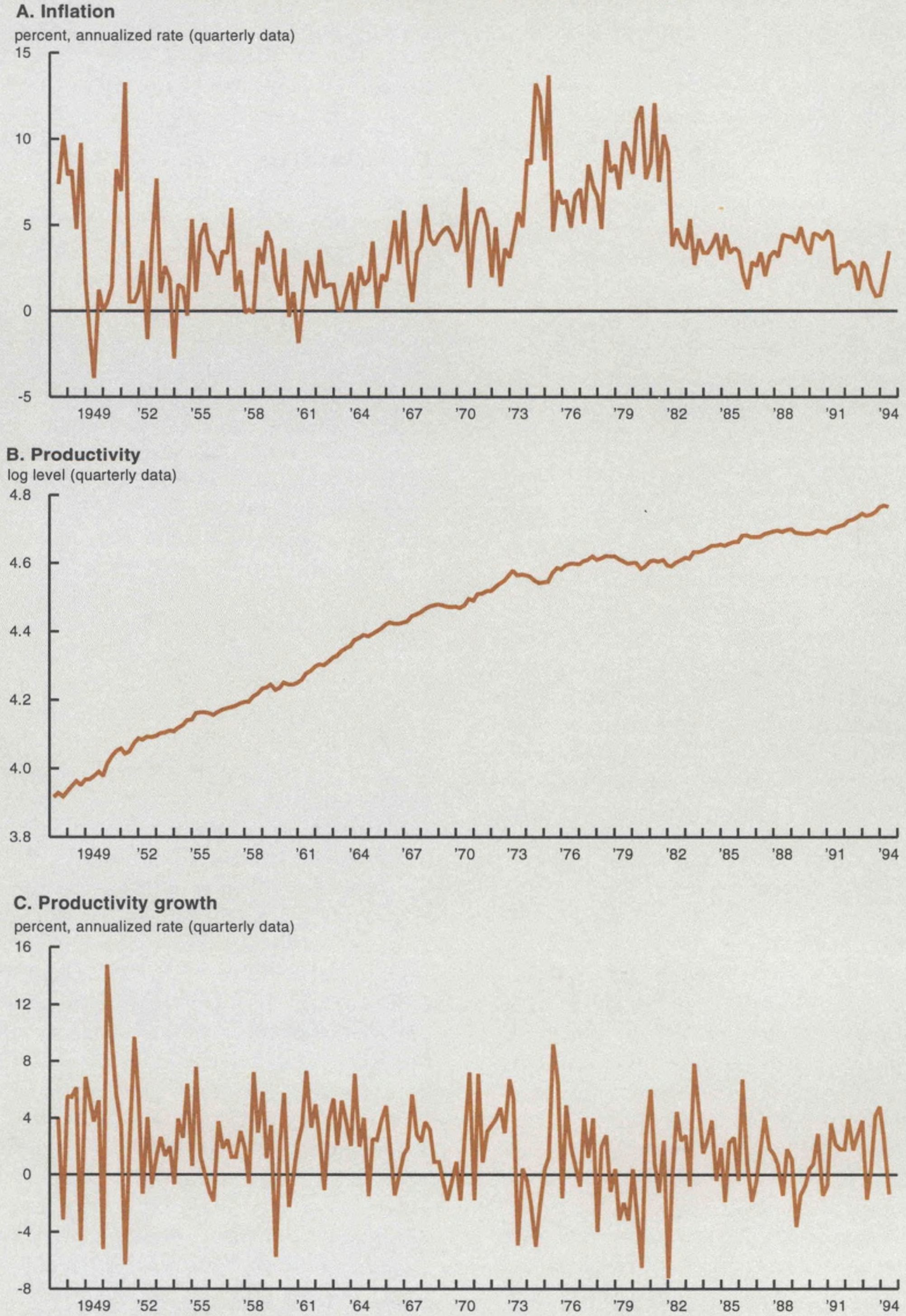
One way to go beyond the simple correlation reported above is, following Rudebusch and Wilcox, to employ tests for Granger causality. Although the name suggests that these tests can determine whether inflation is the underlying cause of productivity fluctuations, their notion of causality is much narrower. All these tests can do is determine whether current inflation is useful for *forecasting* future changes in productivity—clearly quite distinct from the idea of *logical* causality.

Table 2 corroborates the Rudebusch-Wilcox finding that inflation indeed strongly "Granger causes" productivity growth in a simple bivariate relationship. The significant F-statistic for inflation in the productivity regression indicates that inflation contains information useful for predicting future productivity growth, supporting a causal link running from inflation to productivity. The negative sum of the coefficients, reported below the F-statistic, is consistent with the negative relationship visible in figure 2. Although the effect is statistically significant, the $\bar{R}^2$ statistic indicates that lagged productivity growth and inflation together account for only 6 percent of the variance in productivity growth.

This finding, along with the insignificant F-statistic for productivity in the inflation equation, appears to support the contention that inflation reduces productivity. What it does not indicate, however, is whether the bivariate

FIGURE 1

An overview of inflation and productivity



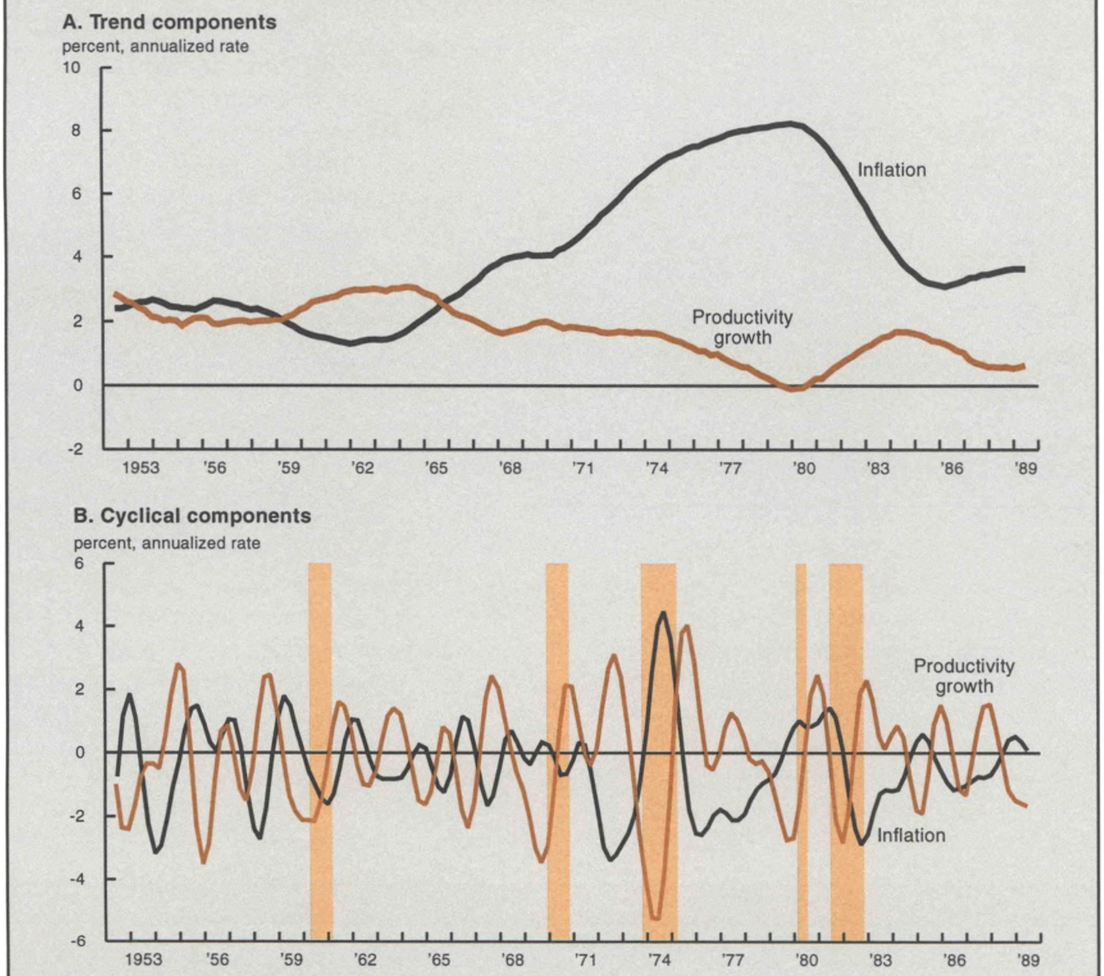
Granger causality represents a structural relationship or is merely an artifact of the short-run co-movements of inflation and productivity over the business cycle.

Sources of cyclical co-movements

A great deal of theoretical and empirical research has gone into exploring mechanisms that can produce a negative correlation

FIGURE 2

Inflation and productivity growth



Note: Vertical bands mark NBER-designated recessions.

between the movements in inflation and in productivity that occur over the business cycle. One plausible mechanism involves the Federal Reserve's reaction to anticipated inflation and the way in which businesses respond to transitory cyclical downturns.

TABLE 1

Descriptive statistics

	1947:Q1 - 1994:Q2	1947:Q1 - 1973:Q3	1973:Q4 - 1994:Q2
Inflation			
Mean	4.02	2.99	5.35
Standard deviation	3.13	2.76	3.08
Productivity growth			
Mean	1.80	2.45	0.98
Standard deviation	3.29	3.40	2.95
Correlation	–0.36	–0.27	–0.37

Suppose, for instance, that the Fed acts to tighten monetary policy in response to impending inflation, and that inflation thereafter declines more slowly than real activity. Faced with costs associated with adjusting their work force, firms will reduce employment only gradually and may retain more workers than they really need—a phenomenon known as labor hoarding. The result is a fall in output and labor productivity, coinciding with high inflation. In this scenario, which

TABLE 2

Inflation and productivity in a bivariate VAR

Equation	$\bar{R}^2$	Right-hand side variables: Productivity	Inflation
Productivity	0.06		
F-statistic		--	3.35***
Sum of coefficients			–0.28***
Inflation	0.61		
F-statistic		0.42	--
Sum of coefficients		0.04	

Note: Each equation in the VAR contains four lags of productivity growth and inflation. The VAR sample period is estimated on quarterly data from 1950:Q1 through 1994:Q2.
***Significant at the .01 level.
**Significant at the .05 level.
*Significant at the .10 level.

is a feature of models similar to the one sketched in the box, the negative correlation between inflation and productivity is only an artifact of the monetary rule and the timing of output and price responses over the cycle.

One way to control for common cyclical factors is to include additional control variables in the regression on which the Granger causality tests are based. Two obvious candidates for cyclical controls are the growth rate of real GDP, which captures the level of overall economic activity, and the federal funds rate, whose movements are related to changes in the Federal Reserve's monetary policy. Table 3 reports results from a VAR that includes these two additional variables.

The table shows that including GDP and the federal funds rate destroys the inflation-productivity link that was present in the bivariate VAR. In the four-variable system, the Granger causality *F*-statistic for inflation in the productivity equation is a statistically *in*significant 0.57. By contrast, the *F*-statistic for the federal funds rate is significant at the .01 level, and increases in the interest rate are associated with declining productivity. Moreover, with output and the interest rate included, the regression now accounts for 20 percent of the variance of productivity growth. The fact that the federal funds rate is itself Granger-caused by each of the other three variables

TABLE 3

Inflation and productivity in a four-variable VAR

Equation	$\bar{R}^2$	Right-hand side variables: Productivity	Inflation	Output	Funds rate
Productivity	0.20				
F-statistic		--	0.57	0.93	3.87***
Sum of coefficients			–0.07	–0.21	–0.26***
Inflation	0.67				
F-statistic		0.85	--	2.74**	5.23***
Sum of coefficients		0.00		0.03	0.08
Real GDP	0.29				
F-statistic		2.11*	0.07	--	4.72***
Sum of coefficients		–0.11	0.02		–0.26*
Funds rate	0.93				
F-statistic		2.37*	2.90**	6.15***	--
Sum of coefficients		–0.20***	0.07	0.16***	

Note: Each equation in the VAR contains four lags of productivity growth, inflation, real GDP growth, and the federal funds rate. The VAR sample period is estimated on quarterly data from 1950:Q1 through 1994:Q2.
***Significant at the .01 level.
**Significant at the .05 level.
*Significant at the .10 level.

suggests that monetary policy is set in large part in response to economic activity and inflation, and it is this mechanism that generates the observed correlation. Clearly, omitting variables that capture the state of the economy and the stance of monetary policy means overlooking a very important part of the picture.

These Granger causality tests can provide only circumstantial evidence on the underlying structural relationship between inflation and productivity. Nevertheless, the results suggest that the negative correlation observed in the data reflects the interaction of monetary policy and real economic activity more than a direct causal link between inflation and productivity.

Inflation and productivity in the long run

An alternative way to eliminate or at least minimize the effects of common cyclical comovements in inflation and productivity is to focus on the long-run relationship between the two series. The analysis will, therefore, build on an econometric model designed to capture long-run effects. The goal will be to determine whether inflation shocks are associated with permanent changes in labor productivity, and if so, whether this relationship is structural, in the sense that a permanent reduction in inflation would lead to a long-run increase in productivity.

As King and Watson emphasize (1992, 1994), an analysis along these lines is possible if inflation and productivity can both be characterized as integrated processes. The salient feature of such processes is that unanticipated movements or "shocks" tend to persist indefinitely as a result of a unit root in the variables' time-series representation.[5] Because the effects of shocks last indefinitely, such series never revert to an underlying mean or deterministic trend; instead, they appear to exhibit a randomly varying or stochastic trend.

Table 4 presents Augmented Dickey-Fuller (ADF) tests for unit roots in inflation and productivity. The τ_μ column reports test statistics from a regression that includes a constant term; the τ_t statistics are from a regression that includes constant and trend terms. The test statistics for inflation and productivity are only barely significant at the .05 and .10 levels, respectively indicating that shocks to inflation and productivity tend to be highly persistent. This suggests treating both series as integrated processes in order to model the long-run effects of permanent changes.

TABLE 4

Tests for unit roots

	ADF t-statistics	
	τ_μ	τ_t
Inflation (π)	−2.91	−3.13
Change in inflation ($\Delta\pi$)	−8.23	−8.20
Log productivity (z)	−2.81	−1.71
Productivity growth (Δz)	−4.56	−5.24
0.01 critical value	−3.51	−4.04
0.05 critical value	−2.89	−3.45
0.10 critical value	−2.59	−3.15

Note: The results are based on regressions containing six lags, estimated on quarterly data from 1950:Q1 through 1994:Q2.

A general econometric model describing the interaction between inflation and productivity can be constructed by allowing the change in the inflation rate, $\Delta\pi_t$, to depend on the current rate of productivity growth, Δz_t, and lags of both variables. Similarly, productivity growth may depend on current inflation and lags of both variables. Formally, the model can be represented by a pair of equations,

$$(1)\quad \Delta\pi_t = \lambda_{\pi z}\Delta z_t + \sum_{j=1}^{p}\alpha^j_{\pi\pi}\Delta\pi_{t-j} + \sum_{j=1}^{p}\alpha^j_{\pi z}\Delta z_{t-j} + \varepsilon^\pi_t$$

$$(2)\quad \Delta z_t = \lambda_{z\pi}\Delta\pi_t + \sum_{j=1}^{p}\alpha^j_{z\pi}\Delta\pi_{t-j} + \sum_{j=1}^{p}\alpha^j_{zz}\Delta z_{t-j} + \varepsilon^z_t,$$

where the ε^π_t and ε^z_t disturbance terms represent inflation and productivity shocks, respectively. An obvious interpretation of the inflation shock is to ascribe it to monetary policy; similarly, the interpretation of the productivity shock is as a random shift in the production function.[6] The "impact multipliers", $\lambda_{\pi z}$ and $\lambda_{z\pi}$, capture within-quarter feedback from productivity to inflation, and from inflation to productivity, respectively.

To evaluate the real costs of inflation, the key parameter in this model is the long-run

Labor hoarding and measured labor productivity

In this box we briefly describe how a negative correlation between inflation and productivity can be generated by firms' "labor hoarding" behavior. The model sketched here follows Sbordone (1993).

We assume that firms face costs of adjusting labor hours and therefore increase labor utilization (as opposed to hours) when they experience changes in their demand conditions. The aggregate production function,

$$(3) \quad Y_t = F(K_t, e_t H_t \Theta_t),$$

expresses output, Y, as a function of capital, K, and effective labor, which is the product of labor utilization (effort), e; labor hours H; and labor-augmenting technological change Θ. The time subscript t denotes current values of all the variables.

Taking logarithms and first differences yields

$$\Delta \ln Y_t = \left(\frac{F_K K}{Y}\right) \Delta \ln K_t + \left(\frac{F_H H}{Y}\right) (\Delta \ln H_t + \Delta \ln e_t + \Delta \ln \Theta_t),$$

where F_K and F_H denote the partial derivatives of the production function with respect to K and H. Assuming constant returns to scale, labor productivity can be written as

$$(4) \quad \Delta z_t \equiv (\Delta y_t - \Delta h_t) = s_K(\Delta k_t - \Delta h_t) + s_H(\Delta \ln e_t) + \varepsilon_t^z,$$

where lowercase letters indicate natural logarithms and $\varepsilon_t^z = s_H(\Delta \ln \Theta_t)$.

It is easy to see from this expression that a procyclical pattern in effort can induce procyclical behavior in labor productivity. Because effort is unobservable, we can model effort variations by solving a dynamic cost-minimization problem, where the costs include a convex cost of adjusting labor hours from one period to the next. The result is that the optimal level of effort depends on how current growth of hours compares to expected future growth. Specifically,

$$\hat{e}_t = -\beta(E_t \Delta h_{t+1} - \Delta h_t),$$

where E_t represents the expectation conditional on information available at time t, $\hat{e}_t$ is the deviation of effort from its steady state value, and the parameter β is a function of the cost of adjusting hours relative to the cost of effort. In words, firms increase labor utilization when they expect future growth in hours will fall below current growth; conversely, they reduce labor utilization when they expect future growth in hours to be higher than current growth. In the latter case, in fact, firms may want to start hiring immediately because the marginal cost of increasing labor is lower once the reduction of future adjustment costs is taken into account. In this context, any variable that affects the forecast of hours may induce variations in productivity through the induced adjustment of effort.

Because effort is a stationary variable in this model, all productivity fluctuations are transitory regardless of whether the demand shock is temporary or permanent. A temporary shift in demand is met with effort changes only; a permanent shift is met with effort changes in the short run and full adjustment of hours in the long run. Any permanent changes in productivity would, therefore, have to come from changes in the capital-to-output ratio, as shown in equation 4. Two mechanisms through which inflation may affect the capital accumulation process are discussed in the body of this article.

---

response of productivity to a permanent change in inflation. This response, denoted $\gamma_{z\pi}$, can be expressed in terms of the parameters of the structural model:

$$\gamma_{z\pi} = \frac{\lambda_{z\pi} + \Sigma_{j=1}^{p} \alpha_{z\pi}^{j}}{1 - \Sigma_{j=1}^{p} \alpha_{zz}^{j}} .$$

Later, we will test the hypothesis that $\gamma_{z\pi} = 0$, that is, that a permanent change in inflation has no long-run effect on productivity. An analogous hypothesis involves the reverse of this effect—that inflation exhibits no long-run response to a change in labor productivity, which is denoted $\gamma_{\pi z}$, and defined analogously to $\gamma_{z\pi}$.

Unfortunately, the econometric model in equations 1 and 2 is not identified. This means that recovering the structural parameters from a reduced-form VAR of productivity growth and inflation on lags of the two variables is impossible, given the simultaneous feedback from inflation to productivity, and vice versa. Further restrictions or identifying assumptions are necessary.[7]

Although the model is written only in terms of real variables, it can generate productivity fluctuations as a response to changes in inflation, or any monetary variable, to the extent that these variables help to predict the behavior of future growth in hours. In this case, in fact, they will generate fluctuations in effort.

Why might inflation forecast growth in hours? Suppose agents know that when inflation rises, monetary policy tightens in anticipation of further inflation. In this case, a positive shock to inflation signals that current growth in hours is going to be lower than what is expected in the next period, and therefore implies a decrease in effort. This generates a decline in output that is larger than the decline in labor hours, causing productivity to fall. In this scenario, the timing of the monetary rule and the "hoarding" of labor produce a negative correlation between inflation and productivity without any fundamental causal link.

To go from the productivity equation 4 to equation 2 of the text, one can solve for effort in terms of current and past inflation variations, and project the capital-to-hours ratio on past productivity growth and inflation, to obtain

$$\Delta z_t = \lambda_{z\pi}\Delta\pi_t + \sum_{j=1}^{p}\alpha_{z\pi}^{j}\Delta\pi_{t-j} + \sum_{j=1}^{p}\alpha_{zz}^{j}\Delta z_{t-j} + \varepsilon_t^z ,$$

where the α and λ coefficients are functions of the adjustment cost parameter and the parameters of the projections of hours and the capital-to-hours ratio. This equation allows for transitory effects of inflation on productivity through variation in labor effort, as well as permanent effects through changes in the capital-to-hours ratio.

Identification in this model requires two restrictions. The first is relatively innocuous: that the inflation and productivity shocks ε^π and ε^z are uncorrelated with one another. The interpretation of this restriction is that although inflation and productivity are related through the λ and α parameters, their random components come from distinct sources such as monetary policy and technology. Even with this assumption, recovering the four structural parameters, $\gamma_{\pi z}$, $\gamma_{z\pi}$, $\lambda_{\pi z}$, and $\lambda_{z\pi}$ from the reduced-form estimates requires one additional restriction.

Lacking clear implications from economic theory about the sign and size of these parameters, we assume a value for one of them, and then estimate the remaining three as a function of the first. This allows us to examine the way in which the conclusions about the long-run relationship between inflation and productivity depend on the form of the assumptions used to identify the model. This approach has the additional advantage of nesting other standard empirical specifications within a common framework. The standard recursive or Choleski decompositions of the reduced-form VAR, for example, correspond to zero restrictions on the impact multipliers: $\lambda_{z\pi} = 0$ for inflation ordered first, and $\lambda_{\pi z} = 0$ for productivity first. Setting the long-run multipliers, $\gamma_{\pi z}$ and $\gamma_{z\pi}$, equal to zero is another way to identify the model.[8] In each case, the system of equations can be estimated by instrumental variables, where the appropriate instruments depend on the identifying assumptions. Details on this estimation procedure appear in Watson (1994).

Table 5 displays the estimates of the λ and γ parameters in equations 1 and 2 under the alternative zero restrictions discussed above. Figure 3 plots the corresponding time paths of the productivity response to an inflation shock of sufficient magnitude to increase the annualized inflation rate by 1 percent in the long run, and the 90 percent confidence bound for the long-run response. The results use the inflation and productivity measures described above and are based on regressions with six lags of each variable running from 1950:Q1 through 1994:Q2.

One important result is that both sets of short-run restrictions, shown in the first two rows of table 5, yield statistically significant *negative* estimates of the long-run response of productivity to inflation, $\gamma_{z\pi}$. Under the assumption that inflation has no within-quarter effect on productivity ($\lambda_{z\pi} = 0$), its long-run effect is a significant –1.86, which suggests that a shock that reduces the inflation rate by 1 percent in the long run will increase productivity by just under 0.5 percent. The estimated long-run effect of inflation on productivity is even larger if we assume instead that productivity has no within-quarter effect on inflation ($\lambda_{\pi z} = 0$). In this case, a permanent 1 percent reduction in inflation would increase productivity by roughly 0.8 percent. The marginally

TABLE 5

Parameter estimates under alternative zero restrictions

Restrictions	Estimated parameter $\lambda_{z\pi}$	$\lambda_{\pi z}$	$\gamma_{\pi z}$	$\gamma_{z\pi}$
$\lambda_{z\pi} = 0$	0	–0.19 (0.05)	0.02 (0.05)	–1.86 (0.66)
$\lambda_{\pi z} = 0$	–0.42 (0.11)	0	0.10 (0.05)	–3.31 (1.01)
$\gamma_{\pi z} = 0$	0.16 (0.35)	–0.26 (0.13)	0	–1.39 (1.18)
$\gamma_{z\pi} = 0$	0.70 (0.25)	–0.46 (0.10)	–0.06 (0.05)	0

Note: Standard errors are in parentheses. The results are based on regressions containing six lags, estimated on quarterly data from 1950:Q1 through 1994:Q2.

significant positive estimate of $\gamma_{\pi z}$ generated by this restriction is puzzling from an economic point of view, however, and casts doubt on the plausibility of the restriction.

Panels A and B of figure 4 show that this result generalizes to a range of λs other than zero. It turns out that any value of $\lambda_{\pi z}$ in the –0.4 to +0.8 range is consistent with a statistically significant negative response of productivity to inflation, as is any value of $\lambda_{z\pi}$ less than 0.2. However, as panel B shows, large positive values of $\lambda_{z\pi}$ are consistent with *positive* values of $\gamma_{z\pi}$.

It is widely recognized that short-run restrictions such as these are often inappropriate for identifying the economic phenomena of interest. Although it is clear from figure 4 that the negative long-run relationship between inflation and productivity holds up for a wide range of λs, the economic interpretation of these impact multipliers is not clear. Take the case of $\lambda_{z\pi}$, for example, which represents the contemporaneous effect of an inflation shock on productivity. While economic theory suggests that inflation may reduce productivity in the long run (by inhibiting capital formation, for example), it is generally silent on the short-run effects. Particularly in light of the cyclical interactions between inflation, monetary policy, output, and productivity highlighted earlier, there is no reason to believe the short-run effect is zero—or any other specific number, for that matter.

This argues for using an alternative restriction to identify inflation's long-run effect on productivity in order to remain agnostic on the contemporaneous relationship between the two variables. One plausible restriction that allows us to do this is to set $\gamma_{\pi z}$ equal to zero. The restriction makes economic sense; it is equivalent to assuming that permanent changes in productivity have no long-run effects on the rate of inflation (although they may lead to changes in the price level). The estimates of $\gamma_{z\pi}$, and the two within-quarter λ coefficients, appear in the third line of table 5.

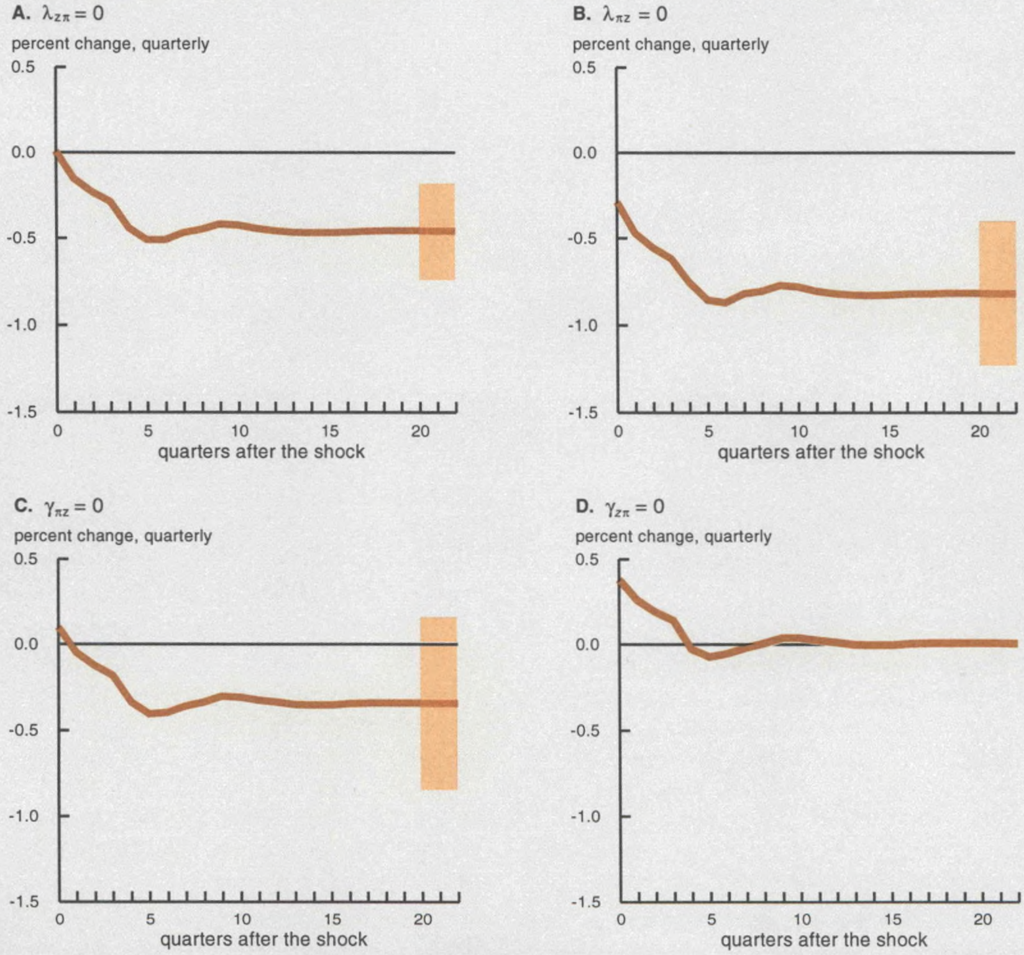
Interestingly, although the point estimate of $\gamma_{z\pi}$ is negative under this identification scheme, it is smaller (in absolute value) than it was under the short-run restrictions, and not statistically significantly different from zero. As shown in panel C of figure 3, the estimated response of productivity to inflation is initially positive, becomes negative after one quarter, but is never statistically significant. Panel C of figure 4 shows that to obtain a statistically significant negative value of $\gamma_{z\pi}$ under this long-run identification restriction requires setting the long-run effect of productivity on inflation ($\gamma_{\pi z}$) to a positive number greater than 0.06; we have no reason to believe that this is a plausible range. One factor contributing to this result is the fact that the standard errors associated with the parameter estimates are much larger under the long-run restrictions than under the restrictions on λ, reflecting the imprecision with which the long-run multipliers are estimated.

The fourth possible identification scheme imposes a restriction on $\gamma_{z\pi}$. Setting it to zero suggests that productivity is unaffected by inflation in the long run. Even though this restriction merely *assumes* an answer to the central question raised in the article, the estimates of the other parameters yield additional insights into the results; these estimates appear in the fourth line of table 5.

Although the model obtained by setting $\gamma_{z\pi}$ is, like the other models, exactly identified and hence unable to test statistically, the parameter estimates it generates are sufficiently unusual to suggest that the restriction is inappropriate. The strangest is the estimated $\lambda_{z\pi}$. Here, the statistically significant positive estimate says that inflation shocks increase productivity

FIGURE 3

Effects of inflation shocks on productivity under alternative parameter restrictions



Note: Shaded areas indicate 90 percent confidence bounds.

contemporaneously, and, as shown in panel D of figure 3, the response is uniformly positive over the first year. While this does not represent a formal rejection of the model, such a large, positive short-run response is hard to rationalize theoretically.[9]

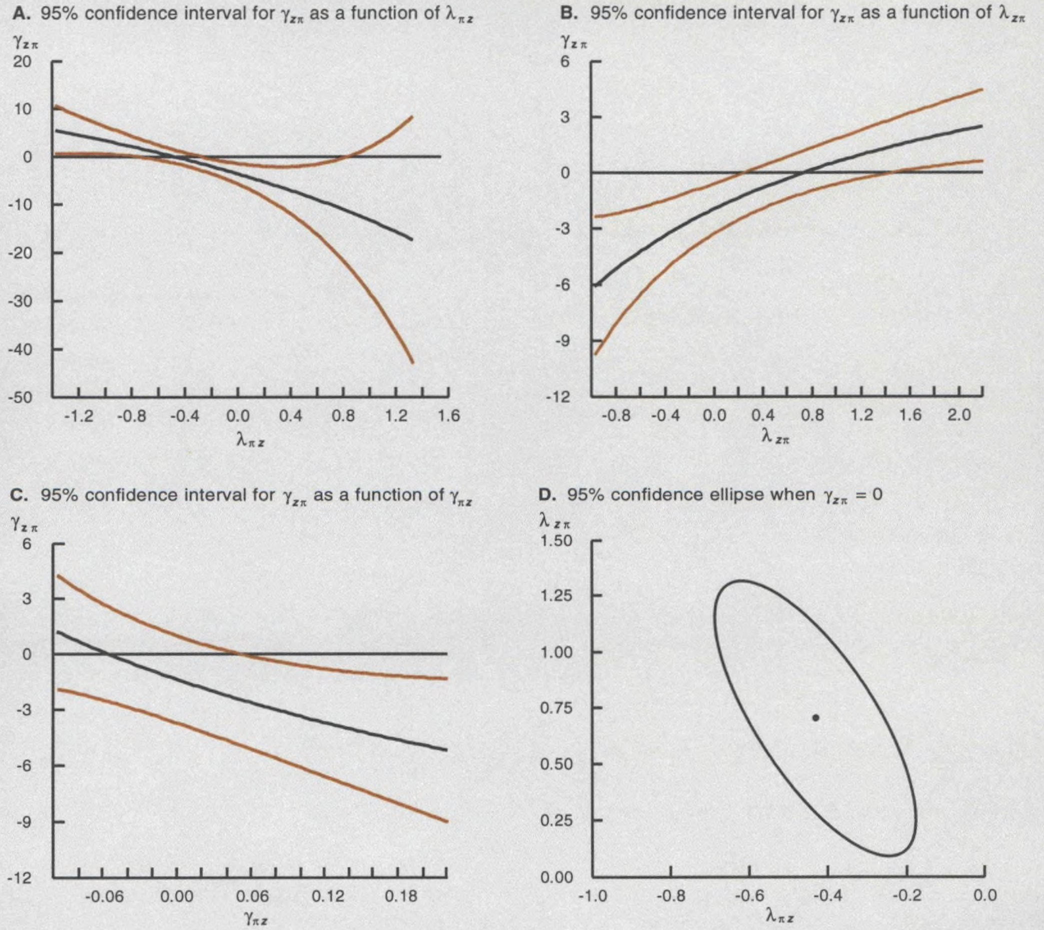
Suppose, then, we set a non-zero value for $\gamma_{z\pi}$. Would the other parameters' estimates seem more reasonable? The rationale for this exercise is that we have some theoretical justification for the hypothesis that the long-run effect can go either way. Tobin (1965) argued that inflation leads investors to reallocate their portfolios away from money and into capital, which reduces the real rate of interest, increases investment, and raises labor productivity. Taking an opposing view, Feldstein (1982) contended that given the U.S. tax structure, an increase in inflation depresses capital accumulation, leading to a long-run decline in labor productivity.

Suppose we believe Tobin's argument.[10] Our search over possible parameter values for $\gamma_{z\pi}$ indicates that for values greater than 1.5, we still get positive and significant estimates of $\lambda_{z\pi}$. In that case, however, we obtain significant negative values of both the long-run and short-run multipliers of productivity to inflation.[11] Using negative values for $\gamma_{z\pi}$, in keeping with Feldstein's arguments, does not change the results obtained under the restriction $\gamma_{z\pi} = 0$. Choosing a value of $\gamma_{z\pi}$ less than –0.5, however, makes all other parameter estimates insignificant.

The results reported in table 6 show that the estimated long-run effect of inflation on productivity, $\gamma_{z\pi}$, is rather sensitive to the changes in sample and lag length. Each of the

FIGURE 4

Long-run effect of inflation on productivity



three right-hand columns corresponds to imposing one of the three zero restrictions discussed above. The first row gives the results for the six-lag model estimated over the entire sample from 1950:Q1 through 1994:Q2, which merely replicates the results already reported in table 5.

The second and third rows of table 6 demonstrate the results' sensitivity to subsample. Specifically, under the $\gamma_{\pi z} = 0$ restriction, the point estimate of $\gamma_{z\pi}$ is positive (albeit statistically insignificant) in the subsample from 1950:Q1 through 1973:Q3, and significantly negative only in the subsample from 1973:Q4 through 1994:Q2. Similarly, the estimates of $\gamma_{z\pi}$ obtained under both sets of short-run restrictions are significant at only the .10 level in the early subsample. These results are consistent with the view that the high-inflation oil shock years are largely responsible for the strength of the statistical association between high inflation and sluggish productivity growth.

The results are also sensitive to the chosen lag length. When four lags are used, the size of the estimated long-run effect of inflation on productivity is less than half of what it was with six lags. Moreover, with eight lags, the estimate of $\gamma_{z\pi}$ is insignificant at the .05 level under both the $\lambda_{\pi z} = 0$ and the $\gamma_{\pi z} = 0$ restrictions.

Overall, these results suggest that higher rates of inflation are associated with lower productivity in the long run. The strength of this conclusion depends, however, on the identifying assumption used to differentiate inflation shocks from productivity shocks. Under the plausible assumption that productivity does not affect (or reduce) inflation in the long run, the evidence connecting inflation to lower productivity is very weak. Furthermore, the effect appears to be strongest in the years following the 1973 oil

TABLE 6

Estimates of $\gamma_{z\pi}$ for alternative samples and lag lengths

Sample	Lags	Restriction imposed: $\lambda_{\pi z} = 0$	$\lambda_{z\pi} = 0$	$\gamma_{\pi z} = 0$
1950:Q1 - 1994:Q2	6	–3.31 (1.01)	–1.86 (0.66)	–1.39 (1.77)
1950:Q1 - 1973:Q3	6	–3.32 (1.94)	–2.04 (1.14)	0.88 (1.36)
1973:Q4 - 1994:Q2	6	–2.58 (0.75)	–1.34 (0.55)	–1.47 (0.90)
1950:Q1 - 1994:Q2	4	–1.57 (0.58)	–0.73 (0.40)	–0.01 (0.63)
1950:Q1 - 1994:Q2	8	–4.11 (1.27)	–2.18 (0.82)	–1.76 (1.58)

Note: Standard errors are in parentheses.

shock, and its magnitude and statistical significance depend heavily on the number of lags included in the regressions.

Conclusions

It is very easy to detect a negative correlation between inflation and productivity in the data. It is much more difficult to conclude that higher inflation causes productivity to fall. The results presented above argue for caution in interpreting the observed correlation as a sign of an underlying structural relationship.

The results from both econometric techniques used in this article demonstrate the fragility of the empirical link between inflation and productivity. In Granger causality tests, including the federal funds rate eliminates inflation's effect on productivity, which suggests that a major part of the correlation is cyclical in nature. Estimates of inflation's long-run effect on productivity in a dynamic structural model are highly sensitive to the identification scheme used to distinguish inflation from productivity shocks.

These findings illustrate a more general point about the pitfalls of drawing policy conclusions from reduced-form statistical relationships. Without a solid theoretical framework, it is impossible to tell whether the negative time-series correlation implies a policy trade-off or merely reflects the way in which output, inflation, and productivity jointly depend on the state of the economy and the actions of monetary policy.

NOTES

[1]Fischer (1993) surveys these costs and evaluates them for a cross section of countries.

[2]See Levine and Renelt (1992).

[3]These are the same series analyzed by Rudebusch and Wilcox (1994). Alternative measures of productivity and price level yield similar results.

[4]The low-pass filter that extracts the trend component is designed to pass components with periodicity longer than 8 years, while the filter to obtain the cyclical components passes the components with periodicity between 6 quarters and 8 years. Both filters are approximated with a moving average from $t - j$ to $t + j$, where $j = 20$ quarters and the weights are normalized to sum to 1.

[5]For an introduction to the use of integrated processes in econometric modeling, see Stock and Watson (1988).

[6]The box shows how to derive equation 2 from a production function.

[7]Technically, the VAR describes only the response of inflation and productivity to *innovations* in each of the two variables, namely to $\upsilon_t^\pi = \Delta\pi_t - E_{t-1}\Delta\pi_t$ and $\upsilon_t^z = \Delta z_t - E_{t-1}\Delta z_t$. The identifying assumptions allow us to map these innovations into the structural disturbances ε_t^π and ε_t^z.

[8]Blanchard and Quah (1989) used this type of restriction to identify aggregate supply and demand shocks.

[9]We should note, however, that the confidence ellipse for the two impact multipliers (shown in panel D of figure 4) suggests a high probability of observing values of $\lambda_{z\pi}$ very close to zero, together with a significantly negative impact of productivity on inflation.

[10]The results of King-Watson (1994), which reject the Fischerian neutrality hypothesis, are consistent with this Tobin effect.

[11]For example, setting $\gamma_{z\pi} = 1.6$ yields $\lambda_{z\pi} = 1.56$ (standard error = 0.47), $\lambda_{\pi z} = -0.7$ (standard error = 0.14), and $\gamma_{\pi z} = -0.11$ (standard error = 0.05).

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A review of regulatory mechanisms to control the volatility of prices

Virginia Grace France, Laura Kodres, and James T. Moser

The stock market crash of 1987 renewed claims that cash market problems can stem from the trading of futures contracts. The crash also led to proposals for increased regulation to control price volatility. These proposals have antecedents in the Populist movement of the 1890s. Farmers of that period complained that wheat futures trading caused high prices at planting time and low prices at harvest. The tradition of curing cash market problems by regulating the futures markets was well established by World War I. In 1917, the New York Cotton Exchange was pressured into incorporating price limits into its cotton-futures contracts as a solution for price volatility following the German threat of submarine attacks on freight shipments into European ports.

After the war, Congress passed a tax on futures transactions that was aimed at solving the problem of low wheat prices. Low grain prices during the early years of the Great Depression led New Deal interventionists to pressure the futures markets to drop the trading of options on futures—then called privileges—and to institute price limits. In addition, contract specifications, including margins on futures contracts, were placed under regulatory oversight. Later, a bout of volatility in onion prices led to an absolute prohibition of trading in onion futures. This prohibition remains in effect today despite evidence developed by Roger Gray that futures contracting probably lowered rather than raised the volatility of onion prices.[1]

Today's attention focuses on stock price volatility. As in earlier years, the proposals garnering most of the attention seek to control stock price volatility by regulating futures markets, particularly stock-index futures contracts. This article reviews the evidence on three mechanisms that have been proposed to control price volatility. The first is to increase margin levels. Proponents of this mechanism argue that higher margins would discourage destabilizing speculation. A second proposed mechanism is to set price limits or "circuit breakers" in futures markets. Proponents of this approach claim it would allow markets to cool off. A third proposed mechanism is to impose a tax on each transaction of a futures contract. Casual descriptions of transactions taxes refer to them as solving volatility by throwing sand in the gears of the futures market. In the sections that follow, we assess the existing research on each of these three methods and their underlying rationales.

Margins and volatility

There is an immense literature on the effects of margin regulations on trading in financial assets, most of which deals with the effects of margins for stock positions. For political as well as economic reasons, the debates over

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margins on futures and margins on stock have become intertwined. First, we will look at stock margin studies.

Evidence from stock markets

Since 1974, Regulation T has required stock purchasers to make initial deposits of 50 percent of the total price of their purchase. Figure 1 plots stock market volatility and Regulation T margin requirements historically. The data are ambiguous on the relationship between the two. If one compares the Great Depression years with the postwar period when margins were federally regulated, it is clear that margins were generally higher and volatility was less after the war than during the 1930s. This suggests that higher margins reduce volatility. Yet studies by Officer (1973) and Schwert (1989a, 1989b) point out that volatility was also low before the Great Depression. Though it is hard to pin down precisely why volatility shifts, it probably has more to do with general macroeconomic conditions than with margins. The postwar decline in volatility may simply reflect a return to normal levels after the turmoil of the 1930s.

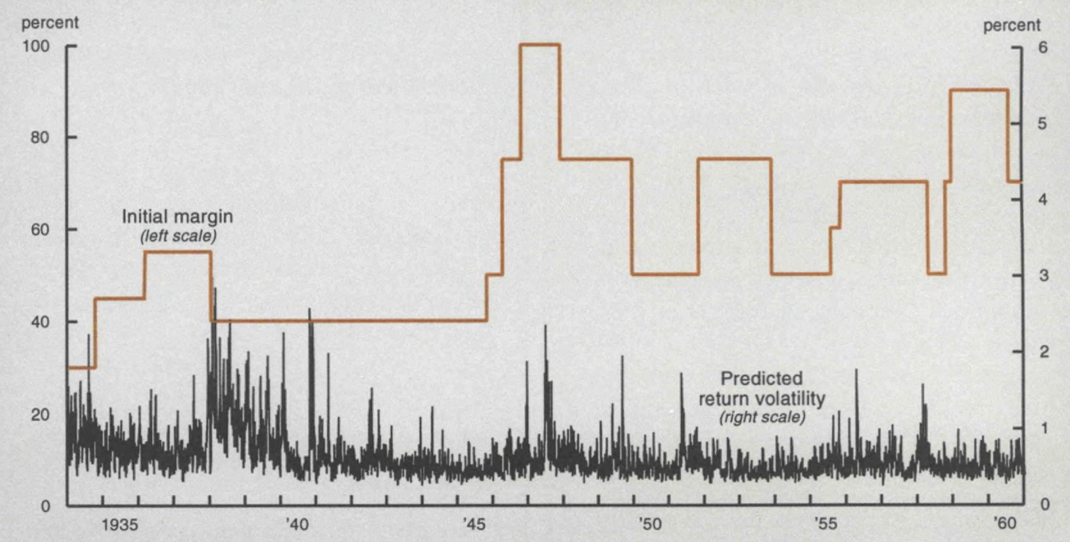
In 1984, the Federal Reserve Board of Governors assessed the existing research on margins and concluded that Regulation T requirements had no reliable, economically useful impact on volatility. As a result, Regulation T margin requirements have been left unchanged since 1974. Yet subsequent studies by Hardouvelis (1988, 1990) found that margins did in fact have an important economic impact on volatility. His analysis suggested that if margin requirements were increased from, say, 50 percent to 60 percent, the average variability of the stock market would decrease by 7 percent or 8 percent—a huge effect relative to prior studies.

This study lent indirect support to the conclusions of the Brady Commission (1988) on the crash of 1987, which called for the harmonization of margins across the stock and derivatives markets. Extrapolating largely from previous studies of stock margins, it called for futures margins that averaged 10 percent before the crash to be raised closer to the 50 percent required for stocks.

A number of economists re-examined Hardouvelis's data.[2] The main criticism, particularly highlighted in the influential paper by Hsieh and Miller (1990), was that Hardouvelis was picking up a spurious relationship. Since margins change only infrequently, the time series has a great deal of persistence, as does volatility. Given two persistent series, regressing the levels of one on the levels of the other can falsely suggest a significant relationship when there is in fact none. Empirical tests that correct for this problem did not find any significant impact of margins on volatility. However, Regulation T margin requirements have

FIGURE 1

Percentage stock margin levels and predicted daily stock return volatility



been changed only 22 times, so there may not be enough observations to show any statistical effect. Second, Regulation T can directly affect only positions held in margin accounts. The amount of margin debt is perhaps 1 percent or 2 percent of the value of stocks listed on the New York Stock Exchange.

Evidence from futures markets

In the last few years, the focus of research on margins has switched to the futures markets. The futures margin that brokers collect from customers is generally viewed as an adequate performance bond for any reasonable price movement.[3] Empirical studies have tested the adequacy of the minimum margins set by the exchanges; in some cases, the actual margin demanded by a broker is substantially greater than the minimum.[4]

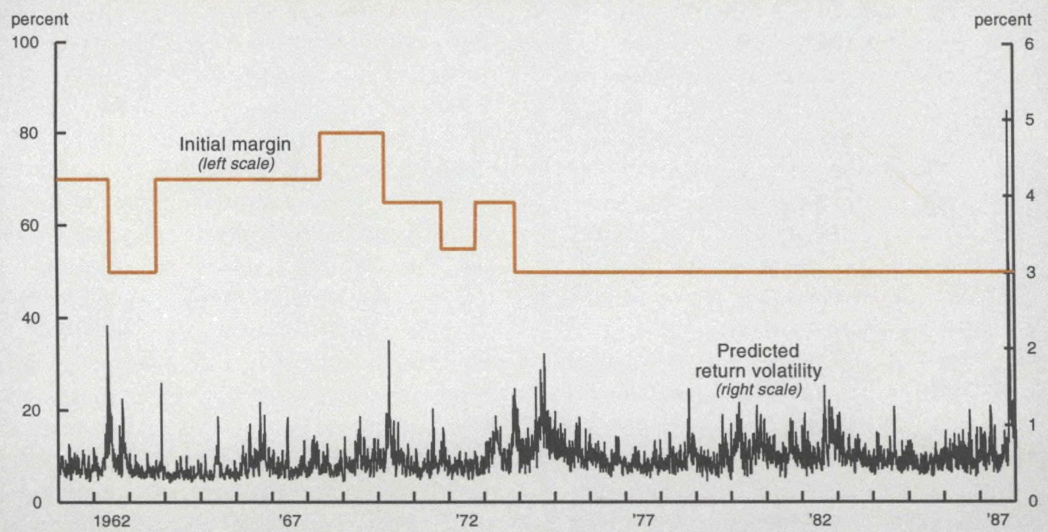
Clearing firms also put up a certain amount of margin with the clearinghouse. Margin deposits are not the only protection provided to the clearinghouse, since clearing firms also face stringent capital requirements. The adequacy of margins at the clearinghouse level has been given little empirical study since the data are not usually available; however, Bernanke (1990) studied the operation of the clearinghouses and the margin system during the 1987 crash.

Margins on futures are, of course, vastly different in purpose and administration from stock margins. However, a relationship between margins and volatility might be easier to detect in futures markets, for two reasons. First, futures margins are set individually for each contract by the exchanges. Thus there are many more changes in futures margins than in stock margins. Second, futures margins apply to all market participants, not just a small percentage as with stocks.

Generally speaking, as a percentage of contract-settlement value, futures margins are smaller than stock margins. However, that does not necessarily mean that futures margins provide inadequate protection against default as compared to stock margins. Ginter (1991) examined the amount of margin deposit necessary to protect against default on stock index futures and on the underlying stocks. Because an index is less volatile than its component stocks, stock index futures have lower volatility, all else being equal. Thus, an adequate prudential margin on an index future could be lower than on the underlying stocks. Also, futures contracts are settled at least once a day, whereas trades in stock are settled only after five days. That also implies that the margin on a futures contract does not have to be as large. Given these two factors, it turns out that some stocks are margined less adequately than futures and some more adequately, depending upon the volatility of the stock. Fenn and Kupiec (1993) explicitly model the trade-off

FIGURE 1 (cont.)

Percentage stock margin levels and predicted daily stock return volatility



between length of settlement interval and margin adequacy and point out that the ability to call for emergency settlement significantly increases the effective protection of the futures margin system.

In futures markets, there is a direct causal link between margins and volatility, but it runs from volatility to margins, not vice versa. Futures exchanges commonly use a risk-based margin system in which margins are set high enough to cover the largest loss experienced by a position if prices move within a certain range. The price range is increased when volatility increases or is expected to increase; thus the margin is a direct function of price volatility. This causal link is usually referred to as the prudential exchange hypothesis.[5]

Is there also a causal link from margin requirements to volatility? There are two theories about how such a link might arise. Higher margins might change the composition of traders. According to this view, when margin requirements increase, certain traders are driven out of the market. Without these traders there is less volatility, either because they were less risk-averse than average or because they were less well informed. One of the first studies of the effect of margins on futures was done by Hartzmark (1986), who examined how changing margin requirements would be likely to affect the composition of traders. He discovered that it was by no means clear which groups of traders would be driven out by higher margins. Thus it is not clear that raising margins would actually lessen volatility.

Another theory hinges on the effects of margins on market activity. When margins increase, the cost of using the market also increases. If this drives out enough traders, the depth of the market may be affected; that is, the market may be unable to absorb large orders without large price increments. Thus, increasing margins might increase volatility because any given order flow moves the price more. These effects might be detected through a decrease in volume or open interest, even if the volatility effects are masked.

Many empirical studies of futures margins focus on effects on volume and open interest as well as on volatility itself. Hartzmark (1986) found that volume and open interest dropped when margins were increased. Fishe and Goldberg (1986) and Fishe, Goldberg, Gosnell, and Sinha (1990) studied a group of Chicago Board of Trade contracts in the 1970s and 1980s. Generally speaking, these studies found that when the margin requirement increased, there seemed to be a small decrease in open interest in some of the near-term contracts, but there were no detectable effects on volatility.

Kupiec (1990) studied the Standard and Poor's (S&P) 500 stock index futures contract during the period 1982 to 1988. There were only nine changes in the dollar amount of the margin requirement over that period, but if margin is expressed as a percentage of the contract value, then the effective margin requirement changes daily. According to Kupiec, an increase in effective margin requirements did not seem to lead to a decrease in volatility. In fact, if anything, there seemed to be a short-run effect in the opposite direction: an increase in margin requirements increased volatility the next day, while having no long-run effect.

Moser (1991) studied the relationship between margin requirements and futures and cash price volatility in the deutsche mark and soybean futures contracts. He found that increases in price volatility tended to be followed by increases in margin requirements. However, he found no consistent relationship between increases in margin requirements and subsequent volatility.

In a separate study, Moser (1992) tried to distinguish empirically between the prudential effect (in which margins increase in anticipation of higher volatility) and the excess volatility effect (in which an increase in margin would, in fact, be causally decreasing excess volatility). His data supported neither hypothesis. Looking at the deutsche mark and S&P 500 contracts, he found that past changes in margins were not associated with future changes in the standard deviations of returns. However, surprisingly enough, changes in volatility did not consistently lead changes in margin requirements either.

Two studies by Bessembinder and Seguin (1992, 1993) suggest that when examining the market impact of regulations, it is helpful to partition volume and open interest into their expected and unexpected components. While these researchers did not study margins directly, their findings suggest that the impact of regulatory changes may differ depending on whether the researcher is examining expected or unexpected changes in market depth, volume, or open interest. This suggests a potentially fruitful line of research on futures margins.

In short, raising margin requirements does not appear to mitigate excess volatility in either the stock or the futures markets. If recent research has highlighted anything, it is that the perceived gap in size between futures and stock margins is largely illusory, and that futures margins are large enough to adequately protect market participants from contract default.

Price limits and volatility

Virtually all exchanges are allowed to set rules to remedy situations in which the integrity, liquidity, or orderly liquidation of contracts is threatened. In order to enhance the integrity and long-run liquidity of their market, futures exchanges have voluntarily chosen to impose limits on potential price changes during any given trading session. Such price limits have been a feature of U.S. markets for some time. In 1925 the Chicago Board of Trade formalized their use in emergency situations. Over time, "garden variety" price limits have been adopted for most commodity futures contracts, although limits remain less common for the newer financial futures contracts.

While price limits have been an institutional feature in futures markets for some time, only recently have they gained front-page coverage in the financial press. Known as circuit breakers, price limits have received renewed attention as a possible shutdown switch to prevent excessive volatility.[6] This section discusses the traditional rationale for price limits and then sketches a slightly different rationale for the era following the 1987 crash. The recent modification in what we expect price limits to do may change the way policy tools work together (in particular, margins and price limits) and alter the evaluative procedures that are required to determine the effectiveness of these particular policies.

Traditionally, price limits have been determined in advance by an exchange. There is a limit on the amount of change from the previous settlement price. If bids and offers match within the bounds prescribed by the limit, then trading takes place as usual. If not, trading stops. But price limits are not a trading halt per se, since they do not create a timeout from the trading process. Trading can resume immediately if both buyers and sellers agree to a price within the limit bounds. The recently implemented circuit breakers, including the type now in place on the S&P 500 contract, require that trading stop for a predetermined period of time after being triggered by a large price move.

Rationale for price limits

The traditional rationale for the adoption of limits boils down to two basic concepts:

1) Price limits serve as a policy tool in conjunction with margin calls to limit default risk. A price limit establishes the maximum margin call that could be made during a given trading session and allows market participants time to gather the funds to make good on the margin call. Sometimes prices may hit their limits for several days in a row. The slower price adjustment then allows losers a longer time period in which to acquire the cash or other marginable securities.

2) Price limits reduce the probability of an overreaction to news. By not allowing prices to move beyond a certain point, they discourage mob psychology and force prices to adjust slowly. Traditional limits "expand" on consecutive days to accommodate the price effects of news over a longer period of time. Since there may be different effects on hedgers' futures and cash positions, futures contracts typically relax this limit restriction during the delivery month so that cash and futures prices can converge.

Since the 1987 crash, proponents of price limits have stressed the second rationale: to reduce the probability of an overreaction. However, the concern today is not merely about the effects of an overreaction, defined as a movement in price that overshoots the equilibrium value and then subsequently returns to its true value. The concern is also about the effects of high volatility, that is, unpredictable rapid movements both up and down. Miller (1990) refers to this as episodic volatility. Some of the reasons for this alleged excess volatility are different now than they were in the pre-1987 environment. The overreaction that price limits were supposed to prevent in the earlier period stemmed from fundamental news such as crop reports, weather announcements, or changes in federal agricultural policy supports. In the current environment, volatility is thought to stem from "noise" traders or certain types of trading strategies, not necessarily from fundamental information. Strategies generating positive feedback trading, most notably dynamic hedging, are thought to be responsible for this new type of volatility. Since the current environment is also characterized by faster execution and information flows, any effects of these volatility-producing strategies are going to be felt more quickly. Thus, the more recent price limit circuit breakers look more like price-contingent trading halts and are meant to provide a cool-down period during which people can collect their thoughts. Notice that these limits are not always connected to margin calls so that their explicit connection to default risk protection is no longer clear.

Some analysts, including Miller, argue that the newer circuit breakers allow clearing firms to remove insolvent traders, thereby providing an element of default protection. However, clearing firms have always had the ability to go down to the floor and remove insolvent traders. So it is not clear that circuit breakers offer anything new in this respect.

Theoretical research

Prior to the post-crash interest in price limits, very few behavioral models had been developed to explain the use of price limits. Perhaps the most widely cited paper was Brennan's (1986). In his model, price limits are used in conjunction with margin to control default risk. In essence, limits hide the true price. This may reduce the probability of default because some individuals who would have defaulted do not know the extent of their losses and thus wait until they are more sure of the price before taking action. Brennan concludes that limits should be more effective in controlling default risk in markets in which the cash price is not easily obtained, such as agricultural markets where the cash markets are less liquid. Conversely, limits should be less effective for financial markets where cash markets are well developed. Brennan notes that almost all financial futures are without limits, and almost all commodity futures contain limits, generally confirming his model's predictions.

Given that the current debate surrounding limits seems to be centered in the financial markets, perhaps we need a new set of models or other explanations to accommodate them. The newer set of models focuses on the benefits of price limits and trading halts given the adverse effects that risk has on the participants of fast-moving markets.

Greenwald and Stein (1991) use the microstructure of the stock market to provide a role for trading halts. In their model, circuit breakers allow individuals to wait and see who else shows up to trade, and thus help individuals share what they call transactional risk. Transactional risk arises because not all expected buyers and sellers come to the market to place orders when prices are moving quickly. This model explains stock market behavior better than futures market behavior but nevertheless shows that circuit breakers can reduce the transactional risk present in stock markets.

Kodres and O'Brien (1994) more explicitly examine the role of price limits in volatile markets. Their analysis develops the circumstances under which price limits can improve the welfare of market participants. They observe that in volatile markets there is price risk between the time an individual decides to trade and the time that the order is actually executed. Like Greenwald and Stein, Kodres and O'Brien argue that price limits can be Pareto-improving because they allow risk to be shared among market participants. While many conditions make some participants better off, fairly few conditions make at least one person better off without making anybody else worse off, that is, the Pareto criterion. In fact, the study finds that all traders must be hedgers or must always trade on the same side of the market for a Pareto improvement to result from imposing price limits. This means that traders taking long positions must want to do so at both the low and high price limits; similarly, traders taking short positions must also want to do so at both high and low price limits.

Unlike the previous models, the models of Greenwald and Stein (1991) and Kodres and O'Brien (1994) accommodate the newer rationale for limits: reducing volatility caused by sudden price moves. Several more recent models are in their infancy, but they address the idea of a trading halt in the stock market and not in derivative markets. Theoretically, then, price limits can be explained as a response to default risk or the risks involved in executing transactions in fast markets.

Empirical evidence

The next important question is, do price limits perform well either in reducing default risk or in helping to reduce execution risks and the attendant volatility? While all of the above models have broad testable implications, the unobservability of true prices makes the models ill-suited for empirical testing. So far, most of the empirical work has centered on one of two areas: 1) the effect of limits on price patterns, or 2) econometric problems posed by using truncated data resulting from the limits.

Khoury and Jones (1984) performed one of the earliest empirical examinations of the effects of price limits. They used a sample period in which no limits were hit and separated prices into three tiers: those close to the upper limit, those close to the lower limit, and those not close to either limit. This construction permitted prices having unequal temporal spacing. They calculated time-series correlations for each of their three tiers of data. They found little difference among the correlation coefficients and concluded that the price behavior around limits was no different than price behavior between limits. The unequal temporal spacing of the data implied that the prices in each range could only partially represent trades that took place consecutively. Thus, perhaps it is not surprising that the time-series correlations within each tier were indistinguishable.

While the lack of continuity in prices was part of the research design, the problem in the case just described—a nonconsecutive sequence of prices—is common to all examinations of price limits. Consider what happens around a limit. Any time a limit is hit, trades that would have occurred can no longer do so and are excluded from the data. As a result, the data are truncated. Truncation of time-series data alters the time-series characteristics of the data. Thus, if we wish to examine whether prices react differently around a limit, we have two choices. Either we use the existing truncated data, or we make "guesstimates" about what the prices would have been had there not been a limit. Either approach requires assumptions and/or econometric procedures that could be restrictive and bias the results.

Ma, Rao, and Sears recently published two empirical studies using truncated data (1989a, 1989b). The authors used event-study methodology to examine the price behavior around limits, as well as the related volume and volatility. They found that T-bond futures prices "stabilize" or reverse (in the case of lower limits) after hitting limits, and that volatility is lower afterwards. Further, they find high volume on the day of the limit and the next day, with volume returning to normal on the second day following the limit.

We find some of these results inconclusive. The basic problem is that there are no data associated with the time interval when the limit is hit. The calendar time for each event varies depending on the trading lapse; thus the length of the event depends on when the market started trading again. As Kuserk (1990) points out, this methodology biases the results in the direction of finding a reversal or flat prices after the limit. Suppose that a limit was hit during the day, but at market close the price is within limits. This means that the price must have "rebounded" away from the limit (reversal) sometime during the trading day. If the data set contains intraday limits, all of which have this characteristic, the results may suggest that on average, limits are "reflective," or stabilizing. Again, it is unclear what to do about the missing "true" prices.

Kodres (1993) and Sutrick (1991, 1993) make (educated) guesses about the distribution of unknown "true" prices when a limit is hit. Kodres focuses on a correct test of the unbiasedness property in the foreign exchange market, taking into account the truncated data. While not examining the behavior around price limits directly, Kodres implicitly assumes that the true distribution of prices is not altered by the existence of limits. Sutrick attempts to find unbiased estimates of regression coefficients and variance using data containing the limited prices. He also assumes that the underlying distribution is unchanged. His work, like that of Kodres, does not focus on the effectiveness of price limits as a policy tool, but on the econometric problems encountered when using limited futures prices.

Future research directions

Some very basic questions remain unanswered that future research needs to address:

1) Do price limits change the character of prices around limits?

2) If price limits change price behavior, do they do so in a way detrimental to the integrity of the market? If so, is it because price limits are too tight or too loose?

3) Do price limits affect liquidity? What happens to bid/ask spreads immediately before and after a limit? What happens to volume? Are there big orders on one side that are broken up into smaller orders to be executed?

4) Do local traders get out of the market and let customers trade with other customers? Do hedgers lose because they cannot establish positions, and do speculators win? In particular, who is rationed out of the market, and do they subsequently lose money because of this rationing? No one has yet examined who is affected by limits. This is an important issue for establishing policy.

5) Do price limits reduce volatility? If so, how? If not, why not?

6) Assuming price limits can be useful, what is the optimal strategy for setting them so as to obtain the most effective outcome?

7) When should exchanges change limits? How can they be proactive and anticipate an optimal time to do so?

8) Should other market structures change to accommodate price limits or circuit breakers? For example, should opening procedures after a limit has been hit be different than for a regular opening?

9) Do price limits lower default risk? How many defaults have occurred in markets without limits versus those with limits, when other factors are controlled?

Research directions that may help answer some of these questions include the following: Theoretically, we need a dynamic model in order to see how limits affect trading behavior. For example, how is demand for liquidity and immediacy affected by limits? Do liquidity providers stay away? Does the demand for immediacy change when limits are imminent? Do prices respond as if there is a magnet effect or a repelling effect around limits? Further, we need dynamic models with testable implications. Currently, the testable implications are too broad and cannot distinguish among several of these issues.

Empirically, we need more and better measures of what happens around price limits. Specifically, we need to understand better the type of volatility we are attempting to reduce with price limits, and we need to construct statistics that more accurately measure that type of volatility. In this context, we must keep in mind that when a limit is hit, there are no true equilibrium prices to measure what volatility would have been had the price limit not been present. Thus, our measures are undoubtedly biased in some way.

We need to measure the costs of limits more carefully. For example, in a limit-bound market, liquidity is effectively zero. What happens to the liquidity surrounding the limit? How is long-run liquidity affected? Are potential participants more or less likely to use a market in which limits are present? Exchange officials and regulators believe that participants are more likely to use a market with limits. How do we consider the welfare of the participants that are locked out of the market during the limit?

In general, both theoretical and empirical work in this area should recognize that coordination among several primary and derivative markets is being attempted. Therefore, an evaluation of policy objectives requires an understanding of how trading takes place in different markets. For example, current reopenings after price limits or circuit breakers are different in the stock market and the futures market. An evaluation of the effects of limits must consider these different details and any ancillary effects they cause. Finally, we need to examine not only existing policies, but also better policies as well as other market structures that can alleviate the problems now being addressed by price limits or circuit breakers.

Transaction taxes and volatility

Transaction taxes are intended to raise the cost of trading and thus to create a barrier to entry for certain categories of trading activity. The goal is to exclude trades that increase price volatility by more than is warranted by changes in relevant information. Implicit in this description is the idea that prices based on relevant information provide appropriate signals as to where capital investment is most productive. Investment dollars placed in response to these signals benefit society by increasing productivity where it is most highly valued. On the other hand, trades not based on this information might lead to prices that give inappropriate signals; as a result, such trades divert capital investment from its best use. Black (1986) refers to trades not based on information as noise trades. Thus, transaction taxes are intended to create an entry barrier to noise trades, thereby increasing the informativeness of market-determined prices.

A simple one-period model usefully demonstrates how transaction taxes can serve as entry barriers. Let p_0 represent the current price of a stock. At the end of one period, this stock will pay dividends of d^U if an up state occurs, and d^D if a down state occurs. Since the point to be made does not require discounting cash flows, we can assume that the expected payoff for an investment is the expected dividend minus the price of the stock. Now consider a market composed of two investor types: information traders whose dividend expectations are based on information about the firm's prospects, which we denote as $E(d|I)$; and noise traders whose dividend expectations are not information-based, denoted $E(d|N)$. In a market comprised of α percent noise traders and $(1-\alpha)$ percent information traders, the consensus forecast of returns to investing in the stock is

$$\pi = (1-\alpha)\,(E[d|I] - p_0) + \alpha(E[d|N] - p_0).$$

If no new stocks are issued, then the gains realized by any individual are the losses incurred by another, so the sum of profits is zero (π=0) and the consensus price of the stock at time 0 is

$$p_0 = E[d|I] + \alpha(E[d|N] - E[d|I]).$$

Thus, the stock price is determined on the basis of the dividend expectations of the information traders, plus a fraction of the deviation between the expectations of information and noise traders. As the percentage of noise traders increases, the amount of noise impounded into the stock price rises. The intent of transaction taxes is to lessen the noise component of prices by reducing α.

This exercise highlights some of the assumptions on which the transaction tax proposition rests. First, the percentage of noise traders must decline as the amount of the transaction tax rises. It is generally accepted that the number of noise traders will decline when transaction taxes rise. Note that the after-tax return realized by noise traders declines as the amount of tax rises. If the expected return is not sufficient to meet the tax expense, the trader will not make the investment. So it appears reasonable to expect a decline in the number of noise trades when transaction taxes increase. From the taxing authority's point of view, the problem is with the incidence of the tax; that is, the transaction tax cannot be imposed selectively. The tax will also apply to information traders who also make their investment decisions on the basis of their expected after-tax return, so that the number of information traders can be expected to decline as the amount of transaction tax increases. Thus, although imposition of a transaction tax does reduce the number of noise traders, its impact on the number of information traders makes its effect on α unclear. If information traders are more sensitive to this tax than are noise traders, α can rise when transaction taxes are increased.

A second problem makes predicting the effect of a transaction tax even more difficult. In the above reasoning, the members of each trading group have identical expectations about the future. While this depiction is unlikely to be entirely true for either group, the term "noise" implies dispersion so that these traders are much less likely to have similar forecasts. This lack of unanimity has two implications that bear on the transaction tax proposition. First, the diverse expectations of this group imply that the trades of one member of the group are likely to be offset by those of one or more other members of the group. This dilutes the impact any one noise trader can have; therefore, noise traders as a group have little if any net impact on prices. Stated differently, the price impacts of trades from a group of noise traders probably diversify away. Second, and perhaps more subtly, the presence of a trading group with diverse opinions produces a degree of inertia in prices so that prices do not change on the arrival of each trade. Price responses occur only when order arrivals are recognized as new information. This resistance to price changes helps insure that trades made for liquidity purposes have little impact on prices. These markets are said to be liquid, a feature valued by investors: redemptions of investments placed in liquid markets are less likely to realize losses in the event of a sale forced by cash needs. Absent liquidity obtained by the presence of noise traders, liquidity is supplied at a price. As the price of liquidity rises, the cost of capital increases. Thus, transaction taxes that reduce the number of noise traders can be expected to raise the cost of obtaining liquidity and the cost of capital.

Kupiec (1991) develops an overlapping-generations model to analyze transaction taxes. Like the simple analysis presented above, Kupiec finds that the effect of a transaction tax depends on the relative proportions of certain trader types; thus its effect cannot be predicted. Importantly, Kupiec adds a further dimension to the effects that can be expected from transaction taxes. Noise traders are affected as described above. In addition, the portfolio re-balancing decisions of all traders are affected. The effect on volatility depends on this lock-in effect. If transaction taxes prevent portfolio re-balancing based on information, noise trading becomes relatively more important. Thus, a useful prediction of the effects of a transaction tax depends on accurate assessments of the tax's effects on decisions to purchase and to sell.

In summary, in order to reduce volatility, the transaction tax must reduce the proportion of noise traders without affecting the re-balancing decisions of information traders and without significantly raising liquidity costs. Any predictions about the effects of a transaction tax must incorporate each of these influences. Without an analytical model encompassing these influences, empirical evidence is likely to be the best predictor of the impacts that can be expected from a transaction tax.

Evidence of the effect on noise traders

Umlauf (1993) studied the experience stemming from a Swedish transaction tax imposed in 1984. Initially set at 1 percent, the tax was raised to 2 percent in 1986. Umlauf confirmed that trading volume declined following imposition of the tax, a result previously found by Lindgren and Westland (1990).[7] Umlauf also found an increase in volatility. However, as this increase might have been due to the condition of the Swedish economy, further investigation is required. As demonstrated above, the relevance of the decline in trading activity depends on the extent to which noise trading was affected. Umlauf showed that ratios of weekly return variances to daily return variances declined following imposition of the tax. This result suggests an increase in fad trading. Fad trading increases return variances observed for short holding periods: As fads dissipate, return variances for longer holding periods decline. As fads represent a type of noise trading, this implies that the Swedish tax increased the proportion of noise trading.

An alternative interpretation of Umlauf's variance ratio results is that positive feedback trading increased—that is, buying after a stock increase or selling after a stock decrease. As this strategy adds no information to that already observed in the initial price response, it is a form of noise trading. The strategy affects return autocorrelations based on the length of holding period examined. Autocorrelations of short holding period returns become more positive because successive trades reflect the initial impact of new information on stock prices. However, because the strategy increases the odds that prices will overshoot their correct values, it implies negative autocorrelation in longer holding periods. This combination of effects implies a decline in variance ratios. Thus, Umlauf's evidence implies that noise trading increased either in the form of fad trading or in positive feedback trading.

Evidence of the effect on liquidity

Umlauf (1993) also investigated volatilities for 11 firms whose shares subsequently began trading in London while continuing to trade in Sweden. Return volatility declined as share classes began trading in London. This result suggests that the tax increased the proportion of noise trading. As it is unlikely that traders in London are better informed on the prospects of Swedish firms than traders in Sweden, it is likely that the proportion of noise trades in these stocks increased. Thus, the reduction in return variance for these stocks is consistent with improvements in liquidity.

The empirical work of Amihud and Mendelson (1990) demonstrates that stock returns increase as the spread increases between the bid and ask prices of stock. Interpreting the bid-ask spread as the cost of obtaining liquidity, Amihud and Mendelson support the argument that higher liquidity costs imply higher costs of capital. Thus, a transaction tax that reduces the extent of noise trading is likely to increase demand for liquidity and drive up its cost. The resulting impact is likely to be an increase in the cost of capital.

Conclusion

This article has reviewed evidence bearing on three approaches that have been proposed to control price volatility. The effects of margin rules on volatility are most extensively researched, but the evidence does not generally support the conclusion that this mechanism can usefully reduce volatility. Limited evidence suggests that circuit breakers in the form of price limits do reduce volatility. Analysis of transactions taxes point to difficulties in implementing this approach; in addition, the actual effect of transaction taxes on volatility remains unclear.

Each of these proposed measures has the potential to cause adverse consequences. Margin rules may reduce participation in futures contracting, an effect that may increase volatility. Price limits may alter price changes as limits are approached. "Magnet effects," drawing prices to the limit, might further increase the speed of price changes and aggravate rather than alleviate volatility. Under plausible conditions, transaction taxes can increase volatility rather than lowering it. Policy decisions on these volatility-control mechanisms should weigh the possibility of such adverse consequences against the benefits anticipated by their adoption.

NOTES

[1]See Gray (1963).

[2]See, for instance, Hsieh and Miller (1990), Kupiec (1989), Salinger (1989), and Schwert (1989a, 1989b).

[3]See, for instance, Figlewski (1984).

[4]Telser and Higinbotham (1977).

[5]See Moser (1992).

[6]It is important to note the difference between price limits and circuit breakers. "Circuit breaker" is a broad term referring to mechanisms by which financial markets can be temporarily shut down to prevent system overload. Moser (1990) identifies three types of circuit breakers, one of which he names price limit circuit breakers. Thus, price limits are only one of several possible mechanisms to prevent system overload.

[7]Ericsson and Lindgren's (1992) estimates for a cross section of 23 markets concluded that a 1 percent reduction in transaction taxes could be expected to double trading volume. This magnitude of effect on trading activity is comparable to that experienced by the Swedish stock market.

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