SFB 649 Discussion Paper 2009-036

Inflation and Growth: New Evidence From a Dynamic Panel Threshold Analysis

Stephanie Kremer*
Alexander Bick*
Dieter Nautz**

* Goethe-Universität Frankfurt, Germany
** Freie Universität Berlin, Germany

This research was supported by the Deutsche Forschungsgemeinschaft through the SFB 649 "Economic Risk".

http://sfb649.wiwi.hu-berlin.de
ISSN 1860-5664

SFB 649, Humboldt-Universität zu Berlin
Spandauer Straße 1, D-10178 Berlin

SFB 649 ECONOMIC RISK BERLIN

Inflation and Growth:
New Evidence From a Dynamic Panel Threshold Analysis

Stephanie Kremer, Alexander Bick and Dieter Nautz*

June 25, 2009

Abstract

We introduce a dynamic panel threshold model to shed new light on the impact of inflation on long-term economic growth. The empirical analysis is based on a large panel-data set including 124 countries during the period from 1950 to 2004. For industrialized countries, our results confirm the inflation targets of about 2% set by many central banks. For non-industrialized countries, we estimate that inflation hampers growth if it exceeds 17%. Below this threshold, however, the impact of inflation on growth remains insignificant. Therefore, our results do not support growth-enhancing effects of inflation in developing countries.

Keywords: Inflation Thresholds, Inflation and Growth, Dynamic Panel Threshold Model

JEL classification: E31, C23, O40

*This research was supported by the Deutsche Forschungsgemeinschaft through the CRC 649 "Economic Risk". We thank Neil Foster and, particularly, Jörg Breitung and Paula Hernandez-Verme for helpful comments and suggestions. An earlier version of the paper has been presented at the 2008 annual meetings of the German and the European Economic Association in Graz and Milan. E-mail: skremer@wiwi.uni-frankfurt.de, bick@wiwi.uni-frankfurt.de, dieter.nautz@fu-berlin.de

1 Introduction

Most economists would agree that inflation has distortional effects on long-term economic growth if it gets “too high”. Yet how high is too high? For industrialized countries, there has been an increasing consensus on inflation targets that center around 2%. In the same vein, recent empirical work by Goncalves and Salles (2008) and Lin and Ye (2009) suggests that inflation targeting in developing countries can lead to significant improvements in terms of inflation and output volatility. However, the appropriate level of the inflation target for developing countries is still under debate. Bruno and Easterly (1998), for example, showed in a cross-country regression that the effect of inflation on growth increases if it exceeds a critical level of 40% — a rather large value which may be of only of limited relevance for monetary policy of many countries.[1]

More recent contributions on critical levels of inflation in the inflation-growth nexus employ the panel threshold model introduced by Hansen (1999) which is designed to estimate the inflation thresholds instead of imposing them. Yet, the application of Hansen’s threshold model to the analysis of the relationship between inflation and growth is not without problems. The most important limitation of Hansen’s model is that all regressors are required to be exogenous. In growth regressions with panel data, the exogeneity assumption is particular severe, because initial income as a crucial variable is endogenous by construction. Caselli, Esquivel and Lefort (1996) already demonstrated for linear panel models of economic growth that the endogeneity bias can be substantial. So far, dynamic versions of Hansen’s panel threshold model have not been available. Therefore, with a view to the central role of initial income for the convergence debate of the economic growth literature, most empirical studies on growth-related thresholds decided to ignore the potential endogeneity bias, see e.g. Khan and Senhadji (2001), Cuaresma and Silgoner (2004) and Foster (2006). In contrast, Drukker, Gomis-Porqueras and Hernandez-Verme (2005) excluded initial income

[1] For example, the Southern African Development Community (SADC) convergence criteria requires a low single digit inflation rate, see Regional Indicative Strategic Development Plan available at `http://www.sadc.int/attachment/download/file/74`.

from their growth regressions to avoid the endogeneity problem. Both ways to deal with the endogeneity of initial income can lead to biased estimates of the inflation thresholds and to misleading conclusions about the impact of inflation on growth in the corresponding inflation regimes.

To overcome the endogeneity problem, this paper introduces a dynamic panel threshold model to shed more light on the impact of inflation on growth for industrialized and non-industrialized countries. Applying the forward orthogonal deviations transformation suggested by Arellano and Bover (1995), we combine the instrumental variable estimation of the cross-sectional threshold model introduced by Caner and Hansen (2004) with the panel threshold model of Hansen (1999). In the dynamic model, the endogeneity of important control variables of economic growth is no longer be an issue for estimating the critical level of inflation.

Our empirical results strongly confirm earlier evidence in favor of inflation thresholds in the inflation-growth nexus. In accordance with Khan and Senhadji (2001), we found notable differences between the results obtained for industrialized and non-industrialized countries. For industrialized countries, the estimated inflation threshold is about 2.5% which provides strong support for the inflation targets of many central banks. In particular, inflation rates above 2.5% lead to lower long-term economic growth in industrialized countries, while the significant positive effect of inflation on growth in the low inflation regime suggests that inflation rates below 2.5% might be "too low". For developing countries, the estimated inflation threshold is 17.2%. If inflation exceeds this critical value, i.e. if it gets '"too high", its growth reducing effect is very close to the one estimated for industrialized countries. In contrast, there is no significant impact of inflation on the long-term economic growth of developing countries when inflation is below 17.2%. Therefore, our findings question the growth enhancing effects of moderate inflation rates in developing countries.

The rest of the paper is organized as follows. In Section 2, we introduce the data and control variables. Section 3 briefly describes the econometrics of the dynamic panel threshold model which we apply to the inflation-growth nexus in industrialized and non-industrialized countries. Section 4 concludes.

2 Data and Variables

The following empirical analysis employs an unbalanced panel-data set of 124 countries. Industrialized and non-industrialized countries are identified in accordance with the International Financial Statistics (IFS) and shown in Tables 3 and 4 in the Appendix A.1. Using data from 1950 to 2004 we extend the samples by Khan and Senhadji (2001) (1960 to 1998) and Drukker et al. (2005) (1950 to 2000). As a consequence, our sample contains more information about the growth effects of low inflation.

For each country, annual growth rates of real GDP per capita in constant 2000 prices (*dgdp*) are obtained from Penn World Table 6.2. Inflation is computed as the annual percentage change of the Consumer Price Index (π) collected from IFS. In line with the empirical growth literature, our results on the determinants of long-term economic growth will be based on five-year averages which gives us 988 observations, 227 for industrialized and 761 for non-industrialized countries.

2.1 Control Variables

Any empirical analysis of inflation's impact on economic growth has to control for the influence of other economic variables that are correlated with the rate of inflation. Following Khan and Senhadji (2001) and Drukker et al. (2005), we consider the percentage of GDP dedicated to investment (*igdp*), the growth rate of population (*dpop*), the initial income level (*initial*) measured as GDP per capita from the previous period and openness (*open*) measured as the logged share of exports plus imports in GDP. These variables are obtained from Penn World Table 6.2. The annual percentage change in the terms of trade (*dtot*) is measured as exports divided by imports. Export and import data are taken from Penn World Table 6.1 until 2000 and for the later years from the World Trade Organization (WTO) database. We also included the standard deviations of the terms of trade (*sdtot*) and of openness (*sdopen*). More information about the control variables is contained in Table 2 in the Appendix. All these variables passed the robustness tests of Levine and Renelt (1992) or Sala-i-Martin (1997).

2.2 Inflation

Inflation has been lower in industrialized countries with an average annual inflation rate over the sample period of 5.86% as opposed to 33.63% for non-industrialized countries. For both set of countries, the dispersion of inflation rates is considerable, see Figures 1 and 3 in the Appendix A.2. In this case, Ghosh and Phillips (1998) strongly suggest the use of logged inflation rates to avoid that regression results are distorted by a few extreme inflation observations. Moreover, using logged inflation rates has the plausible implication that multiplicative, not additive, inflation shocks will have identical growth effects. Since our sample contains negative inflation rates, we follow Drukker et al. (2005), and Khan and Senhadji (2001) and employ a semi-log transformation of the inflation rate π_{it}

$$\tilde{\pi}_{it} = \begin{cases} \pi_{it} - 1, & \text{if } \pi_{it} \leq 1 \\ ln(\pi_{it}), & \text{if } \pi_{it} > 1, \end{cases}$$

where inflation rates below one are re-scaled for sake of continuity. In sharp contrast to the highly skewed and leptokurtic inflation data of industrialized and non-industrialized countries, the distributions of semi-logged inflation rates are much more symmetric and in line with the normal distribution, see Figures 2 and 4 in Appendix A.2.

3 Inflation Thresholds and Growth

3.1 A Dynamic Panel Threshold Model

In the following empirical application, we introduce a dynamic panel threshold model that extends Hansen's (1999) original set up by considering endogenous regressors including lags of the dependent variable. Specifically, we adopt the cross-sectional threshold model of Caner and Hansen (2004), where GMM type estimators are used in order to allow for endogeneity, to a dynamic setting. The main problem is to transform the panel threshold model in a way that eliminates the country-specific fixed effects without violating the distributional assumptions underlying both models, see Hansen (2000). First-differencing, for example, the standard fixed-effects elimination in dynamic panels is not feasible because it induces serial correlation in the transformed cross section specific error terms. We solve this problem by using the forward orthogonal deviations transformation suggested by Arellano and Bover (1995) which eliminates fixed effects but avoids serial correlation in the transformed errors. As a consequence, the forward orthogonal deviation transformation ensures that the original distribution theory of the threshold model applied to static panels as in Hansen (1999) is also valid in a dynamic context.[2] A more detailed description of the econometrics of a dynamic panel threshold model is provided in the Appendix A.3.

Let us now apply the dynamic panel threshold model to the analysis of the impact of inflation on long-term economic growth in industrialized and non-industrialized countries. To that aim, consider the following threshold model of the inflation-growth nexus:

$$dgdp_{it} = \mu_i + \beta_1 \tilde{\pi}_{it} I(\tilde{\pi}_{it} \leq \gamma) + \delta_1 I(\tilde{\pi}_{it} \leq \gamma) + \beta_2 \tilde{\pi}_{it} I(\tilde{\pi}_{it} > \gamma) + \phi z_{it} + \varepsilon_{it}. \quad (1)$$

In our application, inflation $\tilde{\pi}_{it}$ is both, the threshold variable and the regime dependent regressor. z_{it} denotes the vector of partly endogenous control variables, where slope coefficients are assumed to be regime independent.[3] Initial income (*initial*) is considered as lagged endogenous variable, i.e. $z_{2it} = initial_{it}$, while z_{1it} contains the remaining control variables.[4] In accordance with Arellano and Bover (1995), the level of the lagged endogenous variable itself is used as instrument. Note that our results are robust with respect to the choice of instruments in levels or differences.

Table 1 shows the results obtained for industrialized and non-industrialized countries.

[2]We are grateful to Joerg Breitung for this insight.

[3]Included time dummies in equation (1) are insignificant and do not change our main results. Results with time dummies are available on request. The inclusion of time dummies in the model is valid, only time trends are excluded, see Caner and Hansen (2004).

[4]For both industrialized and non-industrialized countries a standard Hausman test indicates that the exogeneity of the remaining control variables cannot be rejected for the model with the estimated threshold. For brevity, these results are not presented and are available on request.

Table 1: Inflation thresholds and growth

	Industrialized Countries	Non-Industrialized Countries
Threshold estimates		
$\widehat{\gamma}$	2.530%	17.228%
95% confidence interval	[1.38, 5.50]	[12.87, 19.11]
Impact of inflation		
$\widehat{\beta}_1$	1.280	−0.141
	(0.520)	(0.121)
$\widehat{\beta}_2$	−0.531	−0.494
	(0.312)	(0.221)
Impact of covariates		
$initial_{it}$	−3.543	−1.761
	(2.731)	(1.240)
$igdp_{it}$	0.093	0.156
	(0.030)	(0.048)
$dpop_{it}$	0.101	−0.503
	(0.387)	(0.350)
$dtot_{it}$	−0.150	−0.072
	(0.043)	(0.0028)
$sdtot_{it}$	−0.003	−0.006
	(0.057)	(0.023)
$open_{it}$	1.361	0.733
	(3.311)	(0.866)
$sdopen_{it}$	0.287	0.050
	(0.288)	(0.188)
$\widehat{\delta}_1$	−0.523	0.753
	(0.607)	(1.199)
Observations	227	761
N	23	101

Notes: Following Hansen (1999), each regime contains at least 5% of all observations. For industrialized countries, feasible inflation thresholds are, therefore, between 1.146 and 15.668% and for non-industrialized countries between 1.002 and 66.146%. Standard errors are given in parentheses.

The upper part of the table displays the estimated inflation threshold and the corresponding 95% confidence interval. The middle part shows the regime-dependent coefficients of inflation on growth. Specifically, $\widehat{\beta}_1$ ($\widehat{\beta}_2$) denotes the marginal effect of inflation on growth in the low (high) inflation regime, i.e. when inflation is below (above) the estimated threshold value. The coefficients of the control variables are presented in the lower part of the table.

3.2 The Inflation-Growth Nexus in Industrialized Countries

The results for the empirical relation between inflation and growth in industrialized countries are presented in the first column of Table 1. The estimated inflation threshold of 2.53% as well as the marginal effects of inflation on growth strongly support the prevailing inflation targets of many central banks. First, the 95% confidence interval of the threshold value includes 2%, the most prominent inflation target in industrialized countries. Second, both regime-dependent coefficients of inflation are significant and plausibly signed. $\widehat{\beta}_1 = 1.28$ indicates that inflation is harmful for economic growth in industrialized countries when inflation gets too low. In particular, if inflation rates increase from say, 0 to 1%, long-term economic growth increases by 1.28 percentage points. Above its threshold, however, inflation has the expected negative impact ($\widehat{\beta}_2 = -0.531$) on growth. Note that the absolute size of the inflation coefficients suggest that it may be more severe for the economic growth of industrialized countries if inflation gets too low. With a view to the 95% confidence intervals, this conclusion holds at least for inflation rates below 1.38%.

3.3 The Inflation-Growth Nexus in Non-Industrialized Countries

The results for non-industrialized countries are shown in the second column of Table 1. They differ from those obtained for industrialized countries in two important aspects. First, the estimated threshold level of inflation (17.2%) is definitely higher than in industrialized countries. The 95% confidence interval indicates that the critical value of inflation for non-industrialized countries is clearly lower than e.g. the 40% proposed by Bruno and Easterly (1998). According to our estimates, even inflation rates above 12.87% may already be seen as "too high". In particular, the coefficient of inflation ($\widehat{\beta}_2$=-0.494) is significant and plausibly signed when inflation gets above its threshold. Therefore we find clear evidence suggesting a growth-dampening effect of high inflation for non-industrialized countries.[5] The second important difference between the empirical results obtained for industrialized and non-industrialized countries refers to the growth effects of inflation when inflation is below its threshold. While inflation can easily get too low in industrialized countries, the inflation coefficient of the low-inflation regime, $\widehat{\beta}_1 = -0.14$, is small and far from significant for non-industrialized countries. Accordingly, there are no growth-enhancing effects of inflation when inflation gets below its threshold value.

4 Concluding Remarks

This paper provided new evidence on the non-linear impact of inflation on long-term economic growth. To that aim, we introduced a dynamic panel threshold model that accounts for the endogeneity of initial income. Confirming the general consensus among economists, we found that inflation distorts economic growth provided it exceeds a certain critical value. However, there are important differences for industrialized and non-industrialized countries concerning both the level of the estimated inflation threshold and the impact of inflation in the various inflation regimes.

For industrialized countries, our results support the inflation targets of about 2% which are more or less explicitly announced by many central banks. In particular, we estimated that inflation dampens growth if it exceeds a critical value of 2.5%. Moreover, according to the significantly positive coefficient of inflation in the low-inflation regime, inflation rates below 2.5% may be too low because they have negative effects on growth. For non-industrialized countries, the estimated inflation threshold is about 17%. The higher inflation threshold for non-industrialized countries could be explained by the

[5] By contrast, Drukker et al. (2005) find significant inflation thresholds but no significant impact of inflation on growth in any regime.

widespread use of indexation systems, which many non-industrialized countries have adopted due to a long history of inflation. These indexation systems may partially reduce the adverse effects of inflation.[6] Inflation has a significant negative effect on growth for non-industrialized countries if it exceeds its threshold value. However, we found no evidence in favor of positive effects of inflation on growth in the "low-inflation" regime, i.e. when inflation is below 17%. Thus, our results for non-industrialized countries shift the emphasis from the growth-enhancing to the growth-dampening effects of inflation.

The empirical setup of the current study controlled for the effect of further variables on growth but assumed that the level of the inflation threshold only depends on whether a country is industrialized or not. In particular for the very heterogenous group of non-industrialized countries, this assumption may be too restrictive. Lin and Ye (2009), for example, show that the performance of inflation targeting in developing countries can be affected by further country characteristics. Accordingly, inflation thresholds in developing countries and, thus, the appropriate level of the inflation target might be also country-specific. The identification of country-specific inflation thresholds in the inflation-growth nexus might provide useful information about the appropriate location and width of an inflation targeting band. We leave this natural extension for future research.

[6]Following e.g. Khan and Senhadji (2001), higher inflation thresholds in non-industrialized countries may also be related to a convergence process and the Balassa-Samuelson effect.

References

Arellano, M. and Bover, O. (1995). Another look at the instrumental variables estimation of error-components models, *Journal of Econometrics* **68**: 29–51.

Bick, A. (2007). Pitfalls in panel threshold models: The role of regime dependent intercepts, *Working Paper Goethe University Frankfurt* .

Bruno, M. and Easterly, W. (1998). Inflation Crisis and Long-Run Growth, *Journal of Monetary Economics* **41**: 3–26.

Caner, M. and Hansen, B. E. (2004). Instrumental Variable Estimation of a Threshold Model, *Econometric Theory* **20**: 813–843.

Caselli, F., Esquivel, G. and Lefort, F. (1996). Reopening the Convergence Debate: A New Look at Cross-Country Growth Empirics, *Journal of Economic Growth* **1**(3): 363–389.

Drukker, D., Gomis-Porqueras, P. and Hernandez-Verme, P. (2005). Threshold Effects in the Relationship Between Inflation and Growth: A New Panel-Data Approach, *Working Paper* .

Foster, N. (2006). Exports, Growth and Threshold Effects in Africa, *Journal of Development Studies* **42**(6): 1056–1074.

Ghosh, A. and Phillips, S. (1998). Warning: Inflation May Be Harmful to Your Growth, *IMF Staff Papers* **45**(4): 672–710.

Goncalves, C. E. S. and Salles, J. M. (2008). Inflation targeting in emerging economies: What do the data say?, *Journal of Development Economics* **85**: 312–318.

Hansen, B. E. (1999). Threshold Effects in Non-Dynamic Panels: Estimation, Testing, and Inference, *Journal of Econometrics* **93**: 345–368.

Khan, M. S. and Senhadji, A. S. (2001). Threshold effects in the Relationship between Inflation and Growth, *Technical Report, IMF Staff Papers* **48**.

Levine, R. and Renelt, D. (1992). A Sensitivity Analysis of Cross-Country Growth Regressions, *American Economic Review* **82**(4): 942–963.

Lin, S. and Ye, H. (2009). Does Inflation Targeting Make a Difference in Developing Countries?, *Journal of Development Economics* **89**: 118–123.

Sala-i-Martin, X. (1997). I just ran two million regressions, *American Economic Review* **87**: 178–183.

A Appendix

A.1 Tables

Table 2: List of Variables

dgdp	Five-year average of the annual growth rate of real GDP per capita in constant 2000 prices
dpop	Five-year average of the annual growth rate of population
dtot	Five-year average of the annual percentage change in the terms of trade, where the terms of trade are measured as exports divided by imports
igdp	Five-year average of the annual percentage of GDP dedicated to investment
initial	Five-year average of GDP per capita in 2000 constant prices, from the previous period, in logs
open	Five-year average of log of openness, where openness is measured as the share of exports plus imports in the GDP
π	Five-year average of the annual percentage change of the CPI index
$\tilde{\pi}$	Semi-log transformed π
sdtot	Five-year standard deviation of the terms of trade
sdopen	Five-year standard deviation of openness
x	Vector of control variables: $initial, igdp, dpop, dtot, sdtot, open, sdopen$

Table 3: Sample industrialized countries

Country	t	$\underset{mean}{\pi}$	$\underset{mean}{dgdp}$	Country	t	$\underset{mean}{\pi}$	$\underset{mean}{dgdp}$
Australia	10	5.26	2.13	Japan	10	3.64	4.43
Austria	10	3.54	3.27	Luxembourg	10	3.49	3.18
Belgium	10	3.73	2.65	Netherlands	10	3.87	2.29
Canada	10	4.14	2.22	New Zealand	10	6.30	1.66
Denmark	10	5.28	2.28	Norway	10	5.03	2.89
Finland	10	5.71	2.86	Portugal	10	9.42	3.71
France	10	5.08	2.79	Spain	10	8.07	3.52
Germany	8	2.60	2.22	Sweden	10	5.21	2.14
Greece	9	10.34	3.23	Switzerland	10	2.95	1.81
Iceland	10	17.84	2.83	United Kingdom	10	5.97	2.22
Ireland	10	6.42	3.74	United States	10	4.02	2.28
Italy	10	6.71	3.06				

Notes: Average of annual inflation rates and average of annual growth rates of GDP in percent over the period 1955-2004. Source: IFS, Penn World Table 6.2.

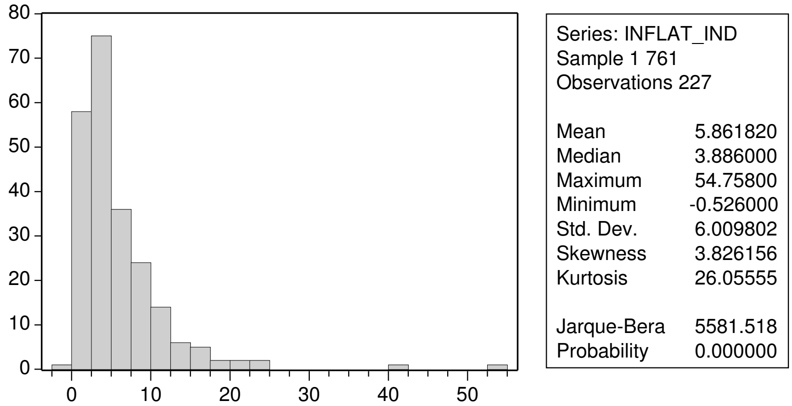
Table 4: Sample non-industrialized countries

Country	T	$\underset{mean}{\pi}$	$\underset{mean}{dgdp}$	Country	T	$\underset{mean}{\pi}$	$\underset{mean}{dgdp}$
Algeria	7	10.58	1.40	Malawi	7	18.82	1.35
Argentina	10	199.63	1.08	Malaysia	9	3.18	4.62
Bahamas	6	4.46	1.30	Mali	7	4.76	2.02
Bahrain	6	3.54	0.71	Malta	6	3.60	5.34
Barbados	7	6.99	1.24	Mauritania	5	6.94	0.24
Benin	2	4.19	2.11	Mauritius	9	8.08	3.12
Bolivia	10	291.40	4.04	Mexico	10	22.79	2.05
Botswana	6	10.43	5.44	Morocco	10	5.05	2.37
Brazil	7	346.25	2.10	Mozambique	4	40.12	3.23
Burkina Faso	8	4.78	1.29	Namibia	5	11.24	0.61
Burundi	8	9.81	0.91	Nepal	8	8.12	1.43
Cameroon	7	7.40	1.19	Netherlands Antilles	6	4.37	0.42
Cape Verde	5	7.33	4.28	Nicaragua	7	791.09	-1.53
Central African Republic	6	5.68	-0.13	Niger	8	5.33	0.84
Chad	7	3.12	0.98	Nigeria	10	15.83	0.96
Chile	9	52.03	2.40	Pakistan	9	.67	2.70
China	7	5.01	7.30	Panama	10	2.30	2.95
Colombia	10	16.83	1.66	Papua New Guinea	6	7.95	2.45
Congo	7	7.65	1.40	Paraguay	9	12.55	1.46
Costa Rica	10	12.41	1.66	Peru	10	266.10	1.10
Cote d'Ivoire	8	6.94	0.66	Philippines	10	9.15	1.75
Cyprus	6	4.82	5.09	Poland	6	46.97	2.03
Dominica	6	5.72	2.56	Romania	7	38.33	3.35
Dominican Republic	9	12.61	2.96	Rwanda	7	10.04	1.88
Ecuador	9	23.27	1.63	Samoa	6	8.45	0.96
Egypt	9	9.08	2.89	Saudi Arabia	6	2.99	-1.84
El Salvador	10	8.19	1.05	Senegal	7	6.22	0.15
Equatorial Guinea	5	12.60	10.96	Sierra Leone	6	39.54	-1.80
Ethiopia	8	6.22	1.68	Singapore	8	2.91	4.98
Fiji	6	5.83	1.10	Solomon Islands	6	10.35	-0.36
Gabon	8	5.78	0.30	South Africa	10	8.13	1.48
Gambia	8	9.56	1.02	Sri Lanka	10	7.59	3.27
Ghana	8	32.65	7.34	St, Lucia	6	5.26	2.68
Grenada	5	4.20	2.61	St,Vincent & Grenadines	6	4.795	4.21
Guatemala	10	7.96	1.07	Sudan	6	43.18	0.48
Guinea-Bissau	3	25.81	1.30	Suriname	6	43.03	3.76
Haiti	6	13.99	0.42	Swaziland	6	11.68	2.75
Honduras	10	8.81	0.89	Syria	8	10.35	1.85
Hong Kong	8	5.98	4.72	Tanzania	8	18.27	1.69
Hungary	6	12.46	2.27	Thailand	10	4.72	4.42
India	10	7.22	2.75	Togo	7	6.43	-1.46
Indonesia	8	53.61	3.53	Tonga	6	8.63	4.13
Iran	9	14.27	2.10	Trinidad &Tobago	10	7.23	3.55
Israel	9	39.92	2.75	Tunisia	7	4.73	3.27
Jamaica	9	15.29	0.80	Turkey	10	36.64	2.46
Jordan	7	6.81	-0.47	Uganda	5	48.62	1.63
Kenya	9	10.19	0.28	Uruguay	10	45.95	0.92
Korea	7	8.85	6.07	Venezuela	10	17.90	0.56
Kuwait	6	2.77	0.94	Zambia	7	35.67	0.21
Lesotho	6	12.93	3.25	Zimbabwe	8	37.10	0.54
Madagascar	8	12.46	-1.23				

Notes: Average of annual inflation rates and average of annual growth rates of GDP in percent over the period 1955-2004. Source: IFS, Penn World Table 6.2.

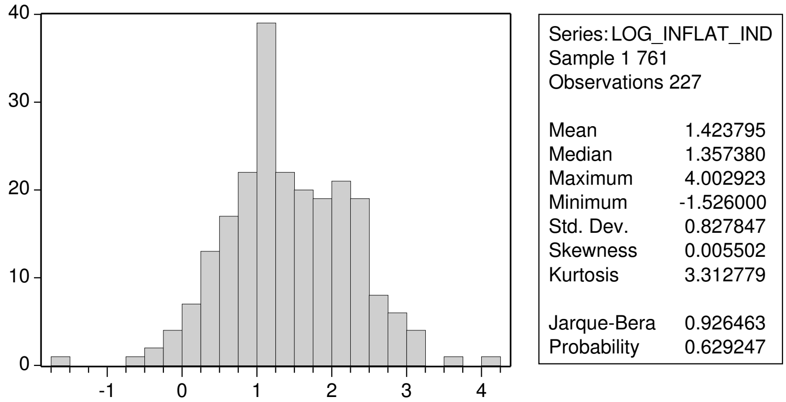
A.2 Figures

Figure 1: Distribution of inflation rates - Industrialized countries



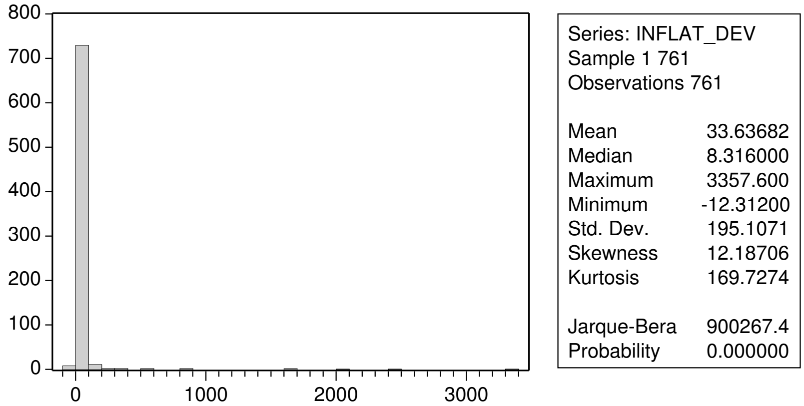
Notes: Five-year average of annual inflation rates (percentage points) for industrial countries, 1955-2004. Source: IFS.

Figure 2: Distribution of log inflation rates - Industrialized countries



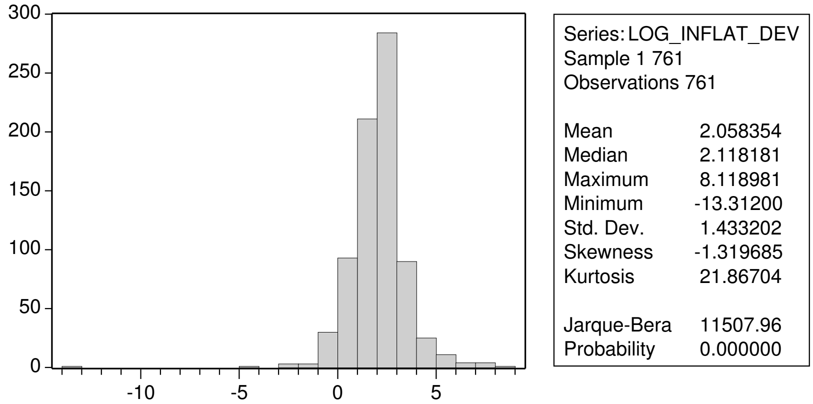
Notes: Five-year average of annual inflation rates (percentage points) after the semi-log transformation for industrial countries, 1955-2004, see Section 2.1. Source: IFS.

Figure 3: Distribution of inflation rates - Non-industrialized countries



Notes: Five-year average of annual inflation rates (percentage points) for non-industrial countries, 1955-2004. Source: IFS.

Figure 4: Distribution of log inflation rates - Non-industrialized countries



Notes: Five-year average of annual inflation rates (percentage points) after the semi-log transformation for non-industrial countries, 1955-2004, see Section 2.1. Source: IFS.

A.3 The Econometrics of the Dynamic Panel Threshold Model

This appendix considers in more detail the econometrics of the following dynamic panel threshold model:

$$y_{it} = \mu_i + \beta_1 z_{it} I(q_{it} \leq \gamma) + \delta_1 I(q_{it} \leq \gamma) + \beta_2 z_{it} I(q_{it} > \gamma) + \varepsilon_{it}, \tag{2}$$

where subscripts $i = 1, \ldots, N$ represents the country and $t = 1, \ldots, T$ indexes time. μ_i is the country specific fixed effect and the error term is $\varepsilon_{it} \overset{iid}{\sim} (0, \sigma^2)$. $I(\cdot)$ is the indicator function indicating the regime defined by the threshold variable q_{it} and the threshold level γ. z_{it} is a m-dimensional vector of explanatory regressors which may include lagged values of y and other endogenous variables. The vector of explanatory variables is partitioned into a subset z_{1it}, of exogenous variables uncorrelated with ε_{it}, and a subset of endogenous variables z_{2it}, correlated with ε_{it}. Following Bick (2007) the model is also augmented by regime-dependent intercepts δ_1. In addition to the structural equation (2) the model requires a suitable set of $k \geq m$ instrumental variables x_{it} including z_{1it}.

In the first step of the estimation procedure, one has to eliminate the individual effects μ_i via a fixed-effects transformation. However, in the dynamic model (2), the standard within transformation applied by Hansen (1999) leads to inconsistent estimates because the lagged dependent variable will always be correlated with the mean of the individual errors and thus all of the transformed individual errors. First-differencing of the dynamic equation (2) as usually done in the context of dynamic panels leads to estimation problems, since it implies negative serial correlation of the error terms. As a result, the distribution theory developed by Hansen (1999) would not be applicable anymore to panel data.[7] For that reason, we apply the forward orthogonal deviations transformation suggested by Arellano and Bover (1995) to eliminate the fixed effects. The distinguishing feature of the forward orthogonal deviations transformation is that serial correlation of the transformed error terms is avoided. Instead of subtracting the

[7] Note that in Hansen (1999) serial correlation in the error terms is irrelevant because of the idempotency of the transformed error matrix, see equation A.12 in Hansen (1999).

previous observation from the contemporaneous one (first-differencing) or the mean from each observation (within transformation), it subtracts the average of all future available observations of a variable. Thus, for the error term, the forward orthogonal deviations transformation is given by:

$$\varepsilon^*_{it} = \sqrt{\frac{T-t}{T-t+1}}[\varepsilon_{it} - \frac{1}{T-t}(\varepsilon_{i(t+1)} + ... + \varepsilon_{iT})]. \tag{3}$$

Therefore, the forward orthogonal deviation transformation maintains the uncorrelatedness of the error terms, i.e. $Var(\varepsilon_i) = \sigma^2 I_T \;\Rightarrow\; Var(\varepsilon^*_i) = \sigma^2 I_{T-1}$, see Arellano and Bover (1995).

As a consequence, the forward orthogonal deviations transformation ensures that the estimation procedures derived by Caner and Hansen (2004) for a cross-sectional model can be applied to the dynamic panel equation (2). In a first step, a reduced form regression is estimated for the endogeneous variables, z_{2it}, as a function of the instruments x_{it}. In step two, equation (2) is estimated via least squares for a fixed threshold γ where the z_{2it}'s are replaced by their predicted values from the first step regression. In step three, the estimator of the threshold value γ is selected as the one associated with the smallest sum of squared residuals. Once $\hat{\gamma}$ is determined, the slope coefficients can be estimated by the generalized method of moments (GMM). Following Hansen (1999) and Caner and Hansen (2004), the confidence interval for the threshold estimate is given by $\Gamma = \{\gamma : LR(\gamma) \leq C(\alpha)\}$, where $C(\alpha)$ is the 95% percentile of the asymptotic distribution of the likelihood ratio statistic $LR(\gamma)$.[8]

[8] In accordance with Hansen (1999), the likelihood ratio is adjusted to account for the number of time periods used for each cross section.

SFB 649 Discussion Paper Series 2009

For a complete list of Discussion Papers published by the SFB 649, please visit http://sfb649.wiwi.hu-berlin.de.

001 "Implied Market Price of Weather Risk" by Wolfgang Härdle and Brenda López Cabrera, January 2009.
002 "On the Systemic Nature of Weather Risk" by Guenther Filler, Martin Odening, Ostap Okhrin and Wei Xu, January 2009.
003 "Localized Realized Volatility Modelling" by Ying Chen, Wolfgang Karl Härdle and Uta Pigorsch, January 2009.
004 "New recipes for estimating default intensities" by Alexander Baranovski, Carsten von Lieres and André Wilch, January 2009.
005 "Panel Cointegration Testing in the Presence of a Time Trend" by Bernd Droge and Deniz Dilan Karaman Örsal, January 2009.
006 "Regulatory Risk under Optimal Incentive Regulation" by Roland Strausz, January 2009.
007 "Combination of multivariate volatility forecasts" by Alessandra Amendola and Giuseppe Storti, January 2009.
008 "Mortality modeling: Lee-Carter and the macroeconomy" by Katja Hanewald, January 2009.
009 "Stochastic Population Forecast for Germany and its Consequence for the German Pension System" by Wolfgang Härdle and Alena Mysickova, February 2009.
010 "A Microeconomic Explanation of the EPK Paradox" by Wolfgang Härdle, Volker Krätschmer and Rouslan Moro, February 2009.
011 "Defending Against Speculative Attacks" by Tijmen Daniëls, Henk Jager and Franc Klaassen, February 2009.
012 "On the Existence of the Moments of the Asymptotic Trace Statistic" by Deniz Dilan Karaman Örsal and Bernd Droge, February 2009.
013 "CDO Pricing with Copulae" by Barbara Choros, Wolfgang Härdle and Ostap Okhrin, March 2009.
014 "Properties of Hierarchical Archimedean Copulas" by Ostap Okhrin, Yarema Okhrin and Wolfgang Schmid, March 2009.
015 "Stochastic Mortality, Macroeconomic Risks, and Life Insurer Solvency" by Katja Hanewald, Thomas Post and Helmut Gründl, March 2009.
016 "Men, Women, and the Ballot Woman Suffrage in the United States" by Sebastian Braun and Michael Kvasnicka, March 2009.
017 "The Importance of Two-Sided Heterogeneity for the Cyclicality of Labour Market Dynamics" by Ronald Bachmann and Peggy David, March 2009.
018 "Transparency through Financial Claims with Fingerprints – A Free Market Mechanism for Preventing Mortgage Securitization Induced Financial Crises" by Helmut Gründl and Thomas Post, March 2009.
019 "A Joint Analysis of the KOSPI 200 Option and ODAX Option Markets Dynamics" by Ji Cao, Wolfgang Härdle and Julius Mungo, March 2009.
020 "Putting Up a Good Fight: The Galí-Monacelli Model versus 'The Six Major Puzzles in International Macroeconomics'", by Stefan Ried, April 2009.
021 "Spectral estimation of the fractional order of a Lévy process" by Denis Belomestny, April 2009.
022 "Individual Welfare Gains from Deferred Life-Annuities under Stochastic Lee-Carter Mortality" by Thomas Post, April 2009.

SFB 649, Spandauer Straße 1, D-10178 Berlin
http://sfb649.wiwi.hu-berlin.de

This research was supported by the Deutsche Forschungsgemeinschaft through the SFB 649 "Economic Risk".

SFB 649 Discussion Paper Series 2009

For a complete list of Discussion Papers published by the SFB 649, please visit http://sfb649.wiwi.hu-berlin.de.

023 "Pricing Bermudan options using regression: optimal rates of convergence for lower estimates" by Denis Belomestny, April 2009.

024 "Incorporating the Dynamics of Leverage into Default Prediction" by Gunter Löffler and Alina Maurer, April 2009.

025 "Measuring the effects of geographical distance on stock market correlation" by Stefanie Eckel, Gunter Löffler, Alina Maurer and Volker Schmidt, April 2009.

026 "Regression methods for stochastic control problems and their convergence analysis" by Denis Belomestny, Anastasia Kolodko and John Schoenmakers, May 2009.

027 "Unionisation Structures, Productivity, and Firm Performance" by Sebastian Braun, May 2009.

028 "Optimal Smoothing for a Computationally and Statistically Efficient Single Index Estimator" by Yingcun Xia, Wolfgang Härdle and Oliver Linton, May 2009.

029 "Controllability and Persistence of Money Market Rates along the Yield Curve: Evidence from the Euro Area" by Ulrike Busch and Dieter Nautz, May 2009.

030 "Non-constant Hazard Function and Inflation Dynamics" by Fang Yao, May 2009.

031 "De copulis non est disputandum - Copulae: An Overview" by Wolfgang Härdle and Ostap Okhrin, May 2009.

032 "Weather-based estimation of wildfire risk" by Joanne Ho and Martin Odening, June 2009.

033 "TFP Growth in Old and New Europe" by Michael C. Burda and Battista Severgnini, June 2009.

034 "How does entry regulation influence entry into self-employment and occupational mobility?" by Susanne Prantl and Alexandra Spitz-Oener, June 2009.

035 "Trade-Off Between Consumption Growth and Inequality: Theory and Evidence for Germany" by Runli Xie, June 2009.

036 "Inflation and Growth: New Evidence From a Dynamic Panel Threshold Analysis" by Stephanie Kremer, Alexander Bick and Dieter Nautz, July 2009.

SFB 649, Spandauer Straße 1, D-10178 Berlin
http://sfb649.wiwi.hu-berlin.de

This research was supported by the Deutsche Forschungsgemeinschaft through the SFB 649 "Economic Risk".