Gauging Exchange Rate Targeting*

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Abstract

In this paper, we examine whether a monetary authority targets the exchange rate *per se*, or instead simply responds to the exchange rate in service to an inflation (or output) target. We combine data-rich estimation with a system of forward-looking equations in order to disentangle these two possibilities. The approach reveals potential biases on the estimates of the extent of exchange rate and inflation targeting. We illustrate the approach with an application to Korea, a *de jure* inflation targeter whose exchange rate policy has been the subject of controversy. The biases are important in this case: in sharp contrast to past exchange rate classifications, we find that the Bank of Korea actively targets inflation, not the exchange rate.

JEL Classification: F3 F4

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1 Introduction

In an open economy, a monetary authority may respond to exchange rate changes in order to insulate their effects on inflation and on economic growth. In this type of monetary policy, a response to the exchange rate is incidental to standard price and output targets. Such a policy differs fundamentally from a policy of exchange rate targeting (sometimes pejoratively referred to as exchange rate manipulation), where the monetary authority responds independently to changes in the exchange rate itself.[1] This paper provides an approach for distinguishing between the two types of policies. Specifically, it combines data-rich estimation with a system of forward-looking equations characterizing a small open economy. To our knowledge, this paper is the first to extend the data-rich approach to the analysis of monetary policy in an open economy framework. The approach clarifies the role of the exchange rate in the monetary policy rule, and it allows for a more accurate assessment of the extent of exchange rate targeting.

The paper builds on the work of Calvo and Reinhart (2002), Reinhart and Rogoff (2004), Shambaugh (2004), Levy-Yeyati and Sturzenegger (2005), Ilzetzki, Reinhart, and Rogoff (2008), and others who provide measures of countries' *de facto* exchange rate arrangements. These papers classify exchange rate arrangements using indicators such as exchange rate variability and monetary aggregates. Like these papers, ours is concerned with discerning a country's *de facto* arrangement.[2] What we do differently from these papers is that we assess the role of the exchange rate arrangement in the context of the conduct of monetary policy itself.[3] Once an economy

[1]Engel (2009) provides a recent theoretical argument for managing the exchange rate in the presence of observed law of one price deviations. Other rationales sometimes given for a *de facto* policy of exchange rate management include concerns about the relative condition of the economy's traded sector, related concerns about export-led growth, and concerns about financial stability.

[2]Frankel et al. (2001) also look at *de facto* arrangements; however, rather than providing measures of exchange rate arrangements, their work is intended to use the behavior of the actual exchange rate to examine the verifiability of the *de jure* arrangements.

[3]Shambaugh (2004) explicitly considers the link between monetary policy and the exchange rate, but his classification of the exchange rate arrangement depends only on the behavior of the

opens its capital markets, exchange rate policy and monetary policy merge. To discern the exchange rate arrangement, one must examine the behavior of monetary policy. Thus, our focus is on the monetary authority's policy rule.[4] Our work more closely follows that of Lubik and Schorfheide (2007), who examine the importance of the exchange rate with a small, forward-looking open economy model; and our work builds on theirs by using data-rich estimation.

The data-rich approach is important for several reasons. First, it is conceptually important in the forward-looking equations that we use here. Forward-looking agents condition on the information available to them when making choices; and, the data rich approach enables the econometrician to correspondingly condition on much of the relevant variation in the large information set that is available. Second, Bai and Ng (2010) carefully demonstrate the superiority of the data rich approach to standard GMM in terms of the consistency and distribution of the estimated parameters. Finally, we find that the data-rich approach makes a meaningful empirical difference.

We rely on the recent work applying data-rich techniques to examine monetary policy rules in closed economies. Such techniques have helped to address a common criticism of much empirical work on closed-economies: that because so few variables are included, they are left with omitted variable bias. The data-rich approach makes it possible to use a great deal of information while retaining a blend of variable parsimony and dynamic generality. Building on the factor-model framework developed by Stock and Watson (1999, 2002), Bernanke and Boivin (2003) illustrate the usefulness of data-rich techniques in estimating a central bank's reaction function. Beyer,

exchange rate.

[4]While our approach has the advantage of a more general treatment of a country's exchange rate arrangement, it offers a complement to the earlier approaches, not a substitute for them. Assessing the exchange rate arrangement in the context of a monetary policy rule requires examining those arrangements over a period of time. So, it is a useful framework for countries with relatively stable exchange rate arrangements, or for those with a small number of changes that can be parameterized - such as observable changes in the stated targets, as in the case we study below. The earlier approaches require data only from short time periods; so, they can yield a useable gauge even when a country's exchange rate arrangements change from year to year.

Farmer, Henry, and Marcellino (2008) use data-rich estimation to study a system of forward-looking equations describing a closed economy.

To illustrate the approach in an open economy – specifically its importance in assessing the extent of exchange rate targeting, we examine the case of Korea. Korea is a relatively small, relatively open economy, whose exchange rate policies have been a subject of some controversy. After its economy was badly battered by the Asian financial crisis, the Bank of Korea officially began targeting inflation. While that has been its official policy since April 1, 1998, several authors have characterized its *de facto* policy quite differently. For example, Ilzetzki, Reinhart, and Rogoff (2008) classify it as having a crawling band or managed float; Levy-Yeyati and Sturzenegger (2005) classify Korea as having a fixed exchange rate from 1999 until their data end in 2004; and, after Korea's initial float, Frankel et al. (2001) find increasing evidence of pegging in the early post-crisis period. In addition, Eichengreen (2004) suggests that the exchange rate is important in Korea's monetary policy rule;[5] and, various U.S. officials, including members of Congress, have criticized Korea for its exchange rate policies.[6] The approach of this paper is intended precisely to address this question of whether a country has targeted inflation (as Korea claims it has) or instead has targeted its exchange rate.

As a benchmark, we first estimate a monetary policy rule with just a single equation. The result from that estimation replicates the key finding of previous studies: namely, it suggests there has been an inappropriately heavy weight on the exchange rate during the inflation-targeting period. This single-equation estimate, however, conflates what may be simply an indirect exchange rate role with what may be exchange rate targeting. In contrast, the data-rich, system approach disentangles

[5]Eichengreen is careful to point out that his results do not distinguish between the indirect and independent roles that the exchange rate may play in Korean monetary policy; however, he does suggest that its role does not merely reflect its usefulness in, say, forecasting inflation.

[6]U.S. Senator Lieberman, for example, re-introduced the "Fair Currency Enforcement Act" in 2005 to require the U.S. government to act against South Korea and other countries that are "engaged most egregiously in currency manipulation."

the two possibilities. It allows us to see clearly that the Bank of Korea's apparent response to the exchange rate was in service to its inflation and output targets. There was no independent role for the exchange rate *per se*. That is, the data-rich, system estimates – in contrast to past work – indicate that the Bank of Korea's monetary policy has not been one of exchange rate targeting.

2 Open-Econony Framework

This section describes a small, open economy. It has three main parts: a new-Keynesian Phillips curve, an Euler equation-based expectational IS curve, and a monetary policy rule.[7] The Phillips curve relies on Galí and Gertler's (1999) equation, which they derived from the optimal behavior of suppliers in a model with Calvo pricing. Our open-economy version of the equation links inflation, π_t, to expectations about future inflation, $E[\pi_{t+1}|\Omega_t]$ and to past inflation, π_{t-1}; to the economy's output gap, x_t; and, to a real depreciation of the home currency, which, following Lubik and Schorfheide (2007), is akin to an unfavorable supply disturbance. We focus on the output gap rather than a marginal cost measure primarily to facilitate a comparison with related work. In doing so, we rely on Galí and Gertler, who argue that these two measures are proportional in a setting with asynchronous pricing.[8] Specifically, the open-economy Phillips curve links inflation to its expected and past values, to the output gap, to a contemporaneous supply disturbance, s_t, and to the lagged real exchange rate depreciation, Δq_{t-1}, as follows:

$$\pi_t = \gamma_0 + \gamma_{E\pi} E[\pi_{t+1}|\Omega_t] + \gamma_\pi \pi_{t-1} + \gamma_x x_t + \gamma_q \Delta q_{t-1} + s_t. \tag{1}$$

The supply disturbance and real exchange rate depreciation, are themselves de-

[7]We focus on estimating the parameters of the monetary policy rule, which – as emphasized by Favero and Rovelli (2003), among others – is a somewhat less ambitious task than untangling the deeper objectives of the monetary authorities.

[8]See especially pages 200-201. Numerous other studies have used unemployment measures.

scribed by first order autoregressive processes:[9]

$$s_t = \rho_s s_{t-1} + \upsilon_{s,t} \tag{2}$$

$$\Delta q_t = \rho_q \Delta q_{t-1} + \upsilon_{q,t} \tag{3}$$

where $\upsilon_{s,t}$ and $\upsilon_{q,t}$ are taken to be stationary, mean-zero, i.i.d. innovations.

Next is a forward-looking, open-economy equation similar to a traditional IS curve. Like the standard, closed-economy version that is often generalized from a representative consumer's Euler equation, this one links the output gap both to its past and to expectations about its future, to the real interest rate, $i_t - E[\pi_{t+1}|\Omega_t]$, and to a contemporaneous demand disturbance, d_t.[10] In the open-economy version, the change in the real exchange rate and the foreign output gap, x^f, also play a role, as follows:

$$x_t = \beta_0 + \beta_{Ex}E[x_{t+1}|\Omega_t] + \beta_i(i_t - E[\pi_{t+1}|\Omega_t]) + \beta_x x_{t-1} + \beta_q \Delta q_t + \beta_{x^f} x_t^f + d_t, \tag{4}$$

Here, the demand disturbance is assumed to be stationary, mean-zero i.i.d.; and the foreign output gap is given by a stationary, AR(1) process:

$$x_t^f = \rho_{x^f} x_{t-1}^f + \upsilon_{x^f,t} \tag{5}$$

where $\upsilon_{y^f,t}$ is a stationary, mean-zero i.i.d. innovation.

By definition, real exchange rate depreciation reflects both nominal exchange rate depreciation, Δe_t, and the domestic and foreign inflation difference, $(\pi_t - \pi_t^f)$.

[9] This treatment of the real exchange rate follows Lubik and Schorfheide's (2007) corresponding characterization of the terms of trade.

[10] Our use of both lagged and expected output follows the hybrid approach of Fuhrer and Rudebusch (2002).

$$\Delta q_t = \Delta e_t - (\pi_t - \pi_t^f) \tag{6}$$

Note that this equation does not constrain Δq_t. That is, we do not impose purchasing power parity here, either in its absolute or relative form.

Foreign inflation, like foreign output, is assumed to be a stationary, AR(1) process.

$$\pi_t^f = \rho_{\pi^f} \pi_{t-1}^f + \upsilon_{\pi^f,t}. \tag{7}$$

Finally, we include a monetary policy rule.[11] Here, we adapt Clarida, Galí, and Gertler's (2000) interest rate rule to allow the central bank to target the expected change in the exchange rate. In their baseline rule, Clarida, Galí, and Gertler also include the contemporaneous output gap and the expected difference between inflation and its target. Thus, the interest rate rule becomes:

$$i_t^* = \bar{i} + \alpha_x(x_t - x_t^*) + \alpha_\pi(E[\pi_{t+1}|\Omega_t] - \pi_t^*) + \alpha_e(E[\Delta e_{t+1}|\Omega_t] - \Delta e_t^*), \tag{8}$$

where asterisks represent the targeted values; and, $\bar{i}$ is a benchmark interest rate. If monetary policy is used to target the nominal exchange rate *per se*, then α_e is nonzero.[12]Noting the renewed controversy over whether a monetary authority

[11]In some countries, the Ministry of Finance influences the monetary authority and is officially responsible for exchange rate policy. However, in this paper, we characterize the policy decisions as being taken by the monetary authority. We believe this is appropriate for two, related reasons. First, sustained exchange rate policies require the cooperation of the monetary authority. Second, and most importantly, we are interested in the monetary policy that goes into effect, regardless who might influence it.

[12]Note that this specification captures the role of nonsterilized intervention: since nonsterilized intervention does not provide an independent avenue for the implementation of monetary policy, it involves concomitant interest rate changes, which are observed here. Sterilized intervention, however, is not captured here: given sufficient financial barriers, sterilized intervention could potentially be used to target the nominal exchange rate in a way that is divorced in the short run from the domestic interest rate. However, our focus here is on countries that, such as Korea, that are opening up their capital markets. We rely on the extensive literature indicating that, for these

should respond to contemporaneous variables or to forecast variables, the estimation section also includes a specification that allows the authority to respond to the contemporaneous exchange rate change, instead of its expected value.

Like Clarida, Galí and Gertler, we also allow for partial adjustment of the interest rate to the target. Empirically, we allow for two periods of adjustment, rather than just one, to accommodate a very gradual adjustment of the call money rate.[13]

$$i_t = (1 - \rho_1 - \rho_2)i_t^* + \rho_1 i_{t-1} + \rho_2 i_{t-2} + \varepsilon_t. \tag{9}$$

Here, ρ_1 and ρ_2 represent the interest-rate smoothing parameters; and ε_t represents the unsystematic component of monetary policy, and it is assumed to have a mean of zero.

Substituting the interest rate target into the partial adjustment equation gives:

$$i_t = \tilde{\alpha}_0 + \tilde{\alpha}_x x_t + \tilde{\alpha}_\pi E[\pi_{t+1}|\Omega_t] + \tilde{\alpha}_e E[\Delta e_{t+1}|\Omega_t] + \varepsilon_t, \tag{10}$$

where we let x^* and Δe^* be constants; and, $\tilde{\alpha}_0 = (1-\rho_1-\rho_2)\bar{i} - \alpha_x x^* - \alpha_\pi \pi^* - \alpha_e \Delta e^*$, $\tilde{\alpha}_x = (1 - \rho_1 - \rho_2)\alpha_x$, $\tilde{\alpha}_\pi = (1 - \rho_1 - \rho_2)\alpha_\pi$, and $\tilde{\alpha}_e = (1 - \rho_1 - \rho_2)\alpha_e$.

Notice that the exchange rate coefficient in Equation 10 involves only the monetary policy parameter, α_e and the smoothing parameters, ρ_1 and ρ_2. If we were to combine the equations into a reduced form version of equation 10, then the exchange rate coefficient would involve all of the policy parameters, α_e, α_x, and α_π, along with the smoothing parameters, ρ_1 and ρ_2. The extra terms in the reduced form coefficient come from two sources. First, the real exchange rate change enters the Phillips curve expression for inflation, and inflation enters the policy rule. Second, the real exchange rate change enters the Euler equation describing output, and output also enters the policy rule. That is, because the real exchange rate influences

countries, sterilized intervention is only effective for extremely brief periods. In such countries, a sustained exchange rate policy must be consistent with monetary policy.

[13] See Bank of Korea (2008), and Kim and Park (2006).

inflation and output, the nominal exchange rate would appear in a reduced form version of the interest rate equation *even if the exchange rate itself is absent from the monetary policy rule.* As we discuss below in the context of the estimation, it is important to keep this observation in mind when interpreting the coefficients on single-equation estimates of monetary policy rules.

3 Estimation

In this section, we present estimates from four alternative approaches. We first use standard GMM to estimate the forward-looking Phillips curve, Euler equation, and policy reaction function described by equation 1, 4, and 10. We estimate these equations both singly and as a system; these initial, standard GMM estimates are useful in comparing our findings to those of existing studies. Next, we follow Bernanke and Boivin (2003) in augmenting the GMM estimation with a data-rich approach. Bernanke and Boivin emphasize the importance of the data-rich approach in estimating a forward-looking policy rule. They note that such an approach captures the fact that the monetary authority conditions on a great deal of information in constructing its forecasts. (Bernanke and Boivin, in turn, build on the macroeconomic forecasting work of Stock and Watson, 1999 and 2002.) Bernanke and Boivin focus their attention on the United States in a closed economy framework, but their insights are equally applicable to estimates of a policy reaction function in an open economy. The same insight is also important in the estimation of the other equations, given that they too involve agents' expectations. So, we use the data-rich approach both to estimate the equations singly and as a system.

In all of the estimates described below, we use Korean data from January, 1999 to April, 2008. This period encompasses most of the Bank of Korea's experience with its stated policy of inflation targeting. During that time, the annual inflation target, π_t^* moved from 3.0 percent for overall CPI in 1999, to 2.5 percent for core inflation (CPI less petroleum and agricultural products) in 2000, to 3.0 percent for the core afterwards. Correspondingly, we allow the inflation targets to change, and we use those official year-ahead targets and inflation rates in the estimation. The overnight call-money rate is used as the interest rate.[14] For the output gap, we first detrend industrial production using a Hodrick-Prescott filter. However, we also report estimates using the Baxter-King filter. The nominal exchange rate is measured bilaterally against the dollar, and for the foreign variables, we use U.S. data.[15] In all of the estimates, the expected values of future variables are instrumented, either through standard GMM or through factor instrumental variables.

3.1 Standard GMM

We start with a standard, single-equation GMM estimation. We use as instruments: a constant and lagged values of the interest rate, inflation, and the output gap; and we adjust for heteroskedasticity and serial correlation.[16] The results of this estimation are given in the first column of Table 1.[17] The first panel gives the estimates of equation 1, the Phillips curve. We find strongly significant coefficients on both expected inflation and lagged inflation, as well as on the output gap, while the real exchange rate is only mildly significant.[18] The second panel gives the Euler equation estimate. There, we find that both expected and lagged output are strongly significant. While the significance of expected output contrasts with the findings of Fuhrer and Rudebusch (2002), it is predicted by Euler equation for consumption. We

[14]The overnight call money rate has been used as the monetary policy operating target since 1999. See Bank of Korea (2008).

[15]As noted by Eichengreen (2004), both McKinnon and Schnable (2003) and Oh (2004) show that the won is more closely linked to the U.S. dollar than to other currencies.

[16]We use the first through sixth lags, along with the ninth and twelfth lags, as is used in so many other studies. We note that correcting for serial correlation is particularly important here since there are overlapping observations of forward-looking expectations.

[17]The J test (not reported) of the joint hypothesis of correct specification and valid instruments is not significant for any of the estimated single equations.

[18]The negative coefficient on the output gap is in keeping with many earlier results. Galí and Gertler (1999) attribute this surprising finding primarily to the fact that movements in output tend to lead the changes in marginal costs that underlie the theoretical relationship (page 204).

also find that the lagged change in the real exchange rate appears to be important as well.

The third panel gives the equation that interests us most: the interest rate equation. Broadly speaking, the estimates of this single-equation are similar to those of Eichengreen (2004), who estimates a Korean policy reaction function for the early part of the period, ending in May, 2003. There is evidence of substantial smoothing; and, the estimated inflation, output gap, and expected exchange rate depreciation coefficients are all positive, as might be expected. The estimated coefficients on the output gap and on the exchange rate are both significantly different from zero. In contrast, the estimated coefficient on the inflation rate is small and is not significantly different from zero. If interpreted as a monetary policy rule, rather than as a reduced form, the estimated exchange rate coefficient would suggest that the interest rate target would be lowered in response to an expected currency appreciation. In contrast, the inflation coefficient estimates would seem to suggest that there is little, if any, response to expected inflation. Such an interpretation would be strongly at odds with a presumption of inflation targeting.

The second column gives the standard GMM estimates of the full system. The Phillips curve estimates are largely unchanged, as are most – but not all – of the Euler equation estimates. The exception is the coefficient on the real interest rate, which has moved from positive and insignificant to negative (as predicted by theory) and mildly significant. We see a few changes in the interest rate equation. First, the estimated coefficient on output is somewhat larger than the single equation estimate, but it is less significant. Second, while the estimated coefficient on inflation has changed sign, it remains very small in absolute value. Finally, the exchange rate coefficient is even larger and is still highly significant.[19]

[19] We also note that – in this one instance – the J test rejects the joint hypothesis of correct specification and valid instruments. This rejection is not found in any of the subsequent estimations, which use factor instrumental variables.

3.2 Factor Instrumental Variables

As discussed above, the expectations of agents, including the central bank, are formed using a multitude of economic indicators. In standard GMM estimation, it would be impossible to condition on all the information available, even if the information were observable by the econometrician. As noted by Bai and Ng (2010) in their work on data-rich estimation, standard GMM estimates using a large number of instruments are known to be biased, and they can be inconsistent as well. We rely on the results of Bai and Ng who combine GMM with the data-rich approach in their "factor instrumental variables estimator." This estimator incorporates more information than is used in the standard GMM estimate, and it has two important statistical properties. First, it is consistent even when the number of instruments exceeds the sample size. Second, it is consistent even when the instruments themselves are invalid, as long as the unobserved factors driving the economy are valid instruments. These two properties mean that we can condition on the informational content of a very large number of variables.

To construct the Bai and Ng estimator, we use 151 monthly, Korean economic series. The list includes a diverse set of variables, representing all of the categories that Stock and Watson (2002) used to forecast U.S. macroeconomic variables.[20] For the foreign variables, we use all of the series in DataStream's "key indicators" grouping that are available on a monthly basis for the United States; this leaves us with 59 U.S. variables. We then transform all of the domestic and foreign series to induce stationarity. The appendix lists the variables and the transformations that were used.[21] Next, we calculate the principal components of the entire set of variables to use as instruments. We use sixteen domestic and sixteen foreign factors,

[20]Stock and Watson (2002) use 215 series in their forecasting exercise. Bernanke, Boivin, and Eliasz (2005) use a subset of that – a balanced panel of 120 variables. Our set of 151 variables also comprise a balanced panel, though – as Stock and Watson (2002) point out – a balanced panel is not necessary.

[21]The transformations largely follow Stock and Watson (2002), except for prices and money, which were first differenced (as in Bernanke, Boivin, and Eliasz, 2005), not twice differenced.

along with six lags of the interest rate.[22]

The single-equation, factor-instrumental variables estimates are given in the third column of Table 1.[23] The Phillips curve again is given in the top panel of the table. We now find a larger, and more precisely estimated coefficient on expected inflation than on lagged inflation. This result echoes that of Beyer, Farmer, Henry, and Marcellino (2008) in their closed-economy study using U.S. data. Like them, we also find (as before) a negative coefficient on the output gap. Given the myriad of differences between the U.S. and Korean economies, the point estimates are remarkably close. In their single equation estimates, Beyer, Farmer, Henry, and Marcellino report U.S. coefficients of .78 on expected inflation, .23 on lagged inflation, and -.07 on the output gap, compared with our corresponding point estimates of .58, .26, and -.01.

The data-rich estimates of the single-equation version of the open-economy Euler condition are given in the second panel. The point estimates are all of the expected sign: all of the estimated coefficients on output (lagged, expected, and foreign) and the exchange rate are positive; and the estimated coefficient on the interest rate is negative. In addition, the output coefficients are all statistically significant, including foreign output. This latter finding is consistent with Lubik and Schorfheide's (2007) finding for Canada, where foreign output also seems to be important in the Euler equation specification.

The interest rate equation is given in the bottom panel. The estimated coefficient on output is slightly larger, but less statistically significant. As before, the coefficient on the exchange rate is positive and statistically significant, though somewhat less so. The estimated coefficient on the inflation rate remains less than one and is again insignificant. If we were viewing this reduced form estimate of the interest

[22]The Bai and Ng (2002) criteria suggest that at least thirteen factors are needed to capture the variation in the series used here for each country.

[23]In this and all of the remaining estimations the J test does not reject the joint hypothesis of correct specification and valid instruments.

rate equation as being indicative of the Bank of Korea's monetary policy rule, we still might be misled into thinking that their exchange rate target trumped their inflation target. As we shall see, the multiple equation, factor-instrumental variable estimation that follows strongly contradicts this interpretation.

Using the full system builds on the work of Beyer et al. (2008), who demonstrate the usefulness of a full-system data-rich GMM approach in the closed economy setting. It is only here that we are able to clearly interpret the estimates in terms of the underlying monetary policy rule. Specifically, only when we estimate the interest rate rule in the context of the full system, are we able to discern whether or not the exchange rate is a distinct target. The system estimation also provides a clearer interpretation of the coefficient on inflation in the interest rate equation. To estimate the complete system, we follow Beyer et al. and again use the Bai and Ng factor instrumental variables approach. Using the same instruments, we now estimate the equations simultaneously. The resulting system estimates are given in the final column.

The top panel gives the new estimate of the Phillips curve. Our system results are similar to the other Phillips curve estimates in many respects. As before, both recent inflation and expectations of future inflation are important in explaining current inflation. The point estimates of the coefficients on recent and forecast inflation are statistically significant, and the point estimates of the coefficient on forecast inflation is somewhat greater than that on lagged inflation. The estimated coefficient on the output gap is again negative and significant. The exchange rate again matters little.

The next panel gives the Euler equation. By and large, the system estimation has little impact on the coefficient estimates, except past output gets a larger weight relative to expected output. All of the output variables, including foreign output, are again positive and statistically significant, while the estimated coefficients on the interest rate remains statistically insignificant. While the exchange rate becomes mildly significant, and the weight on past output is somewhat higher, the use of the full system does not appreciably affect our understanding of the workings of either the Phillips curve or the Euler equation.

Striking differences do arise, however, in the third panel, which gives the estimates of the monetary policy rule. Here, the estimated coefficient on the exchange rate shrinks and loses its statistical significance entirely. At the same time, the estimated coefficients on the output gap and on inflation rise. Both are significant at the one percent level; and the inflation coefficient is large. Most importantly, the inflation estimate exceeds one. In contrast to past findings, this suggests that the Bank of Korea does not accommodate inflation.

Two robustness checks are provided in the next table. Here, we first re-estimate the system using the contemporaneous exchange rate change in lieu of the expected change in the policy equation. Then, we re-estimate the system replacing the Hodrick-Prescott filter with the Baxter-King approach. As shown in the first column, using the contemporaneous exchange rate has little effect on the estimates except that the inflation coefficient becomes somewhat larger. As shown in the second column, the change in the detrending method also has little impact on the results, with the only notable change involving the domestic output variables in the Euler equation. There, the point estimate on lagged output falls somewhat; and the estimate on expected output becomes somewhat less statistically significant.

Overall, we again find that the estimate of α_π, the response to inflation, exceeds one; and the estimate of α_e, the response to the exchange rate change, is essentially zero. Together, these findings reinforce our earlier conclusion that Korea's inflation targeting has not taken a back seat to exchange rate targeting. While the estimates of α_x, the response to the output gap, also remain positive and significant, Korea's *de facto* policy nevertheless is largely in keeping with it's official one: inflation targeting.

4 Conclusions

This paper combines a small, open-economy system with a data-rich estimation technique to study the exchange rate targeting. As countries open up their capital markets, gauges of their exchange rate policies must be embedded in assessments of their monetary policies. Unfortunately, standard, single equation estimates of monetary policy rules conflate the two ways that the exchange rate can influence monetary policy. Policy can respond to the exchange rate because of the exchange rate's influence on output or inflation; or it can respond to the exchange rate because the exchange rate, itself, is a target of policy. By ignoring the indirect role, single-equation estimates of monetary policy rules are left with omitted variable bias. In contrast, data-rich, system equation estimates are designed to address both this particular omitted variable bias and the omitted variable bias that arises from a lack of conditioning on available information. Combining system estimates with data-rich techniques provides a way to disentangle inflation targeting from exchange rate targeting in a monetary policy rule.

We apply the data-rich, system approach to the question of whether Korea's recent *de facto* monetary policy has been the same as its *de jure* policy of inflation targeting, or whether it has been one of exchange rate targeting. We find that the exchange rate influences Korean monetary policy only indirectly, through its effect on output and inflation. In contrast to what has been suggested by past exchange rate classification studies, Korea appears very much to be following its *de jure* policy of inflation targeting. During this period, it has not been an exchange rate targeter.

The framework of this paper can be applied to a broad range of economies for a variety of purposes. It can be used to improve our understanding and assessment of other indicators of *de facto* exchange rate arrangements. It also can provide a clearer insight into an economy's use of inflation targeting. In addition, it may help provide a sense of how monetary policy rules change in the face of institutional developments. For example, it could be used to gauge the extent of exchange rate targeting undertaken by emerging, EU periphery countries in advance of possible EU membership. We regard both pillars of this approach – the system and the data-rich techniques – as steps forward in exploring exchange rate policies.

Table 1: Estimation

		Standard GMM		**Data-Rich GMM**	
		Single Equation	System	Single Equation	System
Equation	Variable	(1)	(2)	(3)	(4)
π_t	$E[\pi_{t+1}\|\Omega_t]$	0.4818***	0.5726***	0.5780***	0.6275***
		(0.1019)	(0.0343)	(0.1071)	(0.0657)
	π_{t-1}	0.4815***	0.5373***	0.2595*	0.4544***
		(0.1125)	(0.0321)	(0.1277)	(0.0806)
	x_t	-0.0069***	-0.0074***	-0.0069***	-0.0042***
		(0.0017)	(0.0011)	(0.0018)	(0.0013)
	Δq_{t-1}	0.0072*	-0.0026	0.0071	0.0032
		(0.0043)	(0.0038)	(0.0046)	(0.0030)
x_t	x^e_{t+1}	0.5729***	0.5565***	0.4315***	0.1882**
		(0.1076)	(0.1106)	(0.0683)	(0.0863)
	$i_t - E[\pi_{t+1}\|\Omega_t]$	0.9256	-1.3873*	-0.3649	0.2427
		(0.9242)	(0.8083)	(0.6876)	(0.4117)
	x_{t-1}	0.4822***	0.4680***	0.5574***	0.9602***
		(0.1578)	(0.1103)	(0.0949)	(0.0773)
	Δq_t	0.9027***	0.7150**	0.2597	-0.3514*
		(0.2353)	(0.2988)	(0.1890)	(0.2078)
	x^f_t	0.0087	0.0097***	0.0087**	0.0200***
		(0.0057)	(0.0035)	(0.0038)	(0.0034)
i_t	$x_t - x^*$	0.0284***	0.0475**	0.0587*	0.0936***
		(0.0066)	(0.0225)	(0.0339)	(0.0329)
	$E[\pi_{t+1}\|\Omega_t] - \pi^*$	0.1258	-0.0118	0.4003	2.1037***
		(0.5168)	(0.5884)	(0.9064)	(0.7797)
	$E[\Delta e_{t+1}\|\Omega_t] - \Delta e^*$	0.0863***	0.1087***	0.0591**	0.0196
		(0.0213)	(0.0260)	(0.0286)	(0.0244)
	i_{t-1}	1.2279***	1.2267***	1.3416***	1.2491***
		(0.0427)	(0.1172)	(0.0459)	(0.0915)
	i_{t-2}	-0.3578***	-0.3731***	-0.4411***	-0.3727***
		(0.0356)	(0.1011)	(0.0347)	(0.0810)

Notes: All variables are observed monthly from January 1999 through April 2008 and are transformed following the procedures in Stock and Watson (2002) except as noted in the text. HAC standard errors allowing for the MA(12) error structure are reported in parenthesis beneath the estimates. The standard GMM instrument set includes lags 1-6, 9 and 12 of the Korean overnight call money rate (monthly average), industrial production and the inflation rate. The Data-rich instrument set includes the first six lags of the Korean call money rate as well as lags 1-6, 9 and 12 of the first two principal components obtained from the 151 variable Korean economic indicators data set, and the 59 variable data set of U.S. economic indicators. Only in column 2 is the J statistic large enough to reject at any standard confidence level; there, the statistic, which is $\chi^2(58)$, equals 89.3 and is significant at the one percent level. Asterisks denote significance at the ten (*), five (**), and one (***) percent levels.

Table 2: Robustness Tests

		Data-Rich System GMM	
		Contemporaneous Exchange Rate	Baxter-King Detrending
Equation	Variable	(1)	(2)
π_t	$E[\pi_{t+1}\|\Omega_t]$	0.6488***	0.6425***
		(0.0685)	(0.0626)
	π_{t-1}	0.4163***	0.4191***
		(0.0838)	(0.0761)
	x_t	-0.0044***	-0.0090***
		(0.0014)	(0.0018)
	Δq_{t-1}	0.0027	0.0006
		(0.0032)	(0.0030)
x_t	x^e_{t+1}	0.2263***	0.2192**
		(0.0850)	(0.1090)
	$i_t - E[\pi_{t+1}\|\Omega_t]$	0.2786	0.2867
		(0.4108)	(0.3587)
	x_{t-1}	0.9396***	0.7787***
		(0.0767)	(0.0982)
	Δq_t	-0.3225	-0.2704
		(0.2006)	(0.1970)
	x^f_t	0.0186***	0.0189***
		(0.0033)	(0.0032)
i_t	$x_t - x^*$	0.1119***	0.0975***
		(0.0296)	(0.0317)
	$E[\pi_{t+1}\|\Omega_t] - \pi^*$	2.5727***	2.2061***
		(0.6082)	(0.7471)
	$\Delta e_t - \Delta e^*$	0.0255	–
		(0.0174)	–
	$E[\Delta e_{t+1}\|\Omega_t] - \Delta e^*$	–	0.0272
		–	(0.0214)
	i_{t-1}	1.2397***	1.2623***
		(0.0917)	(0.0932)
	i_{t-2}	-0.3653***	-0.3941***
		(0.0830)	(0.0824)

Notes: The J-statistics are $\chi^2(76)$ and equal to 88.1 in column 1 and 87.3 in column 2; neither is significant at any standard confidence levels. For other notes, see Table 1.

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Appendix: Data Description

The data, their sources, and their transformations (None, Log, First Difference, First Difference of Logs) are listed below. All of the data are monthly, from 1999:01 to 2008:04.

Korean Variables

Sources:
NSO: Korean National Statistical Office
MOL: Ministry of Land, Transport and Maritime Affairs
KCS: Korea Customs Service
KE: Korea Exchange
BOK: Bank of Korea
IFS: International Monetary Fund

Manufacturing

Industrial Production Index (IPI), NSO, Log Diff
IPI: Mining and Quarrying (MQ), NSO, Log Diff
IPI: Manufacturing, NSO, Log Diff
IPI: Mfg: Intermediate Goods, NSO Log Diff
IPI: Mfg: Consumer Goods NSO Log Diff
IPI: Mfg: Consumer Goods: Durable NSO Log Diff
IPI: Mfg: Consumer Goods: Non-durable NSO Log Diff
Manufacturing Production Capacity Index (MPCI) NSO Log Diff

Employment

Agriculture, Forestry and Fishery (AF) NSO Log Diff
AF: Agriculture and Forestry NSO Log Diff
AF: Fishing NSO Log Diff
Mining and Manufacturing (MM) NSO Log Diff
MM: Mining NSO Log Diff
MM: Manufacturing NSO Log Diff
Social Overhead Capital and Other Services (SO) NSO Log Diff
SO: Construction NSO Log Diff
SO: Wholesale, Retail Trade, Restaurants and Hotels (WR) NSO Log Diff
SO: WR: Wholesale, Retail Trade NSO Log Diff
SO: WR: Hotels and Restaurants NSO Log Diff
SO: Electricity, Transport, Storage and Finance (ET) NSO Log Diff
SO: ET: Electricity, Gas and Water Supply NSO Log Diff
SO: ET: Transport NSO Log Diff
SO: ET: Post and Telecommunications NSO Log Diff
SO: ET: Financial Institutions and Insurance NSO Log Diff
SO: Business, Personal and Public Services (BP) NSO Log Diff
SO: BP: Real Estate and Renting and Leasing NSO Log Diff
SO: BP: Business Activities NSO Log Diff
SO: BP: Public Adm and Defense, Compulsory Social Security NSO Log Diff
SO: BP: Education NSO Log Diff
SO: BP: Health and Social Work NSO Log Diff
SO: BP: Recreational, Cultural and Sporting Activities NSO Log Diff
SO: BP:Other Community,Repair and Personal ServiceActivities NSO Log Diff
SO: BP: Private Households with Employed Persons NSO Log Diff
SO: BP: Extra Territorial Organizations and Bodies NSO Log Diff
Employment NSO Log Diff
Unemployment Rate NSO Log
Unemployment Rate: Age 15 to 19 NSO Log
Unemployment Rate: Age 20 to 24 NSO Log
Unemployment Rate: Age 25 to 29 NSO Log

Unemployment Rate: Age 30 to 34 NSO Log
Unemployment Rate: Age 35 to 39 NSO Log
Unemployment Rate: Age 40 to 44 NSO Log
Unemployment Rate: Age 45 to 49 NSO Log
Unemployment Rate: Age 50 to 54 NSO Log
Unemployment Rate: Age 55 to 59 NSO Log
Unemployment Rate: Age 60 and Over NSO Log
Monthly Earnings: All Industries MOL Log Diff
Labour Force (2 week search) NSO Log Diff
Avg Monthly Man Days: Total MOL Log
Avg Monthly Man Days: Manufacturing MOL Log
Avg Monthly Hours Worked: Overtime: All Industries MOL Log
Avg Monthly Hours Worked: Overtime: Manufacturing MOL Log
Bldgs Authorized for Construction: Total MLT Log Diff
Bldgs Authorized for Construction: Dwelling MLT Log Diff

Miscellaneous

Producers' Inventory Index (PII) NSO Log
LDCI: Consumer Expectation Index NSO Log
Consumer Expectation Index (CEI) NSO Log
Imports cif KCS Log Diff
Exports fob KCS Log Diff
Trade Balance KCS Log Diff

Equities

Index: KOSPI KE Log Diff
Index: KOSPI 200: Composite KE Log Diff
Index: KOSPI 200: Manufacture KE Log Diff
Index: KOSPI 200: Electricity and Communication KE Log Diff
Index: KOSPI 200: Construction KE Log Diff
Index: KOSPI 200: Circulative Service KE Log Diff
Index: KOSPI 200: Financial Service KE Log Diff
Index: KOSPI: Manufacturing Industry Index KE Log Diff
Index: KOSPI: Food and Beverages KE Log Diff
Index: KOSPI: Textile and Wearing Apparel KE Log Diff
Index: KOSPI: Paper and Wood Products KE Log Diff
Index: KOSPI: Chemicals KE Log Diff
Index: KOSPI: Medical Supplies KE Log Diff
Index: KOSPI: Non Metallic Mineral Products KE Log Diff
Index: KOSPI: Iron and Metal Products KE Log Diff
Index: KOSPI: Machinery KE Log Diff
Index: KOSPI: Electrical and Electronic Equipment KE Log Diff
Index: KOSPI: Transport Equipment KE Log Diff
Index: KOSPI: Distribution Industry KE Log Diff
Index: KOSPI: General Construction KE Log Diff
Index: KOSPI: Transport and Storage KE Log Diff
Index: KOSPI: Financial Institutions KE Log Diff
Index: KOSPI: Financial Institutions: Banks KE Log Diff
Index: KOSPI: Financial Institutions: Securities KE Log Diff
Index: KOSPI: Financial Institutions: Insurance KE Log Diff
Dividend Yield: Mth Avg: Weighted: KOSPI: Total KE Log
PE Ratio: KOSPI: Mth End: Weighted: Total KE Log
PE Ratio: KOSPI: Mth Avg: KOSPI 200 KE Log

Exchange Rates

Forex: Korean Won To USD BOK Log Diff
Forex: Korean Won to Swiss Franc BOK Log Diff
Forex: Korean Won to Japanese Yen BOK Log Diff
Forex: Korean Won to British Pound BOK Log Diff
Forex: Korean Won to Canadian Dollar BOK Log Diff

Interest Rates

Discount Rate (End of Period) IFF De-meaned

Money Market Rate IFS De-meaned
Corporate Bond Rate IFS De-meaned
Time Deposit at DMB: 1 Yr. or More IFS De-meaned
Lend Rate on DMB Loans:Minimum IFS De-meaned
Yield on Nat'l Housing Bonds, 1, 2 IFS De-meaned

Money Supply

Reserve Money: Month Avg BOK Log Diff
New M1: Month Avg BOK Log Diff
New M2: Month Avg BOK Log Diff
Liquidity Aggregates of Financial Institutions:Mth Avg BOK Log Diff
New M1: Month Avg: sa BOK Log Diff
New M2: Month Avg: sa BOK Log Diff
Liquidity Aggregates of Financial Inst: Mth Avg: sa BOK Log Diff
New M2: Month Avg: Currency in Circulation BOK Log Diff
New M2: Month Avg: Demand Deposits BOK Log Diff
New M2: Month Avg: Transferable savings Deposit BOK Log Diff
New M2: Month Avg: MMF BOK Log Diff
New M2: Month Avg: Short Term Time and Savings Deposits BOK Log Diff
New M2: Month Avg: Certificate of Deposit BOK Log Diff
New M2: Month Avg: Bills Sold BOK Log Diff
New M2: Month Avg: CMA BOK Log Diff
New M2: Month Avg: Beneficial Certificates (BC) BOK Log Diff
New M2: Month Avg: Short Term Money in Trust BOK Log Diff
New M2: Month Avg: Bills Issued BOK Log Diff
New M2: Month Avg: Securities Investment Savings BOK Log Diff
New M2: Month Avg: Short Term Foreign Currency Deposit BOK Log Diff
New M2: Month Avg: Short Term Financial Debentures BOK Log Diff
New M2: Month Avg: Repurchase Agreement BOK Log Diff
New M2: Month Avg: Central Bank BOK Log Diff
New M2: Month Avg: Other Depository Corporations (OD) BOK Log Diff
New M2: Month Avg: OD: Commercial and Specialized Banks BOK Log Diff
New M2: Month Avg: OD: Merchant Banking Corporations BOK Log Diff
New M2: Month Avg: OD: Investment Trust companies BOK Log Diff
New M2: Month Avg: OD: Trust Accounts of Banks BOK Log Diff
New M2: Month Avg: OD: Mutual Saving Banks BOK Log Diff
New M2: Month Avg: OD: Mutual Credits BOK Log Diff
New M2: Month Avg: OD: Credit Unions BOK Log Diff
New M2: Month Avg: OD: Postal Savings BOK Log Diff
New M2: Month Avg: OD: Community Credit Cooperatives BOK Log Diff
New M2: Month Avg: OD: The Export-Import Bank of Korea BOK Log Diff

Prices

PPI: All Commodities and Services BOK Log Diff
PPI: Commodities BOK Log Diff
PPI: Commodities: Agricultural, Forestry and Marine Products (AF) BOK Log Diff
PPI: Commodities: Mining Products (MP) BOK Log Diff
PPI: Commodities: Manufacturing Industry Products (MI) BOK Log Diff
PPI: Commodities: Mining Products (MP) BOK Log Diff
CPI: Overall NSO Log Diff
CPI: Food and Non-Alcoholic Beverages (FB) NSO Log Diff
CPI: Alcoholic Beverages and Cigarettes (BT) NSO Log Diff
CPI: Clothing and Footwear NSO Log Diff
CPI: Housing, Water and Fuels (HW) NSO Log Diff
CPI: Furnishings and Household Equipment (FH) NSO Log Diff
CPI: Health NSO Log Diff
CPI: Transportation NSO Log Diff
CPI: Communication NSO Log Diff
CPI: Culture and Recreation NSO Log Diff
CPI: Education NSO Log Diff
CPI: Miscellaneous Goods and Services NSO Log Diff
CPI: Agricultural Products and Oils NSO Log Diff
CPI: Core, excl Agricultural Products and Oils NSO Log Diff

U.S Variables
Source: Datastream

Average hourly earnings per worker in manufacturing industry Log Diff
Avg hourly real earnings - private nonfarm industries Log Diff
Avg hrly earn - total private nonfarm Log Diff
Avg wkly hours - total private NONFARM None
Capacity utilization rate - all industry None
Chain-type price index for pce less food and energy (core) Log Diff
Chain-type price index for personal consumption expenditure Log Diff
Chicago purchasing manager business barometer (sa) None
Commercial bank assets - commercial and industrial loans Log Diff
Commercial bank assets - loans and leases in bank credit Log Diff
Construction expenditures - total (ar) Log
Consumer confidence index None
Consumer credit outstanding Log Diff
CPI - all items less food and energy (core) Log Diff
CPI - all urban sample: all items - annual inflation rate Log Diff
CPI - all urban: all items Log Diff
Disposable personal income (monthly series) (ar) Log Diff
Dow jones industrials share price index (ep) Log Diff
Employed - nonfarm industries total (payroll survey) Log Diff
Export price index - all commodities (end use) Log Diff
Exports f.a.s. Log Diff
Federal funds rate (monthly average) Diff
Federal funds target rate (ep) Diff
Federal government budget balance Diff
Foreign net long term flows in securities Log Diff
Foreign reserve assets Log Diff
Import price index - all commodities (end use) Log Diff
Imports f.a.s. Log Diff
Index of help wanted advertising None
Industrial production - manufacturing (naics) Log Diff
Industrial production - total index Log Diff
ISM purchasing managers index (mfg survey) None
Monetary base Log Diff
Money supply M1 Log Diff
Money supply M2 (BCI 106) Log Diff
New passenger cars - total registrations Log Diff
New private housing units authorized by building permit (ar) Log
New private housing units started (ar) Log
Personal consumption expenditures (monthly series) (ar) Log Diff
Personal income (monthly series) (ar) Log Diff
Personal saving as Philadelphia fed outlook survey - diffusion index manufacturing None
Population (estimates used in national accounts) Log Diff
PPI - Finished goods Log Diff
PPI - Finished goods less foods and energy (core) Log Diff
Prime rate charged by banks Diff
Sales of new one family houses (ar) Log
Terms of trade rebased to 1975=100 Log Diff
The conference board leading economic indicators index None
Total civilian employment Log Diff
Total treasury securities outstanding (public debt) Log Diff
Trade-weighted value of us dollar against major currencies Log Diff
Treasury bill rate - 3 month (ep) Diff
Treasury yield adjusted to constant maturity - 20 year Diff
Unemployed - (16 yrs and over) Log Diff
Unemployment rate None
University of michigan consumer sentiment index None
US 3 Month interbank rate (london) (mth.avg.) Diff
Visible trade balance f.a.s.-f.a.s. Diff