Monetary Rules and Policy Targets under Managed Exchange Rates and Capital Controls: *The Case of China*

Hongyi Chen*and Paul D. McNelis‡

November 2017

Abstract

This paper examines the performance of monetary policy rules when the economy finds itself in dark corners, when the real sector experiences a sequence of prolonged negative shocks from world demand, while the central bank faces low world interest rates on its foreign-exchange reserve holdings. We examine variations of policy rules and targets, one with strong restrictions on capital flows and a fixed exchange rate, and the other one of less restricted capital flows and a more flexible managed exchange rate. Our results show that a more flexible managed exchange-rate system, based on welfare-based Ramsey rules, acts as an effective shock absorber when the economy is in a "dark corner", thus reducing the fall in real GDP and consumption. However, this benefit comes at a cost. with a much larger fall in employment and loss in foreign exchange reserves, than in the more restricted fixed-rate environment. By contrast, if the Ramsey rule for monetary policy is based on current-account or external-balance targets, employment and reserve losses are reduced. Our results suggest that external balance, rather than welfare, should be the proper target for monetary policy as the financial system moves toward a more flexible exchange rate and a less restricted capital account, at least when the economy falls into dark corner periods. These results, based on Ramsey rules, extend to the use of optimal simple rules for the interest and the exchange-rate, with the former following a Taylor-rule specification, and the latter adjusting to current account and employment targets. However, in dark corner periods, optimal simple rules exact much higher costs, in terms of lost consumption, relative to Ramsey rules, for stabilizing the current account and employment.

JEL Codes: E58, F41l

Key words: Ramsey rule, optimal simple rule, dark corner dynamics.

*Senior Manager, Hong Kong Institute for Monetary Research, Hong Kong Monetary Authority. Email: hchen@hkma.gov.hk

†Department of Finance, Gabelli School of Business, Fordham University, New York. Email: mcnelis@fordham.edu

‡The views expressed in this paper are those of the authors, and do not necessarily reflect those of the Hong Kong Monetary Authority, Hong Kong Institute for Monetary Research, its Council of Advisers, or the Board of Directors.

1 Introduction

Chinese monetary policy has received considerable attention in recent research. Chang et al. (2015), for example, have drawn attention to the mix of capital controls, exchange-rate management, and sterilized intervention as a constraint on the ability of monetary policy to stabilize the economy in the wake of external shocks. Making use of a calibrated DSGE model mimicking key characteristics of the Chinese macroeconomic setting, these authors conclude that greater capital account liberalization as well as a more flexible exchange-rate regime, based on a welfare-based Ramsey rules, would have made monetary policy more effective in the wake of the global financial crisis.

Our results show that such a managed exchange-rate system, based on a Ramsey rule aimed at welfare optimization, acts as an effective shock absorber for GDP and consumption in good times and bad. However, in dark corner episodes, it leads to a large loss in reserves and a drop in employment. When there is a fall in world demand, domestic consumption falls. To improve welfare, the exchange rate appreciates, when the economy experiences a prolonged sequence of negative shocks. there is a large loss of reserves and a steep fall in employment, relative to the more controlled fixed-rate system. However, if monetary policy is guided in the more flexible and open regime by Ramsey rules targeted at current account stabilization, the large reserve losses and employment collapse disappear during the dark corner episodes.

Of course, managed exchange rates are not unique to China. Chow et al. (2014) examined the managed-exchange rate system in Singapore. They found that an simple Taylor-like rule for the exchange rate outperforms a Taylor rule for the nominal interest rate, when the principle driving forces are terms-of-trade shocks, while a traditional Taylor rule does better, in terms of welfare, when the principle driving forces come from productivity shocks. Of course, unlike China, the capital account in Singapore is almost completely open, on a par with the index for the United States.[1] The key question for China is which type of managed exchange-rate rule works best, in the context of partial, incomplete financial openness.

Welfare-based Ramsey rules for bench-marking monetary policy regimes came to the forefront of research with the work of Erceg et al. (2000). In the context of a closed economy with both wage and price stickiness, these authors found that a simple Taylor rule based on wage inflation, rather than price inflation, closely matches a Ramsey rule for welfare optimization. Since then, welfare criteria have replaced ad-hoc loss functions for assessing alternative regimes or rules for monetary policy.

Figure 1 pictures the evolution of policy instruments for the central bank: namely real bond rate and the annualized change in the exchange rate. It is clear that the People's Bank of China made a major policy change in 2005, with respect to the flexibility of the exchange rate.

[1] Singapore is equal to the United States in the index of capital-account openness developed by Chinn and Ito (2006), with a measure slightly below 2.5 in 2014, while China remains slightly below -1 in the same period of time.

Figure 1: Treasury Bond Rate and Exchange Rate Growth, 1998-2016

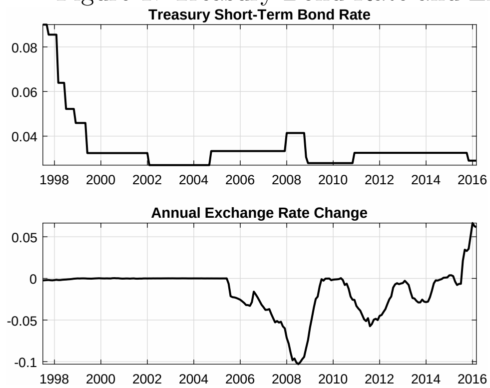
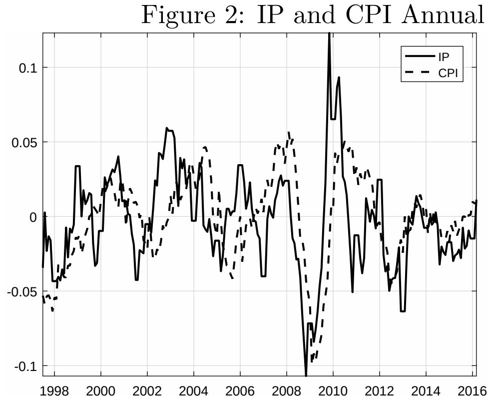


Figure 2: IP and CPI Annual Growth Rates, 1998-2016

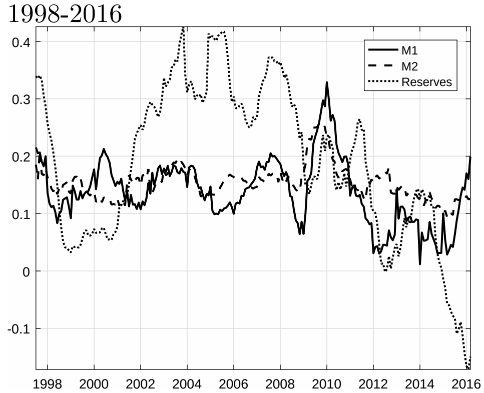


The Chinese economy, to be sure, has enjoyed high growth, but it has not been exempt from experiencing dark corners. Figure 2 pictures the annualized growth rates of Industrial Production and the CPI since 1998. We see that the interval between 2008 and 2010, in the wake of the global financial crisis, was a period of severe decline in production as well as deflation. We also see broad co-movement between the growth rates of the CPI and Industrial Production.[2]

Figure 3 pictures the rate of growth of M1 and M2 as well as Foreign Exchange Reserves in China since 1998. From this figure we see that in periods of crisis, or "dark corners", M1 growth is higher than M2 growth. We see this in the wake of the Asian financial crisis in the late 90's, as well as at the time of the global financial crisis in 2008, and most recently, since 2015. In all of these periods, the growth rate of foreign exchange reserves is slowing down, and, most recently, turning negative. However, Figure 3 shows there is a weak correlation between the growth of foreign currency reserves and the growth of monetary

[2]Due to the seasonal effects of Chinese New Year taking place in the period Jan-March of each year, the IP index was averaged over these periods in each calendar year.

Figure 3: Annualized Growth Rates of Money and Foreign Exchange Reserves, 1998-2016



aggregates.

Much of the international pressure for China to move to a more flexible exchange-rate system comes from a presumption that the RMB, at least prior to 2005, was undervalued, relative to the US Dollar. However, as Cheung et al. (2007) pointed out, comparisons of misalignment between the United States and China, based on a range of statistical criteria, did not confirm any statistically significant degree of undervaluation.

The July 2005 policy change was a switch to a more flexible exchange-rate system, in which the central parity would be tied not just to the US Dollar, but to a basket index of currencies. As for understanding China's switch, as well as any country's choice of exchange-rate regime, for that matter, as Rose (2011) points out, comparisons before/after or across countries are quite difficult to make.

While welfare criteria are standard tools for policy comparison across regimes, they miss an important issue, and contrary to Rose (2011), the consequences may be larger than we think. As Mendoza (2010) noted in his work on sudden stops, standard welfare measures often show little difference since most of the data are generated by the model when the variables are close to their steady-state or stochastic-mean values. When the economy is operating in normal times, close to the stochastic mean, of course, alternative rules for monetary policy should make little difference. What is of interest is how much of a difference these alternative rules make when the economy is in a prolonged crisis or malfunctions badly, and falls into a "dark corner", in the words of Blanchard (2014).

The monetary framework of China is evolving in steady ways, with different instruments coming to the fore at different times. Fernald et al. (2014), for example, found that increases in the bank required reserve ratio were effective for inflation stabilization. However, they also found that Central-bank determined changes in interest rates also played a significant role, while changes to M2 or credit conditions did not play a significant role. Moreover, Chen et al. (2017)

find that the transmission of monetary policy shocks is remarkably similar to that of more advanced economies in terms of both output growth and inflation. However they also find that window guidance has a major influence on bank lending, and that monetary policy has asymmetric effects on asset prices.

Before turning to our assessment of likely monetary rules for China in the context of incomplete financial openness, we first analyze what happened before and after 2005 in the next section. We use the disconnectedness approach of Diebold and Yilmaz (2013). Originally used for measuring volatility spillovers among financial markets in Diebold and Yilmaz (2012), this method makes use of forecast-error variance decomposition analysis among the likely targets of monetary policy. Since the error-variance decomposition matrix is asymmetric, we can assess both the inward and outward degrees of disconnectedness among the monetary targets and indicators. Our results are consistent with previous studies which show multiple channels for the transmission of monetary policy.

Our results show little difference in the measures of disconnectedness before and after 2005, given the incomplete and partial financial openness. Not surprisingly, however, with greater nominal exchange-rate flexibility, the real exchange rate became more important for its outward effects on other variables after 2005.

The third section then gives a brief summary of the model used by Chang et al. (2015) for assessing Chinese monetary policy. Specifically we assess the performance of two versions of the model, one with a relatively closed capital account and a fixed exchange rate, and another with a more open capital account and a more flexible exchange rate. We first examine the properties of the model in terms of the inward and outward disconnectedness of key variables. Then we examine the distributions of the key variables of the model under the two regimes, making use of kernel density estimation due to Epanechnikov (1969). Finally we assess the performance of the two versions of the model when the economy is in a dark corner.

As noted above, we find that in periods when the economy is in a dark corner, when GDP is 1.96 standard deviation below its stochastic mean, that a more open, more flexible managed exchange-rate regime, based on a welfare-based Ramsey rule, does indeed act as a shock absorber, in that sense that it mitigates the fall in GDP and real consumption. But this benefit, however, comes at a very high cost, which does not show up in standard welfare criteria for optimal policy. However, under the more open and more flexible regime, the real exchange rate appreciates, leading to an increase in imported inputs for production, with a consequent large decrease in foreign reserves and losses in employment. However, if the Ramsey rule for monetary policy is directed at current account stability or external targets,, rather than welfare, these large losses in reserves and employment disappear. Lastly we example how well simple rules for the interest rate and the exchange rate (in the more flexible and more open setting) perform relative to the Ramsey rules. A Taylor specification for the interest rate and an exchange-rate rule with current-account and employment targets work well, relative to the Ramsey rule. Our results thus recall the work of more than a half-century ago, that of Mundell (1962), who argued that the appropriate use of monetary instruments in an open economy should be external stability. In our case, we propose an optimal Taylor rule for inflation and domestic output and an exchange-rate rule for current account and employment.

2 Connectedness of Policy Targets

Table 1 gives the inward and outward connectedness measures, based on forecast error variance decomposition, for the growth of Industrial Production (IP) as well as the growth of real money (M2) ,Foreign Exchange Reserves, the Real Effective Exchange Rate and the Real Bond Rate of Return. The connectedness measures come from a VAR regression, on all five variables, with a forecast horizon of two years. Following the example of Chen et al. (2016), we make use of the five-variable VAR. To eliminate serial correlation, we used alternative lag specifications. We report the results for the shortest lag length, for which we obtain serial independence in the residuals. As in Chen et al. (2016), we made of a generalized VAR method by varying the order of the variables in the estimation process, and averaging the results over 100 possible permutations of the system. We report the mean values for the inward and outward measures of connectedness. We put in bold the connectedness measures which are greater than ten percent.

We compare these measures, for the period before and after August 2005, when the exchange-rate became more flexible, as shown in Figure 1.

Table 1: Inward and Outward Connectedness: Before and After 2005

	IP	M2	Res	Ex.Rate	Bond Rate	IP	M2	Res	Ex.Rate	Bond Rate
Industrial Production										
Pre-2005						Post-2005				
In	0.748	0.092	0.092	0.037	0.031	0.812	0.048	0.028	0.075	0.036
Out	0.748	0.088	0.074	0.030	**0.164**	0.812	0.036	0.060	0.053	**0.140**
Real Money Supply										
Pre-2005						Post-2005				
In	0.088	0.686	0.083	0.044	0.099	0.036	0.612	0.075	**0.143**	0.133
Out	0.092	0.686	0.030	0.074	**0.108**	0.048	0.612	0.098	**0.182**	0.072
Foreign Ex. Reserves										
Pre-2005						Post-2005				
In	0.074	0.030	0.753	0.064	0.076	0.060	0.098	0.701	0.094	0.045
Out	0.092	0.083	0.753	0.044	**0.110**	0.028	0.075	0.701	0.061	0.067
Real Effective Exchange Rate										
Pre-2005						Post-2005				
In	0.030	0.074	0.044	0.805	0.046	0.053	**0.182**	0.061	0.636	0.066
Out	0.037	0.044	0.064	0.805	0.029	0.075	**0.143**	0.094	0.636	**0.112**
Real Bond Rate										
Pre-2005						Post-2005				
In	0.164	**0.108**	0.110	0.029	0.587	0.140	0.072	0.067	**0.112**	0.608
Out	0.031	0.099	0.076	0.046	0.587	0.036	**0.133**	0.045	0.066	0.608

Note: Lags for VAR at 5, Forecast horizon 24 months

One of the results from the before/after 2005 measure is that the real effective exchange rate becomes more important. Industrial production, before and after the policy change, affects the real bond yield. However, before 2005, the real money supply affects the bond yield, but after 2005, there is stronger inward and outward connectedness between the real money supply and the real exchange rate. Foreign exchange reserves have stronger effects on the real bond return before 2005 but afterwards have little or not direct effects on other variables. For the real effective exchange rate, before 2005, it generates little or no effects on the other variables, but after 2005, it affects and responds to M2 and has strong effects on the real bond yield. Finally, for the real bond yield, the main factor of importance before 2005 is the real money supply, while after 2005, the real exchange rate has strong effects on its variation, while in turn it has stronger effects on the real money supply.

It should not be surprising that the VAR model does not show stronger effects of M2-growth on real-sector variables. Recently Chen et al. (2016) noted strong asymmetries in the conduct of monetary policy in China, and investigated the transmission mechanism with threshold VAR models. They also noted the importance of the bank lending channel for monetary policy. Our measures of connectedness come from a linear VAR. Since we do not model the banking sector in our theoretical framework, we chose to use a monetary aggregate as the liquidity measure.

Of course, over this period, there have been other regime changes, besides the liberalization of the exchange rate in 2005 towards greater flexibility, such as the reduction in the restrictions for the access of foreigners to financial markets. But the implication of these results is that the regime change generated only small effects on the interconnections of key macroeconomic variables. The key effects was to increase the importance of the real exchange rate for determining the behavior of both the real money supply and the real interest rate.

3 The Model

The model is in many ways a new Keynesian open-economy model. The main departure is the imperfect substitutability of domestic and foreign bonds, due to adjustment costs for changing the proportion of domestic debt in one's portfolio. There are sticky prices in the Rotemberg (1982) framework. But in contrast to the widely-used framework of Smets and Wouters (2007), there are no real-sector frictions in the form of habit persistence or adjustment costs on investment. In fact there is no capital accumulation. Production is simply a function of domestic labor and an intermediate good. The intermediate good, in turn, is a CES composite good of domestically-produced and imported foreign output. Imports are solely for this purpose. There is no explicit banking sector, nor government spending nor taxation.

3.1 Specification

3.1.1 Households and Utility

The representative household optimizes an inter temporal welfare function based on consumption (C_t), real balances (M_t/P_t) and labor (L_t) :

$$\boldsymbol{W}_t = \boldsymbol{E_t} \sum_{t=0}^{\infty} \beta^t \left\{ ln(C_t) + \Phi_m \left(\frac{M_t}{P_t} \right) - \Phi_l \frac{L_t^{1-\eta}}{1-\eta} \right\} \tag{1}$$

subject to the following budget constraint:

$$\begin{aligned} & C_t + \frac{M_t}{P_t} + \frac{B_t + e_t B^*_{p,t}}{P_t} \left[i1 + \frac{\Omega_b}{2} \left(\frac{B_t}{B_t + e_t B^*_{p,t}} - \bar{\psi} \right)^2 \right] \\ & \leq w_t L_t + \frac{M_{t-1}}{P_t} + \frac{R_{t-1} B_{t-1} + e_t R^*_{t-1} B^*_{p,t-1}}{P_t} + \frac{D_t}{P_t} \end{aligned} \tag{2}$$

The variable and parameter definitions are those used by Chang et al. (2015), p. 5. The key wedge with pure uncovered interest parity is the portfolio adjustment cost parameter Ω_b. The household chooses its paths for consumption, C_t, labor L_t,money balances $m_t = M_t/P_t$,real domestic debt B_t/P_t, and privately-held foreign debt, $e_t B_t^*/P_t$, to maximize equation 1 given equation 2.

The first-order conditions yielding the demand for real balances ($m_t = M_t/P_t$), the real wage, and the generalized UIP condition (with portfolio adjustment costs) have the following expressions:

$$\frac{\Phi_m}{\Lambda_t m_t} = 1 - \boldsymbol{E_t} \frac{\beta \Lambda_{t+1}}{\Lambda_t} \frac{1}{\pi_{t+1}} \tag{3}$$

$$w_t = \frac{\Phi_l L_t^\eta}{\Lambda_t} \tag{4}$$

$$\Omega_b(\psi_t - \bar{\psi}) = \boldsymbol{E_t} \frac{\beta \Lambda_{t+1}}{\Lambda_t} \frac{1}{\pi_{t+1}} \left[R_t - R_t^* \frac{e_{t+1}}{e_t} \right] \tag{5}$$

The variable $\Lambda_t$is the Lagrange multiplier associated with equation 2.

3.1.2 Production and Pricing

The production function for differentiated retail goods Y_t(j) has the following form, based on intermediate goods and labor inputs:

$$Y_t(j) = \Gamma_t(j)^\phi \left[Z_t L_t(j) \right]^{1-\phi} \tag{6}$$

The variable $Z_t$is a labor-augmenting technology-progress variable. It grows at the constant rate $\lambda_{z,t} = Z_t/Z_{t-1}$.

In turn, intermediate goods Γ_t are CES composites of domestically produced and imported goods, given by $\Gamma_{h,t}$ and $\Gamma_{f,t}$:

$$\Gamma_t = \Gamma_{h,t}^\alpha \Gamma_{f,t}^{1-\alpha} \tag{7}$$

The relative price $q_{m,t}$ of these goods is function of the the real exchange rate, $q_t = e_t P_t^*/P_t$:

$$q_{mt} = \tilde{\alpha} q_t^{1-\alpha} \tag{8}$$

Cost minimization yields the equilibrium value of the real exchange rates:

$$q_t = \frac{1-\alpha}{\alpha} \frac{\mathit{\Gamma}_{h,t}}{\Gamma_{f,t}} \tag{9}$$

The formulae for the real marginal cost and the factor-price ratio have the following form:

$$\nu_t = \tilde{\phi} q_{mtt}^\phi \left(\frac{w_t}{Z_t} \right)^{1-\phi} \tag{10}$$

$$\frac{w_t}{q_{mt}} = \frac{1-\phi}{\phi} \frac{\Gamma_t(j)}{L_t(j)} \tag{11}$$

Optimal pricing implies the following forward-looking inflation equation:

$$\nu_t = \frac{\theta_p - 1}{\theta_p} + \frac{\Omega_p}{\vartheta_p}\frac{C_t}{Y_t}\left[\left(\frac{\pi_t}{\pi} - 1\right)\frac{\pi_t}{\pi} - \beta E_t\left(\frac{\pi_{t+1}}{\pi} - 1\right)\frac{\pi_{t+1}}{\pi}\right] \tag{12}$$

3.1.3 Current Account and External Sector

The current account, ca_t, is the sum of the trade surplus and the net interest income from foreign assets (both those held by households and by the government):

$$ca_t = X_t - q_t\Gamma_{t,f} + \frac{e_t(R^*_{t-1} - 1)B^*_{t-1}}{P_t} \tag{13}$$

Of course, current account balances imply changes in the stock of aggregate foreign assets:

$$ca_t = e_t\frac{B^*_t - B^*_{t-1}}{P_t} \tag{14}$$

The foreign interest rate follows an autoregressive process:

$$\ln R^*_{t-1} = (1 - \rho_r)\ln R^* + \rho_r \ln R^*_{t-1} + \sigma_r\epsilon_{r,t} \tag{15}$$

Export demand is a function of the real exchange rate, world demand, augmented by domestic productivity (for reasons of generating balanced growth):

$$X_t = q_t^{\theta}\tilde{X}^*_t Z_t \tag{16}$$

World demand follows an autoregressive process:

$$\ln \tilde{X}^*_{t-1} = (1 - \rho_x)\ln \tilde{X}^* + \rho_x \ln \tilde{X}^*_{t-1} + \sigma_x\epsilon_{x,t} \tag{17}$$

There is no government spending in the model, nor taxation. The government purchases privately held foreign assets with financing either from domestic bond expansions or money creation:

$$e_t(B^*_{g,t} - R^*_{t-1}B^*_{g,t-1}) \leq B^s_t - R_{t-1}B^s_{t-1} + M_t - M_{t-1} \tag{18}$$

3.1.4 Simulation and Replication

We make use of the numerical calibration in Chang et al. (2015), p. 9, Table 1. We compare two of the three versions of the model, one with a fixed exchange rate and a relatively closed capital account, with $\Omega_b = .6$, a fixed exchange rate, with a welfare-based Ramsey rule for the interest rate. Then we simulate the more open, flexible regimes, with Ω_b=.2, with a specification of a standard Taylor rule for inflation and output growth, and a welfare-based Ramsey rule for the rate of change of the nominal exchange rate. We designate the first regime the Closed Fixed Regime (CFR) , and the latter, the Open Managed Regime (OMR). In both cases there are two stochastic shocks, one for the foreign interest rate, and the other for the world demand, appearing in equations 15 and 17, respectively.

We note in the model above that the real exchange-rate is a two-edged sword. An appreciation lowers the cost of imported intermediate goods, but it also reduces the world demand for exports. This two-edged effect plays a crucial role for understanding the costs and benefits of moving to a more open, flexible system, especially in times of dark corners, if the Ramsey rule targets welfare.

4 Simulations of the Model

The next sub-section examines the connectedness properties of the two versions of the model. Then we examine the distributions of key variables as well as their dynamics when the economy falls into a dark corner, under the two regimes of the model. This paper makes use of the same methodology found in Lim and McNelis (2016). They compared the distributions and the dark corner dynamics for evaluating the effectiveness of non-traditional policy rules for the central bank and the fiscal authority, relative to a base case of no-policy intervention. In this paper, we compare the closed fixed regime with the more open managed-exchange rate regime.[3]

4.1 Connectedness properties of the model

Table 2 presents the inward and outward connectedness of the same variables discussed above. We illustrate in bold those connectedness measures which are greater than .20, to illustrate the strongest points of connectedness.

We see that there are stronger measures of connectedness of the variables generated by the model than in the actual data. This should not be surprising, since the model-generated data come from well-defined stochastic processes. In one sense the connectedness measures are broadly consistent with the connectedness measures of the actual data, in the sense that if there are any changes in the connectedness measures, they are not markedly large.

One important point stands out in this set of results, relative to the empirical results. One is that the real exchange rate is the key variable, driving IP, M2 Foreign Reserves, and the bond yield. But this is true both in the relatively closed as well as in the more open regimes.

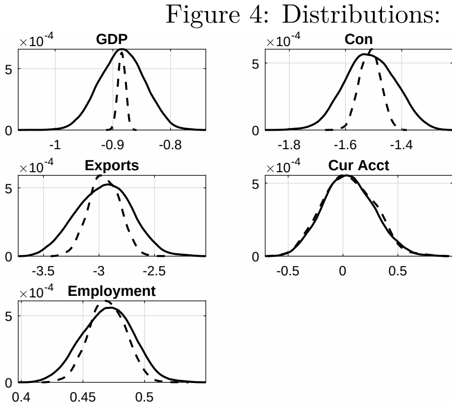
But what stands out in this comparison is how little the connectedness measures change, under the two regimes. This is also true for the measures based on the actual data. Granted, the change in regime is not moving from the completely closed economy to a completely open economy. The movement is one from a fixed rate, financially closed model with a Ramsey rule for the interest rate, to a regime with a Taylor rule, a welfare-based Ramsey rule for the

[3]In Lim and McNelis (2016), the comparison was to evaluate the effectiveness of using optimal simple rules for quantitative easing and tax rates relative to a base do-nothing regime. This paper evaluated two regimes, in which Ramsey rules, not optimal simple rules, are used for exchange-rate management.

Table 2: Connectedness under Two Regimes

	Closed-Fixed Regime					Open- Managed Regime				
Industrial Production										
	IP	M2	Res	RealER	B-Rate	IP	M2	Res	RealER	B-Rate
In	0.152	0.137	0.179	**0.238**		0.141	0,181	0,172	**0.214**	0.133
Out	0.152	0.158	0.145	0.152		0,141	0,141	0,142	0.141	0.149
Real Money Supply										
	IP	M2	Res	RealER	B-Rate	IP	M2	R	RealER	B-Rate
In	0.158	0.167	0.188	**0.231**	0.149	0.142	0.189	0.169	**0.216**	0.130
Out	0.137	0.167	0.142	0.134	0.134	0.181	0.189	0.188	0.185	0.212
Foreign Exchange Reserves										
	IP	M2	Res	RealER	B-Rate	IP	M2	Res	RealER	B-Rate
In	0.145	0.142	0.181	**0.234**	0.148	0.142	0.188	0.168	**0.213**	0.131
Out	0.179	0.188	0.181	0.179	0.179	0.172	0.169	0.168	0.170	0.169
Real Exchange Rate										
	IP	M2	Res	RealER	B-Rate	IP	M2	Res	RealER	B-Rate
In	0.152	0.134	0.179	**0.242**	0.15P2	0.141	0.185	0.170	**0.216**	0.131
Out	**0.238**	**0.231**	**0.234**	**0.242**	**0.241**	**0.214**	**0.216**	**0.213**	**0.216**	**0.215**
Real Bond Yield										
	IP	M2	Res	RealER	B-Rate	IP	M2	Res	RealER	B-Rage
In	0.152	0.134	0.179	**0.241**	0.152	0.149	**0.212**	0.169	**0.215**	0.124
Out	0.150	0.149	0.148	0.152	0.152	0.133	0.130	0.131	0.131	0.124

Figure 4: Distributions: National Income Variables



________Closed Fixed Regime

_ _ _ Open Managed Regime

exchange rate, and a slightly more open capital account. While Chang et al. (2015) report a welfare gain, in terms of consumption compensation, from one regime to the other, of .79%, there appears to be little change, despite the increase in welfare, in the connectedness of key macroeconomic variables, using data based on the overall simulation.

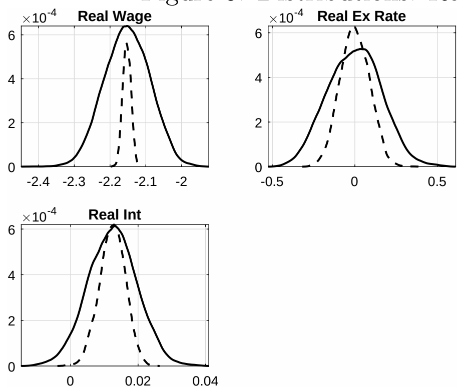
We also note that the statistical properties of the model come from long simulations, with T=20.000, when most of the time, the model is not too far from the stochastic mean. So it should not surprise one that few differences show up between the two regimes, given the change from a fixed, highly restricted capital account to a more flexible less-restricted capital account. The key differences show up when the economy falls into dark corners.

4.2 Distributions: fixed rate vs. welfare-based Ramsey exchange-rate rule

We first examine the distributions of key variables under the two regimes. We first calculate the distributions with Epanechnikov kernel density estimation, for annualized data based on T=20,000 quarters.

Figure 4 pictures the Epanechnikov (1969) densities for GDP, Consumption, Exports, the Current Account/GDP ratio and Employment, under the Fixed/Closed Regime and the relatively Flexible/Open Regime for the exchange rate and the capital account. The results show that the movement towards a more open and flexible system does indeed act as a shock absorber by reducing the volatility of GDP and consumption. However, since exports also depend on exogenous world demand, the effect of the more flexible and open system is more limited. The movement to a more flexible exchange rate has practically no effect on the overall distributions of the current account and employment.

Figure 5: Distributions: Real Wage, Exr. Rate, Interest



________Closed Fixed Regime

_ _ _ Open Managed Regime

Figure 5 pictures the Epanechnikov (1969) kernel density estimates for the real wage, the real exchange rate and the real interest rate under the two regimes. We see that the more open flexible system reduces the volatility of the real wage but has less of an effect on the distributions of the real exchange rate and the real interest rate.

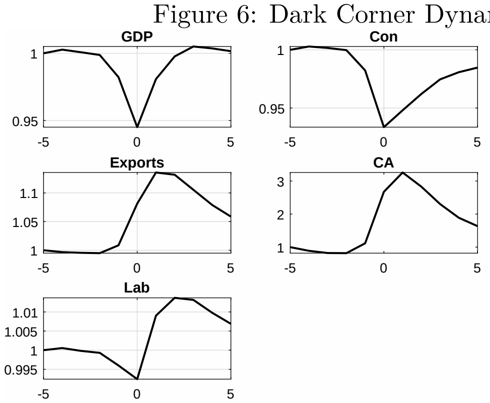
The overall distributions give a broad picture, based on simulations over a very large span of data. These distributions are useful in the sense that they tell is if one regime is more risky relative to another, with risk approximated by the width of the tails at both ends of the curves. However, these distributions are time dimensionless and do not give much information about the relative magnitudes of the before and after changes in key variables during dark corner episodes, when we are on the left side of the distributions.

4.3 Dark corner dynamics: fixed rate vs. welfare-based Ramsey exchange-rate rule

Examining properties of the data based on long simulations, when variables are near to their stochastic mean values most of the time, will show little difference between the regimes. To understand what differences these alternative regimes make, we first examine dark corner dynamics for the benchmark case, when the economy is relatively closed with a fixed nominal exchange rate. Following Mendoza (2010), we simulated the model for T=20,000, and annualized the data. Given that there are two shocks to the economy, one from world demand and the other from the world interest, we isolate periods when the annual GDP growth rate is 1.96 standard deviations below its stochastic mean.

To avoid over-counting of dark corners, we pick the minimum points of GDP growth rates over periods of T = 50, and from these, choose only the periods when the GDP growth rate is less than the critical value. After these periods

Figure 6: Dark Corner Dynamics: National Accounts



Closed Fixed-Exchange Rate Regime

are isolated, at period T_i^*, we then examine the behavior of GDP as well as other key variables. We do this by computing for each variable i, the values from i-5 to i+5. To further understand the relative change of the variables we normalize each of the variables at unity for period i-4. Then we see how the dark corner dynamics change under a more open, flexible exchange-rate regime.

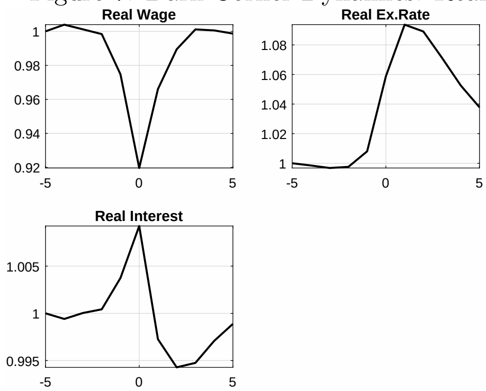
4.3.1 Benchmark closed-fixed rate regime

Figure 6 pictures the dark-corner dynamics of GDP, consumption, exports, the current account and labor (employment) for five years before and five years after the crisis, for the mean values of each variable normalized at unity prior to the crisis, at time t*=-4.

Figure 6 pictures the adjustment of the components of national income. We see that there is a sharp fall in consumption and GDP, and a slight fall in labor (employment), while there is a rise in exports and an increase in the current account. Such dynamics closely resemble those illustrated by Mendoza (2010) during a sudden-stop event for a closed economy. However, in this model, there is no magnification of the crisis due to the collateral constraint becoming binding, leading to Fisherian debt/deflation dynamics. In our setup, the incentive compatibility constraint is always binding.

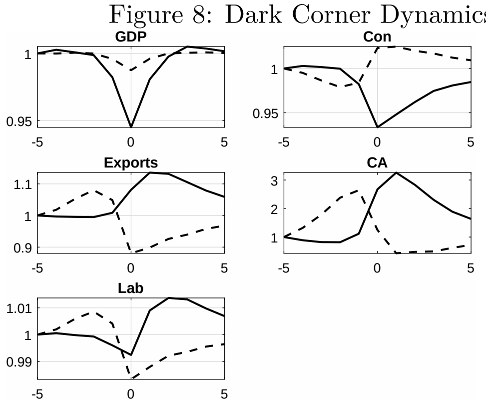
Figure 7 pictures the adjustment of the real wage, the real exchange rate and the real interest rate. We see that there is a sharp drop in the real wage, but a depreciation of the real exchange rate as the real interest rate first rises (due to the fall in prices). The fall in the real wage and the real deprecation explain the increase in exports and the sharp rebound in employment following the onset of the crisis in Figure 6. While there is austerity, the austerity is front end, the employment rate rebounds quickly with the rise in exports and the real depreciation.

Figure 7: Dark Corner Dynamics: Real Wage, Exchange Rate and Interest



Closed Fixed-Exchange Rate Regime

Figure 8: Dark Corner Dynamics: National Income Accounts



________Closed Fixed Regime

_ _ _ Open Managed Regime

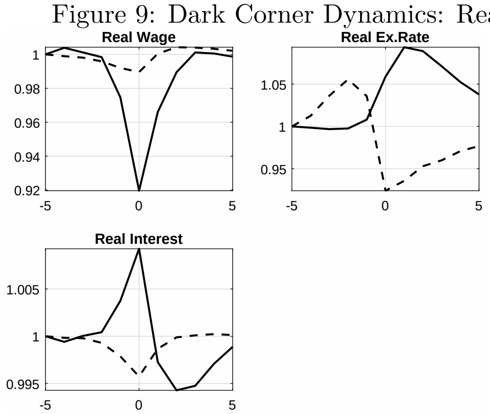
4.3.2 Comparative dynamics: fixed rate vs. welfare-based Ramsey rule

Figure 8 pictures the adjustment of the same national income account components, but under the two regimes. The solid curves represent the base fixed rate, relatively closed financial regime, while the broken curves represent the more flexible open regime.

We see immediately that the more flexible regime acts as a shock absorber on GDP, since the fall is considerably dampened. Consumption actually rises as exports and the current account fall at the time of the crisis. Employment also falls and remains low following the onset of the crisis.

Figure 9 pictures the adjustment of the real wage, the real exchange rate and the real interest rate. As above, the solid curves represent adjustment

Figure 9: Dark Corner Dynamics: Real Wage, Exchange Rate, Interest



________Closed Fixed Regime
_ _ _ Open Managed Regime

under the fixed/close regime while the broken curves represent adjustment for the more flexible open regime. We see that the real wage and real interest rates are stabilized, while the real exchange rate appreciates. The appreciation of the real exchange rate, of course, accounts for the fall in exports and the fall in the current account under the more open, flexible regime, while the stability of the real wage accounts for the larger fall in employment and continued stagnation after the onset of the crisis.

4.4 Distributions under alternative Ramsey rules: welfare vs. external targets

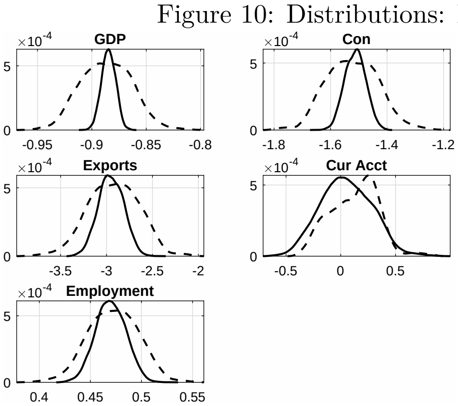
What if the external balance (current-account) is the target for the Ramsey rule for exchange-rate management? Figure 10 pictures the distributions of the same variables as in Figure 4. However, in this case, the solid curves represent the distributions under the welfare-based Ramsey rule while the broken curves represent the corresponding distributions under the Ramsey rule targeting external balance.

This figure shows that the shift in the exchange-rate policy target only slightly reduces the volatility of the current account, while it increases the volatility of GDP, consumption and employment.

Figure 11 pictures the same variables as in Figure 5. As in Figure 10, the solid curves show outcomes under the welfare-based Ramsey rule while the broken curves depict the external-balance target for the Ramsey rule. We see that there is great volatility for the real wage and the real exchange rate, but little or no difference for the real interest rate.

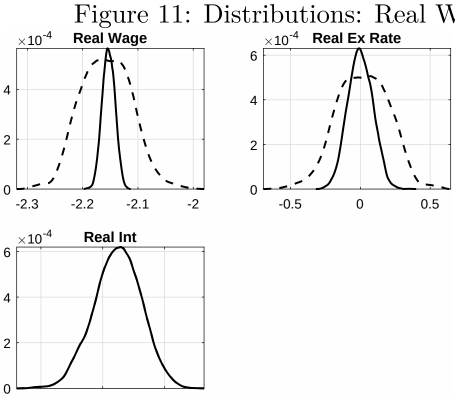
Relying on the outcomes for overall adjustment, an external target for the Ramsey rule is less effective as a shock absorber as the welfare-based Ramsey rule.

Figure 10: Distributions: National Income Variables



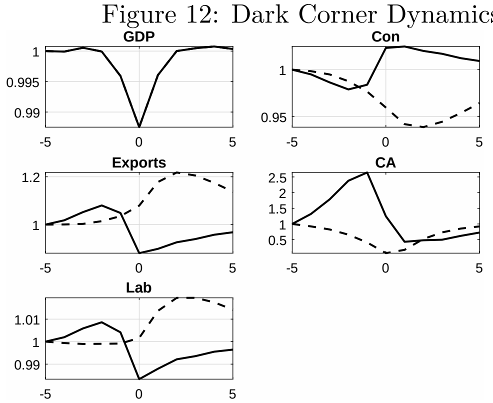
____________ Welfare target for Ramsey rule
_ _ _ _ _ _ _External balance target for Ramsey rule

Figure 11: Distributions: Real Wage, Exchange Rate and Interest



___________ Welfare target for Ramsey rule
_ _ _ _ _ _ External balance target for Ramsey rule

Figure 12: Dark Corner Dynamics: National Income Variables



___________ Welfare target for Ramsey rule
_ _ _ _ _ External balance target for Ramsey rule

4.5 Dark-corner dynamics under alternative Ramsey rules: welfare vs. external targets

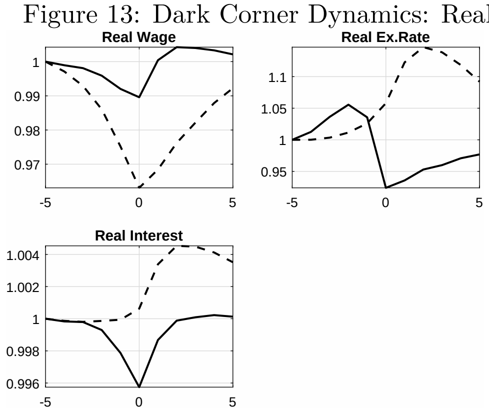
Figure 12 pictures the adjustment of key national income account measures under the welfare and current-account targets for the Ramsey rule. The adjustment shows that there is little or no difference for GDP. However, the depreciation of the exchange rate (aimed at the current account stability) in the dark corner episode leads to a sharper fall in consumption and an increase in exports. While the current account falls under the external-balance target, it does not fall as sharply, at the time of the crisis, as it does under the welfare-based Ramsey rule. The results show that the external target has a front-end cost in reducing consumption, while promoting exports.

Figure 13 pictures the dark-corner adjustment under the welfare and external balance targets for the real wage, real exchange rate and the real interest In the dark corner period, under the external-balance target, the real exchange rate depreciates, which increases the price level, and cuts the real wage. The real interest rate increases. given the Taylor rule. . By contrast, the welfare-based Ramsey rule leads to an appreciation of the real exchange rate, and stabilizes the real wage, since inflation is mitigated. The interest rate falls in accord with the Taylor rule.

4.6 Optimal simple rules for the Taylor rule and the exchange rate depreciation

The obvious question which comes to mind is how well can an optimal simple rule for the exchange rate come close to a Ramsey rule? After all, it was Erceg et al. (2000) who found that a optimal Taylor rule based on wage inflation closely approximates a Ramsey welfare-based rule for the interest rate, in a closed-economy model with wage and price stickiness. Can this result carry

Figure 13: Dark Corner Dynamics: Real Wage, Exchange Rate and Interest



___________ Welfare target for Ramsey rule

_ _ _ _ _ _ External balance target for Ramsey rule

over to an open-economy setting? Alternatively, are there perils to the use of simple rules, even optimal simple rules?

In this specification we use the simple Taylor rule specified by Chang et al. (2015) for the flexible more-open capital account. However instead of a Ramsey rule, the exchange rate is now a function of the current account/GDP ratio as well as employment (relative to their respective steady-state values):

$$\triangle ln(e_t) = \gamma_1[(CA_t/Y_t) - (\overline{CA}/\overline{Y})] + \gamma_2(L_t - \overline{L}) \tag{19}$$

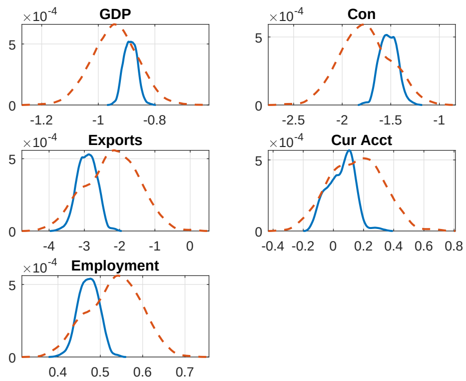
We find the optimal values for these parameters based on the minimization of the capital account as well as employment volatility. The optimal parameters, given the specification of the model, yield $\gamma_1 = -3.118$,and γ_2 =-3.444. The results were robust to alternative specifications, such as first-difference specifications for the current account as well as log first differences for employment.

4.6.1 Volatility measures for Ramsey and simple rules targeting external balance

Figure 14 pictures the volatility measures for the national income variables under the Ramsey and the optimal simple rule. We see clearly that the simple rule extends the right tail of the distribution for exports, the current account and employment, while increasing the lower left tail for GDP and consumption.

Figure 15 pictures the volatility measures for the real wage, the real exchange rate and the real interest rate under the Ramsey and simple rules. We see that the simple rule shifts the volatility of the real exchange rate toward the right tail and the real wage volatility to the left tail of the distribution. The real interest rate is unaffected. The movement toward higher rates of depreciation, of course, improve the current account, while the movement toward lower real

Figure 14: Distributions: National Income Variables



____________ Ramsey rule for external balance
_ _ _ _ _ Optimal simple rule for external balance

wages on the left tail of the distribution leads to compression of consumption and high employment, due to lower costs of labor.

4.6.2 Dark corner dynamics under Ramsey and simple rules targeting external balance

Figure 16 pictures the dark corner dynamics for the national income variables under the Ramsey and simple rule. Consistent with the distributions, we see under simple rules, that in times of dark corners, there are much sharper drops in GDP and Consumption, while exports, the current account and employment rise, relative to the Ramsey rule.

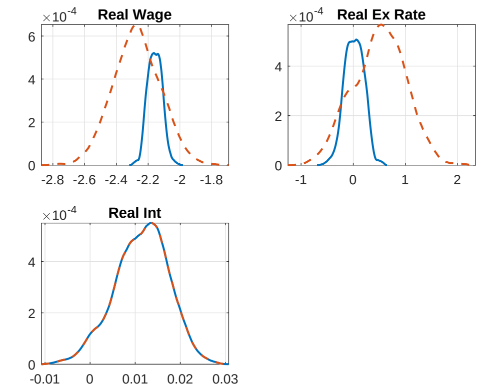
Figure 17 pictures the adjustment of the real wage, real exchange rate and the real interest rate in dark corners. In dark corner periods, there is a collapse of the real wage by about 15 percent, under the simple rule, and a large depreciation, about 30 percent, under the simple rule, relative to the Ramsey rule. For the real interest rate, the change is very small, less that .4 of a percent, consistent with the practically identical distributions shown above.

The results show that simple rules get the job done, of course, in improving external balance and employment, but at a cost of much higher compression of income and consumption, relative to Ramsey rules targeting the same variables.

4.7 Decrypting policy: current account and real-exchange rate movements

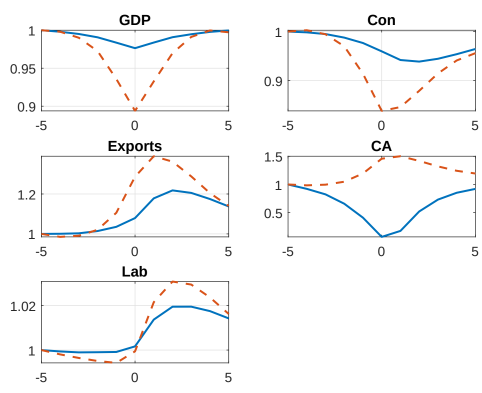
Any rule, Ramsey rule or an optimal simple rule, for interest rate and for the exchange rate, are approximations to the actual practice of monetary policy. As Taylor (1993) would suggest, such rules are never meant to be mechanical

Figure 15: Distributions: Real Wage, Exchange Rate and Interest



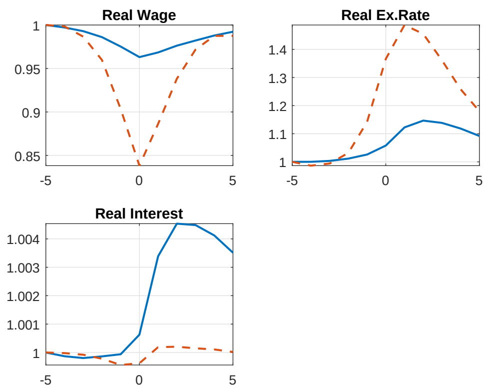
___________ Ramsey rule for external balance
_ _ _ _ _ Optimal simple rule for external balance

Figure 16: Dark Corner Dynamics: National Income Variables



___________ Ramsey rule for external balance
_ _ _ _ _ Optimal simple rule for external balance

Figure 17: Dark Corner Dynamics Real Wages, Exchange Rate and Interest



___________ Ramsey rule for external balance
_ _ _ _ _ _ Optimal simple rule for external balance

procedures for the conduct of policy-making but rather a description and a benchmark. Mark (2009) notes that exchange-rate rules, as well as monetary rules in general, are objects of learning by the private sector, as central bankers themselves adapt to changing conditions in the environments they face. Clearly the People's Bank of China faced changing conditions at home and in the world economy. It would be naive to model their behavior in terms of a simple rule with fixed parameters.

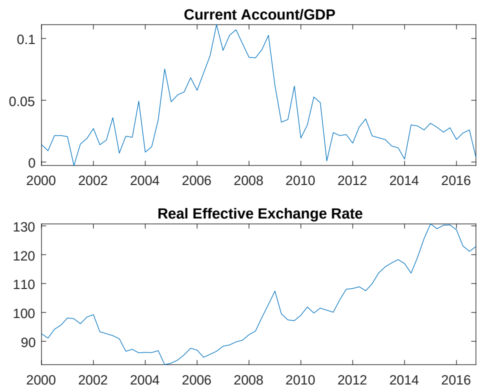
Figure 18 pictures the evolution of the current account/GDP ratio and the real effective exchange rate index for China, compiled by the Bank for International Settlements. In this formulation an increase is an appreciation, while a fall is a depreciation.

Clearly the world was in a dark corner after the onset of the global financial crisis in 2008. Figure 18 shows a steady appreciation of the real exchange rate, with a sharp fall in the current-account/GDP ratio. This adjustment is consistent with a welfare-based Ramsey rule for managing the exchange rate. However as the real exchange rate appreciated and the current-account/GDP ratio remained low, relative to historical levels, we see that a switch in the real exchange rate process took place in 2016, with a mild depreciation and slight improvements in the current account. Such movements in both variables are consistent with a switch to an external-balance target for the management of the exchange rate, based on a Ramsey rule.

5 Conclusion

This paper examined the implications of the switch in the Chinese monetary framework from a fixed and relatively closed financial account to a more open

Figure 18: Current Account/GDP Ratio and the Real Effective Exchange Rate



and more flexible one. While the results of the model simulations show that a more flexible exchange rate acts as an effective shock absorber, there are hidden but significant costs, of a welfare-based Ramsey rule, when the economy finds itself in dark corners. The appreciation of the real exchange rate makes imported intermediate goods a desirable substitute for employment, so that there is a large fall in employment, as well as a collapse of exports and a loss in reserves. The results of these simulations indicate that incomplete liberalization, coupled with greater exchange-rate flexibility, do not bring clear cut benefits, and lead to greater losses during periods of stagnation, when there are collapses in overall demand. Our results suggest that a switch to an exchange-rate management rule based on external targets, rather than welfare, would be more effective in dark corner episodes, under a Ramsey rule.

We do not argue that these outcomes during the dark-corner episodes call for a complete abandonment of welfare targets, but we call for a less rigid use of Ramsey rules in practice. Welfare targets should be the norm in normal times, but should give way to external targets in dark-corner non-normal times.

Our results also show the perils of simple, even optimally simple, rules, targeting external balance and employment, for the exchange rate. Such hard and fast rules do get the job done, but at a high cost in terms of consumption compression.

Of course, knowing when the economy is about to fall into a dark corner, and adopting appropriate models for the implementation of Ramsey rules, often at short notice, is as much an art as well as a science. As Niehans (1978) once noted, central bankers are first and foremost “doers and politicians”, or as Mark (2009) would say, “learners”, facing new problems and pressures each day. In this setting strategic ambiguity, rather than a fixed commitment to one simple rule or another, may better serve the wider range of objectives for monetary policy.

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