CENTRE FOR APPLIED MACROECONOMIC ANALYSIS

The Australian National University

CAMA Working Paper Series **February, 2005**

A PHILLIPS CURVE FOR CHINA

J. Scheibe
St Antony's College, University of Oxford

D. Vines
Balliol College and
Department of Economics, University of Oxford

Research School of Pacific and Asian Studies
Australian National University

Centre for Economic Policy Research

CAMA Working Paper 2/2005
http://cama.anu.edu.au

A PHILLIPS CURVE FOR CHINA

Jörg Scheibe [*]

St. Antony's College
University of Oxford

David Vines [**]

Balliol College and
Department of Economics
University of Oxford

Research School of Pacific and Asian Studies
Australian National University

Centre for Economic Policy Research

28 February 2005

Abstract

This paper models Chinese inflation using an output gap Phillips curve. Inflation modelling for the world's sixth largest economy is a still under-researched topic. We estimate a partially forward-looking Phillips curve as well as traditional backward-looking Phillips curves. Using quarterly data from 1988 to 2002, we estimate a vertical long-run Phillips curve for China and show that the output gap, the exchange rate, and inflation expectations play important roles in explaining inflation. We adjust for structural change in the economy where possible and estimate regressions for rolling sample windows in order to test for and uncover gradual structural change. We evaluate a number of alternative output gap estimates and find that output gaps which are derived from production function estimations for the Chinese economy are of more use in estimating a Phillips curve than output gaps derived from simple statistical trends. Partially forward-looking Phillips curves provide a better fit than backward-looking ones. The identification of a non-increasing exchange rate effect on inflation during a period of large import growth hints at increased pricing to market behaviour by importers. This result is relevant to policies regarding possible exchange rate liberalisation in China.

Keywords: Phillips curve, China, output gap, monetary policy, structural change
JEL classification: E12, E31, E32

[*] Address: St. Antony's College, 62 Woodstock Road, Oxford OX2 6JF; Tel: +44 1865 271089, Fax: +44 1865 271094; Email: jorg.scheibe@sant.ox.ac.uk; URL: www.joergscheibe.de
[**] Address: Department of Economics, Manor Road Building, Manor Road, Oxford OX1 3UQ; Tel: +44 1865 271067, Fax: +44 1865 271094; Email: david.vines@economics.ox.ac.uk
We are grateful to Mardi Dungey, Renée Fry, Carsten Holz, Bent Nielsen, Xin Meng, Adrian Pagan, and seminar participants at the Hong Kong Monetary Authority, the Bank of England, the University of Oxford, the Chinese University of Hong Kong and the Australian National University for helpful comments. Remaining errors are the authors' responsibility. The first author gratefully acknowledges funding support from an ESRC doctoral studentship, and support whilst a Visitor to the Centre for Applied Macroeconomic Analysis, in the Economics Division, Research School of Pacific and Asian Studies, Australian National University.

1 OVERVIEW

Since the start of the reform period in 1978 the Chinese economy has seen two episodes of high inflation where annual changes in the consumer price index have exceeded 25 percent. Both periods of inflation have followed an overheating economy and excess demand,[1] and the overheating has been linked to reform cycles.[2] China's economy has also undergone structural changes: prices have been liberalised, trade has increased, companies have been privatised, and the economy has been marketised. A model of Chinese inflation needs to carefully take account of these changes. This paper does that. It also consolidates most of the results of the few existing papers which analyse inflation in China. At the same time it improves on the existing literature by paying greater attention to two issues which are central to macro-modelling the Chinese economy: adequate adjustment and testing for structural change in the economy, and the careful measurement of an important variable for inflation modelling, namely excess aggregate demand.

Work on Chinese inflation modelling is a timely exercise. The Chinese authorities are putting increased effort into the establishment of a functioning framework for monetary policy via indirect instruments, i.e. interest rates and reserve requirements, and an inflation targeting regime could be an alternative provider of a nominal anchor once the fixed exchange rate regime has been phased out. In any case, inflation will be one of the main variables which Chinese monetary policy tries to control. Thus an investigation into this important variable which is most likely to determine monetary policy can provide the basis or a better understanding of the monetary policy moves in the sixth biggest economy in the world. In this paper we first briefly review the existing literature in Section 2 and then discuss our inflation modelling strategy in Section 3. Section 4 considers the data. Section 5 shows the results from estimating both traditional and New-Keynesian Phillips curves: we consider changes in the inflation dynamics over time, describe thorough tests for structural change, and evaluate the explanatory power of alternative estimates for the output gap. Section 6 concludes.

2 LITERATURE SURVEY

The literature on Chinese macromodelling topics is still scarce overall, and only a few papers have dealt with inflation. Most of the early work was done on annual data, only since the later

[1] Allsopp (1995), Imai (1997)
[2] Brandt and Zhu (2000)

1990s has the literature started to use quarterly data. Most of the work with an explicit focus on inflation has looked at whether variables such as the output gap, exchange rates, or money and credit growth can explain inflation. The evidence from this work is mixed. Imai (1997) is an early paper which tries to formalise the tradeoff of inflation and economic activity and discusses the acceleration of inflation from increases in production beyond the potential level of output. However, the paper stops short of modelling an output-gap Phillips curve. Coe and McDermott (1996) and more recently Ha, Fan and Shu (2003) challenge the output gap model, while Oppers (1997) and Gerlach and Peng (2004) find that the output gap and inflation do move together. The former two studies, on annual (1960-1994) and quarterly data (1989Q1-2002Q4) suffer from a rather simplistic output gap estimate – both are derived from a linear trend.[3] As Ha, Fan and Shu (2003) themselves note, an analysis such as theirs in terms of lagged and forward expected inflation – but no other significant variables – together with import prices and labour costs does not allow for conclusions as to what drives the price series and hence causes the inflation process. The authors estimate a traditional and a forward-looking Phillips curve, but due to their simple output gap estimate never find a significant coefficient for this variable. Hasan (1999) estimates a Phillips curve on annual data, where an output gap (linear trend) and money feature predominantly. Gerlach and Peng (2004) use annual observations (1982-2003) and compare three different output gap estimates: a production function based output gap, a HP-filter, and an ARMA model for the determination of potential output. These output gap estimates are similar in shape and magnitude to the output gap estimates which we use (Scheibe, 2003), and so reinforce the robustness of the work that follows.

The inflationary effects of exchange rate movements have been examined in Zhang (1997), Zhang (2001), Phylaktis and Girardin (2001), and Lu and Zhang (2003). Lu and Zhang (2003), using VARs, find that exchange rate movements (devaluations) had inflationary effects, though small ones.

The role of money in the inflation process is controversial. Chow and Shen (2004) model inflation as an equilibrium correction mechanism for the price level, which ensures that, in the long-run, prices move with the money supply.[4] Burdekin (2000) notes that at higher inflation

[3] Ha, Fan and Shu (2003) also use a Hodrick and Prescott (1997) filter for determining potential GDP.
[4] Chow and Shen (2004) find a cointegrating relationship of prices and M2/GDP with a coefficient of about 0.35 . The authors do not make assumptions about the velocity of money, but a coefficient of

the rate of price increase exceeds the rate of money increase, as the velocity of money increases when consumers dump their money onto the market. Yusuf (1994: p. 87) mentions falling velocity of money in China over time. He also mentions that the inflation spikes in 1985 and 1988-89 had nothing to do with money growth.[5] Phylaktis and Girardin (2001) touch on both of these issues, but don't find significant estimates for either the exchange rate or relative money growth to explain the relative China/US inflation.

This existing literature falls short on three aspects, all of which this paper tries to improve upon. First, apart from Gerlach and Peng (2004), those papers which use an output gap do not take much care in modelling this, which because it is a latent variable requires quite detailed thought. In this paper a number of different candidates for this unobservable variable are used, and compared, in our Phillips curve estimation. Second, the Phillips curve papers so far have found long-run coefficients on lagged inflation of about 0.75. Given the strong theoretical argument for a long-run vertical Phillips curve with a coefficient of unity, the existing work falls short on discussing the reasons for and implications of this result. [6] A discussion of this issue follows in the next section and we will test for whether the long-run Phillips curve is vertical. Third, the literature on quarterly macro-modelling so far has not tried to allow and account for the structural change in the Chinese economy.[7] This is admittedly difficult to model since change in the Chinese economy is of gradual rather than discrete nature. However an attempt to tackle the issue is made in the present paper.

3 HOW TO MODEL INFLATION IN CHINA

Most of the recent papers on inflation in China have used a Phillips curve framework. This is probably the right approach, although there are alternatives which will be considered later. However, since official unemployment figures are hopelessly understated for China and hover around two to three percent for most of the 1990s, even the latest years, an empirical Phillips

---

0.35 appears low. We aim to show in future work that an output-gap Phillips curve can lead to a more coherent understanding of the role of money in the inflation process.

[5] Using quarterly data from 1985-2000, Yusuf agrees with other studies on a falling velocity of money, but argues against the hypothesis that money causes prices. In this paper we will not adjust for time changing money velocity in the Phillips curve, but will merely test whether unadjusted money can explain inflation.

[6] Ha, Fan and Shu (2003) find a higher coefficient on lagged inflation of 0.93 for annual inflation rates but do not report the test for a coefficient of unity. Nor do they comment on the constant term in their equations, which would be inconsistent with such a unit coefficient (see below).

[7] Gerlach and Peng (2004) are a rare recent exception and model structural change as a latent AR(2) process.

curve using unemployment is out of the question for China. What is left for the empirical modeller is an output-gap Phillips curve such as the following.

Let π_t be the annual inflation rate, i.e $\left(\Delta^4 CPI\right)$.[8] Then we may write

$$\pi_t = const_\pi + \gamma^{E\pi} E_t\left[\pi_{t+1}\right] + \sum\nolimits_{i=1}^{4} \gamma_i^{\pi} \pi_{t-i} + \sum\nolimits_{i=0}^{4} \gamma_i^{y^{gap}} y_{t-i}^{gap} + \sum\nolimits_{i=0}^{4} \gamma_i^{\Delta e} \Delta e_{t-i} + \varepsilon_t^{\pi} \qquad [1]$$

Equation [1] is an open economy Phillips curve which incorporates neo-Keynesian aspects. The output gap is defined as actual GDP minus potential GDP $\left(y_t^{gap} = y_t - y_t^*\right)$. A positive output gap corresponds to excess demand. The exchange rate e_t is the trade weighted nominal effective exchange rate (NEER). This varies through the period of estimation even although China has pegged the bilateral exchange rate to the US dollar since 1995. The variable e_t is defined in RMB per foreign currency units such that an increase in e_t corresponds to a depreciation of the Chinese currency; the expected sign on $\gamma^{\Delta e}$ is therefore positive. The exchange rate is included in the Phillips curve because of the significant share of imports in the economy.

The growth rate of money is a potential candidate in any explanation of inflation in China. This variable seems to have been in the mindset of many China economists as a cause for inflation.[9] Theoretically, the amount of money, or credit, in the economy could affect demand, either directly or via its effects on the price of finance (i.e. the interest rate). But the ‘transmission channel’ of these effects through to inflation would then work via the effect of money on demand, and money would not enter directly into the Phillips curve. Of course, another possible effect of excess money growth on inflation is via a depreciating exchange rate, which would then raise the price of imported goods. But that effect is captured by the exchange rate term in our Phillips curve. Including money growth – as an annual growth rate,

[8] Gruen, Pagan and Thompson (1999) mention that an annualised rate of inflation is usually of greater interest to a policy maker than quarterly rates of inflation since annual rates are normally targeted. However, using quarterly changes in the price level can be advantageous for estimation and policy simulation, since doing that avoids potential correlation of the residuals in a Phillips curve based on a variable which uses differences of overlapping periods. Kirby (1981) makes this point for Australian data. The regression results presented in this paper are for annual inflation rates. However, we have also estimated Phillips curves on quarterly difference of the CPI as a robustness check. The results from both sets of regressions are very similar.

[9] See e.g. Chow (1987) and Chow and Shen (2004)

adjusted for GDP growth or not – directly in the Phillips curve is thus not, we believe, the right way to capture the effects of money growth on inflation.[10]

3.1 Should inflation be forward-looking? A New-Keynesian Phillips curve

The question whether inflation in the Phillips curve should be forward looking or not has been debated in the literature on inflation in developed economies (e.g. Fuhrer and Moore, 1995; Gali and Gertler, 1999; Rudd and Whelan, 2001; Mehra, 2004). This paper allows for that possibility, wholly or partially, in China. Since the implications for monetary policy of a forward-looking inflation model are different from those of a backward-looking model, the empirical evaluation of this possibility is important. Entirely forward-looking (new Keynesian) Phillips curves can be derived from microeconomic principles. However hybrid versions with forward and backward looking elements such as Equation [1] seem to better explain the data (in developed countries), see for example Fuhrer and Moore (1995). The main reason for the hybrid properties in their paper is overlapping wage contracts.[11] Fuhrer (1997), Gali and Gertler (1999), Gali, Gertler and López-Salido (2001a), Gali, Gertler and López-Salido (2001b), and Lindé (2001) estimate similar hybrid Phillips curves.

The feature of (partially) forward-looking inflation raises a problem in empirical work. How should $E_t\left[\pi_{t+1}\right]$ be dealt with? There are three options. First, survey data on expectations is sometimes available. In this case, $E_t\left[\pi_{t+1}\right]$ can be treated as an exogenous variable in the regression. For China, there is survey data of inflation expectations available. This data, π^*_{t+1},

$$\pi^*_{t+1} = E_t^{Survey}\left[\pi_{t+1}\right] = \pi_{t+1} + \varepsilon_{t+1}^{Survey} \quad [2]$$

is not necessarily consistent with any rational, adaptive, or any other framework for expectation formation that can be made explicit. Second, the realised value of inflation at time *t+1* could be included in the regression. Doing this in the estimation requires the assumption that expected inflation is on average equal to the realised future value of inflation. What this approach neglects is the endogeneity of future inflation to the inflation equation. Third, the most widely used approach in the modern literature pursues the strategy of modelling

[10] Therefore adding money growth to Equation [1] is not appropriate, we therefore do not report the results of the estimation of Equation [1] with money growth included. In such regressions, we have found that money growth is significant, with a very small coefficient of less than 0.05 for annual money growth rates. We aim to show in future work how the link from money to demand to inflation in China could be studied in the way described above.

[11] The seminal papers are Taylor (1980) and Calvo (1983).

$E_t\left[\pi_{t+1}\right]$ with instrumental variables.[12] Instrumental variable (IV) estimation requires a two equation system such as Equations [3] and [4].

$$E_t\left[\pi_{t+1}\right] = const_\pi + \sum_{i=1}^{4}\gamma_i^{\pi}\pi_{t-i} + \sum_{i=0}^{4}\gamma_i^{y^{gap}} y_{t-i}^{gap} + \sum_{i=0}^{4}\gamma_i^{\Delta e}\Delta e_{t-i} + X_t + \varepsilon_t^{IV1} \qquad [3]$$

$$\pi_t = const_\pi + \gamma_i^{E\pi}E_t\left[\pi_{t+1}\right] + \sum_{i=1}^{4}\gamma_i^{\pi}\pi_{t-i} + \sum_{i=0}^{4}\gamma_i^{y^{gap}} y_{t-i}^{gap} + \sum_{i=0}^{4}\gamma_i^{\Delta e}\Delta e_{t-i} + \varepsilon_t^{IV2} \qquad [4]$$

The residual terms ε_t^{IV1} and ε_t^{IV2} are assumed to be identically, independently distributed (iid). Here X_t represents the instrumental variables. The variables in X_t should be correlated with expected inflation, but exogenous to it.[13] Typical instruments for inflation expectations in the literature are the interest rate spreads between different maturities of the yield curve, marginal production costs, commodity prices, lagged inflation and the output gap. For the case of China, the pool of instrumental variables is very small. Interest rate spreads are not useful, because short term and long term interest rates were set by the central authorities during the estimation period from 1988 to 2002. Marginal production costs would have to be estimated. What remains are oil prices as a proxy for commodity prices, plus, with the right kind of restriction, lagged values of inflation and possibly the output gap. We could impose the vertical Phillips curve restriction on the sum of coefficients on future and lagged inflation, and on lagged changes in the exchange rate, in Equation [4], lagged inflation and/or lagged changes of the exchange rate can be used as instruments in [3], and use the resulting degree of freedom to create an instrument . Alternatively, some lags of the output gap, inflation and the exchange rate which are found to be insignificant in [4], could be used as instruments in [3]. After some experimentation we followed the latter strategy. We will return to the issue of instrument selection in Section 5.1.2.[14]

For the Chinese case, where expectation formation is likely to be more difficult than in developed economies, there seems to be good *a priori* reason for a backward-looking Phillips curve, at least as a starting point for investigation. Therefore our base case Phillips curve for

[12] See the empirical papers mentioned above. This approach requires us to use realised data of π_{t+1} for $E_t\left[\pi_{t+1}\right]$ in Equation [3], whilst using $\hat{\pi}_{t+1}$ as the relevant right hand side variable in Equation [4].

[13] Henry and Pagan (2004) and Mavroeidis (2004) discuss in detail the required properties for instruments in such regressions.

[14] Alternatively, we could estimate Equations [3] and [4] simultaneously with appropriate lag restrictions (see below).

China excludes the expectation of future inflation.[15] For our backward-looking case, we use Equation [5] which is a purely backward looking version of Equation [1].

$$\pi_t = const_\pi + \sum_{i=1}^{4} \gamma_i^\pi \pi_{t-i} + \sum_{i=0}^{4} \gamma_i^{y^{gap}} y_{t-i}^{gap} + \sum_{i=0}^{4} \gamma_i^{\Delta e} \Delta e_{t-i} + \varepsilon_t^\pi \quad [5]$$

Here ε_t^π is again an iid stochastic error.

3.2 Should the Phillips curve be vertical?

The Phillips curve of Equations [1], [4] and [5] is non-vertical in the short-run, i.e. there is a trade-off between inflation and the output gap in the short-term (providing, that is, that it contains some backward looking component). We wish to test whether the long run Phillips curve is vertical. In this case, any sustained level of above-equilibrium output would lead to ever-increasing inflation. The arguments as to why the long-run Phillips curve should be vertical date back to Friedman (1968).

In a closed economy estimating a vertical Phillips curve requires the imposition of two constraints: that $\sum_{i=1}^{n} \gamma_i^\pi = 1 \text{ and } const_\pi = 0$.[16] An open economy Phillips curve is vertical if the coefficients on lagged inflation and the exchange rate coefficients *together* sum to unity, i.e. if $\sum_{i=1}^{n} \gamma_i^\pi + \sum_{i=1}^{n} \left(\gamma_i^{\Delta e}\right) = 1$ and $const_\pi = 0$.[17] In the case of perfect pass-through of exchange rate changes into domestic prices, policy makers have little incentive to inflate the economy in the short-run.

In a world in which the long-run Phillips curve is vertical, policy makers have little incentive to inflate output above potential. This because even if the short-run Phillips curve is not vertical, accelerating inflation could only be stopped again by closing the output gap, and a reduction in inflation back to its target would require a negative output gap, i.e. a recession which exactly mirrored the initial boom. This is, of course, only unattractive if policy makers do not discount future economic outcomes. A political leader with a short-term horizon might

[15] Estrella and Fuhrer (1998) find that entirely backward-looking Phillips curves indeed fit better than forward-looking ones for US data. By contrast, our work suggests that partially forward-looking Phillips curves fit better for China.
[16] The imposition of the second constraint is necessary to ensure that accelerating or decelerating inflation is only avoided at a level of the output gap which is zero. Our construction of the output gao rests on this assumption. See Section 8.2 below.
[17] The open economy case differs from the closed economy case in that, *ceteris paribus*, a rise in domestic prices will cause a depreciation of the nominal exchange rate by an equal proportion so that relative purchasing power parity is maintained.

find it optimal to inflate the economy in order to stay in power. For the Chinese case, the assumption of a long-term growth objective and long-term career objectives for the political leadership seems a reasonable assumption and we do not need to be concerned with steep discounting of future economic outcomes, or with the time-inconsistency problem to which it gives rise (see Kydland and Prescott, 1978, and Barro and Gordon, 1983). As a result, the argument seems relevant for China.

3.3 Capturing the effects of structural change in China

Most economic reforms in China, including price liberalisation and marketisation of the economy, have followed a gradual pattern.[18] It is difficult to capture these gradual changes in a regression analysis. We address the issue of economic change, and of possibly resulting structural breaks in the data in two ways. First, we trace the change (or lack thereof) in regression coefficients via recursive estimations and test with methods proposed in Chow (1960) for break points (at unknown points in time, see Greene, 2000). We use the PcGive software package (Hendry and Doornik, 2003) which, in addition, provides for the Hansen (1992) tests of parameter stability. Second, in order to make explicit any changing structural relationships in the data, we use rolling estimation windows of 36 quarters length (Table 7, p. 31) and pay close attention to changes in parameter values between the rolling estimation periods.[19]

Section 3.3.1 reviews the degree and progress of price liberalisation between 1988 and 2002, while Section 3.3.2 discusses the extent to which structural breaks during the estimation period can be adjusted for.

3.3.1 Price liberalisation

Full price liberalisation was not fully accomplished by 1988 when the estimation period for the Phillips curve starts. A relevant question is therefore whether retail prices in China were sufficiently free during the estimation period to allow for a meaningful estimation of a Phillips curve results.

[18] See e.g., Naughton (1994), Woo (1994), Rawski (1995), Meng (2000), Chai (2000), Huang (2002), Laurenceson and Chai (2003)

[19] A five year rolling estimation window would be an obvious choice for a country operating under five year plans. However, using 36 quarters rather than 20 allows for greater degrees of freedom in estimations.

Prices in China can be sorted into four main categories: industrial ex-factory, agricultural purchase, wholesale, and retail prices.[20] The former two are producer prices. It is a variant of the last category which is the subject of this study: consumer prices. Consumer prices were set by the State Price Bureau based on producer prices plus a profit margin for the intermediary. The link between the two categories was not static, the authorities moved producer prices around without necessarily adjusting the downstream prices, and vice versa. Prices did not invariably reflect cost, and only two major price adjustments happened between 1953 and 1978.[21]

Decontrol of all prices proceeded in stages. In a first stage starting in 1979, (ex-factory) prices were either fixed, floating, i.e. market-determined within a price band, above a floor or below a centrally set ceiling, or fully market-determined. Also, for a transition period, the authorities opted for a two-tiered price system during the journey from planned to market prices. The introduction of dual prices was gradual and it was the agricultural sector where some prices were decontrolled first. From 1979 onwards, farmers were paid fixed prices for quantities determined under the plan, while any surplus production could be sold freely in markets. For consumers, the two-tier system included a coupon system. An equivalent framework was adopted for industrial output in 1984, and by 1985 price reforms started to have profound impact on the economy through the industrial sector.[22] The introduction of a two-tier price framework also had an educational effect: farmers, industrial producers and consumers were able to learn about operating marginal-cost pricing, while still being able to conduct most of their transactions in the familiar environment. Not surprisingly, the dual prices gave rise to arbitrage opportunities and firms increasingly diverted sales away from the planned system and sold it at market prices, which were often much higher. When inflation started to reach undesirable levels in 1988 and 1989, maximum limits to free prices were introduced for some commodities, while a number of prices such as those for fuels and coal were adjusted upwards in these years. By 1992 most dual-track prices had been merged into market prices,[23] and only 89 producer goods and transport prices remained under central planning (Chai, 1997), including prices for basic agricultural goods. Dual prices in agriculture were finally abolished during 1993 throughout the country, the exact month of abolition of the coupon system varied

[20] Chai (1997)
[21] ibid.
[22] Lu and Zhang (2003)
[23] Wen (2003)

across provinces.[24] The effect of the coupon abolition was a steep one-off increase in agricultural prices, especially in 1994. Figure 1 (p. 30) illustrates this.

Turning to the object of this study, consumer prices, a considerable portion of these were decontrolled by 1988, when our estimation begins, and consumer prices carried market driven price signals to quite extent from 1988 onwards. Figure 2 illustrates the progress of price liberalisation for both agricultural and for retail prices. By 1992, more than 90 percent of consumer prices had been liberalised.[25]

3.3.2 Adjustment for structural breaks

Apart from unspecified 'general' gradual change, the 1993 and 1994 round of price adjustment constitutes the only event for which specific allowance has been made by means of a break-point adjustment in the estimation. Figure 4d and 4e show a clear spike in inflation in 1994 which can be partially explained by one of the last steps of price liberalisation described above. The suppressed prices of agricultural goods moved upwards following the abolition of the coupon system, see Figure 1.[26] The upward shift in prices which were previously artificially subdued is a common phenomenon in transition economies (Young, 2002), and second order effects due to relative price adjustments vis a vis agricultural goods are likely to have mattered as well (Correy, Mecagni and Offerdal, 1998). A look at Figure 4b reveals that the rise in consumer prices in 1994 happened at a time of high output gap pressure. We need some kind of dummy variable to avoid our estimation attempting, incorrectly, to attribute all of the rapid price increase at this time to this demand pressure, when it was partly caused by the price liberalisation.

The dummy variable required is *not* a […,0,1,0,…] indicator variable of the usual kind, for the following reason. Consider the effects of a one-off rise in the CPI price level, due to a one-off price liberalisation like that in 1993 and 1994. The price level jumps from zero to one, as in the top left corner of Figure 3. The effect of this on the difference of the CPI is displayed

[24] We thank Xin Meng for drawing our attention to this feature of Chinese price reform. Chai (1997) (table 6.1) shows that during our estimation period from 1987 to 2002, only cigarette prices in 1988 and 1991 and some agricultural goods in 1992 were liberalised. Agricultural goods prices were fully freed during 1993, when the coupon system was finally abolished.

[25] Chai (1997), Oppers (1997: p. 26)

[26] Note the relatively much steeper rise in agricultural prices in 1994. During 1993, the year of the gradual abolition of coupons, there was an increase in agricultural prices. But the main impact of this charge was delayed until 1994.

on the top right in that figure. Inflation first steps up, and then drops back, if (as we assume) the change is understood by economic agents to be a one-off price rise rather than an inception of an inflationary process. In a vertical Phillips curve, the effect of a […,0,1,0,…] indicator variable would be to make the inflation rate rise by 1 and stay there due to the unit root, rather than return to zero as the figure shows it should. In order to take out the one-off price rise and instead allow for a temporary increase in inflation, a dummy variable with a counter response […,0,1,-1,0,…] must be used instead.[27]

There is one other possible date at which a break-point might be used during the estimation period. This is January 1994 when the exchange rate was devalued and subsequently fixed to the US dollar. But the estimation method uses the trade weighted nominal effective exchange rate as a right hand side variable and this should capture that effect.[28]

4 DATA

The use of Chinese data requires a comment for two reasons. First, as with many emerging market economies, some data series have been published for a short period of time only. Second, Chinese data has attracted a fair number of papers looking into the data quality.[29] Although short-comings in data collection or the reporting process are pointed out in most papers, many authors state that the Chinese Statistics Bureau is trying to publish unbiased data and can therefore serve as a first port of call for data on the Chinese macroeconomy. Data sources and all variables entering the Phillips curve are explained in Section 8.2 . All variables in the inflation equation are assumed to be stationary. See the discussion of this in Section 8.2 and the unit root tests displayed in Table 9.

5 ESTIMATION RESULTS

The estimation of the Phillips curve proceeds iteratively in two steps. In the two steps of the estimation, the first step requires a solution to the second, and vice versa. These nested steps of analysis are the selection of the 'best' output gap, and the estimation of the Phillips curve, which is tested for long-run verticality and robustness across rolling estimation periods, using

[27] Our Phillips curve is estimated for annual inflation rates which are fourth differences of data for the level of the CPI. We therefore use four such dummy variables over the four quarters following the initial price level spurt, to allow additional degrees of freedom.
[28] Potential trend or intercept corrections might also be necessary – but turn out to be non-essential.
[29] See, for example, Chow (1993), Wu (1997), Wu (2000), Rawski (2001), Rawski (2002), Wong and Chan (2003), Holz (2003). See Scheibe (2003) for a summary of the data discussion.

this best output gap. But all the detail and care used in estimating the Phillips curve must then feed back into a confirmation that we have selected the best output gap. Section 5.1 documents and discusses the estimation of backward-looking and New-Keynesian Phillips curves. Section 5.2 compares the explanatory power of different output gap estimates for inflation and indeed does confirm our choice of the best output gap . Section 5.3 reviews the implications of our results for whether the Phillips curve is vertical. Section 5.4 comments on the relevance of the Lucas critique, and on the implications of structural change for the estimation of a behavioural equation in a gradually changing economy.

5.1 Our best practise Phillips curve

To summarise our findings, backward-looking output-gap Phillips curves appear to be a good starting point for modelling Chinese inflation dynamics. The output gap and the change in the trade weighted exchange rate are significant right hand side variables. The estimated Phillips curves are accelerationist. Partially forward looking Phillips curves are an important enhancement of the backward-looking inflation equations; they offer a better fit, and slightly more stable coefficients over time. Roughly speaking, inflation dynamics are 25 percent forward-looking, and 75 percent backward-looking. Sections 5.1.1 and 5.1.2 document the estimation results from backward-looking and partially forward-looking Phillips curves. Section 5.1.3 compares the two sets of results.

5.1.1 Backward looking Phillips curve

The Phillips curve is estimated as in Equation [5], Table 1 shows the results. Results are shown for the entire estimation period 1988Q1 to 2002Q4, as well as rolling estimation windows of 36 quarters. Coefficients are stated with their t-statistic, diagnostic tests show the probability of rejecting the hypothesis of a mis-specified regression equation.

Diagnostic tests

Diagnostic tests are generally met for almost all estimation periods.[30] Table 11 in Section 8.3 of the Appendices provides references for and explains the diagnostic tests. Figure 5 in Section 8.3 displays the recursively estimated regression coefficients for the full-period

[30] As mentioned before, the diagnostic tests are weak for small samples such as the 36 observation rolling window estimates.

sample period, including Chow tests for structural breaks. The entry under ‘Vertical PC ChiSqr’ in Table 1 shows the results from the test for a long-run vertical Phillips curve, i.e. whether $\sum_{i=1}^{n}\gamma_i^{\pi}+\sum_{i=1}^{n}\left(\gamma_i^{\Delta e}\right)=1$. The test is Chi-square distributed, and the probability value shown is the one for accepting the hypothesis of a vertical Phillips curve; the hypothesis of a vertical Phillips curve is rejected at conventional significance levels if this probability value falls below 0.05. The hypothesis of long-run vertical Phillips curves is accepted for the 1988-2002 estimation period and for the first three rolling estimation windows, but long-run verticality breaks down in purely backward-looking Phillips curves for the last four estimation windows. The line below this test in Table 1 shows the sum of the relevant coefficients entering the test for a long-run vertical Phillips curve.

Phillips Curve	d4CPI															
	88-02	t-stat	88-96		89-97		90-98		91-99		92-00		93-01		94-02	
DD94q1	0,030	3,75	0,027	2,62	0,029	3,33	0,029	3,62	0,027	4,00	0,025	4,89	0,027	5,21	0,028	5,95
DD94q3	0,018	1,88	0,025	2,05	0,016	1,45	0,023	2,47	0,025	3,11	0,024	4,05	0,027	4,68	0,027	4,79
DD94q4	0,049	5,22	0,042	3,52	0,046	4,54	0,045	4,81	0,038	4,81	0,037	5,20	0,038	6,45	0,039	6,87
d4CPI-1	0,984	15,10	0,910	13,60	0,932	11,40	1,047	11,20	1,016	12,20	1,064	13,00	1,033	15,60	1,115	19,90
d4CPI-3	-0,57	-4,46	- 0,203	-3,43	- 0,547	-3,57	- 0,438	-3,09	- 0,211	-3,49	- 0,457	-3,61	- 0,337	-7,80	- 0,310	-7,14
d1CPI-4	0,3051	3,34			0,302	2,78	0,238	2,51			0,146	1,78				
d4e-1	0,083	2,68	0,162	5,56	0,091	2,15	0,099	3,68	0,088	3,86	0,069	3,68				
d4e-2	0,087	2,38			0,093	1,92										
d4e-3													0,042	1,92		
d4e-4															0,063	2,53
d4e-5	0,071	3,70	0,064	2,63	0,091	3,25	0,074	2,94	0,056	2,25						
d4e-6											0,085	3,16				
d4e-7													0,087	2,79		
d4e-8	0,072	4,45	0,082	4,06	0,069	3,10										
ygap							0,067	1,23	0,152	2,91	0,216	3,40	0,300	5,15	0,201	3,98
ygap-3	0,118	3,34	0,129	2,54	0,138	2,78										
sigma	1,10%		1,46%		1,21%		1,08%		0,92%		0,67%		0,68%		0,66%	
Diagnostic tests																
DW	1,560		1,470		1,620		1,860		1,480		1,870		1,500		1,530	
AR 1-4	2,311	0,07	1,268	0,31	1,076	0,38	1,431	0,26	2,201	0,11	1,557	0,23	0,817	0,50	0,526	0,67
ARCH 1-4	0,587	0,67	0,085	0,96	0,170	0,92	2,662	0,07	0,324	0,81	2,355	0,10	0,538	0,66	0,185	0,91
Normality	1,720	0,42	3,715	0,16	1,211	0,55	2,674	0,26	3,324	0,56	0,310	0,86	0,029	0,99	2,771	0,25
Heteroskedasticity	0,647	0,85	0,551	0,86	0,197	0,99	0,984	0,54	0,927	0,56	0,713	0,74	0,379	0,96	0,611	0,81
RESET	3,967	0,05	0,203	0,66	0,687	0,42	2,153	0,15	0,026	0,88	0,135	0,72	0,623	0,44	0,869	0,36
Vertical PC ChiSqr(1)	2,130	0,14	0,328	0,57	1,361	0,24	0,372	0,54	2,222	0,14	5,890	0,03	21,38	0,00	15,89	0,00
Sum of d4CPI lags	0,72		0,71		0,69		0,85		0,80		0,75		0,70		0,81	
Exchange rate effect	0,31		0,31		0,34		0,17		0,14		0,15		0,13		0,06	
Sum of d4CPI and exchange rate coefficients	1,03		1,02		1,03		1,02		0,95		0,91		0,82		0,87	
Annual output gap effect	0,42		0,47		0,47		0,26		0,60		0,82		1,14		0,81	

Table 1: Estimation results – backward-looking Phillips curve

The annual output gap effect entry shows the accumulated effect of a persistent output gap over a one year period. The sigma value is the residual standard deviation. Due to the exclusion of the constant, a meaningful R-sqr value cannot be computed.[31] However, with a small and statistically insignificant constant included, the R-squared value for all estimation periods is above 0.9 for regression estimations in Table 1. Hansen (1992) tests for parameter stability within a given estimation window are satisfied. No Phillips curve reported in Table 1 contains a constant, as required. The validity of removing the constant is tested for by F-tests, which also monitor the increasing number of excluded variables from the initial general unrestricted model.

Output gap

The output gap coefficient shows an increasing trend over time, and the significant lag switches from the third lag to the contemporaneous one in the mid 1990s. The accumulated annual output gap effect increases from 0.4 at the beginning of the estimation sample to about 0.8. Chinese prices seem to react to excess demand more sensitively the further the marketisation of the economy progresses.[32]

Lagged dependent variable

Four lags for the dependent variable $\left(\Delta^4 CPI\right)$ are allowed for. The first lag is always significant with a coefficient of about 1.0. The second lag is never significant, while the sum of the third and fourth lag decreases from -0.2 to -0.3 during the estimation period. The sum of the coefficients on lagged inflation rates is around 0.7 throughout the estimation period.

Exchange rate

The change in the (trade weighted nominal) exchange rate is an important variable in the determination of inflation in China. A one percent depreciation of the exchange rate results in an increase in the price level of 0.30 percent. For the change in the exchange rate, up to eight lags are tested for. This is because while the formal test with up to eight lags for the 1988-2002 estimation did not indicate that lags of more than four quarters for the output gap and for inflation would be of relevance, it appears that the exchange rate does matter up to lag eight.[33]

---

[31] See Greene (2000: p. 240)

[32] We found an annualised coefficient of 0.4 for the 1988-2002 estimation period on quarterly differenced data of the CPI. The trend in the coefficient seemed to be decreasing though. Quarterly differenced CPI data is likely to carry a higher noise to signal ratio due the construction method of the CPI series.

[33] Campa and Goldberg (2002) review inflation in 25 OECD economies. One of their findings is that a change in the import composition of many countries has had the strongest effect on changes in the pass-through. Their work shows that a pass-through of unity within four quarters is a reasonable

From the results of Table 1 there is evidence for a subtle trend in the relative weight on the coefficients of the exchange rate and lagged inflation. It appears that the exchange rate effect on inflation is falling over the rolling estimation windows.[34] This apparent trend of a decreasing exchange rate coefficient is at odds with a rapidly opening economy, where imports have grown from less than 20 percent to about 30 percent during the estimation period. A declining exchange rate effect in an opening economy can only be reconciled with an increased pricing of imported goods in RMB rather than the currency of their country of origin, that is with “pricing to market”. (See Krugman, 1986, and Aizenmann, 2000). Such a declining sensitivity of inflation to the exchange rate has an important policy implication. Inflation targeting, which is a risky framework for transition economies when exchange rates are volatile,[35] could offer a safe way of providing a nominal anchor for the Chinese economy. That is because, even if the exchange rate fluctuates more after exchange rate liberalisation and the opening of the capital account, the effect of this on inflation might be decreased by pricing to market.[36]

Dummy variables

The reason for the use of dummy variables has been discussed in Section 3.2.1 and 3.2.2. Since the abolition of agricultural coupons started in 1993, we have included double impulse dummies $\left(DD_t\right)$ from 1993Q1 to 1994Q4. None of these is significant in 1993, and only DD_{94Q1}, DD_{94Q3}, and DD_{94Q4} remain as significant dummies. These variables are important for estimating a well behaved model which satisfies the diagnostic tests (which are weak due to the small sample size). As explained in Section 3.2.2, the dummy variables have been introduced in a way which allows for the hypothesis of a vertical long-run Phillips curve.

---

assumption on average. Their estimates further indicate a pass-though elasticity of 0.61 on average across their OECD sample countries in the short-run (one quarter). In order to save degrees of freedom in the regression, up to four lags of all independent variables were allowed for in the base case. However, for the exchange rate up to 8 lags are significant in the regressions, and in the light of Campa and Goldberg (2002) we have extended the initial 4 lag specification. Alternative estimations on the first difference data of the CPI, i.e d1CPI, the quarterly rate of inflation, show that the exchange rate matters up to lag eight in that case, too.

[34] Our regressions on quarterly differenced CPI data confirm this result.

[35] Mishkin (2000) mentions this aspect of inflation targeting for emerging and transition economies.

[36] Note that Ball (1999), and others (including, much earlier, Weale, Blake, Christodoulakis, Meade and Vines, 1989), have argued for this reason for a measure of inflation which excludes direct exchange-rate effects, such as the GDP deflator, for the target variable for open economy inflation targeting regimes. A low exchange rate coefficient makes this issue of less concern.

5.1.2 New Keynesian Phillips curve

One aspect of the Chinese Phillips curve remains to be investigated: forward-lookingness. Two estimation specifications are considered: the first and the third of the approaches of dealing with $E_t\left[\pi_{t+1}\right]$ mentioned in Section 3.1. For the first approach, $E_t\left[\pi_{t+1}\right]$ is obtained from survey data and treated as an exogenous variable. The other approach models the expected rate of inflation using instrumental variable techniques. The conclusion is that in estimating Equation [1], the results from both methods are similar, and expectations of future inflation seem to matter with a coefficient of 0.2, while the *lagged* inflation has an aggregate coefficient between 0.55 and 0.7. The exchange rate coefficients fill the remaining 'gap' to ensure long-run verticality of the Phillips curve.[37] The test of this long-run verticality property is passed in almost all cases. Indeed, the partially forward-looking Phillips curves meet the condition of a vertical long-run Phillips curve even in the later estimation periods. This result points to the increasing importance of inflation expectations for price setting in China.

Survey data

The survey data of expected inflation is used as an exogenous regressor in the estimation. This data survey the current expectation of inflation in one year's time, i.e, $E_t\left[CPI_{t+4} - CPI_t\right] = E_t\left[\pi_{t+4}\right]$. Table 2 displays the estimation results. The estimation period is shorter in this case because survey data on inflation expectations is available since 1991 only. Expected inflation plays an important role, the coefficient is between 0.15 and 0.2, increases to 0.45 for the last rolling window and is always significant.[38] Compared to the purely backward-looking Phillips curve specification, the long-run verticality hypothesis is met throughout. This is an indication for the growing importance of inflation expectations as the Chinese economy becomes more market driven. The output gap effect is similar to the backward-looking estimations, though this time no increasing trend is visible (although the time period for comparison is much shorter). A decreasing exchange rate effect is less pronounced in the hybrid Phillips curve estimations with survey data. The regression contains the same indicator variables as the backward-looking one. Where the diagnostic tests indicate a problem with autocorrelated residuals, Newey and West (1987) adjusted standard errors are used and the adjusted t-statistics are indicated with "NW" in Table 2. The empirical fit,

[37] These numbers are again closely matched in Phillips curve regressions on quarter by quarter changes in the CPI (d1CPI).

[38] d1CPI regressions confirm these results.

measured by the residual standard deviation, sigma, is improved compared to the purely backward-looking specification.

Phillips Curve	d4CPI									
	91-02	NW	91-99		92-00	NW	93-01		94-02	
DD94q1	0,021	6,93	0,020	3,01	0,025	5,74	0,025	5,35	0,019	4,60
DD94q3	0,026	7,75	0,022	3,00	0,019	5,01	0,028	5,48	0,020	4,35
DD94q4	0,036	10,66	0,034	4,53	0,035	13,21	0,037	7,25	0,034	7,40
E[t](d4CPI[t+4])	0,182	3,68	0,163	2,76	0,205	3,57	0,180	3,07	0,447	5,01
d4CPI-1	0,964	13,16	0,974	12,00	0,962	16,82	0,942	14,40	0,871	12,10
d4CPI-3	-0,3315	-4,58	- 0,342	-5,86	- 0,415	-8,84	- 0,383	-9,94	- 0,533	-9,97
d4e-1									0,053	1,84
d4e-3	0,088	3,05	0,104	3,74	0,042	1,53	0,058	2,63	0,085	2,94
d4e-5					0,052	1,74				
d4e-7	0,057	1,98					0,117	4,04		
d4e-8			0,052	1,78	0,082	2,88			0,138	3,76
ygap	0,113	3,00	0,134	2,52	0,169	2,85	0,189	3,01	0,086	1,86
ygap-3										
sigma	0,79%		0,84%		0,66%		0,60%		0,51%	
Diagnostic tests										
DW	1,890		1,680		1,820		1,980		2,240	
AR 1-4	4,026	0,01	2,510	0,08	3,677	0,03	1,560	0,23	0,825	0,49
ARCH 1-4	0,260	0,90	0,191	0,90	1,054	0,39	0,663	0,58	0,600	0,62
Normality	1,599	0,45	3,766	0,15	3,453	0,18	1,198	0,55	5,660	0,06
Heteroskedasticity	2,033	0,06	0,661	0,77	1,930	0,21	1,145	0,43	0,718	0,73
RESET	2,073	0,16	2,513	0,13	0,959	0,34	0,503	0,48	3,400	0,07
Vertical PC ChiSqr(1)	1,848	0,17	0,363	0,55	2,951	0,09	3,81	0,06	1,34	0,25
Sum of d4CPI leads	0,18		0,16		0,21		0,18		0,45	
Sum of d4CPI lags	0,63		0,63		0,55		0,56		0,34	
Exchange rate effect	0,15		0,16		0,18		0,17		0,28	
Sum of d4CPI and exchange rate coefficients	0,96		0,95		0,93		0,91		1,06	
Annual output gap effect	0,41		0,49		0,59		0,66		0,28	

Table 2: Estimation results – hybrid Phillips curve (survey data)

Instrumental variable approach

The results from the instrumental variable approach to modelling inflation expectations are reported in Table 3. These results are similar to and confirm those using survey data for expectations. In order to keep the results below comparable with the results from the survey data, we instrument for $E_t\left[\pi_{t+4}\right]$ rather than $E_t\left[\pi_{t+1}\right]$.[39] The coefficients on future (expected) inflation are lower than in the regressions with survey data at around 0.1. Only in the 1988-1996 estimation window does expected inflation fail to be significant. The pattern of a decreasing exchange rate effect and an increasing output gap effects matches that from the backward-looking Phillips curve estimation. Residual autocorrelation is a problem for all regression windows and we use Newey-West adjusted standard errors.

[39] Estimations with $E_t\left[\pi_{t+1}\right]$ give similar results.

The selection of instruments for $E_t\left[\pi_{t+4}\right]$ is important in this approach to modelling inflation expectations.[40] The instruments used are lags of inflation up to fourth order, the output gap, the change in the exchange rate, and the change in oil prices.[41]

Phillips Curve	d4CPI															
	88-02	NW	**88-96**	NW	**89-97**	NW	**90-98**	NW	**91-99**	NW	**92-00**	NW	**93-01**	NW	**94-02**	NW
DD94q1	0,030	3,96	0,031	3,80	0,031	3,92	0,030	4,34	0,029	4,47	0,028	5,11	0,029	4,08	0,026	5,12
DD94q3	0,017	1,86	0,010	1,04	0,024	2,59	0,026	3,27	0,023	3,11	0,025	3,89	0,028	5,84	0,021	3,58
DD94q4	0,043	4,90	0,040	4,25	0,035	3,96	0,039	5,10	0,034	4,69	0,038	5,98	0,039	6,89	0,037	6,29
d4CPI[t+4] (IV)	0,091	3,27	0,050	1,46	0,184	6,15	0,187	3,93	0,114	3,92	0,068	2,64	0,066	2,43	0,145	2,84
d4CPI-1	1,017	15,50	0,970	11,70	1,024	19,80	0,985	10,70	1,041	12,90	1,031	13,20	1,011	15,50	1,051	15,00
d4CPI-3	-0,5767	-4,61	- 0,652	-4,26	- 0,320	-7,14	- 0,255	-5,03	- 0,240	-4,04	- 0,292	-6,28	- 0,319	-7,55	- 0,326	7,41
d1CPI-4	0,2597	2,71	0,337	2,87												
d4e-2	0,102	3,31	0,151	3,65												
d4e-4											0,047	1,41				
d4e-5	0,039	1,73	0,078	2,72					0,034	1,30						
d4e-7													0,097	3,12		
d4e-8	0,085	5,50	0,097	5,25	0,084	3,89	0,064	2,85			0,040	1,51			0,047	1,45
ygap									0,109	1,90	0,203	3,18	0,259	4,08	0,209	3,46
ygap-3	0,115	3,13	0,122	2,59	0,126	2,63	0,104	1,36								
sigma	1,15%		1,36%		1,44%		1,25%		1,04%		0,76%		0,68%		0,68%	
Diagnostic tests																
AR 1-4	9,790	0,00	8,776	0,00	14,48	0,00	20,26	0,00	41,09	0,00	12,38	0,02	6,980	0,01	7,570	0,01
ARCH 1-4	0,243	0,70	0,041	0,95	0,183	0,83	0,273	0,76	0,378	0,69	0,410	0,67	0,842	0,45	0,598	0,56
Normality	1,120	0,57	1,956	0,38	1,680	0,43	1,060	0,59	1,006	0,60	3,648	0,16	0,117	0,94	1,653	0,44
Heteroskedasticity	0,205	1,00														
Vertical PC ChiSqr(1)	0,651	0,42	1,343	0,25	1,049	0,31	0,267	0,61	1,755	0,19	7,815	0,01	11,73	0,01	3,21	0,07
Sum of d4CPI leads	0,09		0,05		0,18		0,19		0,11		0,07		0,07		0,15	
Sum of d4CPI lags	0,70		0,66		0,70		0,73		0,80		0,74		0,69		0,73	
Exchange rate effect	0,23		0,33		0,08		0,06		0,03		0,09		0,10		0,05	
Sum of d4CPI and exchange rate coefficients	1,02		1,03		0,97		0,98		0,95		0,89		0,85		0,92	
Annual output gap effect	0,41		0,42		0,47		0,39		0,42		0,77		0,96		0,80	

Table 3: Estimation results – hybrid Phillips curve (IV method)

We could have used the results from the backward-looking Phillips curve to give an indication as to what lags of inflation, the output gap and the change in the exchange rate should be included in the New Keynesian Phillips curve and thus what lags remained for use as instruments for $E_t\left[\pi_{t+4}\right]$. However. the simultaneous estimation of Equation [3] and [4] could result in different lags of the variables being chosen in [4] which might then invalidate the decision about what instruments to use for Equation [3]. We therefore also estimated [3] and [4] as a simultaneous system using the full information maximum likelihood method and found that the lags which were significant in our partially forward-looking version of the Phillips curve were almost exactly the same as those which had been obtained in the backward-looking version. We take that finding as a validation of our research strategy of

[40] We thank Mardi Dungey, Bent Nielsen and Adrian Pagan for assistance with this part of the work.
[41] Oil prices are calculated as prices in USD multiplied by the RMB/USD exchange rate. The change of oil prices never turned out to be significant in Equation [3].

proceeding to the New-Keynesian Phillips curve via preliminary analysis of the backward-looking case.

5.1.3 Comparison of backward-looking and New Keynesian Phillips curve

The overriding conclusion from estimating partially forward-looking Phillips curves based on survey data and the instrumental variable method is: expected inflation matters. This result stands out across different estimation windows, estimation approaches, and data specifications, as Phillips curves estimated on quarterly differences of the CPI lead to similar results.[42] Survey data based regressions show a slightly stronger weight on future inflation than the IV set of regressions. Including some measure of inflation expectations helps to preserve the accelerationist properties of the Phillips curve.

Phillips Curve	**d4CPI**									
	91-02	NW	**91-99**		**92-00**	NW	**93-01**		**94-02**	
DD94q1	0,021	3,54	0,019	2,80	0,023	4,38	0,023	4,83	0,019	4,86
DD94q3	0,027	4,09	0,021	2,81	0,024	4,16	0,029	5,41	0,020	4,26
DD94q4	0,036	5,37	0,357	4,72	0,038	6,43	0,038	6,99	0,033	7,31
E[t](d4CPI[t+4])	0,196	3,94	0,250	3,85	0,254	5,15	0,255	5,51	0,366	6,68
d4CPI-1	0,948	12,80	0,934	10,60	1,021	5,40	0,923	13,60	0,931	16,30
d4CPI-3	-0,3159		- 0,416		- 0,435		- 0,379		- 0,512	
d4e-3	0,099	4,69	0,132	4,31	0,071	3,07	0,081	4,25	0,105	6,25
d4e-7	0,072	3,43					0,119	3,94	0,110	3,57
d4e-8			0,100	3,47	0,089	3,61				
ygap	0,066	2,94	0,099		0,053	2,31	0,073	3,43	0,118	4,75
sigma	0,79%		0,88%		0,69%		0,63%		0,51%	
Diagnostic tests										
AR 1-4	4,578	0,04	1,504	0,24	4,970	0,01	1,561	0,22	0,897	0,46
Normality	3,896	0,15	11,53	0,00	4,150	0,13	4,882	0,87	2,918	0,23
Heteroskedasticity	2,390	0,03								
Sum of d4CPI leads	0,20		0,25		0,25		0,25		0,37	
Sum of d4CPI lags	0,63		0,52		0,59		0,54		0,42	
Exchange rate effect	0,17		0,23		0,16		0,20		0,21	
Sum of d4CPI and exchange rate coefficients	1,00		1,00		1,00		1,00		1,00	
Annual output gap effect	0,24		0,35		0,19		0,25		0,40	

Table 4: Estimation results – constrained vertical hybrid Phillips curve (survey data)

The two estimation approaches to the New Keynesian Phillips curve produce broadly similar coefficients on the output gap and the exchange rate to those in the backward-looking Phillips curve, although they differ slightly in the extent to which they reveal trends in these coefficients. On the grounds of residual standard errors, hybrid Phillips curves improve on backward-looking ones.[43] In Table 4 and Table 5 we show the estimation results of hybrid

[42] These results are not reported in this paper.
[43] Hybrid Phillips curve estimations on d1CPI data result in more volatile coefficient estimates across the rolling estimation windows.

Phillips curves on which the long-run verticality condition has been imposed. Imposing this constraint on the estimation of the hybrid Phillips curves tends to increase the coefficient on expected future inflation, and somewhat lowers the output gap and exchange rate effect. Usually, the variables selected in the unconstrained regressions remain significant in the constrained estimations.

Phillips Curve	d4CPI															
	88-02	NW	88-96	NW	89-97	NW	90-98	NW	91-99	NW	92-00	NW	93-01	NW	94-02	NW
DD94q1	0,028	3,58	0,031	3,82	0,032	3,91	0,030	4,38	0,029	4,44	0,029	4,79	0,029	4,84	0,025	4,68
DD94q3	0,022	2,38	0,012	1,18	0,024	2,56	0,027	3,37	0,024	3,09	0,029	4,17	0,031	4,55	0,022	3,48
DD94q4	0,038	4,28	0,039	4,17	0,034	3,89	0,039	5,13	0,034	4,66	0,421	6,07	0,043	6,35	0,037	6,00
d4CPI[t+4] (IV)	0,129	5,03	0,057	1,66	0,198	6,88	0,175	4,23	0,126	4,25	0,102	3,71	0,131	5,10	0,213	5,58
d4CPI-1	0,955	15,20	0,986	12,00	1,024	19,00	1,014	14,10	1,043	12,30	1,104	13,00	1,041	13,10	1,025	13,90
d4CPI-3	-0,2634		- 0,628		- 0,311		- 0,252		- 0,212		- 0,263		- 0,247		- 0,283	
d1CPI-4			0,288	2,58												
d4e-2	0,078	2,64	0,127	3,46												
d4e-4											0,028	-0,74				
d4e-5			0,071	2,51					0,042	1,60						
d4e-7													0,075	2,06		
d4e-8	0,101	6,58	0,099	5,36	0,089	4,06	0,062	2,80			0,029	0,99			0,045	1,31
ygap									0,043	1,52	0,039	1,30	0,054	2,04	0,123	4,68
ygap-3	0,119	3,48	0,149	3,57	0,098	2,43	0,070	1,73								
sigma	1,24%		1,38%		1,50%		1,23%		1,09%		0,88%		0,84%		0,73%	
Diagnostic tests																
AR 1-4	14,20	0,00	9,105	0,01	14,64	0,00	20,68	0,00	51,81	0,00	22,04	0,00	16,41	0,00	9,790	0,00
ARCH 1-4	0,376	0,82	0,091	0,91	0,082	0,92	0,177	0,84	0,009	0,91	0,255	0,87	0,210	0,81	0,148	0,86
Normality	0,688	0,71	1,309	0,52	2,050	0,36	1,486	0,48	1,734	0,42	4,355	0,11	5,820	0,05	6,581	0,04
Heteroskedasticity	0,639	0,83														
Sum of d4CPI leads	0,13		0,06		0,20		0,18		0,13		0,10		0,13		0,21	
Sum of d4CPI lags	0,69		0,65		0,71		0,76		0,83		0,84		0,79		0,74	
Exchange rate effect	0,18		0,30		0,09		0,06		0,04		0,06		0,08		0,04	
Sum of d4CPI and exchange rate coefficients	1,00		1,00		1,00		1,00		1,00		1,00		1,00		1,00	
Annual output gap effect	0,44		0,52		0,37		0,27		0,17		0,16		0,21		0,47	

Table 5: Estimation results – constrained vertical hybrid Phillips curve (IV method)

5.2 Identification of the best output gap

We have identified the 'best' output gap for China which gives us the 'best' Phillips curve. We compare five output gap estimates, where potential output is derived from: a linear trend, a HP trend, an aggregate production function with constant TFP trend, an aggregate growth accounting exercise with a time varying TFP trend, and finally one based on sectoral data with time-varying sector TFP rates. Our criteria for choice amongst these include: test statistics such as the partial R-squared, the t-statistic of the output gap coefficient in the Phillips curve, and the Schwartz criterion.[44]

[44] We have partially confirmed the selection result based on these criteria against the results from the automated model selection programme PcGets (Hendry and Krolzig, 1999; see also Hendry and Krolzig (2004a,b). We used that regression selection programme to search for the dominant congruent

partial R-sqr	88-02	88-96	89-97	90-98	91-99	92-00	93-01	94-02
Linear	2,4%	2,3%	4,6%	0,2%	23,2%	35,6%	28,3%	9,0%
HP	5,2%	0,7%	0,8%	0,5%	13,2%	25,8%	27,6%	20,4%
Sector based, fixed TFP	18,5%	19,3%	30,4%	5,3%	23,3%	30,0%	48,6%	35,3%
aggr data, fixed TFP growth	9,7%	5,3%	11,2%	0,2%	24,9%	42,8%	36,8%	25,8%
aggr data, flex TFP growth	15,2%	14,9%	10,1%	1,8%	25,1%	24,7%	54,4%	27,9%
sigma								
Linear	1,20%	1,67%	1,38%	1,16%	0,93%	0,74%	0,81%	0,79%
HP	1,29%	1,51%	1,58%	1,23%	1,01%	0,78%	0,77%	0,74%
Sector based, fixed TFP	1,10%	1,46%	1,21%	1,08%	0,92%	0,67%	0,68%	0,66%
aggr data, fixed TFP growth	1,30%	1,65%	1,39%	1,24%	0,91%	0,68%	0,75%	0,75%
aggr data, flex TFP growth	1,21%	1,56%	1,49%	1,12%	0,91%	0,79%	0,64%	0,70%
t-stat								
Linear	1,12	0,79	1,14	0,25	2,86	3,86	3,27	1,69
HP	1,66	0,42	0,47	- 0,36	2,10	3,12	3,27	2,73
Sector based, fixed TFP	3,34	2,54	2,78	1,23	2,91	3,40	5,15	3,98
Sector based, fixed TFP	2,34	1,23	1,81	- 0,22	3,05	4,57	4,03	2,62
aggr data, fixed TFP growth	2,96	2,13	1,74	0,70	3,07	3,03	5,78	3,35
Schwartz-Criterion								
Linear	- 8,40	- 7,57	- 7,96	- 8,30	- 8,74	- 9,21	- 9,02	- 9,21
HP	- 8,19	- 7,72	- 7,75	- 8,24	- 8,70	- 9,16	- 9,18	- 9,34
Sector based, fixed TFP	- 8,47	- 7,87	- 8,10	- 8,44	- 8,82	- 9,39	- 9,43	- 9,55
Sector based, fixed TFP	- 8,23	- 7,59	- 7,87	- 8,29	- 8,84	- 9,43	- 9,22	- 9,33
Sector based, fixed TFP	- 8,27	- 7,65	- 7,79	- 8,31	- 8,85	- 9,13	- 9,56	- 9,44

Table 6: Selection criteria for the best output gap

Table 6 displays the results from this ‘horse race’ in the case of the backward-looking Phillips curves (Equation [5]), estimated as described in Section 5.1.1 . For a given estimation period, the lag structure of all variables is (almost) identical across the different output gap specifications. Long-run verticality of the Phillips curves is tested for. Regressions with the ‘best’ output gap rarely suffer from a failed diagnostic test. By all measures, and across most estimation periods, the output gaps derived from production functions explain inflation better than output gaps derived from statistical trends. And the sector based production function is the output gap estimate which explains inflation in China best. It has the highest partial correlation with inflation, results in the lowest residual standard deviation, and leads to the most significant coefficient in the Phillips curve estimation for almost all estimation periods. This output gap has a high correlation with the inflation rate in the mid 1990s, while the output gap estimates derived from statistical trends do not explain the major inflation peak (see Figure 4). Potential GDP determined by a linear trend performs worst. The output gap derived from individual sector production functions stands out as the ‘best’ output gap and has been used as the standard output gap estimate in Section 5.1 .

model among a number of alternative possibilities which included all five of the potential measures of the output gap. But we only did this for the backward-looking Phillips curve.

Of course we have repeated exactly this selection process in the context of our estimation of a hybrid Phillips curve. The results from the output gap selection process are the same. Again they favour the disaggregated production function approach. See Table 12 in Section 8.3.

5.3 The significance of testing for an accelerationist Phillips curve

The present work depends upon our construction of an output gap. That rests upon our assumption of an exogenous capital stock, and the assumption of a fixed labour supply. In this framework increases in demand above potential, i.e. a positive output gap, imply excess demand for labour which should cause accelerating inflation. We thus test for a long-run vertical Phillips curve, i.e. a Phillips curve in which there is no long-run trade-off between output and inflation and in which a positive output gap would lead to accelerating inflation. We do this in order to test whether our results are consistent with our assumptions.

Most of the output-gap Phillips curve papers for China have so far presented an inadequate analysis of this issue. Almost none of the papers so far have tested for a long-run vertical Phillips curve.[45] The estimation of a non-accelerationist Phillips curve would have strong implications. If production above the long-run sustainable level does not lead to ever-increasing inflation due to the exhaustion of productive capacity, this suggests than an expansion of the productive capacity - caused by the overstretching of the economy - would actually be desirable. It would also suggest that a Phillips curve model is the wrong representation of the economy. Instead a plausible alternative modelling strategy would follow a Lewis (1954) type setting of a two sector economy, where the industrial sector is the area of measured economic activity and the agricultural sector is merely a labour pool for this sector to draw on. In such a setup any labour constraint in production would only bind temporarily, until new labour poured in from rural areas to cities.[46] Such a setting would not be non-sensical for the case of China, however it would require the assumption that untrained, rather than specialised, labour is required to expand the production possibility frontier in the short-term. Labour would become an easily adjustable factor of production, so that, even with the standard assumption of a fixed capital stock, output would become expandable without accelerating inflation, calling into question the whole concept of an output gap.

[45] Imai (1997) considers the trade-off explicitly, though not in a formal Phillips curve environment.
[46] See Vines (2004) for a related two sector model.

This paper is the first to test for a long-run vertical Phillips curve. The above argument suggests that this is a necessary test if one is to use the Phillips curve framework for estimating inflation regressions for China. We have tested for a vertical long-run Phillips curve, i.e. a test on whether the sum of the coefficients on lagged inflation and on the change in the nominal exchange rate sum to unity (both of which are specified as quarterly changes). The tests are usually satisfied.

5.4 Structural change and the Lucas critique

A gradually changing economy can pose problems for econometric work since the *ceteris paribus* assumption underlying the regressions could be misguided. The problematic 'change' comes in two guises, both of which can affect the results: changes in private sector behaviour, and changes in macroeconomic policy.

Changes in private sector behaviour can cause breaks in data series, such as intercept breaks in integrated data series. This will cause a change in the estimated coefficients over the break-point, or will mean that estimated coefficients become a contaminated mixture of pre-break and post-break coefficients, if the break is undetected. Hendry (2000) makes this point in relation to integrated data. In fact the data entering our Phillips curve is stationary (see Appendix 8.2). Nevertheless we believe that this problem remains a possibility in our case, too.

We address this problem by carefully testing for breaks points in the estimated parameters. Such tests for structural breaks are passed for the 1988-2002 estimation period and all shorter estimation windows, yet the rolling estimation windows sometimes show increases or decreases of certain coefficients over time. Despite these slight differences between shorter estimations periods, the tests for parameter constancy and for structural breaks all show that the output-gap Phillips curve is valid throughout 1988-2002, and that it is affected very little by the reforms in various sectors of the Chinese economy during the 1980s, 1990s, and early 2000s.

Changes in the policy regime connecting the targets of policy to the instruments of policy can cause the coefficients of regressions to be contaminated by unobserved changes in the policy framework. This is the argument of the "Lucas critique", first presented in Lucas (1976). For our estimation of a Phillips curve in China it seems that changes in the policy regime might affect our estimation results. Monetary policy instruments have changed during the estimation period, and there have been shifts between a target for growth and a target for inflation as the main focus for macroeconomic policy. The relevance of the Lucas critique must therefore be evaluated empirically.

We do this by including expectations in our Phillips curve. In our setup, agents' adoption to changed policy reaction is captured by changes in their inflation expectations. This means that the Lucas critique is avoided in a way which it cannot be in purely backward-looking equations, in which this expectations channel cannot work. There is, of course, a literature which takes issue with the empirical validity of the policy invariance argument. For example, Estrella and Fuhrer (1999) find that purely backward-looking inflation equations do better than partially forward-looking ones for quarterly US data from 1966 to 1997, thus suggesting that the Lucas critique has no power on that data. We have found that partially forward-looking equations can give a good explanation of inflation in China. Furthermore, for the later part of the estimation period, the backward-looking Phillips curve ceases to be vertical. By contrast, this problem does not arise for our partially forward-looking Phillips curve. That suggests the Lucas critique *does* matter in the case of China and that a (partially) forward-looking Phillips curve can fully deal with it. The reason for this is apparent in Figure 4. Following the peak of inflation in late 1994, the rate of inflation comes down faster than would be predicted by a vertical backward-looking Phillips curve, given that the output gap falls only slowly. That is why the data rejects the vertical constraint on the backward-looking Phillips curve over these years. In the forward-looking case, agents expect the future fall in inflation which caused current inflation to fall faster, even although previous inflation has been high.

6 CONCLUSIONS

A Phillips curve appears to be the right framework for inflation modelling in post reform China, at least since 1988. Backward-looking, traditional Phillips curve estimations are a good starting point for inflation modelling in China and result in stable results across rolling estimation windows. Nevertheless, partially forward-looking Phillips curves seem to improve on purely backward-looking Phillips curves in terms of fit. The output gap and changes in the exchange rate are important variables for explaining inflation in China. The estimation of a Phillips curve for China requires a careful analysis with regards to the estimation of the output gap, and adjustment for discrete policy shifts where possible. Comparing output gaps which have been commonly used in the literature on inflation in China with more elaborate, production function based output gap estimates, the later kind lead to greatly improved explanatory power. Equally, our adjustment for the 1994 price liberalisations, with double impulse indicator variables that allow for the maintained hypothesis of a vertical long-run Phillips curve is, important for the estimation of a Phillips curve for China. A further improvement of the work presented here above earlier work is the explicit testing for the robustness of the estimation results across shifting estimation windows. The money supply plays no role in our estimations.

The policy implications of the estimation results are twofold. First, with inflation expectations being part of the inflation process, the effectiveness of monetary policy, subject to monetary policy being credible, will be larger than might otherwise be thought, since reductions or increases in inflation can be brought about by smaller output gap changes than under a purely backward-looking Phillips curve. The exact working of this ‘expectation channel’ must be evaluated in terms of a fully specified macro-model of the Chinese economy. The second policy implication derives from the apparent decline of the exchange rate effect in inflation, despite the trend towards a more open economy. The Phillips curve estimations suggests that there has been increased pricing to market of imports in China. This suggests that an eventual capital account opening, and an exchange rate liberalisation, would have a smaller impact on the volatility of inflation in China than might otherwise be thought, because pricing-to-market reduces the transmission of changes in foreign prices to import prices and thus to domestic inflation.

7 REFERENCES

Aizenmann, J, 2000. "Endogenous Pricing to Market and Financing Costs", *NBER Working Paper*, No 7914.

Allsopp, C, 1995. "Macroeconomic Control and Reform in China", *Oxford Review of Economic Policy*, Vol 11, No 4. 43-53.

Ball, L, 1999. "Policy Rules for Open Economies", in: John B Taylor. *Monetary Policy Rules*. University of Chicago Press.

Barro, R J and D B Gordon, 1983. "A Positive Theory of Monetary Policy in a Natural Rate Model", *Journal of Political Economy*, Vol 91, No 4. 589-610.

Brandt, L and Z Zhu, 2000. "Redistribution in a Decentralised Economy: Growth and Inflation in China under Reform", *Journal of Political Economy*, Vol 108, No 2. 422-39.

Burdekin, R C K, 2000. "Ending Inflation in China: From Mao to the 21st Century", *Cato Journal*, Vol 20, No 2. 223-35.

Calvo, G, 1983. "Staggered Prices in a Utility Maximising Framework", *Journal of Monetary Economics*, Vol 12, No 3. 383-98.

Campa, J M and L S Goldberg, 2002. "Exchange Rate Pass-through into Import Prices: A Macro or Micro Phenomenon", *NBER Working Paper*, No 8934.

Chai, J C H, 1997. "Reforms of the Price System", in: Joseph C. H. Chai. *China: Transition to a Market Economy*. Oxford, Clarendon Press. 94-117.

Chai, J C H, 2000. *The Economic Development of Modern China (Volume 3): Reforms and Opening since 1979*. Cheltenham, Edward Elgar.

Chow, G C, 1960. "Tests of Equality between Sets of Coefficients in Two Linear Regressions", *Econometrica*, Vol 28. 591-605.

Chow, G C, 1987. "Money and Price Level Determination in China", *Journal of Comparative Economics*, Vol 11, No 3. 319-33.

Chow, G C, 1993. "Capital Formation and Economic Growth in China", *Quarterly Journal of Economics*, Vol 108, No 3. 809-42.

Chow, G C and Y Shen, 2004. "Money, Price Level and Output in the Chinese Economy", mimeo

Coe, D T and C J McDermott, 1996. "Does the Gap Model Work in Asia?" *IMF Working Paper*, No 96/69.

Correy, S, M Mecagni and E Offerdal, 1998. "Achieving Low Inflation in Transition Economies", *Finance and Development*, March. 30-33.

Doornik, J A and D F Hendry, 1999. *Empirical Econometric Modelling Using Pcgive*, 2nd. West Wickam, Timberlake Consultants Ltd.

Enders, W, 1995. *Applied Economectric Time Series*, New York, John Wiley & Sons, Inc.

Estrella, A and J C Fuhrer, 1998. "Dynamic Inconsistencies: Counterfactual Implications of a Class of Rational Expectations Models", *Federal Reserve Bank of Boston Working Paper*, No 98/5.

Estrella, A and J C Fuhrer, 1999. "Are "Deep" Parameters Stable? The Lucas Critique as an Empirical Hypothesis", *Federal Reserve Bank of Boston Working Paper*, No 99-4.

Friedman, M, 1968. "The Role of Monetary Policy", *American Economic Review*, Vol 58, No 1. 1-17.

Fuhrer, J C, 1997. "The (Un)Importance of Forward-Looking Behaviour in Price Specifications", *Journal of Money, Credit and Banking*, Vol 29, No 3. 338-50.

Fuhrer, J C and G R Moore, 1995. "Inflation Persistence", *Quarterly Journal of Economics*, Vol 110. 127-59.

Gali, J and M Gertler, 1999. "Inflation Dynamics: A Structural Econometric Analysis", *Journal of Monetary Economics*, Vol 44, October. 195-222.

Gali, J, M Gertler and J D López-Salido, 2001a. "European Inflation Dynamics", *European Economic Review*, Vol 45, No 7. 1237-70.

Gali, J, M Gertler and J D López-Salido, 2001b. "Notes on Estimating the Closed Form of the Hybrid New Phillips Curve", *mimeo*.

Gerlach, S and W Peng, 2004. "Output Gaps and Inflation in Mainland China", Hong Kong, HK Monetary Authority, mimeo.

Greene, W H, 2000. *Econometric Analysis, 4th Edition*, Upper Saddle River, Prentice-Hall.

Gruen, D, A R Pagan and C Thompson, 1999. "The Phillips Curve in Australia", *Journal of Monetary Economics*, Vol 44, No 2. 223-58.

Ha, J, K Fan and C Shu, 2003. "The Causes of Inflation and Deflation in Mainland China", *Hong Kong Monetary Authority Quarterly Bulletin*, September. 23-31.

Hansen, B E, 1992. "Testing for Parameter Instability in Linear Models", *Journal of Policy Modeling*, Vol 14, No 4. 517-33.

Harris, R, 1995. *Cointegration Analysis in Econometric Modelling*, Harlow, Prentice Hall.

Hasan, M S, 1999. "Monetary Growth and Inflation in China", *Journal of Comparative Economics*, Vol 27. 669-85.

Hendry, D F, 2000. "On Detectable and Non-Detectable Structural Change", *Structural change and economic dynamics*, Vol 11, No 1. 45-65.

Hendry, D F and J A Doornik, 2001. *Modelling Dynamic Systems Using Pcgive 10*, 3rd. London, UK, Timberlake Consultants Ltd.

Hendry, D F and J A Doornik, 2003. *Pcgive*, 10. Timberlake Consultants.

Hendry, D F and H-M Krolzig, 1999. *Pcgets 1.0*.

Hendry, D F and H-M Krolzig, 2004a. "The Properties of Automatic Gets Modelling", Sargan Lecture of the Royal Economic Society, 21 September.

Hendry, D F and H-M Krolzig, 2004b. "We Ran One Regressions", mimeo.

Henry, S G B and A R Pagan, 2004. "The Econometrics of the New Keynesian Policy Model: Introduction", *Oxford Bulletin of Economics and Statistics*, Vol 66, September. 581-607.

Hodrick, R J and E C Prescott, 1997. "Post-War Us Business Cycles: An Empirical Investigation", *Journal of Money, Credit and Banking*, Vol 29, No 1. 1-16.

Holz, C A, 2003. "Fast, Clear and Accurate: How Reliable Are Chinese Output and Growth Statistics?" *China Quarterly*. 122-63.

Huang, Y, 2002. "Did the Chinese Government Pursue a Gradualist Reform Strategy in the 1990s?" http://www.economics.utoronto.ca/brandt/

Imai, H, 1997. "Output-Inflation Tradeoff in China", *The Developing Economies*, Vol 35, No 2. 111-41.

International Monetary Fund, 2000. *International Financial Statistics Yearbook*. Washington DC.

Kirby, M, 1981. "An Investigation of the Specification and Stability of the Australian Aggregate Wage Equation", *Economic Record*, Vol 57, No 156. 35-46.

Krugman, P R, 1986. "Pricing to Market When the Exchange Rate Changes", *NBER Working Paper*, No 1926.

Kydland, F E and E C Prescott, 1978. "Rules Rather Than Discretion: The Inconsistency of Optimal Plans", *Journal of Political Economy*, Vol 85, No 3. 473-92.

Laurenceson, J and J C H Chai, 2003. *Financial Reform and Economic Development in China*, Cheltenham, Edward Elgar.

Lewis, W A, 1954. "Economic Development with Unlimited Supplies of Labour", *The Manchester School*, Vol 22, No 2. 139-91.

Lindé, J, 2001. "Estimating New-Keynesian Phillips Curves: A Full Information Maximum Likelihood Approach", *Sveriges Riksbank Working Paper*, No 129.

Lu, M and Z Zhang, 2003. "Exchange Rate Reform and Its Inflationary Consequences: An Empirical Analysis for China", *Applied Economics*, Vol 35. 189-99.
Lucas, R E, 1976. "Econometric Policy Evaluation: A Critique", *Carnegie-Rochester Conference Series on public policy*. 7-33.
Mavroeidis, S, 2004. "Weak Identification of Forward-Looking Models in Monetary Economics", *Oxford Bulletin of Economics and Statistics*, Vol 66, September. 609-35.
Mehra, Y P, 2004. "The Output Gap, Expected Future Inflation and Inflation Dynamics: Another Look", *Topics in Macroeconomics*, Vol 4, No 1. Article 17.
Meng, X, 2000. *Labour Market Reform in China*, Cambridge, Cambridge University Press.
Mishkin, F S, 2000. "Inflation Targeting for Emerging Market Countries", *American Economic Review*, Vol 90, No 2. 105-09.
Naughton, B, 1994. "What Is Distinctive About China's Economic Transition? State Entreprise Reform and Overall System Transformation", *Journal of Comparative Economics*, Vol 18.470-90.
Newey, W and K West, 1987. "A Simple Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix", *Econometrica*, Vol 55. 703-08.
Oppers, S E, 1997. "Macroeconomic Cycles in China", *IMF Working Paper*, No 97/135.
Phylaktis, K and E Girardin, 2001. "Foreign Exchange Markets in Transition Economies: China", *Journal of Development Economics*, Vol 64.215-35.
Rawski, T G, 1995. "Implications of China's Reform Experience", *China Quarterly*, No 144. 1150-73.
Rawski, T G, 2001. "What's Happening to China's GDP Statistics?" *China Economic Review*, Vol 12, No 4.
Rawski, T G, 2002. "Measuring China's Recent GDP Growth: Where Do We Stand?" University of Pittsburgh, http://www.pitt.edu/~tgrawski/ .
Rudd, J and K Whelan, 2001. "New tests on the new-Keynesian Phillips curve", Federal Reserve Board, Washington, DC.
Scheibe, J, 2003. "The Chinese Output Gap During the Reform Period 1978-2002", *Department of Economics Working Paper, University of Oxford*, No 179. http://www.economics.ox.ac.uk/Research/WorkPapers.asp
Taylor, J B, 1980. "Aggregate Dynamics and Staggered Contracts", *Journal of Political Economy*, Vol 88, No 1. 1-23.
Vines, D A, 2004. "Pegged Exchange Rates, Export-Led Growth, and Capital Controls: Managing a Revived Bretton Woods System in the Asia Pacific Region", Oxford University, Department of Economics, mimeo.
Weale, M, A P Blake, N Christodoulakis, J Meade and D A Vines, 1989. *Macroeconomic Policy: Inflation, Wealth and the Exchange Rate*, London, Irwin Hyman.
Wen, M, 2003. "Building Modern Enterprises: Challenges and Requirements", in: Ross Garnaut and Ligang Song. *China - New Engine of World Growth*. Canberra, Asia Pacific Press. 369-85.
Wong, J and S Chan, 2003. "Why China's Economy Can Sustain High Performance: An Analysis of Its Sources of Growth", *Royal Institute of International Affairs, Asia Programme Working Paper*, No 6.
Woo, W T, 1994. "The Art of Reforming Centrally Planned Economies: Comparing China, Poland and Russia", *Journal of Comparative Economics*, Vol 18. 276-308.
Wu, H X, 1997. "Measuring China's GDP", *Australian Department of Foreign Affairs and Trade, East Asia Analytical Unit Briefing Paper*, No. 8. http://www.dfat.gov.au/publications/catalogue/eaaubp8.pdf .
Wu, H X, 2000. "China's GDP Level and Growth Performance: Alternative Estimates and the Implications", *Review of Income and Wealth*, Vol 46, No 4. 475-99.

Young, A, 2002. "The Nature and Implications of Transition Economies", in: Allan Young, Ivan Teodorovic and Peter Koveos. *Economies in Transition: Conception, Status and Prospects*. Singapore, World Scientific Publishing. 3-14.
Yusuf, S, 1994. "China's Macroeconomic Performance and Management During Transition", *Journal of Economic Perspectives*, Vol 8, No 2. 71-92.
Zhang, Z, 1997. *Exchange Rate Reform in China, 1978-1994*. University of Oxford, Department of Economics, DPhil Thesis.
Zhang, Z, 2001. "Real Exchange Rate Misalignment in China: An Empirical Investigation", *Journal of Comparative Economics*, Vol 29. 80-94.

8 APPENDICES

8.1 Appendix to Section 3: Price liberalisation and adjustment for structural change

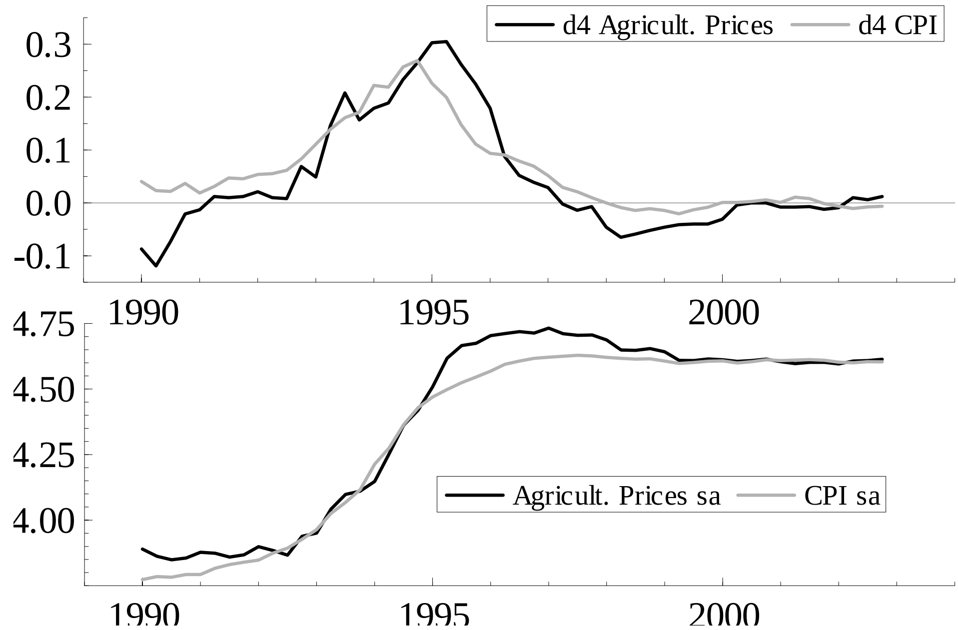
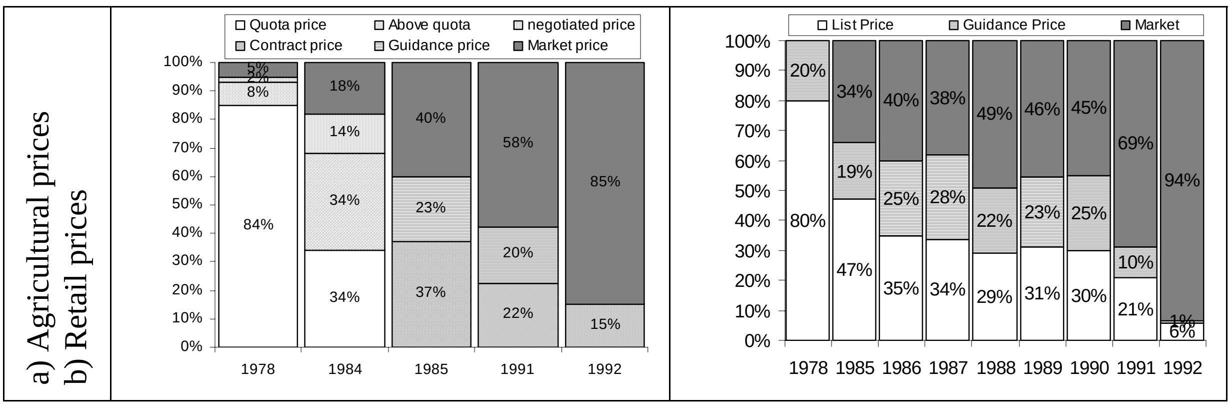


Figure 1: Comparison of agricultural and consumer prices

The top panel shows annual inflation rates, the lower graph displays the constructed, seasonally adjusted price indices.



The data used to construct these charts are taken from various tables in Chai (1997).

Figure 2: Price liberalisation

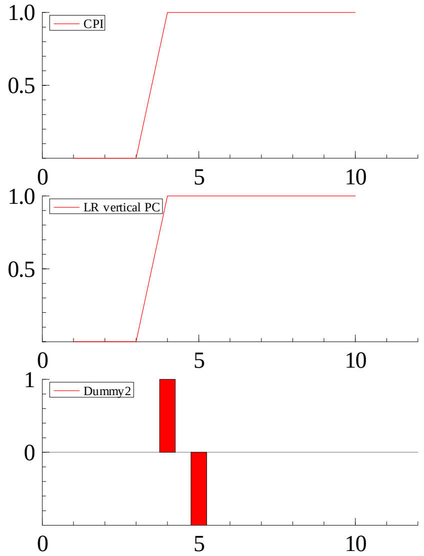


Figure 3: Event dummy in the vertical LR Phillips curve

Period	from - to	# of observations
all	1988q1-2002q4	60
1	1988q1-1996q4	36
2	1989q1-1997q4	36
3	1990q1-1998q4	36
4	1991q1-1998q4	36
5	1992q1-2000q4	36
6	1993q1-2001q4	36
7	1994q1-2002q4	36

Table 7: Estimation periods

8.2 Appendix to Section 4: Data

This section lists the data and its sources.

Variable	Description	Source	Available from
π_t	Annual inflation rate	IMF IFS (92464..XZF)	1987Q1
$E_t\left[\pi_{t+4}\right]$	Inflation expectations	IFO, Datastream (CHIFPR04)	1991Q1
y_t^{gap}	Output gap, various specifications	Constructed, see Scheibe (2003)	1987Q1
m_t	Money M1	IMF IFS (92434...ZF)	1980Q1
p_t^{oil}	Oil price (Brent Crude) in RMB	Datastream	1982Q2
e_t	Nominal effective exchange rate (NEER)	IMF IFS (924..NECZF)	1980Q1

Table 8: Variables in the inflation equation

Inflation

Quarterly data on the CPI exists only as annual CPI inflation rates since 1987.

Expected inflation

The Munich IFO Institute has collected survey data on expectations of inflation from 1991 at quarterly intervals, the data is available from Datastream. The data, which is displayed in Figure 4f, shows the currently expected annual rate of inflation in twelve months time, i.e. $E_t\left[\Delta^4 CPI_{t+4}\right]$.

Output gap

Five output gap estimates are considered in the regressions of the macro-model.[47] In these estimates potential output is determined by a) a linear trend, b) a trend derived from a Hodrick and Prescott (1997) (HP) filter with $\lambda^{HP} = 1,600$,[48] c) a growth accounting approach on aggregate data with a (slightly) flexible total factor productivity component, d) a growth accounting calculation on sector data with a (slightly) flexible trend for total factor productivity (TFP), and e) a fitted regression line on aggregate data with a linear trend for TFP approximation.[49] It is the aim to tests which of the output gap specifications provides the

47 The construction of these is discussed in Scheibe (2003).

48 The smoothing coefficient of λ^{HP}, i.e. the penalty weight on the deviation of an observations from the trend line, is chosen as the standard value for quarterly filtering. This value has been derived for US GDP data, but is used universally across countries by most researchers.

49 The output gap from a regression based estimation is the residual of the (level) regression of GDP on capital and labour. Output gaps derived from a growth accounting exercise use capital and labour weights established from an EqCM estimation which gives superior estimation results but does not

highest explanatory power in inflation regressions. Specifications a) and b) (and a variant of e) in Gerlach and Peng, 2004) have been used in the literature so far. *A priori* our favourite output gap estimate is that of specification d), where the capital and labour share have been estimated for five sectors of the Chinese economy and trend total factor productivity is allowed to slowly change over time. In the first part of the empirical section below the 'best' output gap is determined in terms of explanatory power in a Phillips curve. Figure 4a, b, and c show the relevant output gaps. Note the correlation of the different output gaps with inflation displayed in Table 10 (p.34).

Exchange rate

The nominal exchange rate in the regression equation is the NEER, the nominal effective exchange rate as published by the IMF. By the IMF definition, 'a nominal effective exchange rate index represents the ratio (expressed on base 1990=100) of an index of the period average exchange rate of the currency in question to a weighted geometric average of exchange rates for the currencies of selected countries' (International Monetary Fund, 2000). Formally, the NEER index in the International Financial Statistics of the IMF is calculated as the geometric mean of the bilateral exchange rate weighted by the trade weight w_{it} in overall trade. This coefficient may be varying over time. The number of countries in the NEER calculation is not disclosed, nor is the weight calculation.

$$NEER_t = \prod_i \left(\frac{ER_{it}}{ER_{i\ \mathrm{BaseDate}}} \right)^{w_{it}} \qquad [6]$$

The first difference of the logged index numbers are used for the estimations. A graph of the NEER has been shown in Figure 4h.

Money supply

Money supply M1 is available from the IMF since 1980 This variable is used as annual growth rates, and annual growth rates adjusted for growth in real GDP.

allow for the regression residual to be interpreted as an output gap. Effectively, the results from the two methods are very similar – as they should be – and the most important difference is that it is possible allow for a slightly time-changing trend of total factor productivity in the growth accounting calculations. Scheibe (2003) explains and lists the details of the estimation.

Unit root tests

The results of unit root tests are shown below. The theory induced assumption for the data in the Phillips curve is that of stationarity. From the Dickey-Fuller unit-root tests some of the variables do not pass the test for integration of order zero $\left(I\sim(0)\right)$. Annual inflation data misses the critical value for stationary data. However, due to the lack of power of the unit root tests, annual inflation rates are assumed to be stationary.[50] Annual changes in the nominal trade weighted exchange rate are stationary, while the tests indicate that all the output gap estimates are integrated of order one. All output gaps have been constructed as stationary variables, and the DF results are overruled on these grounds.

Variable	Test period	DF/ADF test lag			
		0	1	4	5
$\Delta^4 CPI_t$	1988q3-2002q4	-1,078	-2,753	-2,099	-2,254
$E_t\left[\Delta^4 CPI_{t+4}\right]$ (IFO data)	1992q2-2002q4	-0,5688	-0,4371	-1,280	-1,606
y_t^{gap} (lin)	1988q3-2002q4	-1,533	-1,914	-1,893	-2,467
y_t^{gap} (HP)	1988q3-2002q4	-2,829	-3,240*	-2,515	-3,097*
y_t^{gap} (Sector based, flexible TFP trend)	1988q3-2002q4	-1,153	-1,663	-1,710	-2,647
y_t^{gap} (AggrGA, flex TFP)	1988q3-2002q4	-1,626	-1,944	-1,754	-2,484
y_t^{gap} (AggrRgr, fixed TFP)	1988q3-2002q4	-1,613	-1,980	-1,885	-2,724
$\Delta^4 m_t$	1988q3-2002q4	-2,609	-2,732	-2,033	-2,510
$\Delta^4 e_t$	1988q3-2002q4	-2,787	-3,396*	-4,884**	-3,375*

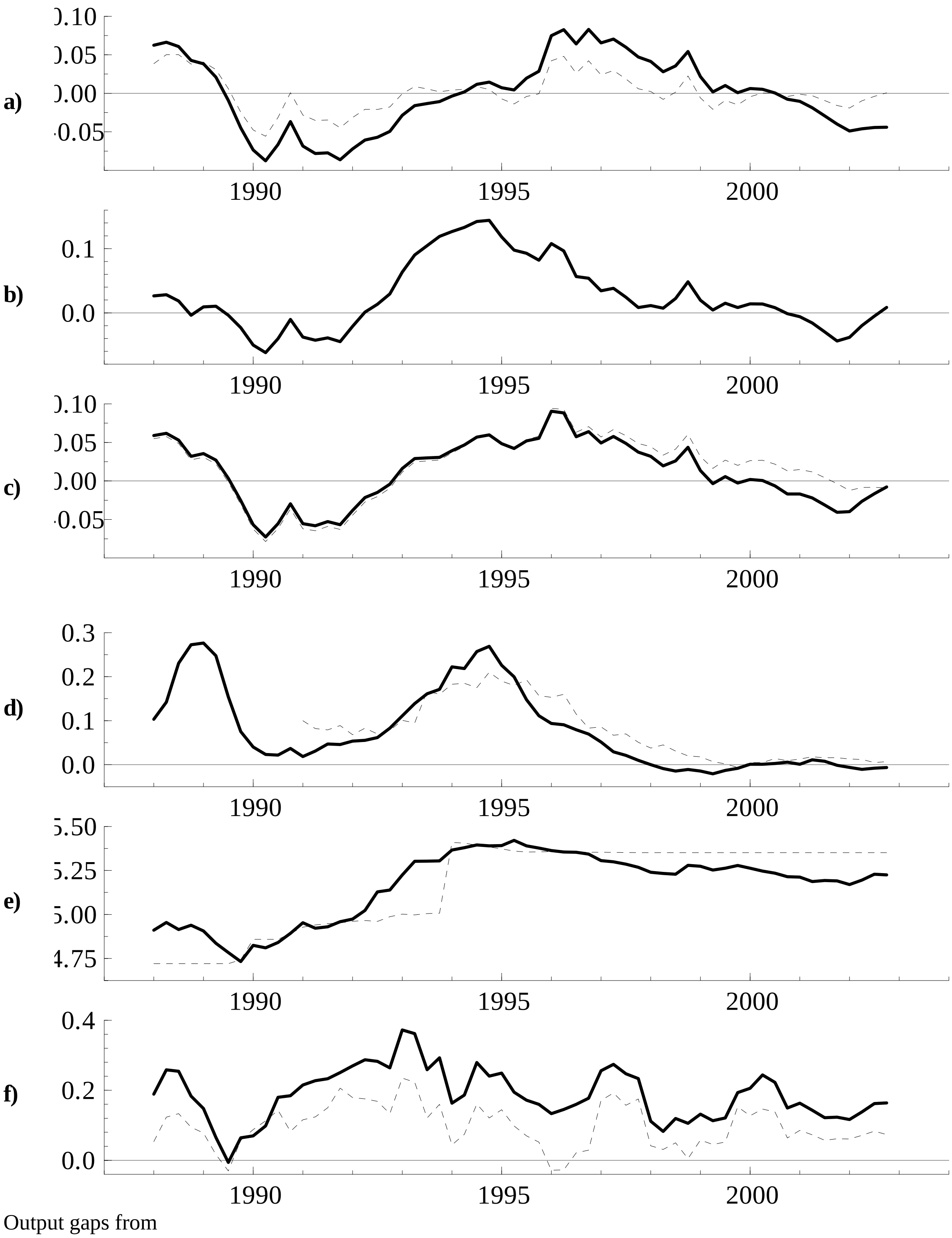
Table 9: Unit root tests

The critical values are -2.91 and -3.55 at the five and one percent level, respectively, for a test with a constant. Rejection of the unit root hypothesis at the five and one percent level is indicated with * and **.

	Linear trend	HP trend	Aggr - linTFP	Sector based	Aggr - flex TFP
HP trend	0,88	1,00			
Aggr - linTFP	0,90	0,84	1,00		
Sector based	0,51	0,47	0,80	1,00	
Aggr - flex TFP	0,93	0,82	0,95	0,72	1,00
d4CPI	0,25	0,42	0,51	0,61	0,32

Table 10: Correlation of output gaps and inflation

[50] In small samples the DF test over-rejects the hypothesis of stationary data. See e.g. Harris (1995), Enders (1995).



Output gaps from
a) linear trend and HP trend (dotted)
b) growth accounting with flexible TFP trend based on five sub-sector of the economy (best output gap)
c) production function regression with fixed TFP trend and growth accounting with flexible TFP trend (dotted)

d) annual inflation (again) and expected inflation (dotted, expectation at *t* of inflation at *t+4*)
e) log of NEER and (mean adjusted) USD-RMB exchange rate (dotted)
f) annual growth rate of M1 and annual growth rate of M1 adjusted for real GDP growth

Figure 4: Data overview

8.3 Appendix to Section 5: Estimation results

Test	Test for	Test distribution
Durban-Watson (DW)	Autocorrelation	NA
AR 1-	Autocorrelation	F( )
ARCH 1-	ARCH	F( )
Normality	Normality of residuals	Chi^2 (2)
Hetero	Heteroskedasticity	F( )
RESET	Omitted variables	F( )

Table 11: Diagnostic tests: explanation and references

In what follows regression estimations are run using the econometrics software PcGive 10 (Hendry and Doornik, 2003).[51] The following diagnostic tests are reported in each table with regression results. The precise F-test depends on the number of observations and the degrees of freedom. The corresponding probability for each test is reported in the regression tables. The tests are specified such that the probability value shows the probability of accepting the null-hypothesis of a well specified model, i.e. at the conventional level of significance probability values of below 0.05 indicate a failure of the test.

[51] The reference manuals are Hendry and Doornik (2001) and Doornik and Hendry (1999).

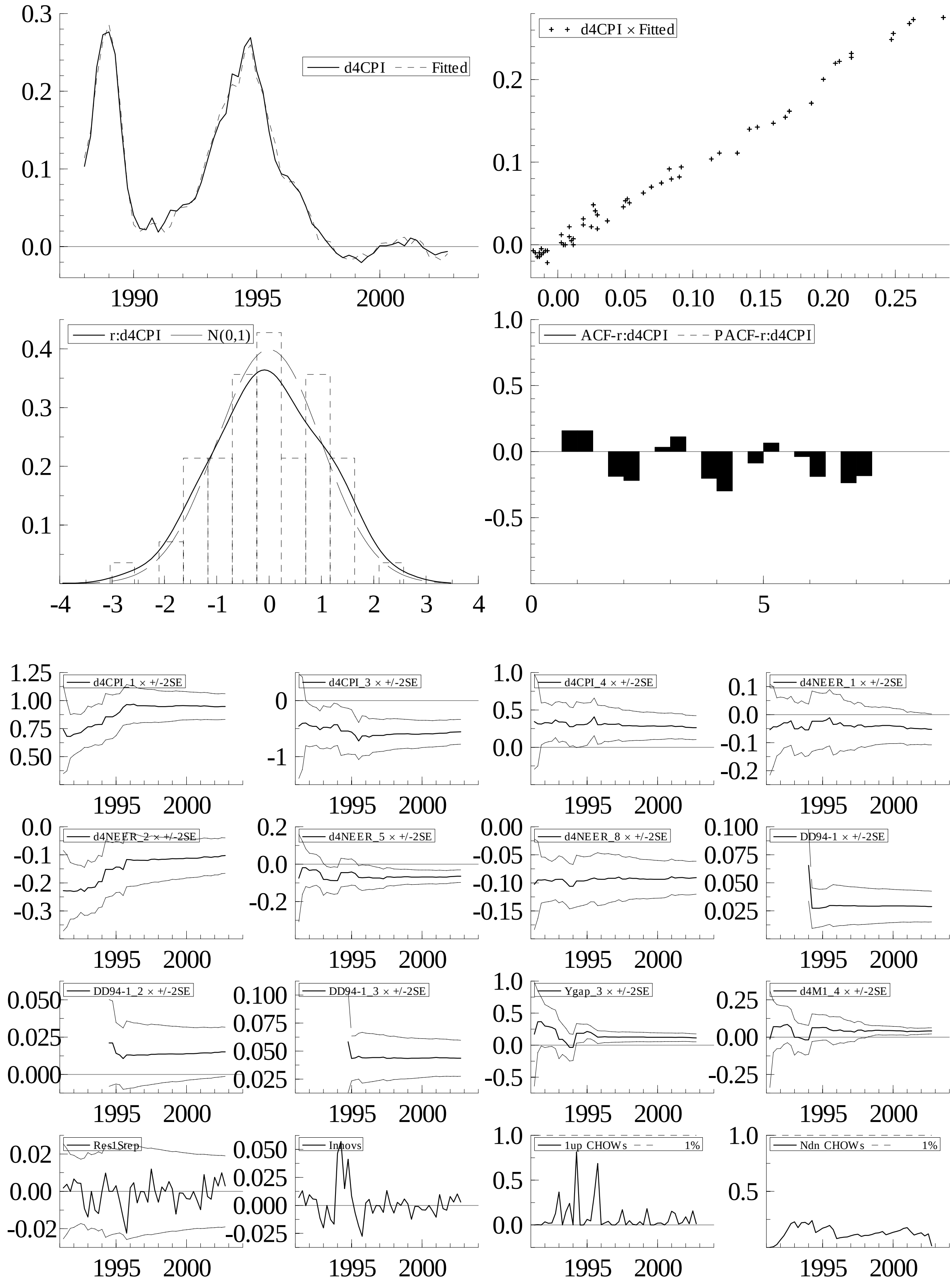


Figure 5: Diagnostic graphics for backward-looking Phillips curve

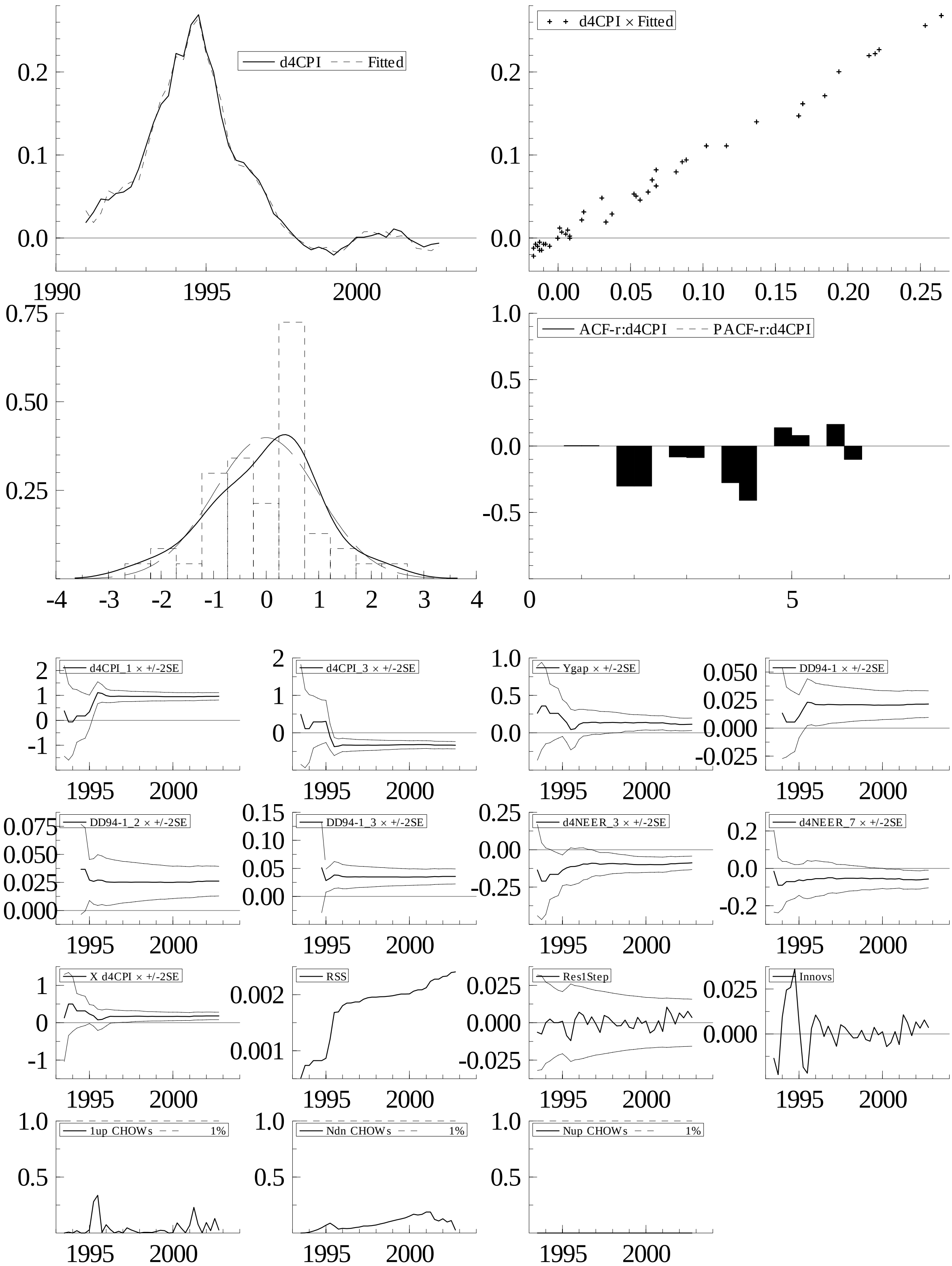


Figure 6: Diagnostic graphics for hybrid Phillips curve (survey data)

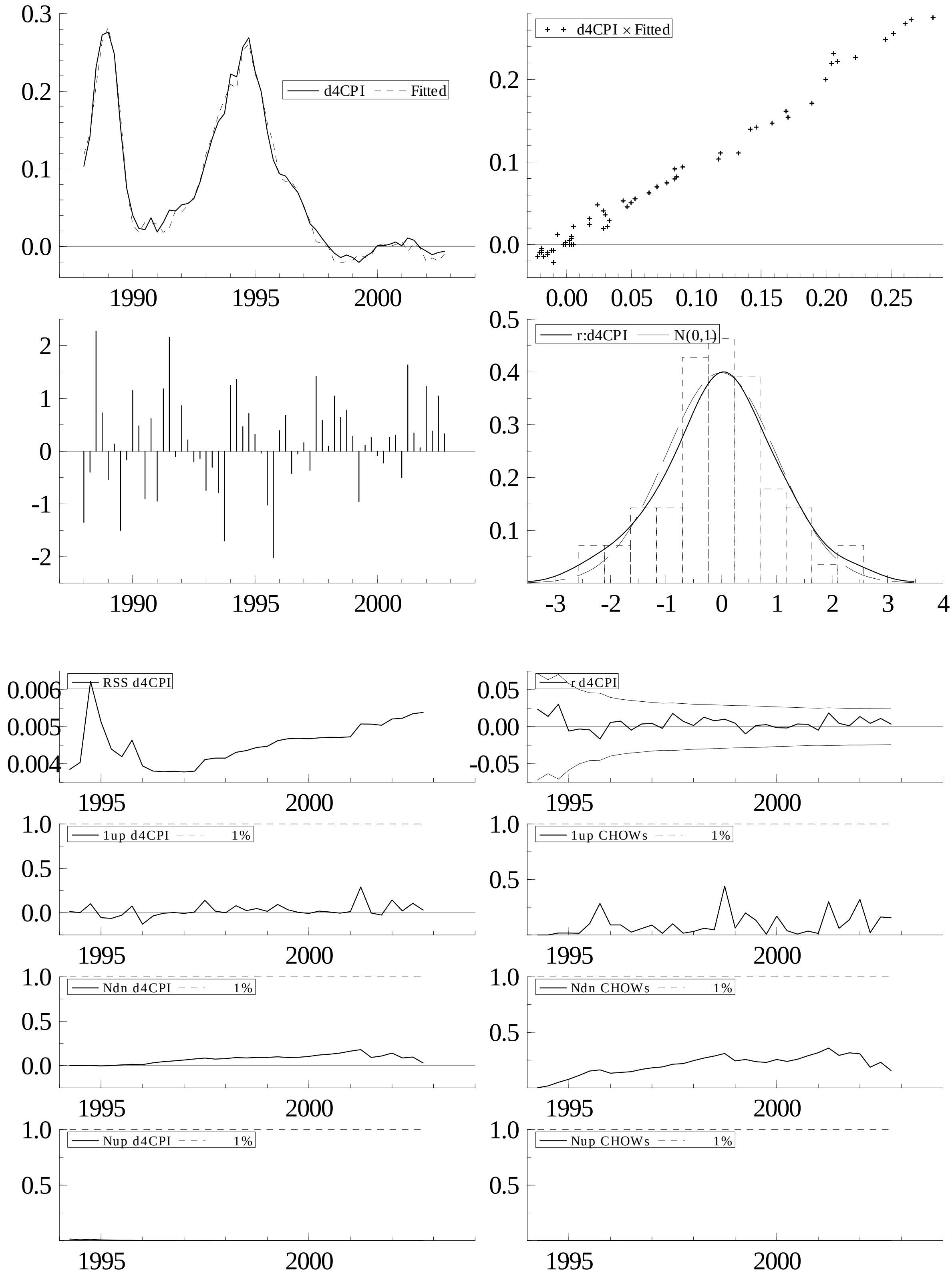


Figure 7: Diagnostic graphics for hybrid Phillips curve (IV method)

sigma	88-02	88-96	89-97	90-98	91-99	92-00	93-01	94-02
Linear	1,23%	1,60%	1,83%	2,23%	1,22%	0,83%	0,80%	0,77%
HP	1,32%	1,93%	1,76%	1,41%	1,14%	0,85%	0,82%	0,72%
Sector based, fixed TFP	1,15%	1,36%	1,44%	1,25%	1,04%	0,76%	0,68%	0,680%
aggr data, fixed TFP growth	1,31%	1,73%	1,59%	1,35%	1,12%	0,77%	0,77%	0,73%
aggr data, flex TFP growth	1,18%	1,90%	1,60%	2,07%	1,23%	0,79%	0,67%	0,683%
t-stat								
Linear	2,23	0,59	1,44	1,84	1,65	3,16	2,97	2,40
HP	1,96	1,07	1,15	1,22	1,61	2,65	2,56	3,06
Sector based, fixed TFP	3,13	2,59	2,63	1,36	1,90	3,18	4,08	3,46
aggr data, fixed TFP growth	2,50	1,20	1,80	0,48	1,80	3,82	3,20	3,02
aggr data, flex TFP growth	3,10	1,04	1,80	1,72	1,62	3,21	4,39	3,87
Schwartz-Criterion								
Linear	- 14,71	- 13,67	- 13,69	- 14,78	- 15,70	- 16,03	- 16,20	- 16,92
HP	- 14,39	- 13,18	- 13,63	- 14,76	- 15,63	- 15,98	- 16,21	- 18,10
Sector based, fixed TFP	- 15,31	- 14,74	- 15,05	- 15,29	- 15,78	- 16,31	- 16,55	- 16,97
aggr data, fixed TFP growth	- 14,56	- 13,30	- 14,10	- 14,55	- 16,24	- 16,40	- 16,41	- 18,08
aggr data, flex TFP growth	- 14,81	- 13,34	- 14,11	- 14,76	- 16,01	- 16,21	- 16,46	- 18,23

Table 12: Selection criteria for the best output gap – hybrid Phillips curve

Table 12 shows the results for the partially forward-looking Phillips curves estimated using our range of possible output gap measures. The hybrid Phillips curve are estimated by the IV method described in Section 3. The results should be compared with those in Table 6. As in Table 6, Table 12 shows a range of relevant test statistics. Partial R-squared data is not available for IV estimations due to the simultaneous estimation of current and future inflation rates. Most of the residual standard errors (sigma) are smaller in the hybrid Phillips curve than in the purely backward looking version (Table 6). However, this is not always the case. This is because the reported equation residual is adjusted for the number of variables in the estimation, and due to the decreased degrees of freedom from the use of instruments, the reported equation standard deviation may become larger. Note that the lag structure of the variable Δe_t, which is determined in each case by the general to specific approach, differs between the two estimation versions and hence the regressions reported on in Tables 6 and 12 are not strictly comparable for one further reason. It is clear from Table 12 that output gaps derived from production functions explain inflation better in the partially forward-looking case as well.