China's Vulnerability to Currency Crisis: A KLR Signals Approach

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Abstract

In this paper we use the Kaminsky-Lizondo-Reinhart (KLR) (1998) approach to conduct an ex-post study of the probabilities of China suffering a currency crisis during the period of January 1991 to December 2004. Two high-probability periods are identified: July 1992-July 1993 and August 1998-May 1999. The first period correctly predicts China's 1994 devaluation. The second period predicts currency devaluation in the aftermath of the Asian crisis, which did not occur. The results of the model indicate that the fundamentals were weak enough for China to experience contagion of the Asian crisis, and raise the question of the possible role of China's institutional arrangements in preventing the crisis. The paper further analyzes the economic fundamentals of China that drive the high probability of crises, and provides some suggestions for further reform.

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Keywords: Early warning systems, Currency crisis prediction, China, Asian crisis.

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1. Introduction

China's economic transformation has been one of the major development successes of the end of the twentieth century. Since the start of the economic reforms in 1978, China has outperformed any other country in the world in terms of economic growth, taking 400 billion people out of poverty in the process. China has become one of the top six largest economies in terms of output produced (when output is measured at market exchange rates), the fourth world trader, and the largest recipient of foreign direct investment (Prasad, 2006).

Despite all this success, the Chinese economy still has some structural weaknesses that may undermine its potential for future growth. In particular, China's financial system is weak: financial intermediation is mainly dominated by state banks, which have high proportions of non-performing loans in their asset portfolios. Furthermore, the currency is non-convertible, and capital controls substantially restrict the ability of Chinese citizens to invest abroad. This institutional structure is in the process of being reformed by the Chinese government, which has expressed its willingness to liberalize its capital account. China is also under pressure from the United States and other economies to revaluate its currency and potentially liberalize its currency system. Some economists see this move as problematic and fear a reproduction in China of the circumstances that led to the Asian financial crisis of 1997 (Goldstein and Lardy, 2006). Given the strong link between China and other Asian economies, destabilization in China could be readily spread over the region.

The East Asian crisis of 1997 was prompted by Thailand's devaluation of its currency in mid-1997 and it rapidly spread to other East Asian economies, which either had to devaluate their currencies or lost important amounts of foreign reserves defending them. Even though the East Asian countries affected by the crisis differed in terms of their economic policies and economic fundamentals, they had some common features that made them vulnerable to a currency crisis. In particular, most economists agree by now that the crisis was the result of a combination of weak financial systems with high

exposure to short-term foreign debt (Lee 2003, Goldstein 1998, Radelett and Sachs 1998, among others).

China was one of the few East Asian emerging economies that were spared from contagion of the currency crisis. There has been a lot of speculation on how fragile the Chinese economy was during the Asian Crisis and the possible role that its exchange rate regime may have played at insulating the country from the crisis. Some authors attribute China's ability to resist contagion to its better fundamentals (Lan, 2002), whereas other authors claim that the non-convertibility of the RMB and capital controls had a crucial role in the insulation (see, for instance, Lee, 2003 and Lardy, 2003).

In order to analyze the level of vulnerability of a country to currency crisis at any given period, a method is needed that is able to identify a set of leading indicators that present abnormal behavior prior to a currency crisis and that gives a measure of the likelihood of a crisis occurring, given the behavior of those indicators. This is precisely the objective of "early warning system" approaches. Even though these methods are designed as forecasting devices, they are also useful, when applied to a single country, in determining the ex-post likelihood of that country suffering a currency crisis at any given period (Edison, 2003).

In this paper we use an early warning system developed by Kaminsky-Lizondo-Reinhart (1998) (the KLR signals approach) to determine, ex-post, the probabilities of currency crises for China for the period of January 1991 to December 2004. Two periods of high probability of crisis are identified: July 1992-July 1993 and August 1998-May 1999.[1] The first period correctly predicts the exchange rate realignment of 1994, when China unified its official and swap-market exchange rates, resulting in a 50 percent devaluation of the renminbi (RMB). The second period coincides with the aftermath of the East Asian crisis. Even though no devaluation occurred in China during this period, the high probability of crisis indicates that, according to the KLR method, China's

[1] A high probability of crisis in a given period implies that a crisis is likely to occur within 24 months of the signal being received. Therefore, the model identifies a high likelihood of currency crises occurring between July 1992-July 1995 and August 1998-May 2001.

fundamentals during the Asian crisis were weak enough to make the country a candidate for contagion.

The paper further analyzes the economic fundamentals underlying the "crisis signaling" periods. We find that the fundamentals signaling the crisis in both periods are radically different, except for an increase in the M2 multiplier, which appears on both periods. For the 1992-1993 period the signaling variables are a rise in M2, a decrease in reserves, and an appreciation of the real exchange rate. For the 1998-1999 period the indicators signaling a crisis are the real interest rate differential, domestic credit relative to GDP, exports, and terms of trade. An analysis of the Chinese economy at that period reveals that the decrease in exports is a direct effect of the recession that the Asian Crisis brought to the region (an important part of Chinese trade at the time was with other East Asian countries). The increase in domestic credit was driven by the government massive investment in infrastructure in order to keep the Chinese growth rate at its target level of 8 percent. This suggests that the government used expansionary fiscal policy in order to face the challenges posed by the Asian crisis, instead of devaluating the currency.

The objective of this paper is twofold. First, by analyzing the Chinese economy under the KLR method we develop a better understanding of the vulnerabilities of China during the Asian crisis and the reasons why China was able to avoid contagion. Second, we shed some light on the use of the KLR method for countries with non-convertible currencies and capital controls. To the extend that currency inconvertibility and capital controls reduce the possibility of sudden and massive capital flights, weak fundamentals may not necessarily lead to currency devaluation. We argue that for such countries, the KLR method is a useful tool to *detect* structural weaknesses in the economy that would lead to exchange rate pressure in a liberalized economy. Detecting these weaknesses is especially important for economies that are in the process of reform and liberalization of their financial and exchange rate systems, since they may increase their vulnerability to currency crises once the controls are lifted.

There is a growing literature based on the KLR signals approach. First developed by Kaminsky-Lizondo-Reinhart (1998) the method determines a set of relevant indicators which present abnormal behavior prior to a crisis. The indicators are determined by observing the experiences of a set of countries during periods of currency crises (sample-based method). For each of the indicators, the method determines a threshold value. A variable that surpasses its threshold value is assumed to issue a signal. The probability of a crisis occurring in the next 24-month period is determined by the nature and amount of indicators issuing signals at a given point in time. Berg and Pattillo (1999) evaluate the predictive power of the KLR approach. Edison (2003) augments the KLR with a few additional explanatory variables and expands the sample of countries used in determining the indicators and thresholds by including more developing countries. Edison (2003) constructs a new set of threshold levels and probabilities of crises based on his expanded sample. Edison also evaluates how this approach can be applied to an individual country, and finds that the model provides some useful information about a country's vulnerability to a crisis. Kaminsky (1998) introduces a composite crisis indicator that she uses to determine the probability of crisis in each period of time. She then applies the model to some out of sample countries to determine, ex-post, whether the method is able to correctly predict their currency devaluations during the Asian crisis. She finds that the method correctly predicted the currency crisis in Thailand, Malaysia and the Philippines, but it failed to predict the crisis in Indonesia. Alvarez-Plata and Schrooten (2004) apply the method to the analysis of the 2002 currency crisis in Argentina.

A few remarks should be made about the application of the KLR method to the case of China. First, it is well known that the quality of the Chinese data is questionable (see, for example, Young 2004). Regarding output data, local authorities may over-report industrial output in order to keep with government targets. Second, there is the question of the information revealed by financial data in a country with vast government controls on the financial and exchange rate system. Lending rates are controlled by the government and may not reflect market conditions. Capital controls reduce people's ability to diversify portfolios and the fact that banks are government owned implies an implicit guarantee on deposits. Therefore, deposit rates may be less responsive to

financial fragility than in free market economies (Prasad, 2006, and Fernald and Babson 1999).

The limitations on the information contained in the financial data discussed above reduce the ability of the KLR model to correctly predict crises in economies like China. The indicators are either government determined (interest rates) or are less responsive to changes in the economy (deposit rates). Furthermore, massive capital flights are not likely to happen, which may increase the set of policy tools that the government can use to face the deterioration of fundamentals in the economy. In summary, for an economy like China we should expect less "crisis signaling" periods when applying the KLR method. Even when the KLR method delivers a high probability of crisis occurring in a given period, we should expect lower probabilities of observing an actual crisis occurring. Therefore, when applied to economies like China, we should view the KLR model more like a detector of weak fundamentals and less like a prediction device. Detecting weak fundamentals is especially valuable for countries that are undergoing financial liberalization, since they can be destabilizing once the reforms are implemented.

Finally, the *index of exchange market pressure* also has a different meaning in a country with capital controls and fixed exchange rates. Given that massive capital flights are unlikely to occur, strong variations in reserves are very unlikely to occur in short periods of time. Therefore, the index is less of a measure of the reaction of investors to fundamentals, and more a measure of fundamentals per se. Therefore, the type of "crises" captured by the index will be either situations where the government chooses devaluation as a policy tool, or situations where foreign reserves are depleted for causes other than investors' behavior.

The rest of the paper is organized as follows: Section 2 briefly describes the Chinese economy in the period of study. Section 3 provides a description of the methodology. Section 4 presents the results and section 5 concludes and provides some suggestions for further reform in China.

2. The Chinese economy during the period of study

Starting in 1978 China introduced economic reforms in order to gradually transform its centrally planned economy into a market oriented economy. Reforms were first introduced in the agricultural sector, where farmers were allowed to sell any surplus production in the market. Reforms in the industrial and financial sectors started in the 1980s and are still ongoing. In 1992, China was officially labeled a "socialist market economy". In this section, we describe the main institutional reforms introduced by the Chinese government and the state of the Chinese economy in our period of study.

1. Early 1990s: overheated economy

The Chinese financial system has traditionally been controlled by the government, with state-owned banks being the main source of industry financing. In the 1980s and early 1990s lending decisions in the provincial branches of the state-owned commercial banks were influenced by local government authorities. As a result, most of the banks loaned heavily to state-owned enterprises (SOE), without taking into account their profitability. As reforms advanced, SOE faced stronger competition, a high proportion of them became insolvent and was not able to service their loans. On the other hand, banks had (illegally) transferred funds to the stock and real estate markets, creating a real estate bubble. These excessive lending and overinvestment overheated the economy and produced double digit inflation.

In order to deal with inflation and the overheated economy, the government introduced reforms to better regulate the financial sector. In July 1993, credit allocation decisions were centralized in the hands of the Central Bank to prevent local authorities from using bank loans as means of financing their "pet projects". In 1994, three policy banks were created. Their role was to provide loans to SOE for the implementation of selected economic development projects. The government encouraged the growth of alternative financial institutions and decided not to cover all financial risks. These measures gave the government more control over bank loans. Finally, in 1995 the "People's Bank of China Law" and the "Commercial Banks Law" were introduced as the basis of China's banking system. They provide more independence for the Central Bank

and a set of regulatory measures that control lending by commercial banks. These measures, among others, lead to a reduction in the inflation rate without a big decrease in GDP growth rates.

2. Late 1990s: the Asian Crisis and its aftermath

China was one of the few East Asian emerging economies that were spared form contagion of the 1997 Asian crisis. There has been a lot of speculation in the literature regarding the reasons why China was immune to the crisis. Some authors attribute China's ability to resist contagion to its better fundamentals (Lan 2002), whereas other authors claim that the non-convertibility of the RMB and capital controls had a crucial role in the insulation (see, for instance, Lee, 2003 and Lardy, 2003). In what follows we briefly describe the Chinese situation during and after the crisis period. We identify similarities and differences from other countries affected by the crisis.

Most economists agree by now that the Asian crisis was the result of a combination of weak financial systems with high exposure to short-term foreign debt (Lee 2003, Goldstein 1998, Radelett and Sachs 1998, among others). According to Lardy (2003), China's domestic economic fundamentals were worse than those of the Asian countries. Prior to the Asian crisis, China was experiencing deflation and a slowdown of GDP growth. Furthermore, China shared with the other East Asian countries the weaknesses of their financial systems: the Chinese banks had high exposures to risk: they loaned mainly to state-owned enterprises, which in turn used their loans to pay wages and further borrowing instead of purchasing new investment. The state-owned enterprises had a debt to asset ratio of 570 percent in 1995, worse than some of the South Korean conglomerates. Conservative estimates put the SOE non-performing loans at 25 percent of existing loans in 1997.

Contrary to the other countries in the region, China had a strong external position, characterized by current account surpluses, low international debt (mostly in the form of long term foreign direct investment), and strong reserve levels. Furthermore, China had capital controls and non-convertibility of its currency, which prevented citizens from

converting their savings into foreign currency, partly insulating the country from speculative attacks, and limiting excessive foreign borrowing by non-financial institutions (Fernald and Babson 1999). Furthermore, state ownership of the banks made people believe that the government would bail out the banks in the event of a crisis, so bank runs did not occur. The data in table 1, taken from Fernald and Babson (1999), compares China's fundamentals with other countries in the region that were affected by the crisis.

Table 1. Indicators for China and other Asian Economies, 1996

	Change in real GDP growth (98-99 minus 95-96)	Bank loans/GDP	Current account/GDP	Total debt/Reserves	Short term debt/reserves
China	-2.7	92.7	0.9	162.0	25.1
Indonesia	-17.5	55.4	-3.4	707.0	150.3
Thailand	-11.5	100.5	-8.0	240.7	50.6

Source: Fernald and Babson (1999), table 1, selected countries.

Even though China was able to avoid devaluating the RMB, it was not completely immune to the Asian crisis: growth slowed down in the first semester of 1998 and exports to the region contracted. Furthermore, the prices of the shares sold abroad decreased sharply to less than one fifth of their domestic value, as reported by Fernald and Babson (1999). This is an indication of the higher risk premium attributed to China by foreign investors. These premiums decreased as growth resumed in the second semester of 1998 following expansionary fiscal policies and as the government reassured investors that they were not devaluating the currency. The growth in the second semester of 1998 is attributed to an increase in domestic demand stimulated by heavy government investment in infrastructure and an increase in investment by the SOE. The government also introduced further reforms aimed at strengthening the financial system. In particular, it tightened capital controls reducing the ability of Chinese firms to borrow or hold assets abroad. The four main state banks were recapitalized and the Central Bank was given

stronger regulatory power. [2] In 1999 four asset management companies were created in order to purchase and administer the large number of non-performing loans owned by the state commercial banks. Furthermore, SOE reforms were accelerated: more firms were restructured and the government made it easier for SOE to lay off workers.

Further reforms in the Chinese economic and financial system will come after China's accession to the WTO in 2001. The treaty calls for a reduction in SOE subsidies and for the opening of the financial system to foreign competition by the end of 2006, which will more likely bring further reforms to the state banks.

3. Exchange rate policy

Since the beginning of the reform period, China has followed a fixed exchange rate policy together with non-convertibility and capital controls. The degree of non-convertibility has been relaxed over time, with China achieving capital account convertibility but not financial account convertibility. Capital controls preventing Chinese citizens from investing their savings abroad and regulating foreign access to short term portfolio investment are still in place.

China's exchange rate reform followed two stages (Zhang, 1999). First, from 1979 to 1993 China followed a dual exchange rate system, where importers of "approved" goods received dollars at a more advantageous rate than regular importers. The dual exchange rate system was gradually eliminated through a series of devaluations of the official exchange rate and was unified in 1994 following a 50 percent devaluation of the RMB which, according to Zhang (1999) brought the currency value close to its black market exchange rate. China kept the fixed exchange rate system with the currency pegged to the US dollar and a very tight band of .25 percent of allowed fluctuations. Following international pressures China changed its peg to a basket of currencies that includes the dollar, euro, and yen among others in July 2005. The change in peg revalued the RMB by 2.1 percent against the dollar.

[2] The China Banking Regulatory Commission was also established to take over some supervisory functions from the People's Bank of China.

3. Methodology

In this section we describe in detail the methodology that we use to identify crisis episodes for China. The methodology follows the signals approach developed in KLR (1998). We adopt the thresholds and sample probabilities from Edison (2003), who extends the sample used in KLR by adding more emerging economies and, therefore, are more appropriate to analyze the case of China. [3]

Definition of a crisis: The first step in a signals approach is to define what the researcher understands by a crisis. KLR define a crisis as a "situation where an attack to the currency leads to a sharp depreciation of the currency, a large decline of international reserves or a combination of the two" (KLR 1998). Notice that this definition includes successful as well as unsuccessful attacks (in terms of whether the currency actually depreciated). KLR (1998) construct an *index of exchange market pressure* that they use as a measure of currency crisis. This index I is calculated as a weighted average of the monthly percentage changes in the exchange rate, Δ_e / e, and the monthly percentage changes in reserves, Δ_R / R, with weights chosen in such a way that the two components of the index have equal sample volatilities. That is,

$$I = \frac{\Delta_e}{e} - \frac{s_e}{s_R} \cdot \frac{\Delta_R}{R}$$

where s_e is the standard deviation of the rate of change of the exchange rate and s_R is the standard deviation of the rate of change of reserves. A currency crisis is defined to occur when this index exceeds its mean by more than three standard deviations (KLR, 1998).

Signals and thresholds: Guided by economic theory and empirical studies of currency crises, KLR (1998) identify fifteen macroeconomic and financial variables that tend to present abnormal behavior prior to a currency crisis. The following is a list of the variables used, which we have grouped into three sectors: financial sector, external sector, and real sector:

[3] Eight countries were added to the original twenty countries in KLR. They are: Korea, Portugal, South Africa, Greece, India, Pakistan, Sri Lanka, and Singapore.

- Financial Sector: M2 multiplier, domestic credit/GDP, real interest rate, lending-deposit rate ratio, excess M1 balances, M2/reserves, bank deposits, stock prices
- External Sector: exports, real exchange rate, imports, terms of trade, reserves, real interest rate differential
- Real Sector: output

In this paper we use all the indicators but the stock prices, due to the lack of data availability. Given the underdevelopment of the Chinese stock market and its low volume of trade we believe that including this indicator would not change our results. A detailed description of the data used can be found in the appendix.

For each economic variable, KLR (1998) construct the corresponding *signaling indicator* as the 12-month percent change in the level of the variable (except for the excess M1 balances, the deviation of the real exchange rate from trend, and the three interest rate variables). Each indicator has a threshold value associated with it. Any fluctuations of the indicator beyond the threshold are considered abnormal and are taken as a signal that a crisis could occur in the next 24 months. The threshold level is chosen to minimize the noise-to-signal ratio, that is, to balance out the risks of an indicator issuing a signal without a crisis occurring with the risk of an indicator issuing no signal when a crisis actually occurred. In this paper we use the thresholds values derived in Edison (2003), except for the threshold of terms of trade variable, which is taken from Berg and Pattillo (1998). Table 2 presents the threshold percentile and the noise-to-signal ratio for each of the signaling indicators. Threshold levels are defined as a function of the indicator's distribution for each country. That is, for a given country, an optimal threshold for the M2 multiplier of 85, for instance, means that a signal is considered to be issued whenever the M2 multiplier is in the highest 15 percent of observations in its distribution for that country.

Table 2. Performance of indicators

Indicator	Threshold percentile	Noise-to-signal ratio
Financial Sector		
Financial liberalization		
M2 multiplier	>85	.86
Domestic credit/GDP	>80	.75
Real interest rate	>80	.66
Lending-deposit rate ratio	>80	2.7
Other		
Excess M1 balances	>90	.55
M2/reserves	>90	.52
Bank deposits	<10	.94
External Sector		
Current account		
Exports	<10	.6
Real exchange rate	<10	.26
Imports	>90	.88
Terms of trade	<10	.93
Capital account		
Reserves	<10	.53
Real interest rate differential	>90	1
Real Sector		
Output	<14	.59

Source: Table 6 in Edison (2003). Terms of trade from table 1, 23 country sample in Berg and Pattillo (1999). The threshold percentile is determined using the "size of the critical region" from table 6. Threshold = 100(1 – size of region) for all variables with a lower bound and threshold = 100(size of region) for all variables with an upper bound.

Composite crisis indicator and probability of a crisis: As described in Kaminsky (1998), we combine the signaling information of all fourteen indicators by calculating a single *composite crisis indicator* that we use to compute the probability of a crisis in any given point in time.[4] The composite crisis indicator is defined as a weighted-sum of the signaling indicators, where each indicator is weighted by the inverse of its noise-to-signal ratio. Notice that indicators with low noise-to-signal ratios are given higher weights,

[4] Notice that a high probability of crisis in a given period implies that a crisis is very likely to occur within 24 months of the given period.

since they are more reliable in predicting crises. The composite crisis indicator is defined as follows:

$$K_t = \sum S_t^i \cdot w^i$$

where S_t^i is equal to one if indicator i crosses the threshold and zero otherwise. w^i is the inverse of noise-to-signal ratio of indicator i.

The sample-based probability of a crisis for each value of the composite crisis indicator is then computed by observing how often a given value of the index is followed by a crisis within 24 months. The conditional probabilities of a currency crisis are calculated as follows:

$$\Pr\left(C_{t,t+24}^n \middle| k_t = j\right) = \frac{\text{Months with } k = j \text{ and a crisis within 24 months}}{\text{Months with } k = j}$$

where k is the composite crisis indicator. $\Pr\left(C_{t,t+24}^n \middle| k_t = j\right)$ is the conditional probability of a crisis for country i in the time interval [t, t + 24 months] given that the composite crisis indicator at time t is equal to j. Table 3 presents the probabilities of a crisis occurring that are associated to the value of the indicators that we use in this paper, taken from Edison (2003).

4. The Results

Figure 1 displays the index of exchange market pressure for China over the period January 1991- December 2004. The horizontal line is the threshold. When the index exceeds this value, it indicates a crisis episode. Two *crisis episodes* for China are thus identified: July 1992 and January 1994. Reserves were redefined in 1992 to exclude foreign-exchange deposits of state-owned entities with the Bank of China, which resulted in a big fall in the level of reserves in July 1992. Since the index of exchange market pressure is just capturing a statistical redefinition, we disregard this crisis episode in what follows. The second crisis episode is consistent with the January 1 1994 devaluation that marked the end of China's dual exchange rate system.

Table 3. Probabilities of currency crises

Value of composite crisis indicator	Probability of crisis
0-0.6	.14
0.6-1.2	.12
1.2-3	.17
3-5	.25
5-7	.32
7-9	.33
9-10	.43
10-11	.51
11-12	.49
Over 12	.50

Source: Table 9 in Edison (2003).

Figure 2 displays the evolution of selected individual indicators for the period January 1991- December 2004. Each indicator is defined as the annual percentage change in the level of the variable, except for the excess M1 balances (in billion yuan), the deviation of the real exchange rate from trend (in percentage terms), and the three interest rate variables (in percentage terms). The horizontal line determines the threshold. When an indicator exceeds the threshold value, it is interpreted as a warning signal.

Figure 3 displays the probabilities of currency crises for China for the period of study. Two periods with unusual high probability of crises are identified: July 1992-July 1993 and August 1998-May 1999, of which the highest probability of a crisis occurring in the 24 months following the signal is about 50 percent in October 1992 and in June 1993. Notice that the first interval correctly predicts the 1994 devaluation. The KLR method predicts another crisis sometime between August 1998 and May 2001, right in the aftermath of the Asian crisis, which actually did not occur.

Table 4 takes a closer look at the periods that signal high probabilities of currency crises in China. Column 1 shows the identified months. For each month, we report the number of signals, the composite index, the crisis probability, and the indicators which issue signals. The M2 multiplier signaled in almost every identified month. Two indicators, the lending-deposit ratio and bank deposits, did not issue any signals. This

may suggest the poor ability of these two indicators to predict currency crises in the case of China, since interest rates in China are not determined by the market and there exist few saving instruments other than bank deposits. The high probabilities of currency crises for the period July 1992 to July 1993 are due to a high increase in M2, decrease in reserves, and real exchange rate appreciation. The real exchange rate appreciated about 1.7 percent relative to its trend in August 1992. The reason why the KLR method stops signaling after July 1993 is a sharp drop in the M2/reserves indicator that can be traced to an increase in the reserves indicator and a decrease in the M2 indicator. These changes in the indicators coincide with major reforms on the credit system implemented by the government in July 1993 in order to reduce bank lending and which, presumably, produced the sharp decrease in M2. It seems that in this period the high probability of crisis identified by the model was mainly driven by a large expansion of credit, which increased M2, together with low reserves.

The second period with high probability of crisis delivered by the KLR method is August 1998-May 1999, where the probability of a crisis occurring within the next 24 months is consistently at around 32 percent. The indicators that are signaling are mainly the real interest rate differential, domestic credit to GDP ratio, exports, terms of trade, and M2 multiplier. Of these indicators, only the real interest rate differential was above threshold since 1997; all the other indicators send a positive signal only during the identified period. Most of the changes in these indicators can be rationalized by the effects of the Asian crisis on China and the policies introduced to mitigate those effects. Recession in the region reduced demand for Chinese exports from its main trade partners. High real interest rate differentials are probably related to the deflation that China was suffering during the Asian Crisis. Expansionary fiscal policy in the second half of 1998, introduced to counteract a growth slowdown experienced in the first half of the year, sharply expanded domestic credit as the government issued securities to finance the new public investment projects. An important thing to notice is that, contrary to the July 1992-July 1993 signaling episode, the increase in the M2 multiplier indicator is not accompanied by a decrease in reserves or an increase in the M2/reserve indicator, reflecting the strong foreign reserve position of China during this signaling episode. As

figure 2 shows, the reserves indicator is low, but still above threshold during this signaling period.

We end this section by comparing the two crisis signaling periods: the July 1992-July 1993 period, which ended with the realignment of the exchange rate in 1994, and the August 1998-May 1999 period, which did not end with a crisis episode. In the first period, the signaling variables were mainly external, with an important role played by the reserves indicator and the real exchange rate indicator. In the second period, the signaling indicators are mainly financial, with the domestic credit to GDP indicator and the real interest rate differential indicator signaling. According to table 2, three out of the four indicators signaling in the first period have the lowest noise-to-signal ratio. This means that the KLR method assigns them the highest precision. In the second signaling period, the signaling indicators are less precise, according to the method, and the probability of crises is also lower (33 percent compared to spikes of 43-51 percent in the first signaling period).

Regarding the financial system, the main difference between these two periods was the fact that the credit system was more centralized in the second period, with less political influence by local officials in the lending decision process. The Central Bank was more independent and banking regulation was stricter. Furthermore, recapitalization of state banks was under way, as part of the government efforts to strengthen the financial system.

An important question that arises from our analysis is why the deterioration of the fundamentals did not lead to a currency crisis in China. Although the Chinese economy showed a resemblance to those of pre-crisis countries, especially with regard to the poor financial regulation and fragility of the financial system, China did not experience any currency crises. What explains China's immunity to the crises? Why could China survive the "Asian flu"? The answers to these questions should be found on the differences between China and the other East Asian economies at the time. We have identified two main differences in section 2: China's strong external position (current account surpluses

and large foreign reserve levels) and its exchange rate regime. Regarding the former, the KLR method reveals that, independently of the external position, the other fundamentals were weak enough to signal a crisis with high probability and, thus, to make China vulnerable to currency speculation. The KLR method, therefore, suggests a potential role for capital controls and currency non-convertibility in the prevention of the crisis. As argued by Fernald and Babson (1999), capital controls reduced China's exposure to short term foreign debt. Currency inconvertibility made it harder for speculators to attack the RMB. Therefore, relatively closed capital markets may have insulated China against sudden and massive capital flight and the subsequent loss of reserves and unavoidable devaluation suffered by other Asian countries.

5. Conclusions

In this paper we use the KLR signals approach to conduct an ex-post study of the probabilities of currency crises for China for the period of January 1991- December 2004. The method correctly predicts the exchange rate realignment of 1994, and signals the aftermath of the Asian Crisis, August 1998 to May 1999 as another period with high probability of crisis. The fact that China did not experience an actual currency crisis in that period suggests a potential role for China's capital controls and non-convertibility regime in insulating China from the Asian crisis.

The results of this paper have some implications for future policy. The underlying economic weaknesses that China had during the Asian crisis, namely a fragile financial system, are still in place today in the Chinese economy. First, it is clear that a largely insolvent banking sector already exists in China, which leaves the economy vulnerable to future financial crisis. Hence, the creation of a modern banking system with adequate supervision and regulation is essential for China today. Second, the majority of the state-owned enterprises are insolvent. Moreover, their dependence on state-owned banks has left the banking sector with large non-performing loans. Further SOE reform is needed if China is to keep its current growth. Third, our analysis suggests that China's exchange rate regime had a potential role in sparing the country from the Asian crisis. If this is indeed the case, a liberalization of the capital market or a sudden realignment of the

exchange rate peg without addressing the problems of the financial system may make China more vulnerable to future currency crises. A theoretical model is needed in order to fully understand the links between the exchange rate regime, the fragility of the financial system, and the vulnerability to currency crises. Constructing such a model is left for further research.

This paper also derives some implications for the use of the KLR approach. First, by applying it to a country with capital controls and non-convertibility of the currency it sheds some light on the interpretation of the results of the KLR method. In particular, based on this application to the case of China, financial fragility may not lead to currency crisis in economies where short term massive capital flights are unlikely. Drops in reserves, on the other hand, may have effects similar to more liberalized economies. This observation suggests a possible role for institutional variables in early warning approaches.

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Appendix: The Indicators

Data source: International Financial Statistics (IFS). Unless otherwise noted, all variables are in 12-month percent changes.

1. **M2 multiplier:** The ratio of M2 (lines 34 plus 35) to base money (IFS line 14). Monthly M2 and base money were interpolated from quarterly data.
2. **Domestic real interest rate:** Deposit rate (line 60l) deflated by consumer price inflation (line 64).
3. **Lending-deposit rate ratio:** Lending rate (line60p) divided by deposit rate (line 60l).
4. **Domestic credit/GDP:** Domestic credit (line 32) deflated by consumer prices was divided by real GDP (line 99b.p.). Monthly domestic credit was interpolated from quarterly data. Monthly real GDP was interpolated from annual data.
5. **Excess M1 balances:** M1 (line 34) deflated by consumer prices (line 64) less an estimated demand for money. The demand for money is estimated from a regression of real M1 balances on real GDP, consumer price inflation, and a linear time trend.
6. **M2/reserves:** M2 (lines 34 plus 35) converted into dollars (using line 00ae) divided by reserves (line1L.d). Monthly M2 was interpolated from quarterly data.
7. **Bank deposits:** Deposits (line 24 plus 25) deflated by consumer prices (line 64). Monthly deposits were interpolated from quarterly data.
8. **Exports:** line 70_d.
9. **Imports:** line 71_d.
10. **Real exchange rate:** The real exchange rate is derived from a nominal exchange rate (line 00ae), adjusted for relative consumer prices (line 64). The indicator is measured as the percent deviation from trend.
11. **Reserves:** line 1L.d.
12. **Real interest rate differential:** The difference between domestic real interest rate and the real interest rate in the United States.
13. **Terms of trade:** Global Development Finance & World Development Indicators. Monthly terms of trade was interpolated from annual data.

14. **Output:** Industrial production (line 66). This indicator was only available from 1992M12 to 2002M12.

Figure 1. Index of Exchange Market Pressure

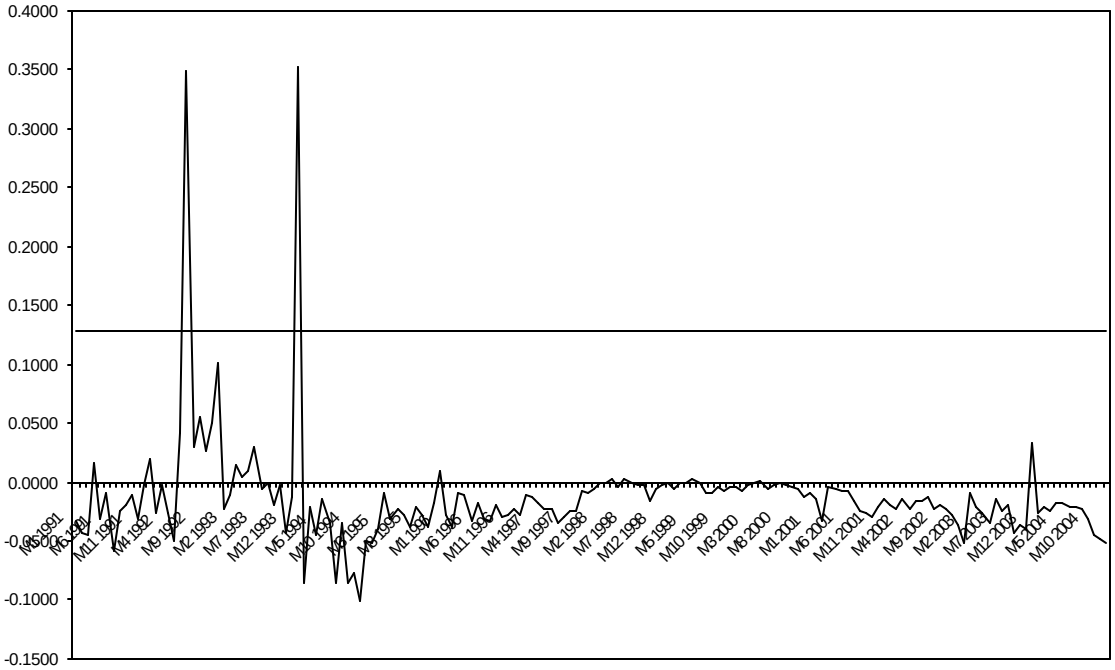
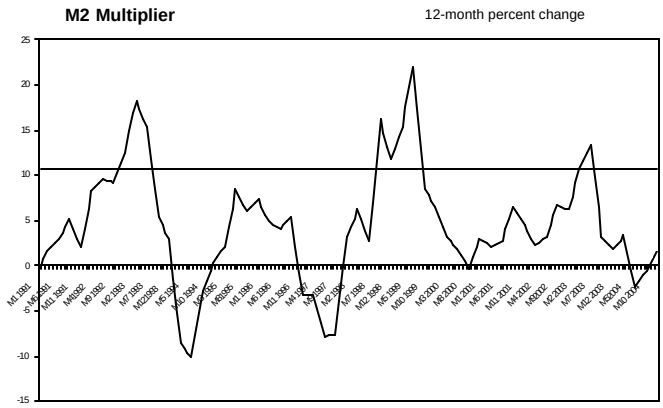
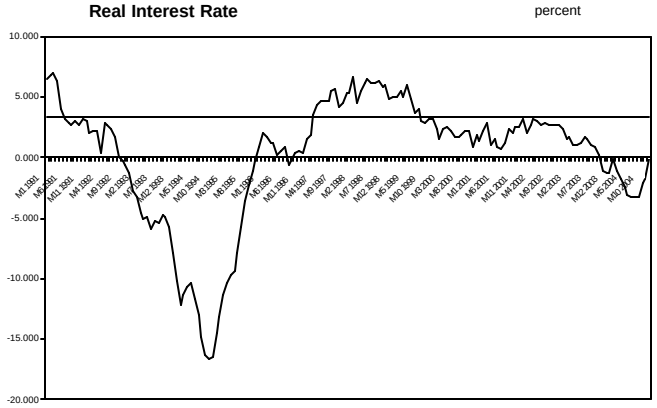
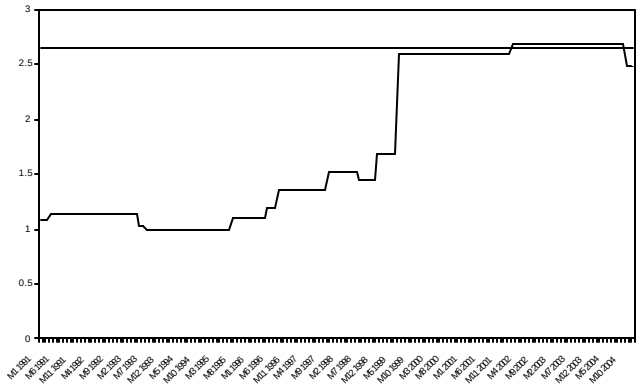


Figure 2. Indicators of Vulnerability

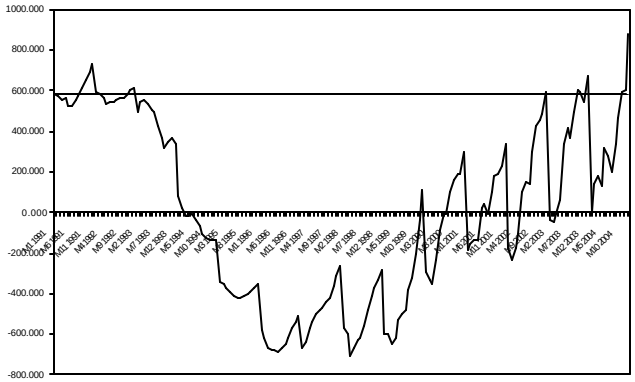




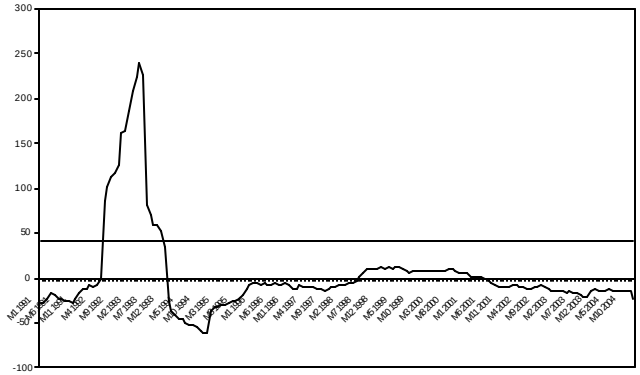
Lending-Deposit Rate Ratio



Excess M1 Balances billions of Yuan

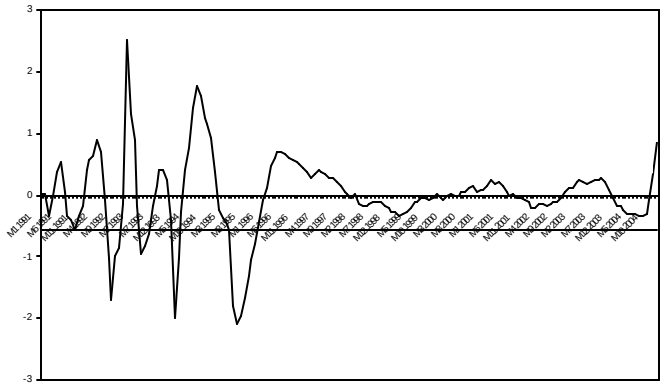


M2/Reserves 12-month percent change

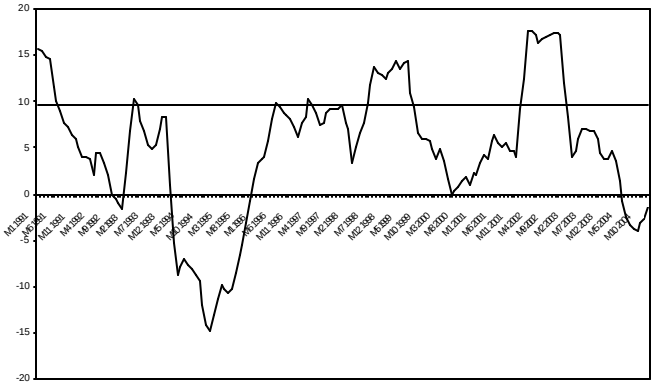


Bank Deposits 12-month percent change

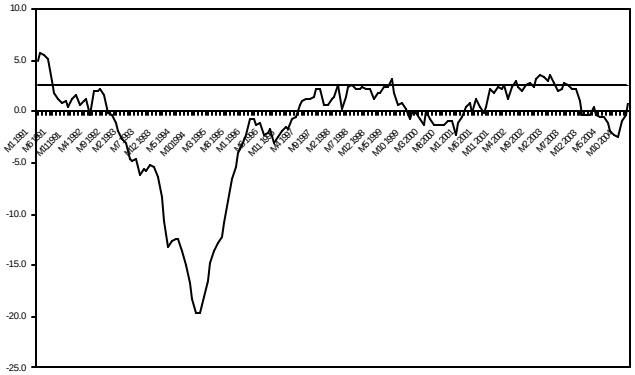
Real Exchange Rate percent deviation from trend



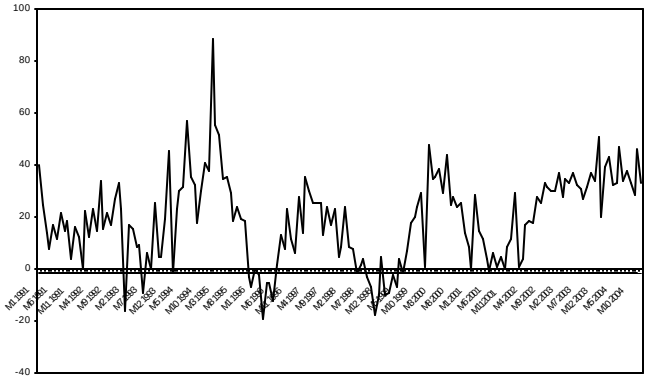
Domestic Credit/GDP 12-month percent change



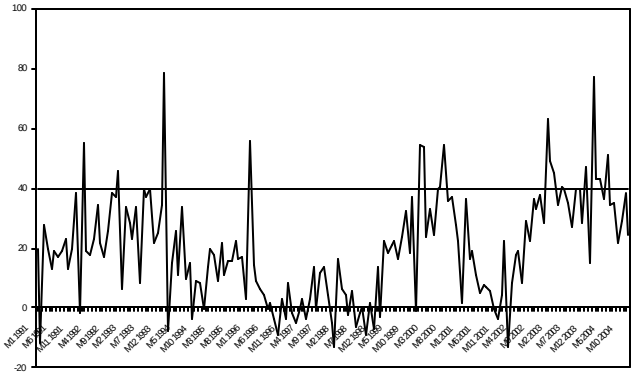
Real Interest Rate Differential Percent



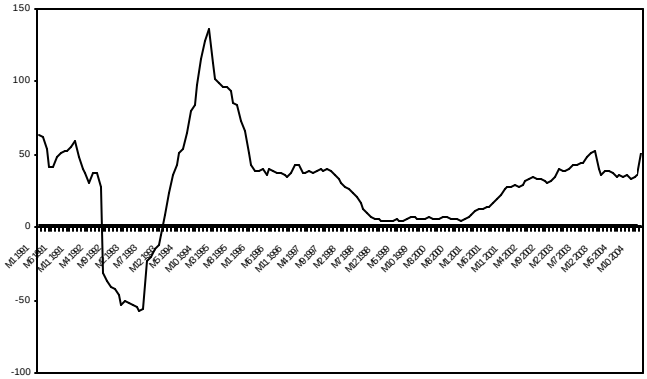
Exports 12-month percent change



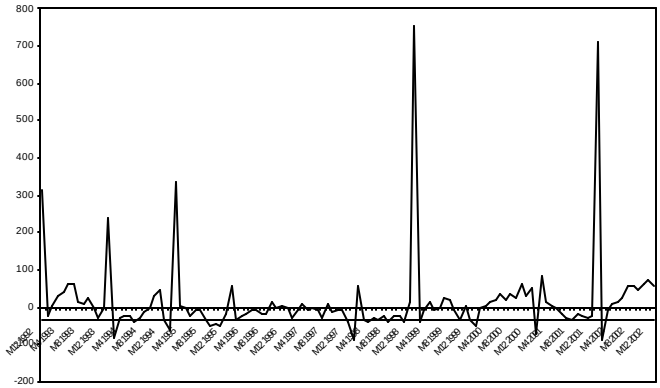
Imports 12-month percent change



Reserves 12-month percent change



Output 12-month percent change



Terms of Trade 12-month percent change

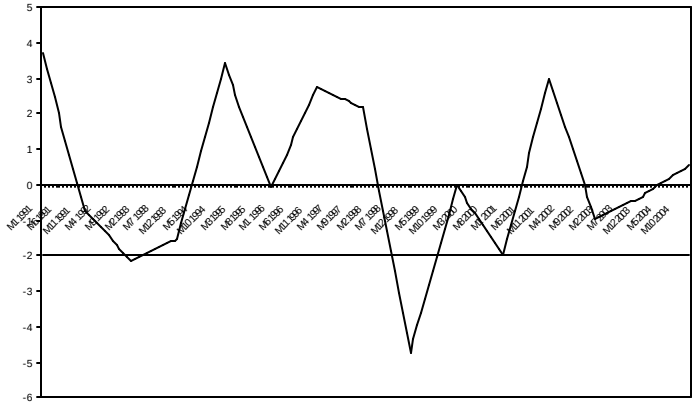


Figure3. Probabilities of Currency Crisis

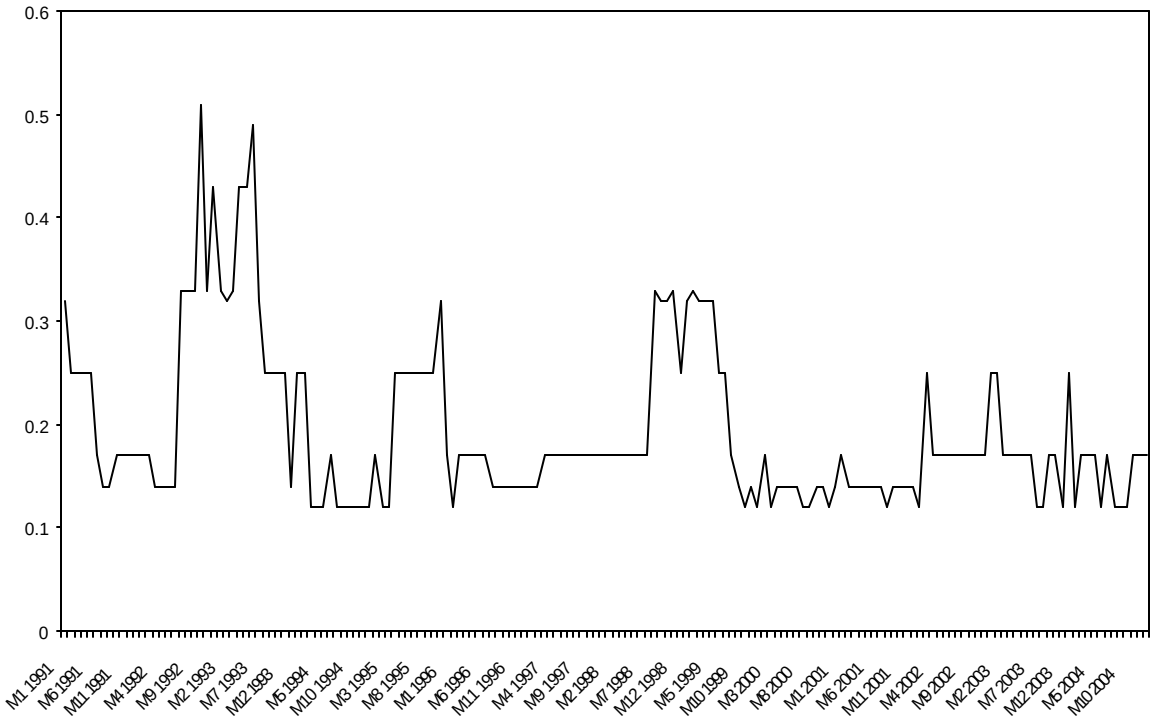


Table 4. Periods with high probabilities of currency crises

	# of signals	Composite index	Crisis Prob	M2 Mult	Real Int	L/D	EM1	M2/R	RER	Bank Dep	DC/GDP	Real Int Diff	Exports	Imports	Reserves	Output	TOT
M7 1992	3	8.84	0.33	0	0	0	0	1	1	0	0	0	0	0	1	0	0
M8 1992	3	8.84	0.33	0	0	0	0	1	1	0	0	0	0	0	1	0	0
M9 1992	3	8.84	0.33	0	0	0	0	1	1	0	0	0	0	0	1	0	0
M10 1992	4	10.50	0.51	0	0	0	1	1	1	0	0	0	0	0	1	0	0
M11 1992	5	8.46	0.33	1	0	0	1	1	0	0	0	0	0	0	1	0	1
M12 1992	6	9.32	0.43	1	0	0	1	1	0	0	0	0	0	1	1	0	1
M1 1993	5	8.46	0.33	1	0	0	0	1	0	0	0	0	1	0	1	0	1
M2 1993	4	6.79	0.32	1	0	0	0	1	0	0	0	0	0	0	1	0	1
M3 1993	5	8.07	0.33	1	0	0	0	1	0	0	1	0	0	0	1	0	1
M4 1993	4	9.71	0.43	1	0	0	0	1	1	0	0	0	0	0	1	0	0
M5 1993	4	9.71	0.43	1	0	0	0	1	1	0	0	0	0	0	1	0	0
M6 1993	5	11.38	0.49	1	0	0	0	1	1	0	0	0	1	0	1	0	0
M7 1993	3	5.71	0.32	1	0	0	0	1	0	0	0	0	0	0	1	0	0
M8 1998	6	7.09	0.33	1	1	0	0	0	0	0	1	0	1	0	0	1	1
M9 1998	5	6.22	0.32	1	1	0	0	0	0	0	1	0	1	0	0	0	1
M10 1998	5	6.22	0.32	1	1	0	0	0	0	0	1	0	1	0	0	0	1
M11 1998	6	7.09	0.33	1	1	0	0	0	0	0	1	0	1	0	0	1	1
M12 1998	4	4.55	0.25	1	1	0	0	0	0	0	1	0	0	0	0	0	1
M1 1999	5	6.22	0.32	1	1	0	0	0	0	0	1	0	1	0	0	0	1
M2 1999	6	7.09	0.33	1	1	0	0	0	0	0	1	0	1	0	0	1	1
M3 1999	5	6.22	0.32	1	1	0	0	0	0	0	1	0	1	0	0	0	1
M4 1999	5	6.22	0.32	1	1	0	0	0	0	0	1	0	1	0	0	0	1
M5 1999	5	5.30	0.32	1	1	0	0	0	0	0	1	1	0	0	0	0	1