DIFFERENCES IN INFLATION'S IMPACT UPON PRODUCTIVITY GROWTH ACROSS INFLATION REGIMES: THE GERMAN CASE

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ABSTRACT

This paper tests for Threshold Effects in inflation's impact upon German productivity growth. We find differences in the impact of inflation upon German productivity growth depending upon the inflationary regime. No statistically significant impact from an inflation shock upon productivity growth is found if at the time of the shock inflation was in its "low" inflationary regime. If, however, inflation was in its "high" regime at the time of the inflationary shock, then the inflationary shock is found to have a significant negative impact upon productivity growth. This result is contrary to the existing literature examining inflation-productivity linkages for Germany, which fails to find any statistically significant impact from inflation upon productivity growth for the modern German era. The previous literature, however, did not allow for the possibility of a differential impact from inflation depending upon the initial level of inflation itself as in this work.

INTRODUCTION

One of the widespread macroeconomic policy success stories for industrialized nations in the 1980's and 1990's was the reduction of inflation rates from double to low single digits. The relatively low inflation rate environment of the past several years, however, has not eliminated all calls for further reductions in average inflation rates in the industrialized economies. There has remained in some quarters the call for further inflation reductions, perhaps even to zero, with the expectation of improved economic growth and productivity as a consequence of even further reductions in inflation. This paper examines for Germany whether there is empirical support for the position that reducing already low inflation rates further will lead to increased labor productivity growth and thereby increased overall economic growth. Germany has had one of the lowest average rates of inflation in the world over the past 40 years, so it is a prime candidate for investigating the productivity benefits, if any, from further inflation reductions.

There are a number of arguments in the literature for why high rates of inflation reduce economic growth and productivity growth:

1) Even fully anticipated inflation acts as a tax on money balances and causes agents to incur shoe-leather and menu costs.
2) Unanticipated inflation biases the tax system against capital assets by understating true depreciation costs. Since the bias increases with time, both the level and composition of capital are likely to be affected, with short-lived assets more heavily favored.

3) Unanticipated inflation tends to generate price uncertainty, distorting relative price signals and increasing decision-making errors.
4) Uncertainty about prices can induce firms to increase inventories of buffer stocks and reduce expenditures on long-term basic research (Feldstein, 1982; Fischer, 1986; Briault, 1995, Thornton, 1996).

While it is quite plausible that adverse inflationary effects would arise through these channels at high rates of inflation, it is much less certain that inflation in the low single digits adversely impacts productivity growth in a meaningful way. In addition, the above adverse inflationary effects may be muted at very low inflation rates by the possible benefit of inflation as "grease" in labor markets. If downward nominal wage rigidity is widespread, then small rates of inflation may aid in the real wage adjustments needed to facilitate the movement of labor out of contracting sectors of the economy and into growth sectors.

Previous empirical work on this issue imposed linear relationships in the testing for inflation-productivity linkages (see Smyth, 1995; Freeman & Yerger, 1997; Freeman & Yerger, 2000). After accounting for the impact of business cycle effects upon measured productivity, these papers fail to find an adverse impact from inflation upon measured productivity growth for Germany. This paper extends the previous literature by testing for the existence of "Threshold Effects" from inflation upon measured productivity growth. If the impact of inflation upon productivity growth varies depending upon the initial level of inflation itself, then it is possible that the absence of findings in the prior literature was due to estimation techniques that forced the same relationship across the "high" versus "low" inflation regimes.

We find that threshold effects are in fact present. No statistically significant impact from inflation upon productivity growth is found when inflation is in the low inflation regime at the time of an inflation shock. An adverse impact from an inflation shock, however, is found when the economy is in the high inflation regime at the time of the shock. The threshold critical value separating the low from high inflation regimes is found to be approximately 3.0%.

LITERATURE REVIEW

Prior to the early 1980's, research on inflation and productivity growth assumed the relationship to be unidirectional from exogenous productivity growth to inflation. The sharp decline in productivity growth in industrialized nations in the 1970's, and the coincident rise in inflation rates, caused investigators to more closely examine the causality issue. The theoretical rationales noted above for potentially adverse effects from inflation upon productivity served as the motivation for a series of causality studies. Clark (1982) and Ram (1984) found that inflation negatively granger-caused productivity growth in the U.S. while Jarret and Selody (1982) found the same effect for Canada. The productivity measures used in these studies were a highly aggregated index of output per hour of labor.

Follow-up studies appeared to confirm these earlier findings. Simios and Triantis (1988) analyzed U.S. data through 1986 while Saunders and Biswas (1990) examined U.K. manufacturing productivity through 1985, with both studies finding a significant negative impact from inflation upon productivity growth. Smyth (1995a, 1995b) analyzed both German and U.S. multifactor productivity data and found a significant negative effect from contemporaneous inflation.

The conclusions to be drawn from these studies are limited, however, by several factors. First, these studies for the most part include only the run-up of inflation through the early 1980's and not the subsequent decline. Given the widespread extent of the productivity slowdown across the industrialized world in the 1970's, it would be surprising not to find a negative association between inflation and productivity growth over this time period. A much better causality testing sample period would include both the rise and fall of the inflation spike of the latter 1970's and early 1980's. Another shortcoming of these studies was that most of the papers failed to control for potentially relevant business cycle effects, including the possible endogeneity of contemporaneous inflation and the impact of variations in aggregate demand growth upon measured productivity. A final limitation of these studies was their failure to test for stationarity of the data. Since stationary variables are necessary for valid causality testing, this is a relevant omission.

Several papers have addressed some or all of the above issues, and the findings call into question the conclusions of the prior literature. These studies do not find consistent evidence of a negative impact from inflation upon productivity growth. Sbordone and Kuttner (1994) examine U.S. labor productivity and find that any observed correlation between inflation and labor productivity is due to cyclical comovements rather than to any causal link. Cameron, et al (1996,) test for the existence of a cointegrating relationship between the relevant aggregate price index and productivity series for Canada, Germany, U.K., and U.S. They fail to reject the null hypothesis of no cointegration between inflation and productivity, and interpret their results as not supporting a link between inflation movements and productivity movements for these nations. Freeman and Yerger (1997, 1998) include cyclical variables in their analysis to control for the possible endogeneity of contemporaneous inflation in a reexamination of Smyth's (1995a, 1995b) U.S. and German data. With the business cycle proxies in the model, they find no statistically significant impact from inflation upon productivity growth for either the U.S. or Germany. Freeman and Yerger (2000) test the hypothesis that inflation has a causal impact in the granger sense on labor productivity growth in manufacturing for 12 OECD nations. They find that when controls for cyclical effects are included, there is no evidence of a consistent relationship between inflation and productivity growth with regard to either sign or magnitude.

While these more recent time series studies fail to find any robust relationship between inflation and productivity growth, it remains possible that such a relationship exists but only after inflation increases past a certain threshold. Certainly some evidence consistent with this view exists in the literature utilizing cross-sectional tests of inflation-productivity linkages. In early studies, Fisher (1993) and Bruno (1995) both find that high inflation, approximately 2% per month or greater, has adverse consequences on economic growth when examining a cross section of industrialized and developing nations.

Subsequent cross sectional studies examining inflation and economic growth have estimated a wide range of threshold critical values. Sarel (1996) finds a structural break at approximately an 8% inflation rate, below which no adverse effect from inflation on growth is discernable but above which there is a negative impact from inflation. Ghosh and Phillips (1998) find a similar threshold, but at the much lower critical value of a 2.5% inflation rate. Confining their examination to transition economies, Christoffersen and Doyle (1998) estimate the threshold critical value to be a 13% inflation rate. Bruno and Easterly (1998) claim that negative relationships between inflation and growth are found only in cross-country regressions with high frequency data and very high inflation rate outliers. They find no negative relationship between inflation and growth for inflation rates below approximately 40%. Khan and Senhadji

(2000) estimate that the inflation threshold effects upon economic growth is at around 1% inflation rate for industrial economies and 11% inflation rate for developing countries.

These cross-sectional results on threshold effects for the inflation-economic growth relationship suggest at least two conclusions for the present study. First, it does seem to be the case that inflationary threshold effects are likely to exist for a number of the industrialized and developing nations. The wide range of estimated threshold critical values, however, leads to a second conclusion. Namely, that the actual inflationary threshold critical values probably vary, sometimes significantly, across nations given the wide range of estimated critical values generated from studies using different country samples and estimation techniques. Given the many differences across nations in their tax systems, labor market rigidities, and inflation histories, the second conclusion is not surprising. The greater the variation in these factors across nations, the greater the likelihood of variation across nations in the point at which inflation moves from being relatively benign to measurably productivity reducing.

Rather than impose the same inflationary threshold value across multiple nations as in a panel setting, this paper returns to a time series analysis of a single nation, Germany, but modifies the estimation technique to allow for the existence of threshold effects. While the results here cannot be generalized to other nations, the approach used could be replicated on other industrialized nations and the consistency of the findings compared.

DATA

This study uses quarterly data for Germany from 1962 Q1 to 1998 Q4 provided by the Central Bank of Germany. The end date allows the German data to include only the former West Germany and does not include reunified German data statistics in the latter quarters of the sample period, thereby eliminating a structural break in the data unrelated to the inflation regime itself. Also, by ending the sample period prior to the replacement of the German currency by the Euro, another potential source of noise in estimating Germany's inflation-productivity growth linkage is eliminated. Germany was selected for analysis because its average rate of inflation over this period was among the lowest of all industrialized nations. If an adverse impact from inflation upon productivity growth is found for Germany, then it becomes more probable that similar effects exist for higher average inflation industrialized nations.

All variables are expressed as annual growth rates, computed as log first differences, on a year-over-year quarterly basis (e.g. the growth rate of variable X in period t, $dX_t = \log X_t - \log X_{t-4}$) so the data available for estimation begins with 1963 Q1. Inflation is computed as the growth rate in the CPI and the computed productivity growth rate is based on the growth in real output per worker in the manufacturing and mining sector. To control for potential spurious correlation between inflation and business cycle effects, the model also includes the growth rate of Germany's industrial output index.

These three growth rate variables all were tested for stationarity using the Augmented Dickey-Fuller test statistic with a constant term included in the estimating equation. The results are summarized below in Table 1. The null hypothesis of non-stationarity is strongly rejected for each of the three variables, so the estimation techniques utilized in this paper are valid. The resultant ADF test statistics, their associated p-values, and # lags in the ADF equation were as follows (lag length based on minimizing AIC):

TABLE I. STATIONARITY TEST RESULTS

Variable	ADF Statistic	P-Value	#Lags
Inflation	-3.17	0.02	10 lags
Productivity Growth:	-3.69	0.004	4
Industrial Output Growth	-4.82	0.001	6

THE THRESHOLD MODEL

The general form of the threshold model used in this paper is given in equation one below. The model includes industrial output growth as an explanatory variable in order to account for the potential cyclicality of measured productivity growth with the business cycle. Failing to include a control for business cycle effects may lead to findings of spurious correlation between inflation and productivity growth (Sborrone & Kuttner, 1994; Freeman & Yerger 2000). Also, recall that while it is correct that the dependent variable already is adjusted for inflation as it is real output per worker, we still may find an impact from inflation upon this inflation-adjusted variable via one of the four channels outlined in the introduction section of this paper.

In the model, the parameter estimates on all variables can differ depending upon whether the observation comes from the "low" or the "high" inflation regime. Observations are assigned into the low (high) inflation regime if the value of their inflation threshold variable is below (above) the critical switching value used to divide the sample into two inflation regimes. If in Germany the adverse effects of inflation upon productivity growth are notably more pronounced in the upper end of the inflation range Germany experienced, then the threshold model should find a more deleterious impact from inflation in the high inflation regime.

$$(1) \quad prod_t = A^0(L)\, prod_{t-1} + B^0(L)X_t + \{A^1(L)\, prod_{t-1} + B^1(L)X_t\}*DUM(thresh > critval) + e_t$$

$A^0(L)$, $A^1(L)$, $B^0(L)$, and $B^1(L)$ are lag polynomials; $prod_t$ is the productivity growth rate; X_t is the vector containing the inflation and industrial output growth measures; thresh is the threshold variable used to sort inflation regimes; critval is the selected critical value against which thresh is compared; and DUM(thresh > critval) = 1 if thresh > critval and 0 otherwise.

For any given lag length structure on the exogenous and predetermined variables, if both the threshold variable "thresh" and the threshold value "critval" were known, then testing for nonlinear behavior of threshold would simply require testing the hypothesis that $A^1(L) = B^1(L) = 0$. In this case, however, economic theory alone does not provide guidance on the correct values for thresh and critval so they both must be estimated. As a result, standard inference techniques are not appropriate since, under the null hypothesis of no threshold effect, the variables thresh and critval are not identified. Over the past decade, a literature has emerged for testing procedures when "nuisance" parameters are present under the null hypothesis. In this paper we utilize one of the more straightforward tests developed by Andrews (1993).

Andrews derives test statistics for tests of parameter instability when the change point is unknown, or known to lie in a restricted interval. His sup-LR test statistic is the largest maximum likelihood ratio statistic found over the tested range of all possible threshold variables and threshold values (the sup-LR is asymptotically equivalent to the sup-Wald statistics similarly defined). In his paper, critical values are given for the rejection of the linearity null hypothesis in favor of the alternative hypothesis that threshold effects exist. These critical values are used for the linearity tests on equation (1) in this paper.

Since economic theory does not support any particular lag length structure a priori, we proceeded as follows. The lag length on all variables (productivity growth, inflation rate, and industrial output growth) was varied from one to six lags. Additionally, since the standard practice in these types of threshold estimating equations is to use some lag of the hypothesized causal variable as the threshold variable, for each lag-length specification, one to six lags of inflation rate was tested as the threshold variable. (See Tsay (1989) for a discussion of this issue in the context of a univariate estimation model). Next, for each inflation rate lag threshold variable, the threshold critical value was varied by initially setting the threshold critical value at 1.60% and then raising the threshold critical value in 0.05% steps until the final iteration utilized a threshold critical value of 5.15%. These critical value boundaries were set in order to keep at least 15% of the observations in each inflationary regime. While these cut-offs are admittedly somewhat arbitrary, it turns out not to be an issue because the results find the threshold critical value to be comfortably removed from either of these two endpoints.

The 3 lag specification of equation (1) with 1 lag of inflation rate as the threshold variable, and 2.95% as the threshold critical value, generated the largest maximum likelihood ratio test statistic over the range of tested models. This is the value needed to compare against the critical values provided by Andrews (1993). As seen in Table 2, the linearity null hypothesis for equation (1) is strongly rejected as the max-LR test statistic of 31.55 is well above even the 1% critical value of 25.75. The findings imply a threshold critical value of 2.95% as the switching point between the low and high inflation rate regimes.

TABLE II. ESTIMATION OF EQUATION (1) SUMMARY OF RESULTS

Model's Estimated Sup-LR Test Statistic	Sup-LR Critical Values 10%	5%	1%
31.5	18.08	20.35	25.75

Estimated Parameter Values For Equation (1)

Variable	Low Inflation Regime: Sum of Coefficients	Low Inflation Regime: P-value	High Inflation Regime: Sum of Coefficients	High Inflation Regime: P-value
Inflation	0.060	0.79	-0.297	0.03
Industrial Output Growth	-0.063	0.26	-0.305	0.000
Productivity Growth	0.676	0.000	1.040	0.000

The sums of the relevant parameter coefficients also are reported in Table II. Pay particular attention to the sum of the inflation rate coefficients in the two inflation rate regimes. In the low inflation rate regime, the coefficients sum to a positive 0.060 but the sum is not statistically significant as the p-value = 0.79. In the high inflation rate regime, however, the impact of inflation rate upon productivity growth is both negative and statistically significant with a parameter value of -.297 and p-value of 0.03.

These results contradict previous findings of no impact from inflation rate upon German productivity growth in studies that imposed a constant linear relationship between inflation rate and productivity growth. Apparently, the prior findings of no adverse effects from inflation rate were due to the mixing of the low inflation rate and high inflation rate regimes' observations in the same regression estimation.

We do not argue that an inflation rate of 2.95% strictly divides the German Data into low versus high inflationary regimes across which the impact of inflation upon productivity growth differs as a consequence of some abrupt regime change. Instead we interpret these results as being broadly consistent with negative effects from inflation upon productivity growth emerging for Germany once the inflation rate moves into the upper one-half of the inflation range experienced by Germany over this sample period. The threshold switching model's abrupt regime change approach likely is approximating less abrupt changes in the underlying inflation-productivity relationship.

As a check on the conclusions derived from Table II, we analyze the results of equation (1) for each of the tested threshold critical values from 1.60% to 5.15% while maintaining the 3 lag for each variable specification with 1 lag of inflation rate as the threshold variable. These findings are summarized in Table III and indicate that the conclusions drawn from Table II are not sensitive to modest changes in the threshold critical value. First, note the sum of the inflation rate coefficients in the low inflation regime is never statistically significant for any of the potential threshold critical values. In contrast, examine the inflation rate coefficient results for the high inflation rate regime over the threshold critical value range from 2.00 to 4.00%. The sum of coefficients always is negative and in most cases is statistically significant (pvalue < .10).

TABLE III. EQUATION (1) WITH VARYING THRESHOLD VALUES

Threshold Value	LOINF	LOINF PV	HIINF	HINF PV	Threshold Value	LOINF	LOINF PV	HIINF	HIINF PV
0.016	0.351	0.653	-0.202	0.040	0.034	0.174	0.324	-0.338	0.055
0.0165	0.665	0.283	-0.171	0.097	0.0345	0.183	0.289	-0.325	0.068
0.017	0.647	0.295	-0.179	0.086	0.035	0.183	0.289	-0.325	0.068
0.0175	0.647	0.295	-0.179	0.086	0.0355	0.183	0.289	-0.325	0.068
0.018	0.647	0.295	-0.179	0.086	0.036	0.175	0.301	-0.307	0.089
0.0185	0.651	0.250	-0.179	0.090	0.0365	0.072	0.657	-0.392	0.068
0.019	0.579	0.273	-0.203	0.071	0.037	0.072	0.657	-0.392	0.068
0.0195	0.579	0.273	-0.203	0.071	0.0375	0.074	0.642	-0.363	0.098
0.02	0.764	0.127	-0.182	0.094	0.038	0.069	0.663	-0.383	0.094
0.0205	0.532	0.227	-0.190	0.086	0.0385	0.069	0.663	-0.383	0.094
0.021	0.354	0.370	-0.192	0.088	0.039	0.064	0.678	-0.405	0.087
0.0215	0.354	0.370	-0.192	0.088	0.0395	0.063	0.670	-0.392	0.109
0.022	0.335	0.393	-0.222	0.054	0.04	0.101	0.483	-0.225	0.363
0.0225	0.407	0.269	-0.214	0.063	0.0405	0.077	0.591	-0.243	0.345
0.023	0.430	0.233	-0.196	0.090	0.041	0.061	0.665	-0.292	0.296
0.0235	0.304	0.389	-0.212	0.071	0.0415	0.080	0.566	-0.330	0.265
0.024	0.232	0.507	-0.256	0.031	0.042	0.084	0.548	-0.320	0.321
0.0245	0.320	0.359	-0.201	0.099	0.0425	0.084	0.548	-0.320	0.321
0.025	0.291	0.399	-0.208	0.100	0.043	0.024	0.863	-0.440	0.191
0.0255	0.291	0.399	-0.208	0.100	0.0435	0.058	0.663	-0.352	0.342
0.026	0.291	0.399	-0.208	0.100	0.044	0.055	0.675	-0.358	0.353
0.0265	0.211	0.471	-0.189	0.140	0.0445	0.055	0.675	-0.358	0.353
0.027	0.165	0.554	-0.183	0.154	0.045	0.055	0.675	-0.358	0.353
0.0275	0.165	0.554	-0.183	0.154	0.0455	0.055	0.675	-0.358	0.353
0.028	0.151	0.565	-0.296	0.021	0.046	0.055	0.675	-0.358	0.353
0.0285	0.187	0.454	-0.281	0.035	0.0465	0.032	0.804	-0.474	0.233
0.029	0.060	0.794	-0.297	0.032	0.047	0.032	0.804	-0.474	0.233
0.0295	0.060	0.794	-0.297	0.032	0.0475	0.032	0.804	-0.474	0.233
0.03	0.167	0.449	-0.263	0.079	0.048	0.043	0.732	-0.429	0.327
0.0305	0.300	0.156	-0.248	0.115	0.0485	0.043	0.732	-0.429	0.327
0.031	0.255	0.218	-0.236	0.144	0.049	0.043	0.732	-0.429	0.327
0.0315	0.255	0.218	-0.236	0.144	0.0495	0.049	0.687	-0.272	0.556
0.032	0.255	0.218	-0.236	0.144	0.05	0.049	0.687	-0.272	0.556
0.0325	0.212	0.294	-0.252	0.132	0.0505	-0.039	0.739	-0.393	0.425
0.033	0.254	0.172	-0.276	0.108	0.051	-0.039	0.739	-0.393	0.425
0.0335	0.254	0.172	-0.276	0.108	0.0515	-0.022	0.841	-0.356	0.483

LOINF- sum of inflation coefficients from equation (1) in low inflation regime; LOINFPV- pvalue of test that LOINF=0; HIINF- sum of inflation coefficients from equation (1) in high inflation regime; HIINFPV- pvalue of test that HIINF=0

These findings support two general conclusions regarding inflation's impact upon productivity growth in Germany. First, as inflation rates approached and exceeded 3.0%, further inflationary shocks did appear to have an adverse impact upon productivity growth. Once inflation rates fell close to or below 2.0%, however, there is no evidence that any further reduction in inflation favorably impacted productivity growth.

CONCLUSION

Previous research investigating the impact of inflation upon German productivity growth over the past 40 years failed to find a statistically significant negative impact from inflation after correctly controlling for business cycle effects. That research, however, utilized standard causality testing methods that impose a constant linear relationship between inflation and productivity. This paper allows for the existence of threshold effects and finds that for Germany in the 1960's through 1990's inflation did have an adverse effect upon productivity growth.

The finding, however, is confined to the defined "high" inflation rate regime and when inflation is in the "low" inflation rate regime, there is no statistically significant impact from inflation upon productivity growth. The threshold value dividing the high and low inflation rate regimes lies in the upper 2% to low 3% inflation range. Once inflation exceeds that level, further inflation shocks do appear to reduce productivity growth. This finding supports those who argue for low inflation rates as a means to aid productivity growth. In particular, it is consistent with the view that the German Central Bank's strong commitment to low inflation in the post World War II era contributed to Germany's strong record of productivity growth over this time. The finding suggests that if the European Central Bank ultimately is as successful as was Germany's Central Bank at maintaining low inflation rates, then productivity growth across the entire Euro zone will be enhanced.

At the same time, however, this paper's findings do not support a policy goal of zero inflation as has been called for by some. Once inflation rates reach the low 2% range or below, this paper finds no evidence that further inflation reductions would aid productivity growth.

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