What Explains Recent Changes in International Monetary Policy Attitudes toward Inflation? Evidence from Developed Countries

MELODY LO
Department of Economics, College of Business, University of Texas at San Antonio, USA

JIM GRANATO
Center for Public Policy and Department of Political Science, University of Houston, USA

SUNNY M. C. Wong
Department of Economics, University of San Francisco, USA

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Abstract

Since Alogoskoufis and Smith (*AER*, 1991), several studies have stated that there are seemingly universal shifts in monetary policy attitudes toward inflation. However, no coherent empirical evidence is yet provided either to confirm whether there were universal monetary policy regime shifts or to explain what fundamentals may drive such shifts. Using long time series data from a group of 18 developed countries, this paper provides evidence revealing a recent stylized international shift in monetary policy making. Our findings, based on both cross-country and individual country analyses, show that policymakers in developed countries have dealt with inflation shocks much more aggressively as the 1990s ensued. Further, this increase in aggressiveness is attributed to an increased policy response to economic openness. The identified positive openness-aggressiveness relation has no historical precedent in the data.

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"[A]logoskoufis and Smith (1991) argue that sharp increases in inflation persistence can be attributed to changes in the exchange rate regime...... At the very least, our analysis suggests that economists should not automatically assume that changes in the exchange rate regimes are as important as Alogoskoufis and Smith (1991) imply."

Richard Burdekin and Pierre Siklos (*JMCB*, 1999, p. 235 and p. 246)

Does the exchange rate regime affect how the monetary authorities react to inflation shocks and the persistence of these shocks? Theoretically, one can show an affirmative answer. However, recent developments in the literature document shifts in inflation persistence, which signals shifts in monetary authorities' attitudes toward inflation, are unrelated to shifts in the exchange rate regime. This paper examines factor(s), unrelated to the exchange rate regime, that leads to changes in policy attitudes/aggressiveness toward inflation (shocks).

Among several inflation estimates used to measure inflation performance, researchers often estimate inflation persistence to reveal monetary policy intentions regarding how aggressive a policymaker has been to counteract inflation shocks.[1] Using samples from developed countries, several empirical studies have mentioned increasing inflation persistence after the breakdown of the Bretton Wood system (See Obstfeld 1995 as a representative study). They find that the estimate of inflation persistence is at a much higher level in the post-Bretton Wood period. These studies conjecture that the shifts in the international monetary standard lead to shifts in the degree of inflation persistence and, consequently, to changes in monetary policy aggressiveness. Specifically, the monetary policy regime shift has been toward tolerating more inflation persistence after entering the floating exchange rate regime.

[1] Other than inflation persistence, the most frequently used inflation estimate is the inflation level (See Romer (1993) as an example). Temple (2002), however, notes that the inflation level lacks power in revealing the policy intentions of monetary authorities.

Relevant theoretical work, such as Alogoskoufis and Smith (1991), Alogoskoufis (1992), and Bleaney (2001), suggest that the increasing trend in inflation persistence is plausible.[2] The higher inflation persistence results when policymakers are forced to adopt a more accommodative monetary policy under the floating exchange rate regime than under the fixed regime. More importantly, the findings from Alogoskoufis and Smith (1991) and Alogoskoufis (1992) are viewed as supportive evidence of the Lucas critique (Lucas 1976) since they argue that shifts in the expectations-augmented Phillips curve can be linked with shifts in inflation persistence.

However, the general acceptance of Alogoskoufis and Smith (1991), and Alogoskoufis (1992) findings has been less than overwhelming in recent years. Researchers argue that the major problem in related empirical studies centers on the difficulty in isolating the exchange rate regime shift effect, if any, on monetary policy intentions. In particular, Burdekin and Siklos (1999) caution that dividing the investigated sample at arbitrarily pre-specifying dates, at which the floating exchange rate regime was initiated, cannot appropriately identify the effect of exchange rate regime shifts.[3]

To assess whether shifts in international monetary arrangements are responsible for the changes in inflation persistence, Burdekin and Siklos (1999) use an econometric technique which allows them to identify and date unknown multiple structural breaks in an inflation persistence regression.[4] Analyzing long-run data for Canada, Sweden, the United Kingdom (U.K.), and the United States (U.S.), Burdekin and Siklos examine in a sequential manner the timing of structural

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[2] See also Dornbusch (1982) who derives a theoretical pattern showing that the more the exchange rate accommodated inflation shocks, the more persistent the shocks.

[3] Previous empirical studies on inflation persistence always use the dates at which the international monetary system changes as the cutoff points for the full sample period data that is under investigation. They then compare the size of inflation persistence estimates under various subsamples to draw inferences regarding whether shifts in monetary policy were attributed to changes in the exchange rate regime.

[4] Results from Burdekin and Siklos (1999) are based on a modification of the Perron and Vogelsang (1992) procedure. See Bai and Perron (1998) for the details of this modified procedure. The uniqueness of the procedure is it allows for multiple structural breaks to be either jointly or sequentially estimated. In addition, the timing of the breaks is treated as an unknown and estimated by the data.

breaks in inflation persistence. Their results show that in all 4 countries studied, the date of the imposition of a floating exchange rate regime does not lead to a shift in inflation persistence. Examining a group of 15 OECD countries, Bleaney (2001) also confirms that inflation persistence has changed over time for 'unknown' reasons but they are unconnected to exchange rate regime shift.

This paper argues that economic openness is a compelling candidate to account for observed changes in monetary policy responses to inflation shocks. The foundation of our argument follows a prominent line of literature (starting with Romer (1993)) that has used economic openness to explain cross-country differences in monetary policy implementation.[5] The literature tests and documents a unique economic openness-inflation pattern across countries: The more open an economy is, the better its inflation performance will be. This pattern is interpreted as the result of monetary authorities in more open economies responding more extensively to inflationary pressures because they potentially face greater costs of high and variable inflation (Temple 2002). By the same reasoning, we argue that within a country policymakers can also be expected to react to inflationary pressures more strongly as its economy becomes more open. We obtain our empirical results by performing both cross-country and individual-country analyses on a group of 18 developed countries' data.

We organize the paper as follows. Section 1 introduces an alternative inflation persistence estimate — the die-out-rate of inflation shocks (see Granato, et al. (2006)) to capture monetary policy aggressiveness toward inflation shocks. The purpose of using this alternative estimate (instead of a conventional one) is to relax an overly restrictive constraint in a typical inflation persistence re-

[5] The representative studies in this line of research include Lane (1997), Clarida, et al. (2001, 2002), and Granato, et al. (2006). The difference among these studies centers on the estimate used to capture the degree of monetary policy reaction to inflation. Both Romer (1993) and Lane (1997) use the inflation level. Clarida, et al. (2001, 2002) use an inflation parameter in the Taylor-type interest rate policy rule (Taylor 1993). Granato, et al. (2006) use inflation volatility and persistence.

gression. That constraint assumes different countries (or even the same country under various time periods) face inflation shocks coming from similar disturbances. Section 2 presents the preliminary results, at a cross-country level, on the relation between economic openness and the die-out-rate of inflation shocks. The preliminary finding indicates that there is an emerging negative relation between the die-out-rate and economic openness across countries in the 1990s. With this finding, section 3 examines if this emerging cross-country pattern in the 1990s is connected to historical changes in monetary policy making within each individual country in our sample. Using the Bai and Perron (1998, 2003) methodology to formally identify and date the unknown structural breaks, we provide an extensive empirical investigation assessing each individual country's historical time series (on both economic openness and the die-out-rate). Two findings emerge. First, dramatic changes in the die-out-rate over time in all sample countries signal there was indeed a monetary policy attitude change regarding inflation between 1985-1990. Second, this emerging policy attitude change toward inflation can be attributed to an increasing response to the degree of economic openness in the majority of sample countries as the 1990s ensued. Section 4 concludes the paper.

1. AN ALTERNATIVE INFLATION PERSISTENCE ESTIMATE: DIE-OUT-RATE OF INFLATION SHOCKS

The inflation persistence literature finds that aggressive monetary policy lowers the persistence of inflation (Siklos 1999). The standard methodology used in the literature to estimate the size of inflation persistence is an autocorrelation, AR (1), on annual inflation data:

$$\pi_t = a + b\pi_{t-1} + \epsilon_t, \tag{1}$$

where π_t is the inflation rate at period t, measured by the log difference of the consumer price index (CPI), and ϵ_t is a stochastic term.

The coefficient on lagged inflation, b, estimates the persistence of inflation. Within a country, researchers typically compare the size of the estimated b over different sample periods to infer whether monetary authorities in a country have over time acted more aggressively to inflation shocks. Similarly, researchers compare the size of the estimated b among different countries to judge which country's policymakers have taken the most aggressive anti-inflation roles. While the use of an AR(1) specification is standard when testing for inflation persistence, it poses a potential danger for valid inference. That danger is assuming that either a country always faces shocks coming from a similar disturbance over time or all countries face shocks from a similar disturbance. These overly restrictive assumptions can affect the validity of the inference made through the results of regression (1). Therefore, we adopt an alternative and less restrictive measure of inflation persistence to allow for the variation of the shocks:

$$\triangle\pi_t = c + d\pi_{t-1} + \sum_{j=1}^{h} e_j \triangle\pi_{t-j} + z_t, \tag{2}$$

where Δ denotes the first difference operator. This equation (2) is similar to an augmented Dickey-Fuller regression. The size of coefficient d indicates the average "die-out-rate" of the inflation shock (hereafter DOR) faced by a country over a sample period under investigation. If policymakers act more aggressively in response to inflation shocks, d would be observed to be negative and larger in absolute value. It indicates a higher speed of mean-reversion in inflation and less persistent inflation shocks. Throughout this paper, we use the estimate of the DOR (the size of d) as a proxy for the aggressiveness of monetary policy in counteracting inflation shocks.

We use quarterly CPI data from the International Monetary Fund's (IMF) *International Financial Statistics* (IFS) for 18 developed countries.[6] The percentage change in the CPI is used as

[6] These 18 countries are: Australia, Austria, Belgium, Canada, Finland, France, Germany, Italy, Japan, Netherlands,

the measure of inflation (π_t). All sample countries' raw CPI data used in the analysis starts from 1957:1 and ends at 2004:2.

2. PRELIMINARY EVIDENCE FROM CROSS-COUNTRY ANALYSIS

As discussed earlier, our work is partly motivated by a rationale from the economic openness-inflation literature. This literature examines how economic openness influences international differences in the responsiveness of monetary policy (to inflation) because economic openness raises the potential cost of high inflation. Following this rationale, we argue a policymaker within his own country would presumably also adjust the aggressiveness of monetary policy according to changes in the degree of economic openness. Consequently, evidence on the cross-country pattern of more aggressive monetary policies in more open economies (as the literature has suggested) provides a basic foundation to conjecture about our subsequent analysis at the individual country level.

To assess the relationship between economic openness and monetary policy aggressiveness across countries, we use the following regression:

$$DOR_i = f_i + g_i Open_i^A + \mu_i, \tag{3}$$

where DOR_i is country *i*'s inflation shock die-out-rate, estimated by equation (2); $Open_i^A$ (as used in Frankel and Rose (1996) and Romer (1993)) is country *i*'s economic openness measured as the ratio of imports of goods and services to Gross Domestic Product (GDP); and μ_i is a stochastic term.[7]

We report the associated regression results for the whole sample period (1957:1-2004:2)

New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the U.K., and the U.S.

[7] Since we use quarterly data in the analysis, seasonality of price changes is expected. To properly account for the seasonal effect, we include seasonal dummies in equation (2) when estimating the DOR for each country.

in regression (1) of Table 1. The openness coefficient is negative (-0.009) and significant ($t = -3.804$) at the 1% level. This result indicates that inflation shocks are less persistent and die out faster in more open economies. Examining this results further, we see in relation to the sample average of DOR of -0.22, a 1 standard deviation increase in economic openness (equivalent to 14 percentage points) decreases DOR (on average) by 0.58.[8]

Does this result hold for different time periods? Within the span of our sample period, two widely mentioned international monetary regime shifts are 1973 and 1990. The year 1973 is associated with the breakdown of the Bretton Woods system, and the year 1990 is suggested by the inflation targeting literature.[9] To provide a preliminary indication regarding whether these suggested breaks alter the behavior of monetary responses to inflation (in relation to openness), we rerun regression (3) using these two pre-specified cutoff points.

We report the regression results for the subsample periods of "whole floating" (1973:1-2004:2), "earlier floating" (1973:1-1989:4), and "post 1990s" (1990:1-2004:2) in regressions (2), (3), and (4) of Table 1, respectively. The results show that the coefficient on openness for the post 1990s period is negative and significant but it is not significant for either the whole floating or earlier floating periods. These results indicate that it is primary after the 1990s when inflation shocks die out faster in more economically open countries. To ensure the robustness of these results, we redo the analysis by adding various independent variables for rival arguments to equation (3), and later by excluding outliers from sample countries.[10] The associated regression results reported as

[8] This result comes from the following calculation: $(14.18 \times -0.009)/-0.22 = 0.58$, where the standard deviation of openness is 14.18 and the mean of DOR is -0.22.

[9] The inflation targeting literature suggests that there is a universal regime shift in the practice of monetary policy since the 1990s. The shift involves monetary authorities placing greater weight on reducing inflation instability (See Bernanke, et. al. (1999) as a representative study).

[10] The literature has mentioned 4 factors, other than economic openness, which could affect monetary authorities' intentions/attitudes in fighting inflation. First, it is noted that a more severe supply shock tends to generate a larger trade-off between inflation and output volatilities. This larger trade-off in turn could induce policymakers to be less aggressive in fighting inflation. We compute the variance of real output growth for each country to account for the size of the supply shock. Second, we use the real GDP per capita to account for the potential influence of the status

regressions (5)-(12) in Table l show that our findings are robust.

With this cross-country evidence suggesting that more aggressive monetary policies are being adopted in more open economies emerged in the 1990s, we raise the paper's main concern: if this emerging cross-country DOR-openness pattern in the 1990s is the result that the majority of individual countries in our sample did have their monetary policies react most extensively to economic openness as the 1990s approached. We set out the analysis in the rest of this paper to answer this key question.

3. ECONOMIC OPENNESS AND DOR: EVIDENCE FROM INDIVIDUAL COUNTRY'S TIME SERIES DATA

To assess the long-term relation between economic openness and the DOR in each individual country, we will use a rolling regression technique to generate the DOR and economic openness time series for a country. The DOR time series for an individual country is obtained by running regression (2) where we set the rolling regression window at 10 years (equivalent to 41quarters) and move the window forward at a 1-quarter interval until we reach the last estimation window of 1994:2-2004:2. For the economic openness time series, we generate the estimates based on an economic theory that is widely used in a number of macroeconomics studies (see Romer (1993)).

3.1 Openness Data/Estimates from an Economic Theory

Macroeconomists assume that in an open economy, where international trade takes place, the general domestic price takes the following form:

of economic development on the link between economic openness and inflation performance (see the argument in Romer (1993)). Third, we include the inflation level in our robustness regressions as it is primary a control variable in the majority of monetary policy regressions in the literature. Finally, some researchers note that there may be a potential impact from country size on the openness-inflation relation. We use total real GDP (as in Lane (1997)) and land size (as in Romer (1993)) to account for this effect.

$$p_t^G = wp_t^f + (1-w)p_t^d, \;\; w \in [0,1), \tag{4}$$

where p_t^G is the log of the general domestic price level, p_t^f is the log of the domestic price level of foreign goods, p_t^d is the log of the domestic price level of domestic goods, and w represents the share of domestic consumption of foreign goods and services. The coefficient of w is commonly referred to as "economic openness" and it is aimed to capture the degree of the influence from external factors (p_t^f in this case) on the general domestic price level. For ease in imposition, a large body of literature assigns values to w (openness) by simply calculating the ratio of imports of goods and services to GDP.

To comply with economic theory, we will generate w (openness) using the relation expressed in equation (4). Since the data for p_t^d is unavailable for half of the countries in our sample, following the literature, we write equation (4) into a more extensive form. First, assume that the Law of One Price holds so that the domestic price of foreign goods is the same as the relative price in the foreign market:

$$p_t^f = e_t + p_t^*, \tag{5}$$

where e_t is the log of nominal exchange rate, defined in units of domestic currency per unit of foreign currency, and p_t^* is the foreign price of foreign goods.

Second, Macroeconomists believe that the price level in the domestic market is governed by the quantity theory:

$$m_t + v_t = p_t^d + y_t, \tag{6}$$

where m_t is the log of domestic money supply, v_t is the log of velocity of money, and y_t is the log of real domestic output. Further, both Blanchard and Kiyotaki (1987) and Romer (1996) note that it is appropriate to consider the velocity of money (v_t) as the aggregate disturbance in countries where there are no hyperinflations. Thus, a reduced form of the quantity theory can be expressed as:

$$p_t^d = m_t - y_t. \tag{7}$$

Now, substituting both equations (5) and (7) into (4) yields:

$$p_t^G = w(e_t + p_t^*) + (1 - w)(m_t - y_t). \tag{8}$$

Conceptually, the coefficient of w in equation (8) measures the effect of external factors - e_t and p_t^*, in comparison to that of internal factors - m_t and y_t, to affect the general domestic price level. Alternatively, the size of w can also indicate how vulnerable the general domestic price level is to external factors. In fact, researchers find this attribute intuitively appealing for their argument regarding how a country's monetary policy aggressiveness depends on how vulnerable the country's price level is to external factors. We note that estimating the coefficient of w from equation (8) and regarding it as openness data complies with our paper's pursuit: examining whether historical changes in monetary policy (aggressiveness) are the result of changes in the policymakers' reactions to economic openness.

It is important to notice that most recently Lo and Wong (2006) validate the theoretical predictions of equation (8) in a large sample of 63 countries. The robustness of their empirical findings lend support for generating openness data using equation (8). In what follows, we assess the relation among p_t^G, $(e_t + p_t^*)$, and $(m_t - y_t)$ to generate an economic openness time series for each country in our sample:

$$p_t^G = \gamma + \alpha(e_t + p_t^*) + \beta(m_t - y_t) \tag{9}$$

As before, we use quarterly data from the IMF's IFS. For each country, we use the CPI for p_t^G; money plus quasi-money for m_t; GDP at a constant price for y_t. We treat the largest trading partner as the base foreign country for the domestic economy, and consequently we use the price of the base foreign country's currency and the base foreign country's CPI for e_t and p_t^*, respectively.[11] The data are available at different lengths among sample countries. We use the maximum length of data available for each country in the analysis. The longest data period we have for a country is 1957:1-2004:2, while the shortest data period is 1987:4-2004:2. Table 2 lists the data length available for each country.[12]

We use Hansen's (1992) FMOLS (test statistics of Lc) to estimate the cointegrating relation of equation (9).[13] To be consistent with the length of the DOR series, when generating the openness series of α, we also set the estimation window at 41 quarters and we move it forward for 1-quarter each iteration. Hansen (1992) cautions that rejection of the null hypothesis only provides evidence that a "standard" cointegration model does not hold ("standard" in the sense that a structural break is not included in cointegrating regressions). In a few cases where the Lc test statistics reject the null hypothesis, we perform Gregory and Hansen's (1996) residual-based test (G&H test) to identify where the level regime shift (model 2 of the G&H test) occurs. We then estimate the cointegration coefficients of α and β by modifying equation (9) to include a level shift dummy, as identified by the G&H tests.

3.2 Initial Results with Pre-specifying Cutoff Points

To examine the potential historical changes in monetary policy aggressiveness to economic openness in individual countries, we initially regress each country's DOR series on its own eco-

11 The foreign country with the largest share of trade (imports plus exports) within a domestic country is regarded as the largest trading partner (for the domestic country). The data source is CIA-The World Factbook. Detailed data are available on request.

12 For countries participating in the European Monetary Union (EMU), their sample period ends earlier than that of other countries in our sample. This situation is because their exchange rate data ends at 1998:4.

13 A precondition for the existence of a cointegrating relation in equation (9) is that all three variables of p_t^G, $e_t + p_t^*$, and $m_t - y$ are nonstationary (i.e. $I(1)$). Using the unit root test of DF-GLS proposed by Elliott et. al. (1996), we find the data for the full sample period from all 18 sample countries meets this precondition. Unit root results are not reported here but are available on request.

nomic openness series across different sample periods via pre-specified cutoff points:

$$DOR_{i,t} = h_{i,t} + k_{i,t} OPEN^B_{i,t} + \upsilon_{i,t}, \tag{10}$$

where $DOR_{i,t}$ is country *i*'s die-out-rate time series at period *t* (generated via equation (2)); $OPEN^B_{i,t}$ is country *i*'s openness time series at period *t* (generated via equation (9)); and $\upsilon_{i,t}$ is a stochastic term. Besides two earlier used cutoff points of 1973:1 and 1990:1, we now include 1985:4 to further divide the sample period. This added cutoff point is a data management consideration: EMU countries in our sample do not have their post 1990s period available for the analysis. Since EMU countries' exchange rate data ends at 1998:4, it is not feasible to generate their 1st openness data point for the post 1990s period (requiring raw data of 1990:1-2000:1). This situation constrains our ability to check whether monetary policies react more extensively to economic openness as the 1990s approached. We therefore use the Plaza Agreement (reached in September 1985) as an additional cutoff point. The Plaza Agreement was made by the G-5 countries in an effort to depress the value of $US by means of coordinated interventions in the foreign exchange markets. This exchange rate agreement could potentially change monetary policy behavior as it forces policymakers among countries to be more accommodative to each other's policy initiatives.

Table 2 summarizes estimation results for equation (10) across the full sample period, and 4 subsample periods of Pre-1973, Post-1973, the Post-1985:4 (the Post Plaza Agreement), and the Post-1990s. For the full sample period's results, we find no evidence of a negative DOR-openness relation except for two countries (Finland and New Zealand). We next compare results from different subsample periods. Since we lack raw data for most countries in the Pre-1973 period, we focus attention on results from the Post-1973 period. The results for the Post-1973 period are similar to those for the full sample period: very little empirical support for the negative

DOR-openness relation. Alternatively, for either the full sample period or the Post-1973 period, we do not find a pattern that more aggressive monetary responses were used as an economy becomes more open. Yet, such patterns start to emerge when the time period approaches the 1990s. Under the Post-1985:4 (the Post Plaza Agreement) period, results from 9 countries (out of 18) give a significant negative DOR-openness relation. These countries include Belgium, Canada, Finland, France, Germany, New Zealand, Norway, Portugal, and Sweden. This negative relation emerges for 2 additional countries, Australia and the U.S., when moving into the Post-1990s period.

Overall, these initial results with pre-specified cutoff points indicate that about 61% ($= 11/18$) of the sample countries seem to have shifted, around 1985-1990, in their monetary policy making. That is, policymakers in more recent years seem to conduct monetary policy in reaction to changes in the degree of economic openness. To validate this emerging shift in monetary policy making, we next apply Bai and Perron's (1998, 2003, henceforth BP) methodology, designed to formally test and date multiple structural breaks.

3.3 Results with Structural Break Points Being Identified by BP Methodology

Using procedures developed by BP, our investigation will be at two levels.[14] First, we examine whether individual countries experience breaks (particularly in the neighborhood of Post-1985 or Post-1990s period) in monetary policy making. If there are indeed monetary policy shifts dated in recent years, we then proceed with our second examination – whether these breaks are associated with changes in policy responses to economic openness.

We perform our first test by using BP's procedures to sequentially search for structural breaks (if any) in equation (2) for all 18 countries.[15] We consider the possibility that equation

[14] The BP procedures, which we use to generate this paper's results, are available at Pierre Perron's website: http://people.bu.edu/perron/code.html.

[15] Since BP procedures allow autocorrelation and heteroskedasticity in the regression model residuals, we do not include any lags of the dependent variables as the explanatory variables in equation (2) to remove potential serial

(2) is a "pure" structural change model ("pure" in the sense that both the constant term (c) and the DOR parameter (d) are allowed to change). BP (2003) caution that there are instances where the sequential procedure can be improved. They refer to instances where there exists multiple structural breaks. In such cases, it is difficult for the sequential test statistics (sup$F_T(l+1|l)$) to reject the null hypothesis of no break versus one break but not difficult to reject the null of no breaks versus a higher number of breaks. To deal with this problem, BP's recommendation is to examine double maximum test statistics ($WD\ max$ or $UD\ max$) and determine if at least one break exists. If the answer is affirmative, then we proceed with a sequential examination (but ignore sup$F_T(1|0)$) to determine the maximum number of breaks in the regression model. We follow this recommendation in all relevant test applications.

Panel A of Table 3 reports BP test statistics (of $WD\ max$, and sup$F_T(l+1|l)$) and dates for the structural breaks on the regression model of (2) for each of the 18 counties. The uniform rejection by the test statistics of $WD\ max$ for all 18 countries indicates that there is at least one regime shift in each country for the regression of (2). The estimation results for break points (reported in the last column of Panel A in Table 3) show that many countries did have a monetary policy regime shift in the neighborhood of the 1985 to 1990s period. There are only 3 exceptions: Germany, Italy and the U.K. appear to have their most recent monetary policy (toward inflation) change prior to 1985 (1982:4 for both Germany and Italy, and 1981:2 for the U.K.). Using these identified break points as cutoff points for the whole sample period, we redo the estimation on regression (2) for each country under different sample periods. Panel B of Table 3 reports associated regression results. Our focus is on the changes in the size of coefficient "d" (i.e., DOR).

One important trend we observe is that 13 (out of 18) countries have their inflation shocks die out faster in the last regime sample period rather than the previous one. Using the case of the

correlation in the residuals.

U.S. for illustration, the DOR from the last regime period of 1990:4-2004:2 is -0.723. This is larger in absolute terms than -0.472, the DOR from the previous regime period of 1981:3-1990:3. Countries with this pattern include Australia, Belgium, Canada, France, Germany, Japan, Netherlands, New Zealand, Norway, Portugal, Sweden, Switzerland, and the U.S. Further, among these 13 countries, 8 countries' DOR from the last regime period is the largest (in absolute value) in comparison to that from any other regime period.[16] We interpret these results as evidence that there are historical regime shifts in monetary policy making among all sample countries. In addition, it is evident that the monetary regime shift in recent years is more of a universal similarity: policymakers in many developed countries have dealt with inflation shocks much more aggressively.

With this evidence, we proceed to use BP procedures to perform our second examination – the main concern of this paper: Can the observed historical changes in the size of the DOR in individual countries be linked to shifts in the monetary authorities' reaction to economics openness? For each of the 18 countries, we now sequentially search for structural breaks in equation (10), which aims to capture the DOR-openness relation. While we consider a pure structural change model in this examination, our focus is more toward the changes in the openness parameter (k) in equation (10). Panel A of Table 4 gives results on test statistics used to determine the numbers of structural breaks for each country, and associated dates for the breaks.

The results show that all 18 countries have at least one structural break in the DOR-openness relation. More importantly, the majority of countries did have their most recent break dated in the neighborhood of 1985-1990, except for Canada, Norway, and the U.K. For these three countries, the most recent break is dated prior to 1985 (1981:1, 1980:3 and 1983:3 for Canada, Norway, and the U.K, respectively).

[16] They are Belgium, France, Germany, Netherlands, New Zealand, Portugal, Sweden, and Switzerland.

Using these break points, we cut each country's entire sample period into various regime periods and re-run equation (10). We report associated regression results in Panel B of Table 4. A trend we find is that there are 14 out of 18 country's openness parameter(s) from the "last" regime period now become significantly negative. These countries are Australia, Belgium, Canada, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, and the U.S. The openness parameter in these 14 countries from the prior regime period is either statistically indistinguishable from zero or showing a positive sign. We note that this universal shift is particularly striking in that the emerging negative DOR-openness relation has no precedent (prior to the last regime period) in 12 out of 14 countries.[17] These results provide evidence that monetary authorities in the majority of developed countries did start to adjust their inflation stabilization policies in reaction to their economic openness in recent years. The pattern of such a reaction is that when the economy becomes more (less) open over time, the monetary authorities tend to act more (less) aggressively to counteract the inflation shocks.

4. CONCLUSIONS

In this paper, we provide empirical evidence, in a sample of 18 developed countries, documenting that economic openness is a compelling factor in the international differences in monetary policy aggressiveness to inflation shocks.

To measure the aggressiveness of monetary policy in counteracting inflation shocks, we use the estimate of DOR (die-out-rate of inflation shocks). If policymakers act more aggressively in response to inflation shocks, these shocks would be less persistent and the estimate of DOR would be observed to be negative and larger in absolute value.

[17] They are Australia, Belgium, Canada, Finland, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, and the U.S.

The central argument of this paper is motivated by a rationale from the economic openness-inflation literature. This literature examines how economic openness influences international differences in the responsiveness of monetary policy (to inflation) because economic openness raises the potential cost of high inflation. Specifically, this literature suggests a negative economic openness-inflation relation across countries. Following this rationale, we argue a policymaker within his own country would also adjust the aggressiveness of monetary policy according to changes in the degree of economic openness.

Our empirical results across countries show a negative openness-DOR relation. This negative relation indicates that more an aggressive monetary policy is adopted in more open economies. More importantly, the results show that it is primary after the 1990s when inflation shocks die out faster in more open countries. Using this cross-country evidence as the basis for the paper's central argument, that economic openness can account for monetary policy attitude changes within a country, we examine data at the individual-country level. The initial result with pre-specified cutoff points find no evidence of a negative openness-DOR relation in any sample period prior to the 1990s. Yet, the negative relation starts to emerge when the time period approaches the 1990s. These findings suggest that countries in our sample seem to have shifted around 1985-1990 in their monetary policy making in reaction to changes in their degree of economic openness. Applying BP methodology (to formally test and date structural breaks in the data) validates this emerging shift in monetary policy making in the 1990s. We find that the majority of countries in the sample have their DOR estimates shift in a more negative direction as the 1990s ensued. We interpret this result as evidence that policymakers in many developed countries have dealt with inflation shocks much more aggressively after the 1990s. Further, we find that the majority of countries in the sample also have their openness-DOR relation shift to a significant negative sign when entering the 1990s.

Taken all this evidence together, this paper has documented that changes in the DOR (an alternative estimate of inflation persistence) in recent years is a stylized international phenomena that has a coherent explanation. The recent universal decrease in the persistence of inflation shocks is a reflection of monetary authorities in many (developed) countries adjusting the aggressiveness of monetary policy responses according to changes in the degree of openness within their economies. This universal change in monetary policy making at the individual country level serves as a basis for the documented cross-country pattern that more aggressive monetary policies were adopted in more open economies (primarily) in the 1990s.

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TABLE 1

CROSS-COUNTRY EVIDENCE ON ECONOMIC OPENNESS AND DIE-OUT-RATE (DOR)

Time period	Whole sample: 1957:1-2004:2	Whole Floating: 1973:1-2004:2	Earlier Floating: 1973-1989:4	Post 1990s: 1990:1-2004:2
Regression	(1)	(2)		(4)
Constant	0.056	-0.071	-0.152	-0.129
	(0.708)	(-1.326)	(-1.407)	(-0.886)
Openness	-0.009***	-0.002	-0.001	-0.010**
	(-3.804)	(-1.029)	(-0.413)	(-2.246)
R^2	0.475	0.062	0.011	0.240
Numbers of Obs.	18	18	18	18

Robustness check:	Additional regressors added to (1)	Outliers excluded from (5)	Additional regressors added to (2)	Outliers excluded from (7)	Additional regressors added to (3)	Outliers excluded from (9)	Additional regressors added to (4)	Outliers excluded from (11)
Regression	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Constant	-0.923	-0.875**	-0.064	--	1.497**	1.393**	-0.238	0.276
	(-1.427)	(-2.403)	(-0.166)		(2.863)	(2.638)	(-0.341)	(0.331)
Openness	-0.007*	-0.011***	-0.001	--	-0.003	-0.003	-0.014**	-0.011*
	(-2.078)	(-5.295)	(-0.597)		(-0.844)	(-0.806)	(-2.660)	(-1.997)
Real GDP volatility	4.71E-04	0.002	0.001	--	0.001	0.001	0.006	0.010
	(0.243)	(1.421)	(0.726)		(0.352)	(0.465)	(1.133)	(1.742)
Real GDP per capita	5.0E-05	5.16E-05**	-7.15E-06	--	-1.17E-04**	-1.11E-04**	-3.69E-07	-3.41E-05
	(1.235)	(2.272)	(-0.336)		(-3.050)	(-2.895)	(-0.012)	(-0.959)
Inflation	0.771*	0.802***	0.105	--	-0.556***	-0.516**	0.901	0.733
	(1.980)	(3.662)	(0.608)		(-3.351)	(-3.064)	(1.189)	(0.832)
Total Real GDP	-2.07E-08	-3.08E-08	5.45E-09	--	3.59E-08	5.77E-08	-1.07E-08	4.68E-08
	(-0.623)	(-1.643)	(0.260)		(0.921)	(1.322)	(-0.249)	(0.525)
Land Size	1.90E-09	3.32E-09	5.22E-09	--	3.62E-08	-4.20E-09	-5.77E-08	-6.63E-09
	(0.059)	(0.184)	(0.195)		(0.878)	(-0.076)	(-0.992)	(-0.099)
R^2	0.666	0.903	0.242	--	0.568	0.377	0.274	0.637
Number of Obs.	18	17	18	--	18	17	18	16

Notes: *t*-statistics is in parentheses. ***, **, and * denote 1%, 5% and 10% significance levels in two-tailed tests, respectively. We use Welsch Distance test (Welsch, 1982) to identify outliers and excluded them from associated regressions. For Regression (5), Netherlands is an outlier. For Regression (9), Canada is an outlier. For regression (11), Switzerland, and the United States are outliers.

TABLE 2

OPENNESS AND DIE-OUT-RATE (DOR) FOR INDIVIDUAL COUNTRY ACROSS DIFFERENT PERIODS OF TIME

		Full sample		Pre-1973		Post-1973		Post 1985:4 (Post Plaza Agreement)		Post-1990s	
Country	Data Length	Const.	Openness	Const.	Openness	Const.	Openness	Const.	Openness	Const.	Openness
Australia	1960:2-1992:1	-0.026	0.013	-0.177	-0.009	-0.024	0.001	-0.014	0.326	-0.885***	-2.131**
		(-1.620)	(0.712)	(-0.649)	(-0.028)	(-1.308)	(0.067)	(-0.401)	(0.178)	(-13.579)	(-2.766)
Austria	1970:2-1997:4	-0.032	0.017			-0.030	0.010	-4.465***	3.045***		
		(-0.370)	(0.249)	--	--	-0.309	0.140	(-4.627)	(3.509)	--	--
Belgium	1980:4-1998:4	-0.035	0.008			-0.035	0.008	1.588*	-2.832***		
		(-0.625)	(0.188)	--	--	(-0.625)	(0.188)	(2.293)	(-3.479)	--	--
Canada	1957:4-2004:2	-0.026	0.020	-0.191	0.085	-0.004	-0.010	-0.055	-0.618**	-0.111***	-0.238***
		(-1.963)	(1.101)	(-1.346)	(0.969)	(-0.197)	(-0.359)	(-0.595)	(-2.140)	(-2.938)	(-3.157)
Finland	1970:3-1998:4	-0.030*	-0.056**			-0.045**	-0.043	-0.136**	-0.289**		
		(-1.912)	(-2.199)	--	--	(-2.296)	(-1.436)	(-2.754)	(-2.305)	--	--
France	1978:2-1998:4	-0.089	0.076			-0.089	0.076	0.424**	-1.058***		
		(-1.264)	(0.890)	--	--	(-1.264)	(0.890)	(3.140)	(-6.369)	--	--
Germany	1969:3-1998:4	-0.008	-0.005			-0.011	-0.001	-0.766***	-0.090**		
		(-0.687)	(-0.341)	--	--	(-0.890)	(-0.088)	(-31.507)	(-2.867)	--	--
Italy	1975:2-1998:4	-0.071*	0.051*			-0.071*	0.051*	0.044	-0.884		
		(-1.854)	(1.718)	--	--	(-1.854)	(1.718)	(0.178)	(-1.443)	--	--
Japan	1957:4-2004:2	-0.013	-0.010	-0.231*	0.008	-0.017	-0.087	-0.102	0.001	-0.167**	-0.309
		(-1.040)	(-0.685)	(-1.918)	(0.173)	(-1.161)	(-1.049)	(-1.599)	(0.003)	(-2.249)	(-1.482)
Netherlands	1977:3-1997:4	-0.082**	0.086**			-0.082**	0.086**	-0.356	-0.290		
		(-2.251)	(2.063)	--	--	(-2.251)	(2.063)	(-1.562)	(-1.647)	--	--
New Zealand	1987:4-2004:2	-0.094	-0.407*			-0.094	-0.407*	-0.094	-0.407*	-0.029	-0.540**
		(-1.492)	(-2.044)	--	--	(-1.492)	(-2.044)	(-1.492)	(-2.044)	(-0.296)	-2.244
Norway	1961:3-1998:4	-0.027*	0.013	-0.607***	-0.231	-0.066***	-0.047**	-0.059	-0.293*		
		(-1.824)	(1.036)	(-6.629)	(-2.072)	(-2.822)	(-2.207)	(0.874)	(-2.167)	--	--
Portugal	1980:2-1998:4	-0.039	-0.066			-0.039	-0.066	-0.233***	-0.228***		
		(-1.167)	(-1.611)	--	--	(-1.167)	(-1.611)	(-14.589)	(-4.403)	--	--
Spain	1970:3-1998:4	-0.047	0.030			-0.083	0.080	-1.177***	1.929		
		(-0.913)	(0.455)	--	--	(-1.356)	(0.987)	(-3.114)	(1.229)	--	--
Sweden	1980:3-1998:4	-0.087	-0.014			-0.087	-0.014	-0.448***	-0.110*		
		(-1.699)	(-1.001)	--	--	(-1.699)	(-1.001)	(-20.119)	(-1.896)	--	--

Switzerland	1970:3-1998:4	-0.004	0.697			-0.023	0.026	-0.162	0.070**		
		(-0.148)	(0.343)	--	--	(-0.856)	(1.450)	(-2.360)	(2.195)	--	--
UK	1957:4-2004:2	-0.031**	0.005	0.032	-0.086	-0.083**	0.021	-0.318***	0.038**		
		(-2.034)	(0.315)	(0.743)	(-1.145)	(-2.193)	(1.365)	(-40.635)	(2.395)	--	--
US	1957:4-2004:2	-0.021	0.014	0.014	-0.119	-0.018	-0.005	-0.173**	-0.013	-0.674***	-0.143***
		(-1.494)	(0.950)	(0.173)	(-1.093)	(-0.986)	(-0.307)	(-2.110)	(0.653)	(-26.613)	(-3.396)

Notes: *t*-statistics is in parentheses. ***, **, and * denote 1%, 5% and 10% significance levels in two-tailed tests, respectively. The column named "data available" gives the length of raw data we used to generate each country's die-out-rate and openness time series via rolling regression technique where a rolling regression window is set at 41 quarters (10 years).

TABLE 3

TESTS ON BREAK POINTS IN THE DIE-OUT-RATE TIME SERIES FOR INDIVIDUAL COUNTRIES AND ASSOCIATED ESTIMATIONS

Panel A: Tests on the existence of break points for the die-out-rate time series (equation (2))

Country	Test on no break versus unknown # of breaks: *WD max* (5%)	Test of *l* versus *l+1* breaks: $SupF_T(l+1\|l)$		Conclusion on # of breaks	Break points
Australia	27.624***	$SupF_T(3\|2)$ = 33.932***	$SupF_T(4\|3)$ = 8.644	3	1972:4, 1977:1, 1990:4
Austria	41.162***	$SupF_T(2\|1)$ = 5.323	--	1	1984:1
Belgium	33.564***	$SupF_T(3\|2)$ = 12.728*	$SupF_T(4\|3)$ = 6.889	3	1984:1, 1988:1, 1994:3
Canada	48.854***	$SupF_T(4\|3)$ = 16.414**	$SupF_T(5\|4)$ = 4.095	4	1964:4, 1972:4, 1982:2, 1991:1
Finland	32.945***	$SupF_T(2\|1)$ = 17.881***	$SupF_T(3\|2)$ = 10.191	2	1973:2, 1976:3
France	26.980***	$SupF_T(4\|3)$ = 15.043**	$SupF_T(5\|4)$ = 4.878	4	1982:2, 1985:2, 1991:4, 1996:2
Germany	18.913***	$SupF_T(2\|1)$ = 4.473	--	1	1982:4
Italy	15.889**	$SupF_T(2\|1)$ = 10.091	--	1	1982:4
Japan	29.580***	$SupF_T(5\|4)$ = 21.095***	$SupF_T(6\|5)$ = 9.984	5	1961:4, 1972:4, 1977:2, 1981:4, 1993:3
Netherlands	28.228***	$SupF_T(2\|1)$ = 12.973**	$SupF_T(3\|2)$ = 10.840	2	1985:2, 1989:1
New Zealand	14.598**	$SupF_T(2\|1)$ = 8.603	--	1	1990:2
Norway	46.999***	$SupF_T(3\|2)$ = 15.048**	$SupF_T(4\|3)$ = 6.317	3	1969:4, 1978:3, 1990:4
Portugal	28.507***	$SupF_T(3\|2)$ = 31.695***	$SupF_T(4\|3)$ = 11.456	3	1982:4, 1985:1, 1992:2
Spain	32.813***	$SupF_T(6\|5)$ = 29.163***	$SupF_T(7\|6)$ = 11.428	6	1973:1, 1975:4, 1978:3, 1982:2, 1986:1, 1995:2
Sweden	26.047***	$SupF_T(2\|1)$ = 4.484	--	1	1991:1
Switzerland	23.605***	$SupF_T(2\|1)$ = 29.283***	$SupF_T(3\|2)$ = 11.769	2	1974:4, 1993:2
UK	17.201**	$SupF_T(3\|2)$ = 14.945**	$SupF_T(4\|3)$ = 11.063	3	1969:4, 1975:2, 1981:2
US	32.829***	$SupF_T(4\|3)$ = 17.691**	$SupF_T(5\|4)$ = 6.462	4	1965:3, 1976:4, 1981:3, 1990:4

Panel B: Estimates of die-out-rate across different subsample periods

Country	Constant	Die-out-rate (*d*)	Country	Constant	Die-out-rate (*d*)
Australia			Austria		
1957:3-1972:3	0.043 (0.624)	-0.019 (-0.247)	1969:3-1983:4	0.162* (1.803)	-0.475*** (-4.123)
1972:4-1976:4	1.664*** (4.845)	-0.973*** (-3.871)	1984:1-1997:4	-0.095 (-0.853)	-0.460* (-1.896)
1977:1-1990:3	0.310** (2.357)	-0.104 (-0.758)			
1990:4-2000:1	0.139 (1.321)	-0.770*** (-4.607)			

Belgium			Canada		
1980:1 1983:4	0.961*** (2.908)	-1.166*** (-3.743)	1957:3 1964:3	0.337*** (3.958)	-1.087*** (-5.398)
1984:1 1987:4	-0.134 (-1.579)	-0.154 (-0.970)	1964:4 1972:3	0.103 (0.961)	-0.804*** (-3.960)
1988:1 1994:2	0.155* (1.755)	-0.779*** (-4.275)	1972:4 1982:1	0.265 (1.609)	-0.430*** (-3.044)
1994:3 1998:4	0.072 (0.720)	-1.322*** (-5.149)	1982:2 1990:4	0.076 (0.766)	-0.434*** (-3.094)
			1991:1 2004:2	0.025 (0.355)	-0.748*** (-5.672)
Finland			France		
1970:1 1973:1	0.204 (0.541)	-0.640 (-1.707)	1977:4 1982:1	0.276 (1.012)	-0.369* (-1.873)
1973:2 1976:2	1.483* (2.025)	-1.065** (-2.825)	1982:2 1985:1	0.364 (1.275)	-0.497 (-1.439)
1976:3 1998:4	-0.132** (-2.108)	-0.088 (-1.561)	1985:2 1991:3	0.161** (2.190)	-0.576** (-3.254)
			1991:4 1996:1	0.217*** (5.906)	-0.807*** (-3.796)
			1996:2 1998:4	0.104 (1.481)	-0.929* (-2.314)
Germany			Italy		
1969:1 1982:3	0.245*** (4.494)	-0.374*** (-3.360)	1974:4 1982:3	1.425*** (5.064)	-0.613*** (-3.743)
1982:4 1998:4	0.100 (1.546)	-0.760*** (-6.078)	1982:4 1998:4	0.293*** (7.005)	-0.163*** (-3.342)
Japan			Netherlands		
1957:3 1961:3	-0.192 (-0.905)	-0.541* (-2.066)	1977:1 1985:1	0.314*** (3.015)	-0.575*** (-3.577)
1961:4 1972:3	0.965*** (6.130)	-1.296*** (-5.614)	1985:2 1988:4	0.200** (2.283)	-0.826*** (-3.289)
1972:4 1977:1	0.916** (2.288)	-0.568** (-2.245)	1989:1 1997:4	0.239*** (4.613)	-0.883*** (-5.208)
1977:2 1981:3	0.288** (2.198)	-0.499** (-2.490)			
1981:4 1993:2	0.340*** (6.387)	-0.812*** (-5.393)			
1993:3 2004:2	0.034 (0.631)	-1.067*** (-6.765)			
New Zealand			Norway		
1987:4 1990:1	0.517 (0.697)	-0.850 (-0.998)	1961:1 1969:3	0.142 (0.990)	-0.863*** (-4.779)
1990:2 2004:2	0.087 (1.420)	-0.472*** (-3.139)	1969:4 1978:2	0.671*** (3.402)	-1.045*** (-5.808)
			1978:3 1990:3	-0.0002 (-0.002)	-0.244* (-1.863)
			1990:4 2004:2	0.372*** (4.932)	-1.016*** (-7.847)
Portugal			Spain		
1979:4 1982:3	1.342 (1.738)	-0.603 (-1.627)	1970:1 1972:4	1.678*** (5.110)	-1.577*** (-5.612)
1982:4 1984:4	1.668 (1.649)	-0.782 (-1.865)	1973:1 1975:3	2.132** (3.332)	-0.902** (-3.149)
1985:1 1992:1	0.252 (0.814)	-0.399* (-1.847)	1975:4 1978:2	1.652 (1.663)	-1.005** (-2.447)
1992:2 1998:4	0.186* (1.820)	-0.472*** (-2.877)	1978:3 1982:1	0.957** (2.302)	-0.791*** (-3.339)
			1982:2 1985:4	0.716* (2.217)	-0.692** (-2.343)
			1986:1 1995:1	0.298* (2.023)	-0.688*** (-4.204)
			1995:2 1998:4	0.150 (1.620)	-0.647** (-2.935)

Sweden			Switzerland		
1980:3 1990:4	0.183 (1.177)	-0.257* (-1.803)	1970:1 1974:3	1.050*** (5.162)	-0.737*** (-3.210)
1991:1 2000:4	0.128 (1.041)	-0.449** (-2.702)	1974:4 1993:1	0.200*** (3.170)	-0.489*** (-5.258)
			1993:2 2003:3	0.025 (0.510)	-0.745*** (-3.798)
UK			US		
1957:3 1969:3	0.387*** (4.447)	-0.862*** (-5.848)	1957:3-1965:2	0.166 (1.254)	-0.757*** (-4.264)
1969:4 1975:1	0.544** (2.791)	-0.119 (-0.648)	1965:3-1976:3	0.074 (0.495)	-0.141* (-1.824)
1975:2 1981:1	0.520 (1.364)	-0.533** (-2.716)	1976:4-1981:2	0.340 (0.791)	-0.238 (-1.382)
1981:2 2004:1	0.078 (0.844)	-0.266*** (-3.383)	1981:3-1990:3	0.261 (1.021)	-0.472*** (-2.911)
			1990:4-2004:2	0.385*** (3.104)	-0.723*** (-5.239)

Notes: *t*-statistics is in parentheses. ***, **, and * denote 1%, 5% and 10% significance levels in two-tailed tests, respectively. The date shown under the break-points column gives the starting point of the data we used to generate die-out-rate time series for individual countries using rolling regression technique where a rolling regression window is set at 41 quarters (10 years).

TABLE 4

TESTS ON BREAK POINTS IN THE RELATION BETWEEN DIE-OUT-RATE AND OPENNESS TIME SERIES FOR INDIVIDUAL COUNTRIES AND ASSOCIATED ESTIMATIONS

Panel A: Tests on the existence of break points in the relation between die-out-rate and openness (equation (10))

Country	Test on no break versus unknown # of breaks: *WD max* (5%)	Test of *l* versus *l+1* breaks: $SupF_T(l+1\mid l)$		Conclusion on # of breaks	Break points
Australia	18.699***	$SupF_T(2\mid 1)$ = 13.246**	$SupF_T(3\mid 2)$ = 11.887	2	1981:1, 1989:2
Austria	23.266***	$SupF_T(3\mid 2)$ = 14.589**	$SupF_T(4\mid 3)$ = 12.949	3	1981:1, 1984:1, 1985:4
Belgium	29.036***	$SupF_T(2\mid 1)$ = 4.464	--	1	1984:1
Canada	27.351***	$SupF_T(2\mid 1)$ = 8.488	--	1	1981:1
Finland	641.921***	$SupF_T(5\mid 4)$ = 16.807**	$SupF_T(6\mid 5)$ =2.726	5	1973:3, 1976:2, 1978:1, 1980:2, 1985:4
France	3078.828***	$SupF_T(4\mid 3)$ = 22.183***	$SupF_T(5\mid 4)$ = 6.521	4	1980:3, 1982:3, 1985:2, 1987:1
Germany	43.437***	$SupF_T(5\mid 4)$ = 20.387***	$SupF_T(6\mid 5)$ = 13.717	5	1973:2, 1975:4, 1981:1, 1982:4, 1986:2
Italy	19.886***	$SupF_T(2\mid 1)$ = 15.630***	$SupF_T(3\mid 2)$ = 5.075	2	1985:1, 1986:2
Japan	39.957***	$SupF_T(3\mid 2)$ = 23.018***	$SupF_T(4\mid 3)$ = 7.158	3	1963:1, 1980:1, 1989:4
Netherlands	54.221***	$SupF_T(2\mid 1)$ = 23.944***	$SupF_T(3\mid 2)$ = 9.451	2	1981:3, 1983:3
New Zealand	2026.642***	$SupF_T(3\mid 2)$ = 80.881***	$SupF_T(4\mid 3)$ = 10.814	3	1989:1, 1989:4, 1991:2
Norway	21.863***	$SupF_T(3\mid 2)$ = 13.943**	$SupF_T(4\mid 3)$ = 9.653	3	1966:1, 1970:1, 1980:3
Portugal	40.628***	$SupF_T(2\mid 1)$ = 9.229	--	1	1985:2
Spain	21.532***	$SupF_T(2\mid 1)$ = 22.724***	$SupF_T(3\mid 2)$ = 10.336	2	1974:2, 1986:3
Sweden	1100.757***	$SupF_T(2\mid 1)$ = 94.875***	$SupF_T(3\mid 2)$ = 7.127	2	1981:3 1985:4
Switzerland	18.666***	$SupF_T(2\mid 1)$ = 5.135	--	1	1984:2
UK	312.615***	$SupF_T(6\mid 5)$ = 24.640***	$SupF_T(7\mid 6)$ = 2.205	6	1960:4, 1963:4, 1966:4, 1969:4, 1972:4, 1983:3
US	383.132***	$SupF_T(2\mid 1)$ = 15.805***	$SupF_T(3\mid 2)$ = 7.582	2	1980:1, 1989:1

Panel B: Regress die-out-rate on openness across different subsample periods

Country	Constant	Openness (*k*)	Country	Constant	Openness (*k*)
Australia			Austria		
1966:1 1980:4	-0.041** (-2.309)	-0.019 (-1.402)	1970:3 1980:4	0.053 (0.476)	-0.140 (-1.316)
1981:1 1989:1	-0.075* (-1.988)	-0.019 (-0.225)	1981:1 1983:4	-0.117 (-1.463)	-0.024 (-0.566)
1989:2 1992:1	-0.953*** (-13.122)	-3.293*** (-4.399)	1984:1 1985:3	-0.882 (-1.006)	0.312 (0.425)
			1985:4 1987:4	-3.779** (-3.600)	2.731** (3.190)

Belgium			Canada		
1981:1 1983:4	0.047 (0.843)	-0.029 (-0.799)	1958:1 1980:4	-0.028* (-1.791)	0.030 (1.340)
1984:1 1988:4	3.157*** (3.824)	-4.621*** (-4.692)	1981:1 1994:2	-0.054** (-2.457)	-0.093*** (-3.525)
Finland			France		
1970:4 1973:2	-0.484*** (-19.185)	-0.012 (-0.241)	1978:3 1980:2	-0.184 (-1.393)	0.254 (1.287)
1973:3 1976:1	-0.363*** (-7.113)	0.010 (0.054)	1980:3 1982:2	0.263 (1.790)	-0.435** (-2.649)
1976:2 1977:4	-0.268*** (-9.867)	0.092 (0.410)	1982:3 1985:1	-1.012*** (-8.418)	0.901*** (6.345)
1978:1 1980:1	-0.176*** (-99.018)	-0.009 (-1.232)	1985:2 1986:4	-0.391* (-2.503)	-0.227 (-1.046)
1980:2 1985:3	-0.309*** (-26.570)	0.051 (1.042)	1987:1 1988:4	0.189 (0.534)	-0.789* (-1.804)
1985:4 1988:4	-0.243*** (-11.085)	-0.263* (-1.776)			
Germany			Italy		
1969:4 1973:1	-0.383*** (-57.320)	-0.167 (-1.724)	1979:4 1984:4	-0.198*** (-2.905)	0.097** (2.100)
1973:2 1975:3	-0.424*** (-36.131)	-0.076 (-1.100)	1985:1 1986:1	-1.401 (-0.729)	4.181 (0.614)
1975:4 1980:4	-0.295*** (-16.363)	0.121 (1.510)	1986:2 1988:3	0.121 (1.164)	-1.037*** (-4.066)
1981:1 1982:3	-0.421*** (-4.992)	-0.391* (-1.955)			
1982:4 1986:1	-0.718*** (-112.541)	0.005 (0.355)			
1986:2 1988:4	-0.321 (-1.556)	-0.642** (-2.571)			
Japan			Netherlands		
1958:1 1962:4	-4.167 (-3.185)	3.962 (3.075)	1977:4 1981:2	-0.592*** (-5.190)	0.325*** (5.189)
1963:1 1979:4	-0.340 (-28.997)	0.708 (7.116)	1981:3 1983:2	-0.167** (-2.601)	0.156 (0.065)
1980:1 1989:3	-0.404 (-2.990)	3.784* (1.853)	1983:3 1987:4	-0.202* (-1.912)	-0.142* (1.900)
1989:4 1994:2	-0.159* (-1.995)	-3.396* (-1.774)			
New Zealand			Norway		
1988:1 1988:4	-0.542*** (-30.819)	0.033 (0.244)	1961:4 1965:4	0.001 (0.015)	-0.060 (-0.575)
1989:1 1989:3	-0.517*** (-197.800)	-1.099 (-4.065)	1966:1 1969:4	0.016 (0.394)	-0.012 (-0.768)
1989:4 1991:1	-0.537*** (-14.526)	-0.920 (-0.996)	1970:1 1980:2	-0.045 (-1.048)	-0.026 (-0.663)
1991:2 1994:2	-0.688*** (-151.735)	0.117 (0.202)	1980:3 1988:4	-0.076* (-2.007)	-0.208*** (-4.089)
Portugal			Spain		
1980:3 1985:1	-0.046 (-0.468)	0.021 (0.165)	1970:4 1974:1	-0.008 (-0.015)	-0.744 (-0.613)
1985:2 1988:4	-0.222*** (-9.340)	-0.335*** (-5.048)	1974:2 1986:2	-0.062 (-0.425)	-0.025 (-0.090)
			1986:3 1988:4	5.285* (2.032)	-22.304* (-2.001)
Sweden			Switzerland		
1980:4 1981:2	-1.830* (-12.954)	2.192* (9.211)	1970:4 1984:1	-0.052 (-0.994)	-0.190*** (3.182)
1981:3 1985:3	-0.584*** (-60.852)	0.011 (0.852)	1984:2 1988:2	0.004 (0.245)	0.079*** (3.288)
1985:4 1988:4	-0.448*** (-20.119)	-0.110* (-1.896)			

UK			US		
1958:1 1960:3	-1.044*** (-9.039)	0.319** (2.316)	1958:1 1979:4	-0.052*** (-2.699)	0.007 (0.267)
1960:4 1963:3	-0.198* (-1.856)	-0.453** (-2.287)	1980:1 1988:4	-0.126*** (-2.819)	-0.015 (-0.755)
1963:4 1966:3	-0.042 (-0.331)	-0.066 (-0.482)	1989:1 1994:2	-0.652*** (-24.027)	-0.133*** (-3.203)
1966:4 1969:3	-0.285** (-3.095)	0.074 (0.754)			
1969:4 1972:3	-0.313*** (-5.486)	0.039 (1.095)			
1972:4 1983:2	-0.273*** (-4.692)	0.012 (0.687)			
1983:3 1988:4	-0.115** (-2.412)	0.010 (0.289)			

Notes: *t*-statistics is in parentheses. ***, **, and * denote 1%, 5% and 10% significance levels in two-tailed tests, respectively. The date shown under the break-points column gives the starting point of the data we used to generate die-out-rate and openness time series for individual countries using rolling regression technique where a rolling regression window is set at 41 quarters (10 years).