What Should Central Banks Target? Evidence on the Impact of Monetary Policy Regimes on Economic Growth

Chong, Terence Tai Leung and Wong, Kin Ming

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Kin-Ming Wong[1] and Terence Tai-Leung Chong[2]

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Abstract:

Economists and policy-makers have long sought the ideal framework for monetary policy as it is arguably one of the most important tools for government to influence the economy. Exchange rate and inflation are believed to be the most appealing anchors for providing guidance to the conduct of monetary policy and are thus widely used in the real world. Most existing studies on the effect of exchange-rate arrangements and inflation targeting on economic growth suffer from the absence of a clear counterfactual, rendering it difficult to interpret their results. Based on a new classification scheme on monetary policy regimes, this paper helps to fill that gap by investigating the effect of monetary policy regimes on growth. Our results consistently support that an inflation targeting regime has a positive impact on economic growth when compared with an exchange-rate targeting regime.

JEL Classifications: E42, E52, E58, F43

Keywords: Monetary Policy Regimes; Inflation Targeting; Exchange-rate Targeting; Economic Growth

[1] Kin-Ming Wong, Department of Economics, The Chinese University of Hong Kong and Business Faculty, Chu Hai College of Higher Education, Hong Kong. Email: arieswong@chuhai.edu.hk.
[2] Corresponding author: Terence Tai-Leung Chong, Department of Economics, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong. Email: chong2064@cuhk.edu.hk.

"In principle, one can only assess the effects of inflation targeting by having a clear alternative monetary policy regime as a benchmark. That is, to draw conclusions about inflation targeting, one must ask what it is being compared to."

Mark Gertler, Comment in Ball and Sheridan (2005)

1. Introduction

The modern fiat monetary system requires a nominal anchor to guide the conduct of monetary policy. Three nominal variables—exchange rate, monetary aggregate, and inflation—are suggested to be the most appealing anchors in the literature[3]. Exchange rate targeting has a great advantage in its simplicity and clarity, which is able to establish the credibility of monetary policy in a short time. Fixed exchange rate, on the other hand, imposes severe constraints on the ability of monetary authorities to respond to domestic shocks and is likely to be a target of speculative attacks. Inflation is a good candidate to guide monetary policy in its own right since price level stability is usually agreed to be the most important ultimate objective for central banks. Friedman (1968), however, argued that the link between monetary policy actions and inflation could be indirect, and targeting inflation is "therefore likely to make monetary policy itself a source of economic disturbance because of false stops and starts." Friedman instead suggests the use of monetary targeting but reminds that "perhaps, as our understanding of monetary phenomena advances, the situation will change." The situation did change when the relationship between money and economic variables became more and more unstable in the later period, creating great challenges to the monetary targeting strategy. There is wide agreement about the advantages and disadvantages of monetary policy regimes using alternative targets, but there is little agreement on their "net" effects in promoting economic growth.

[3] The three nominal variables are usually mentioned in the monetary policy literature; for example, see Friedman (1968), Bernanke et al. (1999) and Mishkin (1999).

There is a large literature on the theoretical evaluation of alternative monetary policy rules[4], but the influence of alternative rules on growth critically depends on the assumptions of their effects on the adjustment to shocks and on anchoring the public's inflation expectations. The economic effect of alternative monetary policy regimes is therefore largely an empirical matter. Since the validity of seriously pursued monetary targeting strategy in the real world has been critically challenged[5], the empirical literature is more focused on the economic performance of the exchange rate targeting and inflation targeting regimes.

The results on the relationship between economic growth and exchange rate arrangements are relatively mixed. Ghosh et al. (2003) and Klein and Shambaugh (2010) report higher economic growth for the fixed exchange rate regime. Frankel and Rose (2002) also provide indirect evidence that currency union, as the strongest form of fixed exchange rate, could promote economic growth through its positive effect on trade[6]. Levy-Yeyati and Sturzenegger (2003) and Husian et al. (2005), on the contrary, show that a flexible exchange rate arrangement achieves higher growth rate. One of the explanations of the mixed results may rest on the evidence provided by Aghion et al. (2009). Their results suggest that a flexible exchange rate promotes economic growth only above a certain threshold of financial development.

The inflation targeting monetary policy framework has been receiving increasing attention since the 1990s[7]. Bernanke et al. (1999) and Mishkin (1999) analyze the international experience of several inflation targeting countries using the case study approach and suggest that inflation targeting could be an ideal candidate for the modern monetary policy framework. Surprisingly, Ball and Sheridan (2005) and Ball (2011) and Walsh (2009) fail to reveal any significant effect of inflation targeting regime on growth using either difference-

[4] Some of these examples include Svensson (1999), Rudebusch and Svensson (1999), and Jansen (2002).

[5] Monetary targeting is said to have been a strategy mostly used in the 1970s. However, many studies, including Mishkin (2001), have argued that this strategy was not seriously pursued. Bernanke and Mishkin (1997) and Bernanke et al. (1999), on the other hand, suggest that many monetary targeting countries, including the two classic examples, Germany and Switzerland, are better viewed as "hybrid" inflation and monetary targeters and "distinction between inflation and money targeting is overstated." Other studies such as Bernanke and Mihov (1997) and Clarida et al. (1998) support these views with the estimations of policy reaction functions. Identification of the monetary targeting regime in the empirical classification is also rare. For example, Stone and Bhundia (2004) only classified 35 country-year observations as money anchor in their 1,353 data.

[6] Indeed, there is large literature on the positive effect of currency union and fixed exchange rate on trade, including Rose (2000), Rose and Wincoop (2001), and Klein and Shambaugh (2006).

[7] See, for example, Rose (2007) on durability and exchange volatility, Mishkin and Schmidt-Hebbel (2007) and Lin and Ye (2007, 2009) on inflation and other studies on economic growth discussed in the paper.

in-difference or propensity score matching approach. Unlike the studies on exchange rate arrangements, the results of which are mainly based on *de facto* classification, the evaluation of the inflation targeting regime heavily relies on *de jure* classification using the official announcement of inflation target for identification. Several studies in the exchange rate literature, including Calvo and Reinhart (2002), Reinhart and Rogoff (2004) and Levy-Yeyati and Sturzenegger (2005), however, show that policies of many countries in practice may not be consistent with their publicly disclosed regimes. The assessment of economic performance according to the *de jure* classification could therefore be misleading.

Existing studies on the effect of exchange rate arrangements and inflation targeting on economic growth have one major imperfection—nearly all of them are isolated and separated in two areas of literature.[8] Research in the exchange rate arrangements literature classifies regimes into fixed and floating exchange rate regimes. While a fixed exchange rate is equivalent to an exchange rate targeting monetary policy, floating exchange rate is not a well-defined monetary policy, as suggested by Rose (2011). Similarly, the monetary policy of the non-inflation-targeting countries is usually ignored in the inflation targeting literature. As commented by Mark Gertler in Ball and Sheridan (2005), the absence of a benchmark with clear monetary policy makes assessment of the economic performance of an inflation targeting regime difficult to interpret. This isolation and separation, in turn, may be explained by the absence of a complete classification of monetary policy regimes[9].

This paper examines the effect of monetary policy regimes on economic growth using the new classification of Wong and Chong (2014). This contributes to the literature by providing a direct comparison of two well-defined alternative monetary policy regimes, namely exchange rate targeting, and inflation targeting based on *de facto* classification. The main result of this paper shows that inflation targeting regime, when directly compared with the exchange rate targeting regime, reports a positive effect on economic growth. The estimation results under an augmented Solow model and other empirical growth models are similar. The finding is also robust under various model specifications, various methods to exclude outliers, and estimations using instrument variable.

[8] Bailliu et al. (2003) is one of the exceptions and will be discussed in a later section.

[9] A "De Facto Classification of Exchange Rate Regimes and Monetary Policy Frameworks" has been included in the IMF's Exchange Arrangements and Exchange Restrictions, but the classification is only available after 2001.

The rest of the paper is organized as follows. Section 2 discusses the data and classification used in this paper. Section 3 presents a first pass of data using the propensity score matching approach. Section 4 provides the empirical evidences of the effect of monetary policy regimes using a simple augmented Solow model and other empirical growth models in the literature. Section 5 concludes the paper.

2. Data and the Classification of Monetary Policy Regimes

This study covers observations for the 228 countries report of the IMF over the post-Bretton Wood period from 1974 to 2009[10]. Most of the economic data come from the databases of International Monetary Fund, World Bank, and Penn World Table prepared by Heston, Summer and Aten (2012). Data on crisis and schooling year are from the dataset of Reinhart and Rogoff (2011) and Barro and Lee (2010) respectively. Following the literature, structure-adjusted trade openness is captured from the residual of a regression of total trade ratio on a set of structural variables. The details of sources and definitions of data are explained in Appendix A.

Studies on the economic performance of well-defined alternative monetary policy regimes are rare. Most notably, Bailiu et al. (2003) estimate the growth effect of pegged exchange rate regime and floating exchange rate regime with a nominal anchor for monetary policy. A two-step classification is used in their study. Observations with low exchange rate volatility are classified as pegged regime in the first stage, and the unclassified observations (i.e., countries with floating exchange rate) with a publicly announced nominal anchor in the monetary policy are further identified in the second stage. This classification strategy, however, could prove challenging for several reasons. First, classification which solely depends on the exchange rate volatility may misleadingly group countries with small shocks in a pegged regime, as argued by Levy-Yeyati and Sturzenegger (2005). Second, it is also not uncommon for inflation targeters such as New Zealand, Finland, and Norway to maintain relatively stable currencies with heavy intervention in foreign exchange markets in order to achieve stable inflation. These observations are likely to be classified as pegged regime in the first

[10] In some cases, the data of a country may not be available since the country does not exist in the entire sample period. Out of the 228 countries reported in the list of the IMF, 186 have been classified at least for one period.

step of classification. The misclassification of observations with smaller shock and low exchange rate volatility achieved by inflation targeting policy is therefore likely to result in an overestimation of the effect of pegged regime on growth.[11] Finally, the use of a publicly announced nominal anchor in the monetary policy in the second step also makes the classification for the floating regime with nominal anchor highly *de jure*.

This paper uses Wong and Chong's (2014) new *de facto* classification of monetary policy regimes to examine the effect of alternative monetary policy regimes on economic growth. In Wong and Chong (2014), country-year observations are grouped into two well-defined monetary policy regimes, exchange rate targeting and inflation targeting, according to the similarity in the observed volatility of the instrument variable, interest rate and two outcome variables, exchange rate and inflation rate using k-means cluster analysis. The inclusion of inflation targeting as the alternative policy framework in a simultaneous classification could avoid misplacing inflation targeting countries with low exchange rate volatility in the exchange rate targeting regime as in the two-step approach. For example, several well-known inflation targeters such as New Zealand, Finland, and Norway with heavy foreign exchange intervention are correctly classified as inflation targeting regime in Wong and Chong (2014). Interest rate, as the main instrument used in monetary policy, is also included in the classification to minimize the misclassification of observations with small shocks into either monetary policy regimes.[12]

3. A First Pass at the Data with Propensity Score Matching

This section presents a first pass at the data using propensity score matching method. Estimations from simple OLS are also provided for reference. The simple OLS provides a naïve comparison between the averages of two monetary policy regimes. Estimation using the propensity score matching, on the other hand, uses a control group to mimic a randomized experiment. To address the self-selection problem, the treatment group (i.e., the inflation targeting regime in this case) is matched to a control group with similar values in a set of

[11] Indeed, Bailiu et al. (2003) report a higher growth effect for the pegged regime than floating regime with anchor using the mixed *de jure-de facto* approach (or hybrid mechanical rule used in the paper). This result is in contrast to the estimation obtained from a pure *de jure* approach based on official classification.

[12] The robustness of classification, nevertheless, comes with a tradeoff of a number of inconclusive observations.

control variables. In practice, a propensity score based on the probability of policy adoption estimated from Probit or Logit model is used for the matching. In this sense, propensity score matching method provides a more reasonable comparison for the economic performance between two monetary policy regimes.

Table 1. Probit Regression Results for Inflation Targeting Regime

	Dependent variable: Dummy for Inflation Targeting	
	(1)	(2)
Real GDP (in log)	-0.126***	0.236***
	(0.034)	(0.089)
Trade openness	-1.218***	-0.009
	(0.300)	(0.008)
Trade concentration	-0.353	0.002
	(0.363)	(0.010)
Capital openness	-4.206***	-8.111***
	(0.951)	(2.939)
Years in office	-0.029***	-0.024
	(0.007)	(0.021)
Advanced Country	1.710***	2.063***
	(0.179)	(0.468)
Emerging Country	0.890***	0.762**
	(0.160)	(0.389)
N	2,516	411
Pseudo R2	0.229	0.193

All regressions include an intercept and year dummies.
*Standard errors are in parentheses. ***, **, and * represent significance at 1%, 5%, and 10%, respectively.*

Table 1 presents the typical estimations of the probability of inflation targeting adoption on a set of variables estimated by Probit model using short-run (column 1) and long-run data (column 2).[13] The set of variables used for estimation follows Wong and Chong (2014), which in turn adopts the theory-based variables suggested in Levy Yeyati et al. (2010). Unsurprisingly, the results in Table 1 are similar to Wong and Chong (2014) and mirror the results in Levy Yeyati et al. (2010). Inflation targeting is more likely to be adopted by countries with larger economic size, less open to both trade and capital flows, and weaker governments, which make it more difficult to sustain a pegged exchange rate under speculation. Advanced countries are also more likely to target inflation. One of the possible explanations is that advanced countries may have more favorable institutional factors such as central bank independence and transparency to implement the inflation targeting framework.

Table 2 presents the comparisons of short-run and long-run economic performance using simple OLS and propensity score matching method. The short-run performance is estimated with annual data, while the long-run performance uses five-year averages of non-overlapping periods. Differences between the two monetary policy regimes are expected and highly consistent in the short-run and long-run data. Inflation targeting regimes report lower inflation and inflation volatility on average, even after removing the high inflation observations. This, however, comes with a cost of higher nominal exchange rate volatility. Overall, the treatment effect of inflation targeting regime is positive on the economic growth and negative on the volatility of economic growth. Unlike the simple OLS estimations, the treatment effects on most economic variables estimated with the propensity score matching approach are not statistically significant.

[13] In practice, a separate Probit model is estimated depending on the data availability of the variable under evaluation. Estimations presented in Table 1 are for economic growth. For short-run data, dummy for inflation targeting equals to 1 if a country-year observation has been classified in the inflation targeting regime in Wong and Chong (2014) and 0 otherwise. For long-run data, dummy for inflation targeting equals to 1 if a country has been classified as inflation targeting over half of the non-overlapping five-year period and 0 otherwise.

Table 2. Inflation Targeting versus Exchange Rate Targeting Regime

Treatment Group:	Annual Data		5-year Averages	
Inflation Targeting Regime	**Simple OLS**	**Propensity Score Matching**	**Simple OLS**	**Propensity Score Matching**
Economic growth	0.546*** (0.209)	0.242 (0.331)	0.593** (0.240)	0.208 (0.434)
Economic growth volatility			-1.381*** (0.236)	-0.109 (0.347)
Inflation	-31.202*** (10.611)	-50.915** (20.193)	-50.023*** (18.538)	-95.205** (39.808)
excluding inflation > 40%	-0.300 (0.323)	0.252 (0.576)	-1.404** (0.672)	-0.872 (1.448)
Inflation volatility			-66.695** (28.74)	-80.140 (49.637)
excluding inflation > 40%			-1.873*** (0.486)	-0.733 (0.866)
Nominal exchange rate volatility	0.205*** (0.110)	0.372* (0.221)	-0.187 (0.214)	0.301 (0.393)

Results of propensity score matching method are estimated with the nearest neighbor matching replacement. Standard errors reported for OLS estimations are robust.
*Standard errors are in parentheses. ***, **, and * represent significance at 1%, 5%, and 10%, respectively.*

4. Empirical Estimations

4.1. A Simple Solow Model with Monetary Policy Regime

The classic Solow Model provides theoretical support of the use of several fundamental variables in explaining the economic growth across countries. The role of monetary policy regime in economic growth can be illustrated with a simple Solow model augmenting the baseline framework in Mankiw et al (1992). In this model, the production function of an economy is assumed to be

$$Y_t = (M_t K_t)^{\alpha} H_t^{\beta} (A_t L_t)^{1-\alpha-\beta} \quad (1)$$

where

$$M_t = \theta^{MR_t}$$

and Y is the output, K is the capital, H is the human capital, L is the labor and A is the labor-augmenting technology. The capital-augmenting factor, M depends on the monetary policy regime MR and its marginal effect on capital, θ. In this paper, exchange-rate targeting monetary policy regime is taken as the base case for comparison and therefore MR equals to zero for exchange-rate targeting regime and equals to one for inflation targeting regime.

Defining k as the stock of capital per effective unit of labor (K/AL), h as the stock of human capital per effective unit of labor (H/AL) and y as the output per effective unit of labor (Y/AL). The evolution of the economy is determined by

$$\dot{k}_t = s_k y_t - (n+g+\delta)k_t$$

$$\dot{h}_t = s_h y_t - (n+g+\delta)h_t$$

where s_k is the fraction of income invested in physical capital, s_h is the fraction of income invested in human capital, n is the growth rate of labor and g is the growth rate of labor-augmenting technology. The depreciation rate of the physical and human capital is assumed to be the same of δ. The motion equations imply the economy converges to a stead state defined by

$$k^* = \left(\frac{M_t^{\alpha} s_k^{1-\beta} s_h^{\beta}}{n+g+\delta} \right)^{\left(\frac{1}{1-\alpha-\beta}\right)}$$

$$h^* = \left(\frac{M_t^{\alpha} s_k^{\alpha} s_h^{1-\alpha}}{n+g+\delta} \right)^{\left(\frac{1}{1-\alpha-\beta}\right)}$$

and the steady-state output per worker is

$$\ln\left(\frac{Y_t}{L_t}\right) = \ln A_0 + gt + \frac{1}{1-\alpha-\beta}\alpha \ln M_t - \frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g+\delta) + \frac{\alpha}{1-\alpha-\beta}\ln s_k + \frac{\beta}{1-\alpha-\beta}\ln s_h$$

Finally, the model suggests the growth rate of output per worker is determined by

$$\begin{aligned}\ln y_t - \ln y_0 = {} & \left(1-e^{-\lambda t}\right)\ln A_0 + gt + \left(1-e^{-\lambda t}\right)\frac{1}{1-\alpha-\beta}\alpha \ln M_t \\ & - \left(1-e^{-\lambda t}\right)\frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g+\delta) + \left(1-e^{-\lambda t}\right)\frac{\alpha}{1-\alpha-\beta}\ln s_k \\ & + \left(1-e^{-\lambda t}\right)\frac{\beta}{1-\alpha-\beta}\ln s_h - \left(1-e^{-\lambda t}\right)\ln y_0\end{aligned} \tag{2}$$

where λ is the convergence rate derived from Taylor approximation around the steady state and y_0 is the output per worker at an initial state. Using the relationship between M, MR and θ, the equation could be rewritten as follow for empirical estimation

$$\begin{aligned}\ln y_t - \ln y_0 = {} & \left(1-e^{-\lambda t}\right)\ln A_0 + gt + \left(1-e^{-\lambda t}\right)\frac{1}{1-\alpha-\beta}\alpha MR_t \ln\theta \\ & - \left(1-e^{-\lambda t}\right)\frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g+\delta) + \left(1-e^{-\lambda t}\right)\frac{\alpha}{1-\alpha-\beta}\ln s_k \\ & + \left(1-e^{-\lambda t}\right)\frac{\beta}{1-\alpha-\beta}\ln s_h - \left(1-e^{-\lambda t}\right)\ln y_0\end{aligned} \tag{3}$$

Empirical estimations of the simple augmented Solow model are based on the cross-country sample using the average of variables over the period 1974 to 2009. Following Mankiw et al (1992), s_k is the average share of investment in GDP, the average fraction of the eligible population enrolled in secondary school is used as the proxy of s_h and the sum of g and δ is assumed to be 0.05. The variable of monetary policy regime, MR is the average of years a country implemented the inflation targeting strategy according to the classification of Wong

and Chong (2014).

The estimation results are reported in Table 3. Regressions are estimated without any restrictions on the coefficients in the first two columns and are estimated with restrictions implied by the theoretical model in the last two columns. Results reported in columns 2 and 4 include additional controls for geographical factors including region, island and landlocked. In all cases, the average output per worker over 1970 to 1973 is used as the instrument variable for the initial output per worker.

Table 3. Cross-country Estimation of Solow Model

	Unrestricted Model		Restricted Model	
	(1)	(2)	(3)	(4)
Inflation Targeting	0.808**	0.790*	0.828**	0.816**
	(0.401)	(0.399)	(0.403)	(0.392)
Initial output per worker	-0.934***	-0.892***	-0.930	-0.926***
	(0.167)	(0.214)	(0.165)	(0.200)
$\ln(s_k)$	1.453***	1.143**		
	(0.457)	(0.505)		
$\ln(s_h)$	0.811***	0.410		
	(0.246)	(0.283)		
$\ln(n+g+\delta)$	-3.23***	-2.812*		
	(0.779)	(1.419)		
$\ln(s_k) - \ln(n+g+\delta)$			1.515***	1.201**
			(0.449)	(0.494)
$\ln(s_h) - \ln(n+g+\delta)$			0.897***	0.478
			(0.217)	(0.264)
Control for region, island and landlocked	No	Yes	No	Yes
Implied θ	-	-	1.727	1.973
Observations used	114	111	114	111
Adjusted R^2	0.373	0.462	0.374	0.464

* significant at 10%, ** significant at 5%, *** significant at 1%
Standard errors are robust to heteroskedasticity. Intercept are included in the model but not reported.

Results in Table 3 show that the coefficients on the factors suggested in the traditional Solow model are highly significant with the predicted signs across estimations. The effect of inflation targeting regime on economic growth is found to be significant positive under various specifications. In the long-run, inflation targeting regime grows 0.8% faster than the exchange-rate targeting regime. In particular, the restricted model suggests that the effective capital under inflation targeting regime could be 73% to 97% higher than exchange-rate targeting regime.

4.2. Empirical Growth Models

4.2.1. Methodology

To offer greater flexibility in exploring the determinants of economic growth and minimize the problem of omitted variables, empirical models are also commonly-used in the literature[14]. In this section, the effect of monetary policy regime is estimated with the following empirical dynamical growth model

$$y_{i,t} - y_{i,t-1} = (\alpha\text{-}1)\, y_{i,t-1} + \beta X_{i,t} + \gamma MR_{i,t} + \mu_t + \eta_i + \varepsilon_{i,t} \qquad (4)$$

where $y_{i,t}$ is the logarithm of output per worker; $MR_{i,t}$ is a dummy for monetary policy regime, which equals to 1 for inflation targeting regime; $X_{i,t}$ is a set of control variables; μ_t is the time-specific effect; and η_i is the country-specific effect. To filter out business cycle fluctuations, the equation is estimated for the long-run growth at a non-overlapping five-year interval with explanatory variables in five-year averages.

The baseline model closely follows Levine et al. (2000) and Aghion et al. (2009) with initial output per worker, education, structure-adjusted openness, and government burden included as the control variables. Unlike the two studies, inflation is intentionally removed from the baseline model since price level stability is believed to be one of the key channels for various monetary policy regimes to influence the economic growth. Nevertheless, inflation will be

[14] See, for example, Levine and Renelt (1992), Levine et al. (2000), Levy and Sturzenegger (2003) and Aghion et al. (2009).

included later in an alternative specification.

The dynamic panel data model in equation (4) is estimated with the approach developed in Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998) to address the endogeneity issue and potential biases induced by country-specific effect. In particular, results are estimated using the two-step system GMM approach with the robust standard errors suggested in Windmeijer (2005) following Levine et al. (2000) and Aghion et al. (2009). The standard instrument set for the system GMM estimation typically grows quadratic in time and results in the problem of instrument proliferation. One of the main approaches to address this problem is to restrict the instruments to certain lags instead of all available lags. This approach is simple, but the number of lags used in instrument set could be arbitrary and subjective. Roodman (2009) proposes another approach using a collapsed instrument matrix to address the problem. This approach uses all available lags as instruments to retain most information. Meanwhile, the instrument set is collapsed into smaller set through addition to address the instrument proliferation problem. The baseline model is estimated with both approaches, but estimations for alternative specifications and robustness tests use the collapse instrument matrix only for brevity.

4.2.2. Estimation Results

Estimations of the baseline model are presented in Table 4. The first two columns report estimations of the traditional random effects and fixed-effects models for reference. The results of the last two columns are estimated with dynamic panel data model using GMM approach. To address the problem of instrument proliferation[15], the estimation in the third column uses the single lag of the variables as instruments while the estimation in the fourth column uses the collapsed instrument matrix approach in Roodman (2009). The GMM estimations using both approaches report control variables with expected signs. The main results across various estimations of Table 4 consistently show that inflation targeting regime has a significantly positive effect on economic growth.

[15] Empirically, GMM estimation uses the full instrument matrix with all available lags always reporting a p-value close to 1 in the Sargan test, which is an important syndrome of instrument proliferation. The two methods used to control instrument proliferation, on the other hand, are able to address the problem as reflected in the Sargan test statistics in Table 4.

Table 4. Baseline Model for the Growth Effect of Inflation Targeting Regime

	Panel Data Model		GMM: Dynamic Model	
	Random	**Fixed**	**Single Lag**	**Collapse**
Inflation Targeting	1.08*** (0.12)	0.741* (0.449)	1.21*** (0.446)	0.866** (0.442)
Initial output per worker	-0.713*** (0.092)		0.051 (0.616)	-0.012 (0.579)
Education	0.334* (0.190)	-2.526** (1.072)	0.259 (0.900)	0.605 (0.905)
Adjusted trade openness	1.798*** (0.159)	4.333*** (0.833)	3.945** (1.632)	3.851*** (1.238)
Government burden	-0.193 (0.160)	-0.352 (0.861)	-3.330** (1.511)	-1.93 (1.577)
Financial development	-0.390*** (0.087)	-1.312*** (0.464)	0.363 (0.586)	0.155 (0.564)
Observations used	439	439	910	910
Adjusted R^2	0.219	0.103	0.099	0.100
Sargan test (p-value)			0.161	0.131
Difference-Sargan test (p-value)			0.921	0.150
Second-order serial correlation (p-value)			0.091	0.131

* significant at 10%, ** significant at 5%, *** significant at 1%
Year effects and intercept are included but not reported.
Estimation with random effect also includes dummy variables for region, landlocked, island, and advanced and emerging economy which are commonly used in the literature, while the average of output per worker between 1970 and 1973 is used for the initial output per worker, as in Levy-Yeyati and Sturzenegger (2003).
Standard errors of OLS estimation are robust and clustered at country level. Standard errors of system GMM estimation are robust with Windmeijer (2005) finite sample correction.

Table 5 reports estimations of alternative specifications with additional variables included in the baseline model. The first column includes the crisis variable in Reinhart and Rogoff (2011). Unsurprisingly, the crisis variable is found to have a strong negative effect on economic growth. This specification, however, comes with the cost of data availability, which reduces the observations used for estimation from 910 to 529. The estimation in the second column includes the sum of absolute values of inward and outward flows of portfolio investments as a ratio of GDP to capture the effect of capital openness on growth. The last three columns of Table 5 control the effects of several major channels for monetary policy regime to influence economic growth, including price level as well as nominal and real exchange rate stability. Consistent with the literature, the results in the last three columns show that the volatility of all these variables negatively affects economic growth.

Estimations across alternative specifications in Table 5 report similar positive effects of inflation targeting regime on growth and expected variations in the estimated effects. The inflation targeting regime, when compared with the exchange rate targeting strategy, is likely to suffer from a higher nominal exchange rate. As shown in the third column, the inflation targeting regime reports a largest positive effect on growth when its negative effect on growth through the nominal exchange rate volatility is controlled. Similarly, this effect is weakest[16] but remains positive when the positive effect of inflation targeting on growth through a more stable price level is controlled in the fourth column. The fifth column of Table 5 presents the estimation with the effects of both channels controlled through the inclusion of real exchange rate volatility. The estimation reports an estimated effect between the two ends. These results support that the stability of the target itself is an important channel for monetary policy regime to influence the economy. The result in the last column, however, also suggests that inflation targeting policy could promote economic growth beyond reducing the inflation level. One of the explanations rests on the effect of alternative monetary policy regimes on the expectation formation of various economic variables. These expectations, in turn, lead to different levels of economic activities contributing to the economic growth.[17]

[16] The effect is weakest both economically and statistically, which is marginally rejected at 95% confidence level and remains significant at 90% level.

[17] For example, Klein and Shambaugh (2006) also provide evidences that fixed exchange rate promotes trade beyond reducing the exchange rate volatility. They suggest that a strong likelihood of a stable exchange rate in the near future provided by the presence fixed exchange rate is a likely explanation.

Table 5. Growth Effects of Inflation Targeting Regime in Alternative Specifications

	(1)	(2)	(3)	(4)	(5)
Inflation Targeting	0.833**	0.783*	1.296**	0.662*	1.138***
	(0.331)	(0.422)	(0.577)	(0.378)	(0.398)
Crisis	-0.760***				
	(0.236)				
Capital openness		0.173			
		(0.206)			
Inflation				-0.853**	
				(0.335)	
Nominal exchange rate volatility			-0.902*		
			(0.531)		
Real exchange rate volatility					-0.976**
					(0.389)
Observations used	529	621	556	840	487
Sargan test (p-value)	0.646	0.404	0.491	0.299	0.733
Second-order serial correlation (p-value)	0.259	0.259	0.208	0.153	0.396

* significant at 10%, ** significant at 5%, *** significant at 1%
Results are estimated with all available lags as GMM instruments using a collapsed instrument matrix and robust with Windmeijer (2005) finite sample correction.

4.2.3. Robustness Tests

Table 6 reports the results of various robustness tests on the baseline model. The model with the crisis variable, as discussed, comes with a cost of fewer observations but could minimize the concern of omitted variables and therefore is also included in robustness tests. The first set of robustness tests removes observations in the free-falling category in the Reinhart and Rogoff (2004) classification. The second test applies a similar but stricter principle of free-falling category to remove all observations with inflation rate higher than 20%.[18] The results of Table 6 indicate that the effect of inflation targeting regime on economic growth is robust to the exclusion of outliers, either using the definition of Reginhart and Rogoff or a stricter

[18] The free-falling category in the Reinhart-Rogoff classification is identified with country-year observations which have inflation higher than 40%.

definition.[19]

Literature suggests that policy regime is likely endogenous.[20] One may therefore argue that the relationship between economic growth and monetary policy regime runs from growth to policy regime rather than another way round. In the inflation targeting literature, the lagged regime variable has been used by Mishkin and Schmidt-Hebbel (2007) to instrument for the inflation targeting regime. Ball (2011), however, challenges the use of lagged regime variables as instruments since omitted variables in the error term such as central bank independence are likely to correlate with both the current and lagged adoption of inflation targeting regime. The lagged regime variable therefore is not a valid instrument to address the concern on reverse causality.

Estimations with instrument variables are more common in the exchange rate regime literature. One of the commonly used variables to instrument for exchange rate regimes is the proportion of countries pegging their currency in a region.[21] The main rationale is that a country is more likely to have its currency pegged to stabilize its currency with neighbors when more countries in its region have done so. The adoption of neighboring countries, on the other hand, is unlikely to relate to the economic growth of the home country. This paper applies the other side of the same rationale to instrument the inflation targeting regime using the proportion of countries with exchange rate targeting regime in a region. Given that this proportion is positively related to the choice of exchange rate targeting regime of a country, it must be negatively related to the adoption of inflation targeting policy.[22] The results estimated with this instrument variable are presented in the last two columns of Table 6.[23]The estimations continue to report a positive effect of the inflation targeting regime on economic

[19] The baseline estimation on the sample removing the free-falling category fails to reject the null hypothesis of the Sargan test and second-order serial correlation test at 10%. It is advisable, therefore, to interpret the results with caution. The estimation including the crisis variable on this sub-sample, nevertheless, reports a significant coefficient on the inflation targeting dummy and passes the corresponding two tests.

[20] For example, see Levy-Yeyati et. al. (2010), Wong and Chong (2014), Gerlach (1999) and Carare and Stone (2006).

[21] For example, see Levy-Yeyati and Sturzenegger (2003), Klein and Shambaugh (2006), and Tenreyro (2007).

[22] In a simple regression, the estimated coefficient of the percentage of countries in a region which peg their currencies on the inflation targeting dummy is negative and highly significant with a t-statistics of 18.

[23] The estimations with instrument variables using all available lags as GMM instruments and a collapsed instrument matrix fail to reject the null hypothesis of the Sargan test and second-order serial correlation test at 10% as well. Column (5) and (6) are therefore estimated with up to two lags of the possible endogenous variables using a complete matrix instead.

growth. In particular, the coefficient estimated in the model with the crisis variable is qualitatively consistent with the results in other estimations.

Table 6. Robustness Tests

	No free-falling		No inflation >20%		IV	
	Baseline	**w/ Crisis**	**Baseline**	**w/ Crisis**	**Baseline**	**w/ Crisis**
Inflation Targeting	0.974*	0.800*	1.044**	1.063**	2.177*	1.091*
	(0.541)	(0.463)	(0.480)	(0.432)	(1.122)	(0.613)
Crisis		-0.544*		-0.700*		-0.707***
		(0.282)		(0.365)		(0.241)
Observation used	834	462	686	400	910	529
Sargan test (p-value)	0.083	0.667	0.117	0.558	0.259	0.622
Second-order serial correlation (p-value)	0.064	0.112	0.177	0.174	0.136	0.269

* significant at 10%, ** significant at 5%, *** significant at 1%
All results are robust with Windmeijer (2005) finite sample correction.
Results from column (1) to (4) are estimated with all available lags as GMM instruments using a collapsed instrument matrix. Results estimated with IV using all available lags as GMM instruments and a collapsed instrument matrix fail to pass the Sargan test. Estimation in column (5) and (6) therefore instrument up to two lags using the complete instrument matrix.

4.2.4. On Growth Volatility

The result of propensity score matching in Table 2 shows that the inflation targeting regime reports lower economic growth volatility but the effect is not significant. Table 7 presents the results estimated with a specification similar to the baseline empirical model for economic growth. Results of the baseline estimations in the upper panel provide no clear evidence on the effect of inflation targeting policy on growth volatility. The results estimated with the instrument variable in the lower panel, however, suggest that inflation targeting policy could largely reduce the impact of terms of trade shock on economic growth volatility. Based on the estimates in the second and fourth columns, inflation targeting policy mitigates about 64% to 88% of the influence of terms of trade shock on growth volatility. With an average terms of trade volatility of 14%, inflation targeting policy could lower the annual growth volatility by 0.2% to 0.6%. The direct effect of inflation targeting on growth volatility in the absence of shock, on the other hand, is not significant.

Table 7. Growth Volatility and Inflation Targeting Regime

	Random Effect		Fixed Effect	
	(1)	(2)	(3)	(4)
(a) Baseline estimations				
Inflation Targeting	-0.357	-0.232	0.220	0.068
	(0.295)	(0.582)	(0.393)	(0.726)
TOT volatility	0.125***	0.129***	0.108***	0.104**
	(0.029)	(0.040)	(0.040)	(0.051)
TOT volatility * Inflation Targeting		-0.130		0.017
		(0.054)		(0.064)
Observations used	496	496	496	496
Adjusted R^2	0.356	0.356	0.161	0.161
(b) Instrument variable estimations				
Inflation Targeting	-0.671***	-0.074	-0.603	0.003
	(0.135)	(0.272)	(0.399)	(0.720)
TOT volatility	0.113***	0.131***	0.108***	0.136***
	(0.015)	(0.019)	(0.040)	(0.050)
TOT volatility * Inflation Targeting		-0.084***		-0.119*
		(0.026)		(0.071)
Observations used	496	496	496	496
Adjusted R^2	0.250	0.227	0.157	0.140

* significant at 10%, ** significant at 5%, *** significant at 1%
Year effects, intercept, and other variables in the baseline specification including initial output per worker, adjusted trade openness, government burden and private credit are included but not reported.
Estimation with random effect also includes dummy variables for region, landlocked, island, and advanced and emerging economy which are commonly used in the literature.
Standard errors are robust and clustered at country level.

5. Conclusion

Monetary policy is arguably one of the most important policies influencing the economy. Empirical studies on alternative monetary policy frameworks are not rare, but are isolated and separated in two areas of the literature. The absence of a well-defined alternative monetary policy regime in the estimations makes the evidence in existing studies less solid. Using a new classification of Wong and Chong (2014), this paper offered the first evidence for the effect on economic growth of two well-identified monetary policy regimes: inflation targeting and exchange rate targeting.

The main result of this paper comes from the empirical estimations of growth model.

Inflation targeting is found to have a significantly positive effect on economic growth under both an augmented Solow model and other empirical growth models. This conclusion is robust across various model specifications and exclusions of outliers. The use of the proportion of countries that peg their currency in a region to instrument the adoption of inflation targeting policy also provides similar results. On the magnitude of growth effect, the estimated coefficients in most models suggest that an inflation targeting regime grows 0.8% to 1.1% faster than the exchange rate targeting regime per annum. This magnitude in general agrees with some other findings in the related literature[24] but this conclusion is more solid with a well-defined counterfactual monetary policy in the analysis.

Inflation targeting has been emerging as one of the major monetary policy frameworks and receives increasing attention in the literature. Unfortunately, empirical works on the effect of inflation targeting policy on the economy usually cover a relatively limited number of countries and relatively short periods. Using a classification covering nearly 200 countries and a period from 1974 to 2009, this paper offers solid evidence on the growth-enhancing effect of this new emerging regime.

[24] See, for example, Levy-Yeyati and Sturzenegger (2003), who report a negative growth effect of 0.7% to 1.3% on fixed exchange rate using the random effect model. Even though the results are not statistically significant, Ball and Sheridan (2005) provide an estimated growth effect of 0.7% to 1.9% on economic growth.

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Appendix A. Data Definitions and Sources

Variables	Definitions and sources
Adjusted trade openness	Residual of a regression of the log of the sum of exports and imports over GDP from IFS on the logs of area, population, and dummies for regions, island and landlocked countries.
Capital openness	The sum of absolute value of inward and outward flows of portfolio investments as a ratio of GDP (source: IFS)
Crisis tally	Crisis tally in the database from Reinhart and Rogoff (2011).
Economic growth	The log difference of real output per worker from Heston, Summer and Aten (2012).
Education	Average years of total schooling from Barro and Lee (2010)
Financial development	The ratio of domestic credit claims on private sector to GDP (source: World Bank).
Government Burden	Ratio of government consumption to GDP (source: World Bank)
Inflation	Annual percentage change in consumer price index, supplemented with retail price index (source: IFS).
Nominal effective exchange rate volatility	The average of absolute monthly percentage changes of nominal effective exchange rates in a calendar year (source: IFS).
Population growth rate, n	Heston, Summer and Aten (2012)
Real effective exchange rate volatility	The average of absolute monthly percentage changes of real effective exchange rates in a calendar year (source: IFS).
Share of human capital, s_h	The percentage of population completed secondary education from Barro and Lee (2010)
Share of physical capital, s_k	Investment share of GDP from Heston, Summer and Aten (2012)
Trade concentration	The maximum share of total trade to a specific country (source: Direction of Trade Statistics, IMF)
Trade openness	The sum of exports and imports over GDP (source: IFS).
Years in office	Years the incumbent administration has been in office (source: database of Political Institutions 2012)