A PHILLIPS CURVE FOR CHINA

Jörg Scheibe [a,*]

St. Antony's College
University of Oxford

David Vines [b,*]

Balliol College and
Department of Economics
University of Oxford

Research School for Asian and Pacific Studies,
Australian National University, Canberra

Centre for European Policy Research, London

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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 traditional backward-looking as well as partially forward-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 and the exchange rate 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. The identification of a decreasing 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

[a)] 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: http://users.ox.ac.uk/~sant0997/index.html
[b)] Corresponding author; 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
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1 OVERVIEW

Since the start of the reform period in 1978 the Chinese economy has seen two periods 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 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 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 my inflation modelling strategy in section 3. Section 4 considers the data. Section 5 shows the results from estimating traditional and New-Keynesian Phillips curves, and changes in the inflation dynamics over time, careful test for structural change, and the evaluation of the explanatory power of alternative estimates for the output gap is considered. 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 points, some of the

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

literature since the later 1990s started to use quarterly data. Most of the work with an explicit inflation focus 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 acceleration of inflation from increased production beyond the potential output level. 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) note themselves, 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) but compare three different output gap estimates.[4] Their paper uses a second order autoregressive process of an unobservable variable as a proxy for structural change. Also, at the annual estimation frequency contemporaneous and first lags of the output gap, though significant, seem to be offsetting each other almost.

Burdekin (2000: p. 227) notes that at higher inflation 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. Had the central bank followed more austere money growth targets, growth would have been suppressed. He also mentions that the inflation spikes in 1985 and 1988-89 had nothing to do with money growth.[5] The inflationary effects of exchange rate movements have been

[3] Ha, Fan and Shu (2003) also use a Hodrick and Prescott (1997) filter for determining potential GDP.
[4] The authors use 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 in Scheibe (2003) and both papers reinforce the robustness of each others results.
[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.

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. Phylaktis and Girardin (2001) touch on the issue, but don't find significant estimates (exchange rate related and relative money growth related) that explain the relative China/US inflation.

The existing literature falls short on three aspects 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 latent variable. In this paper a number of different candidates for this unobservable variable are used in the Phillips curve estimation. Second, the Phillips curve papers so far have found long-run coefficients on lagged inflation of about 0.75.[6] 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. A discussion of this issue follows in the next section, and long-run vertical Phillips curves will be empirically tested for. Third, the literature so far has not tried to allow and account for the structural change in the Chinese economy.[7] This is an admittedly difficult area 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 this paper.

3 HOW TO MODEL INFLATION IN CHINA

Most of the recent papers have used the Phillips Curve framework for explaining inflation in China. Is this the right approach? Probably, although there are alternatives, which will be considered later. What factors should be considered for modelling inflation in China? And how would these variables influence inflation? A Phillips curve setting is a useful reference for empirical inflation modelling in China. Since official unemployment figures are hopelessly understated for China and hover around two to three percent for most of the (even late) 1990s, an empirical unemployment Phillips curve is out of the question for China. What is left for the empirical modeller is a general output gap Phillips curve such as equation [1].

[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 nor comment on the treatment of the constant term in the Phillips curve estimation.

[7] Gerlach and Peng (2004) are the only recent exception.

π_t is the quarterly difference in the price level, $\Delta^1 CPI$, i.e. the quarterly (non-annualised) rate of inflation.[8]

$$\pi_t = const_\pi + \gamma_i^{E\pi} E_{t1}\left[\pi_{t+1}\right] + \sum_{i=1}^{4} \gamma_i^{\pi} \pi_{t-i} + \sum_{i=0}^{4} \gamma_i^{y^{gap}} y_{t-i}^{gap} + \sum_{i=0}^{8} \gamma_i^{\Delta e} \Delta e_{t-i} + \varepsilon_t^{\pi} \qquad [1]$$

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. e_t is the trade weighted nominal effective exchange rate (NEER), which is more meaningful than the bilateral RMB-USD exchange rate as China has pegged their currency to the US dollar in January 1994. The exchange rate is defined in foreign currency units per RMB and a decline in e_t corresponds to a deprecation of the Chinese currency. The expected sign on $\gamma^{\Delta e}$ is therefore negative. 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 additional regressor in equation [1]. This variable seems to have been in the mindset of many China economists as a cause for inflation, although the empirical evidence reviewed above does not lend much support to such a claim. Theoretically, the amount of money, or credit, in the economy could affect demand if the quantity rather than the price of finance available to the economy matters. The 'transmission channel' into inflation would work via a demand effect though and not directly in the Phillips curve. Another conceivable effect of excess money growth on inflation would work via a depreciating exchange rate, which would then raise the price of imported goods. By including money growth – as a quarterly or annual growth rate, adjusted for GDP growth or not – in the Phillips curve directly any reduced form effects which would not be captured by excess demand or the exchange rate are allowed for.

Gruen, Pagan and Thompson (1999) mention that an annualised rate of inflation is usually of greater interest to a policy maker – since annual rates are normally targeted – than quarterly rates of inflation. However, quarterly changes in the price level can be advantageous for estimation, as otherwise problematic correlation of the residuals in a Phillips curve based on a variable which uses differences of overlapping periods.[9]

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[8] Gruen, Pagan and Thompson (1999) give an overview of the developments of the Phillips curve (in Australia) and the typical issues when estimating Phillips curves.

[9] Kirby (1981) makes this point for Australian data.

3.1 Should inflation be forward-looking? The New-Keynesian Phillips Curve

The question whether inflation in the Phillips curve should be forward looking or not has been debated in the literature. This paper does not take sides in this discussion. However, since the policy implications from a backward and forward looking inflation model are different for monetary policy, the empirical evaluation of the validity of partially forward-looking Phillips curves is justified. 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] can explain data behaviour (in developed countries) better, as inflation does not display jumps in the data. Fuhrer and Moore (1995) model inflation as a hybrid Phillips curve, where future inflation plays a role.[10] The main reason for the forward-lookingness in their paper is overlapping wage contracts. Fuhrer (1997), Gali and Gertler (1999), Gali, Gertler and López-Salido (2001a), Gali, Gertler and López-Salido (2001b), and Lindé (2001) estimate purely forward looking and 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, $E_t\left[\pi_{t+1}\right]$ is treated as an exogenous variable. For China, survey data of inflation expectations is available. This data, π^*_{t+1},

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

does not necessarily comply with rational, adaptive, or any other framework for expectation formation. However, this data has the advantage of being a valid exogenous variable. Second, the realised value of inflation at time *t+1* could be included in the regression. This requires the assumption that under rational expectations the 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 $E_t\left[\pi_{t+1}\right]$ with instrumental variables.[11] Instrumental variable (IV) estimation requires a two equation system such as equations [3] and [4]. X_t includes contemporaneous and lagged values of instrumental variables other than lagged inflation, the output gap, or the change in the exchange rate. The residual terms ε_t^{IV1} and ε_t^{IV2} are identically, independently distributed (iid).

[10] The seminal paper is Taylor (1980).
[11] See the empirical papers listed on the last page.

$$E_t\left[\pi_{t+1}\right] = const_\pi + \sum\nolimits_{i=1}^{n} \gamma_i^{\pi} \pi_{t-i} + \sum\nolimits_{i=0}^{n} \gamma_i^{y^{gap}} y_{t-i}^{gap} + \sum\nolimits_{i=0}^{8} \gamma_i^{\Delta e} \Delta e_{t-i} + X_t + \varepsilon_t^{IV1} \qquad [3]$$

$$\pi_t = const_\pi + \gamma_i^{E\pi} E_t\left[\pi_{t+1}\right] + \sum\nolimits_{i=1}^{4} \gamma_i^{\pi} \pi_{t-i} + \sum\nolimits_{i=0}^{4} \gamma_i^{y^{gap}} y_{t-i}^{gap} + \sum\nolimits_{i=0}^{8} \gamma_i^{\Delta e} \Delta e_{t-i} + \varepsilon_t^{IV2} \qquad [4]$$

In order for this system to be identified, there need to be instruments, i.e. $X_t s$, which are included in [3] but not in [4]. These variables should be highly correlated with expected inflation, but exogenous to it.[12] Typical instruments for inflation expectations in the literature are the output gap, marginal production costs, lagged inflation, interest rate spreads between different maturities of the yield curve, or commodity prices. For the case of China, the pool of instrumental variables is very small. Interest rate spreads are not useful as short term and long term interest rates are 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. Imposing restrictions on the sum of coefficients on future and lagged inflation in equation [4], lagged inflation can be used as an instrument in [3]. If different lags of the output gap and inflation are relevant for equations [3] and [4], respectively, the output gap and inflation could be used as an instrument, too.[13]

3.2 Backward-looking Phillips curve

Estrella and Fuhrer (1998) find that backward-looking Phillips curves indeed fit better than forward-looking ones. All in all, for the Chinese case there seems to be good reason to go back to a backward-looking Phillips curve, too. Therefore the base case Phillips curve for China excludes the expectation of future inflation. Equation [5] is the purely backward looking version of equation [1].

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

The Phillips curve of equation [5] (and [1]) is non-vertical in the short-run, i.e. there is a trade-off between inflation and the output gap in the short-term. Long-term, however, for $\sum\nolimits_{i=1}^{n} \lambda_i = 1$ and $const_\pi = 0$ the long-run (closed economy) Phillips curve is vertical, i.e. any level of above-equilibrium output would lead to ever-increasing inflation. In such a world in which the Phillips curve is vertical, policy makers have little incentive to inflate output above

[12] Henry and Pagan (2004) and Mavroeidis (2004) discuss instrument properties in detail.
[13] From equation [3] it is apparent that equation [4] is entirely based on backward-looking information and Rudd and Whelan (2001) have argued that a forward looking Phillips curve is observationally equivalent to a backward looking one, and the issue of whether one version is better than the other is obsolete.

potential, since inflation could only be stopped by closing the output gap.[14] A reduction in inflation would require a negative output gap, i.e. a recession. An open-economy Phillips curve is vertical if the coefficients on lagged inflation and the exchange rate coefficients (with a negative sign) sum to unity, i.e. $\sum_{i=1}^{n}\gamma_i^{\pi} + \sum_{i=1}^{n}\left(-\gamma_i^{\Delta e}\right) = 1$. In the case of perfect pass-though of exchange rate changes into domestic prices, policy makers have little incentive to inflate the economy in the short-run. ε_t^{π} is an iid stochastic error.

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.[15] It is difficult to capture these gradual changes in a regression analysis. We address the issue of economic change and potential structural breaks in the data in two ways. First, we trace the change 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)). The PcGive software package (Hendry and Doornik (2003)) also provides for 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 4, p. 30) and pay close attention to parameter constancy within an estimation period and changes between the rolling estimation periods. 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 accomplished yet 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 interpretation of the Phillips curve results.

[14] This assumes that policy makers do not discount future economic outcomes at the present day. A political leader with a very short-term horizon might find it optimal to inflate the economy in order to stay in power for a few more months. 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.

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

Prices in China can be sorted into four main categories: industrial ex-factory, agricultural purchase, wholesale, and retail prices.[16] 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 prices around without necessarily adjusting the upstream/downstream prices. Prices did not necessarily reflect cost, and only two major price adjustments happened between 1953 and 1978.[17]

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 would include a coupon system. An equivalent framework was adopted for industrial output in 1984, and it was in 1985 that the price reforms started to have profound impact on the economy through the industrial sector.[18] The temporal two-tier price framework also had an educational effect: farmers, industrial producers and consumers were able to learn operating under 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 the often much higher market prices. 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 fixed prices such as fuels and coal were adjusted upwards in these years. In 1992 most dual track prices were merged into market prices,[19] and only 89 producer goods and transport prices remained under central planning (Chai, 1997) – including prices for basic agricultural goods, for which the dual prices were abandoned in January 1994.

[16] Chai (1997)
[17] ibid.
[18] Lu and Zhang (2003). According to Yiping Huang (2001), the dual price policy encouraged corruption and rent-seeking by arbitraging between the two prices. Alwyn Young (2000) argues the same.
[19] Wen (2003)

Turning to the object of this study, consumer prices, most of these were decontrolled by 1986. Figure 1 illustrates the progress of price liberalisation for agricultural and for retail prices. After the initial price reforms, the changes were most profound during the period of 1985 to 1992, with a slight backstep during 1989 to 1990. By 1992, more than 90 percent of consumer prices had been liberalised.[20] Figure 1 reveals two pieces of information relevant for empirical inflation modelling. Retail prices, though not perfectly liberalised by the start date of the quarterly inflation estimations in 1988, to a large extent carried market driven price signals from 1988 onwards. As the figure shows, the final 15 percent of remaining contract prices in the agricultural sector were not yet liberalised by 1992. They were fully freed in 1994, when the coupon system was finally abolished.[21]

3.3.2 Adjustment for structural breaks

Apart from unspecified 'general' gradual change the 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 3d (and e) shows a clear spike in inflation in 1994 which can be partially explained by one of the last steps of price liberalisation. The suppressed prices of agricultural goods moved upwards. The upward shift in prices which were previously artificially subdued is a common phenomenon in transition economies (Allan 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 3b reveals that the price rises in 1994 happen 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 demand pressure, when it was partly caused by the price liberalisation.

The dummy variable required is *not* one of the usual […,0,1,0,…] indicator variables. What is required is a dummy variable that is consistent with the maintained hypothesis of a vertical long-run Phillips curve. That necessitates a double impulse indicator variable of the kind […,0,1,-1,0,…]. Simply dummying out the 1994 (Q1 to Q4) inflation period would not be helpful for the identification of the output gap effect, as a conventional dummy variable would absorb all the variation in inflation. This is clearly undesirable and indeed wrong. In an

[20] Chai (1997), Oppers (1997: p. 26)
[21] We are grateful to Xin Meng for drawing our attention to this point.

accelerationist Phillips curve a one-off positive output gap results in permanently increased inflation. Imagine now the case where there is a one-off rise in the CPI price level, due to a one-off price liberalisation like in 1994. The price level jumps from zero to one, as in the top left corner of Figure 2. The (first) difference of the CPI, i.e. the inflation rate d1CPI, is displayed on the top right in that figure. In a vertical Phillips curve, the inflation rate would stay at 1 due to the unit root, rather than return to zero. In order to take out the one-off price rise (which is non-fundamental in the sense that it is not caused by increased demand) in a regression estimation, the usual dummy variable (middle right) is not appropriate. Such an […,0,1,0,…] indicator variable would explain the rise in the price level, however increased inflation would remain in the long-run. Using the double impulse dummy assumes that consumers are aware of the one-off nature of the price adjustments and do not expect the unit-root in inflation to lead to steadily rising prices after the initial round of adjustment. In order to avoid a long-run increase in inflation and instead allow for a temporary increase in inflation, a dummy variable with a counter response […,0,1,-1,0,…] must hence be used.

There is one other possible date at which a break-point could be used during the estimation period. This is January 1994 when the exchange rate was devalued and subsequently fixed to the US dollar. The estimation method uses the trade weighted nominal effective exchange rate as the right hand side variable which should capture the effect.[22]

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, while others are not available at all and need to be constructed from other available data. Second, Chinese data has attracted a fair number of papers looking into the data quality.[23] 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. Since some data for the Chinese economy cannot be taken off the shelf as for G3 economies,

[22] Potential trend or intercept corrections might also be necessary – but turn out to be non-essential.
[23] e.g. Chow (1993),Wu (1997), Rawski (2001), Rawski (2002), Wong and Chan (2003). See Scheibe (2003: p. 13) for a summary of the data discussion.

a detailed discussion of the data is necessary and is available in the appendix. All variables entering the Phillips curve are assumed to be stationary.[24]

5 ESTIMATION RESULTS

The estimation of the Phillips curve proceeds in two nested steps. These are the selection of the 'best' output gap and the estimation of a Phillips curve for China which is tested for long-run verticality and robustness across rolling estimation periods. In the two steps of the estimation, the latter issue requires a solution to the former, while all the detail and care of estimating a Phillips curve for China enter into the selection process of a 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, section 5.3 reviews the implications of vertical Phillips curves, and 5.4 comments on the relevance of the Lucas critique to the estimation of a behavioural equation in a gradually changing economy.

5.1 Best Practise Phillips Curve

Backward-looking output gap Phillips curves appear to be a good representation of Chinese inflation dynamics. The output gap and the change in the trade weighted exchange rate are significant right hand side variables, while growth rates of money do not seem to play a role in the reduced form estimation. The estimated Phillips curves are accelerationist in the long-run. Partially forward-looking Phillips curves could matter, but the empirical results for purely backward-looking Phillips curves are more robust. Sections 5.1.1 and 5.1.2 document the estimation results from backward 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.

[24] See the discussion in the appendix and Table 7 for unit root tests.

Phillips Curve	d1CPI															
Output gap: derived from growth accounting by sector, flexible TFP trend																
	88-02	t-stat	**88-96**		**89-97**		**90-98**		**91-99**		**92-00**		**93-01**		**94-02**	
D88-1	0,022	2,82	0,022	2,41												
D88-3	0,636	7,72	0,062	6,41												
D90-1	0,039	4,68	0,042	4,29	0,042	4,24	0,038	4,01								
DD94-1	0,035	5,94	0,035	5,02	0,034	3,21	0,036	5,33	0,034	4,65	0,035	4,74	0,033	5,53	0,035	5,58
DD94-3	0,024	4,15	0,022	3,32	0,022	3,21	0,022	3,43	0,021	3,12	0,032	4,13	0,037	6,03	0,037	6,67
d1CPI-1	0,553	10,50	0,565	9,02	0,560	7,57	0,642	6,80	0,597	5,39	0,742	4,48	0,874	6,96	1,029	8,45
d1CPI-2											- 0,211	-1,61	- 0,258	-2,39	- 0,329	-3,28
d1e-1	- 0,142	-6,02	- 0,164	-5,66	- 0,155	-3,81	- 0,124	-2,80	- 0,096	-2,06						
d1e-3	- 0,122	-4,31	- 0,117	-3,29	- 0,117	-2,69	- 0,120	-2,86	- 0,147	-2,81	- 0,176	-3,29	- 0,202	-4,61	- 0,148	-2,67
d1e-5	- 0,044	-1,74	- 0,044	-1,41	- 0,044	-1,35	- 0,072	-1,74	- 0,097	-2,03	- 0,087	-1,58				
d1e-6															- 0,051	-1,69
d1e-7	- 0,039	-1,73									- 0,093	-1,59	- 0,058	-1,65		
ygap	0,106	4,49	0,115	3,91	0,119	3,48	0,083	2,05	0,094	2,11	0,105	1,64	0,092	1,89	0,075	1,85
sigma	0,78%		0,92%		0,92%		0,84%		0,86%		0,86%		0,70%		0,61%	
Diagnostic tests																
DW	1,800		1,930		1,890		1,910		1,870		2,210		2,380		2,440	
AR 1-4	0,878	0,48	0,429	0,73	0,399	0,76	0,967	0,43	1,546	0,23	0,561	0,65	1,066	0,38	1,640	0,21
ARCH 1-4	0,349	0,84	0,057	0,98	0,016	1,00	0,012	1,00	0,160	0,92	0,545	0,66	0,656	0,59	1,165	0,35
Normality	2,551	0,28	1,467	0,48	1,026	0,60	3,690	0,16	2,462	0,33	1,224	0,54	3,525	0,17	2,212	0,33
Heteroskedasticity	0,652	0,83	0,206	1,00	0,355	0,97	1,138	0,43	1,307	0,33	0,944	0,56	1,925	0,14	0,576	0,84
RESET	7,728	0,01	4,636	0,04	5,028	0,03	2,826	0,10	2,690	0,11	1,320	0,26	6,913	0,01	10,34	0,00
Vertical PC ChiSqr(1)	2,798	0,09	3,827	0,05	2,959	0,09	0,246	0,62	0,467	0,49	0,703	0,40	1,266	0,26	1,122	0,29
sum of d1CPI and d1NEER coefficients	0,900		0,890		0,875		0,957		0,937		0,887		0,877		0,899	
Annual output gap effect	0,422		0,461		0,475		0,331		0,378		0,421		0,370		0,300	
Exchange rate effect	- 0,347		- 0,325		- 0,315		- 0,316		- 0,340		- 0,356		- 0,261		- 0,199	

Table 1: Estimation results – backward-looking Phillips curve

Diagnostic tests

Diagnostic tests are generally met for most estimation periods, apart from five failures (two of them marginal at the five percent level) of the RESET test for misspecification.[25]

Table 9 provides references for and explains the diagnostic tests. Figure 4 displays the recursively estimated regression coefficients for the full-period sample period. The entry under 'Vertical PC ChiSqr' in Table 1 shows the results from the test for a long-run vertical Phillips curve. The test is Chi-square distributed, and the probability value is the one for accepting the hypothesis of a vertical Phillips curve. 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. The sigma value is the residual standard deviation. Hansen (1992) tests for parameter stability within a given estimation window are satisfied.

[25] As mentioned before, the diagnostic tests are weak for small samples such as the 36 observation rolling window estimates. For the full, 60 quarter observation period the failure of the RESET test is more serious. However, including a non-significant and small constant in the model would make the probability of acceptance jump to about 3.5 percent, and the PcGets programme, which considers diagnostic tests in the model selection would chose a model very similar to the one presented in Table 1.

The output gap is strongly significant for the full estimation period with a coefficient of 0.1. This is to say that a steady positive output gap of one percent raises annual inflation by 0.4 percent. The output gap coefficient is fairly stable across the estimation periods. Hence, the estimations seem to show a robust structural relationship. 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 inflation at about 0.35 percent on average. No Phillips curve reported in Table 1 contains a constant. 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. Due to the exclusion of the constant, a meaningful R-sqr value cannot be computed.[26] However, with a small and statistically insignificant constant included, the R-sqr value for all estimation periods is between 0.89 and 0.93. The hypothesis of long-run vertical Phillips curves is accepted throughout.

Lagged dependent variable

Four lags for the dependent variable $\left(\Delta^1 CPI\right)$ are allowed for, and while the first lag is the only significant lag in the early years of the sample, the second lag becomes significant in the later part of the estimation period.

Output gap

The output gap coefficient shows a slightly decreasing trend over time. Bearing in mind that quarterly inflation rates are used in the regression, the annualised coefficient on the output gap is around 0.40.[27] The size of the output gap coefficient stays reasonably stable over time, however the coefficient loses a little in significance over time. This is most likely due to an increased noise to signal ratio during the late 1990s and early 2000s when inflation was low, and the output gap was small in absolute size. Regarding the changes on the coefficient on the output gap, Razin and Yuen (2001) suggest that with consumption smoothing under capital mobility, prices become more sticky, hence output responses to nominal shocks are stronger, and by the same token the coefficient on the output gap in the Phillips curve is lowered. Although officially China maintains a closed capital account, the slightly decreased output

[26] see Greene (2000: p. 240)
[27] See the second last line of Table 1.

gap effect on inflation in the last two estimation windows could be related to a possibly more porous capital account in recent years.[28]

Exchange rate

For the change in the exchange rate, up to eight lags are tested for. While 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 inflation would be of relevance, the exchange rate does matter up to lag seven.[29] From the results of Table 1 (the last line shows the sum of the exchange rate coefficients) 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 initially rising over the rolling estimation windows, but then falls in the last two estimation periods. The robustness of this result is supported by the increasing lag coefficient on inflation and the continued long-run verticality of the Phillips curve. The apparent trend of a decreasing exchange rate coefficient in the last two estimation periods is at odds with a quickly opening economy, where imports have grown from less than 20 percent to about 30 percent during the estimation period. While initially the increasing import to GDP ratio together with a liberalisation of prices could have driven upwards the (absolute value of the sum of the) exchange rate coefficient, the declining exchange rate effect in an opening economy can only be reconciled with an increased marketing of imported goods in RMB rather than the currency of their country of origin (pricing to market, see Krugman (1986) and Aizenmann (2000)). The declining sensitivity of inflation to the exchange rate recently would bear an important policy implication: inflation targeting, which is seen as a risky framework for transition economies with unstable exchange rates,[30] could offer a viable alternative for providing a nominal anchor to the Chinese economy. Even if the exchange rate would fluctuate after exchange rate and capital account liberalisation, the effect of this on inflation would not be tremendous.[31]

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[28] Capital controls are more difficult to monitor in the Pearl River Delta than in Beijing, a view bankers and officials in the region are likely to agree with in private.

[29] Campa and Goldberg (2002) review 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 in the long-run (4 quarters) is a reasonable 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). Our homogeneity assumption for a long-run vertical Phillips curve is hence reasonable for our *a priori* lag structure of up to eight quarterly lags.

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

[31] Of course, Ball (1999), and others, have argued for measured of inflation which exclude direct exchange rate effects as the target variable for open economy inflation targeting regimes. However, this issue of determining the right target for policy, the public would still feel the price effects of exchange rate changes. A low exchange rate coefficient in the Phillips curve would keep public and policy setter’s unease with inflation more aligned, and lower.

Money growth

Money growth, possibly adjusted by economic growth, is a likely candidate for an inflation equation – at least according to a popular views on Chinese inflation. Added to an inflation equation such as [5], none of the following four variables at lags 0 to 4 were significant: the first and fourth difference of money supply M1, the first and fourth difference of M1 minus the annual growth rate in GDP. This result rejects the hypothesis that money causes inflation through channels other than via demand or exchange rate effects.

Dummy variables

The most important reason for the use of dummy variables has been discussed in section 3.2.1 and 3.2.2. In general, the use of dummy variables is an undesirable but often unavoidable feature in empirical macromodelling of emerging markets economies, and China is no exception to this rule. The use of dummy variables is undesirable as it tends to cloud structural relationships of variables and potential outliers should ideally be explained with structural variables. However, emerging market data is at times badly measured, and can only be adjusted for by the use of dummy variables. Up to five dummy variables are used in the Phillips curve regressions. The first three, standard indicator variables with a single impulse of unity in 1988Q1, 1988Q3, and 1990Q1 are used to take out unexplained outliers in quarterly inflation.[32] Figure 3e (p. 36) reveals that in these three quarters the first difference of the constructed CPI shows one-off movements in the differenced data which are not in line with the overall movement of quarterly inflation at that time. In 1988/9 inflation reached a peak in China. Though most of this inflationary period can be explained by the output gap and the exchange rate movement, three unexplained observations remain. Certainly the construction of the quarterly price index is taking its toll, in the periods of large annual price changes, the constructed quarterly index results in volatile changes at times, even after seasonal adjustment. No particular political or economic event could account for any of the first three events which are dummied out. The other two dummy variables are the carefully selected double impulse dummies $\left(DD_t\right)$ during the period 1994 Q1 to Q4, of which DD_{94Q1} and DD_{94Q3} remain as significant dummies.[33] These variables are important for estimating a

[32] In the forward-looking Phillips curve estimations, all dummy variables are included with a one period shift forward.

[33] For the second and fourth quarter of 1994 the double impulse dummy variables are borderline significant.

well behaved model which satisfies the (due to the small sample size weak) diagnostic tests and allow for the hypothesis of a vertical long-run Phillips curve.

5.1.2 New Keynesian Phillips curve

One aspect of the Chinese Phillips curve remains to be investigated yet: forward-lookingness. Two estimation specifications are considered. Of the three approaches of dealing with $E_t\left[\pi_{t+1}\right]$ mentioned in section 3.1 we use the first and third one. 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. Estimating equation [1], the results from both methods are similar, and expectations of future inflation seem to matter with a coefficient of about 0.15 to 0.2, while the first *lag* of inflation has a coefficient in the range of 0.55 to 0.7. The long-run verticality property of the Phillips curves remains intact. Compared to the traditional Phillips curve for China, the coefficient on the output gap slightly decreases in size and significance under both methods.

Survey data

The survey data of expected inflation is used as an exogenous regressor in the estimation. Table 2 displays the estimation results. Expected inflation plays a role, the coefficient is around 0.15 for the entire estimation period but increases to 0.57 in the last estimation period.[34] Expected inflation in most estimation windows is marginally significant.

Since the data on surveyed inflation expectation is on the expected annual inflation rates in twelve months time, i.e. $E_t\left[CPI_{t+4} - CPI_t\right]$, the construction method of the quarterly index gives the expectation at time *t* of the change in the price level between *t+3* and *t+4*. Apart from the variables included in the general model for the backward-looking Phillips curve, expected inflation of up to lag 3 is included in the general model. Only the expectation at *t* of the quarterly inflation rate at *t+4* is significant. This result seems to indicate that what is important is the *current expectation* of future inflation.

Compared to the purely backward-looking Phillips curve specification, most coefficients on the exchange rate and the output gap display a less stable pattern across the estimation

[34] d1CPI[t+1] marks the relevant line in Table 2

periods, and slightly smaller coefficients. This result is plausible, as forward looking Phillips curves will adjust inflation to a degree through expectations rather than contemporaneous or past changes in the output gap – which are effectively expected as well. The regression contains the same indicator variables as the backward-looking one, however this time DD_{94Q4} is significant, too. Because the survey data on inflation expectations starts in 1991, fewer rolling estimation windows are analysed. The diagnostic test for homoskedasticity fails for the full estimation period, and White (1980) heteroskedasticity adjusted (HSCE) standard errors are used for the calculation of the coefficient t-statistics for the 1991-2002 estimation window.

Phillips Curve	d1CPI									
Output gap: derived from growth accounting by sector, flexible TFP trend										
	91-02	*	**91-99**		**92-00**		**93-01**		**94-02**	
DD94-1	0,028	4,94	0,029	3,51	0,025	3,89	0,029	5,17	0,020	4,50
DD94-3	0,031	6,36	0,023	3,19	0,040	6,35	0,039	7,22	0,031	8,73
DD94-4	0,013	7,30			0,019	2,82	0,021	3,75		
E(t)[d1CPI(t+1)]	0,169	1,54	0,151	1,22	0,204	1,57	- 0,022	-0,17	0,571	5,01
d1CPI-1	0,581	3,97	0,566	4,04	0,541	3,96	0,627	5,59	0,614	7,69
d1CPI-4									- 0,312	-5,55
d1e-3	- 0,161	-3,24	- 0,160	-2,93	- 0,189	-4,17	- 0,176	-4,43	- 0,152	-3,68
d1e-4					- 0,074	-1,54	- 0,088	-1,98	- 0,137	-3,93
d1e-5	- 0,069	-1,17	- 0,099	-1,95						
d1e-7					- 0,080	-1,54	- 0,070	-1,52		
ygap	0,048	1,47	0,058	1,25	0,020	0,31	0,074	1,43	0,014	0,39
sigma	0,76%		0,91%		0,72%		0,61%		0,44%	
Diagnostic tests										
AR 1-4	0,530	0,71	1,031	0,40	1,524	0,23	0,825	0,49	2,028	0,14
ARCH 1-4	1,456	0,24	2,097	0,13	0,002	1,00	0,129	0,94	0,188	0,90
Normality	0,140	0,93	0,713	0,70	5,301	0,07	6,596	0,04	2,712	0,26
Heteroskedasticity	2,904	0,01	1,754	0,18	1,256	0,38	1,918	0,16	0,424	0,94
RESET	5,843	0,02	4,092	0,05	2,132	0,16	4,386	0,05	6,15	0,02
Vertical PC ChiSqr(1)	0,066	0,80	0,055	0,81	0,395	0,53	0,239	0,62	0,280	0,09
sum of d1CPI and d1NEER coefficients	0,979		0,976		1,087		0,940		1,163	
Annual output gap effect	0,193		0,232		0,079		0,295		0,058	
Exchange rate effect	- 0,229		- 0,259		- 0,343		- 0,334		- 0,289	

*) Based on heteroskedasticty adjusted standard errors (HCSE)

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 discussed above.

The coefficient on future (expected) inflation is between 0.15 and 0.2 for most estimation windows, and rises to 0.36 for the 1994-2002 estimation period. Similar to the hybrid Phillips curve estimated with survey data, the coefficient on the exchange rate and output gap is slightly reduced compared to the case of backward-looking estimation. As mentioned before, the full-model properties of a partially forward-looking Phillips would show that less output gap or exchange rate variation is required to remove a given amount of inflation. Overall, diagnostic tests perform better than in the New Keynesian Phillips curve based on survey data.

Phillips Curve	**d1CPI (IV)**															
Output gap: derived from growth accounting by sector, flexible TFP trend																
	88-02	t-stat	**88-96**		**89-97**		**90-98**		**91-99**		**92-00**		**93-01**		**94-02**	
D88-1	0,015	1,86	0,015	1,63												
D88-3	0,055	6,77	0,055	5,70												
D90-1	0,033	4,00	0,035	3,54	0,036	3,57	0,036	3,65								
DD94-1	0,034	6,47	0,034	5,29	0,034	5,20	0,034	5,27	0,032	4,51	0,033	4,73	0,028	4,62	0,036	9,86
DD94-3	0,025	4,06	0,027	3,70	0,027	3,63	0,028	3,74	0,028	3,45	0,032	3,85	0,038	5,41	0,025	4,86
DD94-4	0,013	2,16	0,013	1,89	0,013	1,87	0,013	1,96	0,013	1,85	0,014	2,11	0,020	3,30	0,018	3,92
E(t)[d1CPI(t+1)]	0,188	2,24	0,162	1,67	0,156	1,51	0,154	1,39	0,187	1,49	0,148	1,16	- 0,026	-0,21	0,363	3,12
d1CPI-1	0,511	9,02	0,532	7,89	0,541	7,24	0,562	4,93	0,551	4,34	0,707	4,98	0,691	5,90	0,536	5,80
d1e-1	- 0,097	-3,22	- 0,114	-2,97	- 0,119	-2,95	- 0,107	-2,40	- 0,075	-1,54						
d1e-3	- 0,091	-3,38	- 0,088	-2,63	- 0,091	-2,08	- 0,107	-2,42	- 0,120	-2,02	- 0,136	-2,01	- 0,186	-3,02		
d1e-4													- 0,096	-1,98	- 0,122	-2,75
d1e-5	- 0,029	-1,25														
ygap	0,080	3,23	0,091	2,91	0,089	2,51	0,080	2,02	0,073	1,59	0,027	0,52	0,063	1,40	0,031	1,02
sigma	0,71%		0,85%		0,85%		0,81%		0,86%		0,81%		0,66%		0,46%	
Diagnostic tests																
AR 1-4	1,510	0,22	1,987	0,17	2,229	0,15	2,551	0,12	2,795	0,11	4,674	0,04	0,059	0,81	3,933	0,06
ARCH 1-4	1,625	0,19	0,585	0,45	0,504	0,48	0,876	0,36	1,273	0,27	1,436	0,24	0,006	0,94	0,550	0,47
Normality	1,841	0,40	2,873	0,24	3,059	0,22	5,180	0,08	1,297	0,52	0,366	0,83	7,293	0,03	1,865	0,39
Heteroskedasticity	0,617	0,87	0,108	1,00	0,221	1,00	0,729	0,72	0,612	0,81	0,467	0,91	3,406	0,03	0,485	0,90
Vertical PC ChiSqr(1)	3,470	0,06	3,784	0,05	1,567	0,21	0,757	0,38	0,534	0,46	0,007	0,93	0,297	0,59	0,076	0,78
sum of d1CPI and d1NEER coefficients	0,915		0,896		0,907		0,930		0,933		0,990		0,947		1,020	
Annual output gap effect	0,319		0,365		0,356		0,319		0,291		0,107		0,252		0,124	
Exchange rate effect	- 0,217		- 0,202		- 0,210		- 0,214		- 0,195		- 0,136		- 0,282		- 0,122	

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

The selection of instrument for $E_t\left[\pi_{t+1}\right]$ is the crucial aspect in this approach to modelling inflation expectations. Instruments are inflation up to lag 4, the output gap up to lag 4, the change in the exchange rate up to lag 8, and the change in oil prices up to lag 4 – excluding those lags of inflation, the output gap and the change in the exchange rate which are reported in Table 3. Although the results from the backward-looking Phillips curve can give an indication as to what lags of inflation, the output gap and the change in the exchange rate are likely to be significant in the New Keynesian Phillips curve, the simultaneous estimation of equation [3] and [4] could equally result in different lags of the variables being chosen in [4]. We therefore estimate [3] and [4] as a simultaneous system using the full information maximum likelihood method and use those lags which are not significant in [4] as instruments. Some of these instruments are significant right hand-side variables in equation [3]. Reassuringly, lags excluded from the set of instruments are not significant in equation [3].[35]

5.1.3 Comparison of backward-looking and New Keynesian Phillips curve

The results from both approaches to estimating a New Keynesian Phillips curve are very similar. Partially forward-looking Phillips curves appear to have empirical validity. The long-run verticality property and a forward-backward looking proportion of a magnitude found in other economies can be established.[36] The partially forward-looking Phillips curves result in a lower residual standard deviation than the traditional Phillips curve. However, the coefficient on forward-looking inflation is often only marginally significant in the shorter, rolling estimation windows. Noteworthy is the doubling of the coefficient on expected inflation in the last estimation window. Two explanations can be brought forward for this result. The first is that indeed a stronger impact of inflation expectations in the last nine years of the sample period could be true, as economic agents managed to learn how to incorporate inflation expectations into their decision making. An alternative explanation is the lack of variation in both inflation and the output gap after 1994, when both series where trending downwards (see Figure 3). In such an environment with current inflation close to zero, 'expected' inflation, i.e. next period inflation which is of the same value as current inflation and could become a seemingly good explanatory variable as inflation gradually declines over time. All in all, the evidence in favour of inflation expectations playing a role in the Phillips curve process seems reasonably robust, however the purely backward looking Phillips curve leads to more stable results.

5.2 Identification of the best output gap

The 'best' output gap is established from two sets of criteria. The first set comprises test statistics such as the partial R-squared, the t-statistic of the output gap coefficient, and the Schwartz criterion. The second search strategy uses the software PcGets (Hendry and Krolzig (1999), see also Hendry and Krolzig (2004a) and Hendry and Krolzig (2004b)), a regression selection programme which automatically searches for the dominant congruent model among a number of alternative variables to chose from. The 'best' output gap has been used as the

[35] We thank Mardi Dungey, Bent Nielsen and Adrian Pagan for assistance with this part of the work.

[36] Fuhrer (1997) finds an 0.2 to 0.8 weight on forward and backward-looking inflation in a Phillips curve with US data.

base case variable for the more detailed discussion of the Chinese Phillips curve that was discussed above. The selection of the 'best' output gap is cast in the setting of the purely backward-looking Phillips curve as these estimations appear more robust.

On the grounds that output gap estimates have to be evaluated empirically for their fit in an inflation equation, the 'best' output gap estimate remains to be established, yet. *A priori,* production function based output gaps would be preferable to output gaps which are derived from a statistical trend. Equally, an output gap which is the sum of the output gaps from a number of economic sectors would be preferred to one based on aggregate data. Comparing 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 sector data with time-varying sector TFP rates. Phillips curves like equation [5] are estimated following a general to specific approach using up to four lags on the dependent variable and the respective output gap, and again up to 8 lags on the exchange rate. The 1994 Q1 to Q4 double impulse indicator variables are included in the regression, as are three more dummy variables which were discussed earlier. Progress on the general to specific model reduction is again monitored by F-tests for the valid exclusion of variables, including in a last step the deletion of the constant term. 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. Table 10 (p. 41) displays the results from the horse race.

Regressions with the 'best' output gap rarely suffer from a failed diagnostic test. Diagnostic tests are usually satisfactory for all regressions, apart from the occasional failed RESET and heteroskedasticity tests which indicate a misspecification of the regression – if the tests would not suffer from a lack of power from the small sample sizes they are used on. By all measures, and across most estimation periods, the output gap derived from sector based production functions is the output gap 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. This output gap has a high correlation with the inflation rate in the mid 1990s, while other output gap estimates do not explain the major inflation peak at all (see Figure 3, p. 36 and Table 8, p. 35). Table 10 (p. 41) also shows that output gaps derived from a production function approach in general perform better in, i.e. explain better, inflation regressions. Potential GDP determined by a linear trend performs worst. Following the second peak in inflation in 1994, inflation has been low. Together with the output gaps of small absolute size derived from any of the five methods, the signal to noise ratio becomes weaker and differences in explanatory decrease for later regressions. The sector-and-production-function-based output gap has been used as the standard output gap estimate in section 5.1.

The second selection strategy uses the automated selection of the PcGive programme. Using the conservative estimation strategy (see Hendry and Krolzig (2001)) which minimises the number of selected variables in the final model, the output gap derived from sector production functions again does best. As in the manual general-to-specific estimations, the general unrestricted model (GUM) contains four lags of the dependent variable, eight lags of the change in the nominal exchange rate, four double impulse dummy variables for quarters 1994 Q1 to Q4, and the three additional indicator variables to be discussed below, and the contemporaneous lag of all five output gaps.[37] The output gap derived from sector data is selected for the 1988-2002 estimation period as well as the first four rolling estimation windows. The presumably low signal to noise ratio in the output gap and inflation in the latter part the estimation period results in all output gaps being ejected from the final model by PcGets for the last three estimation windows. As Table 10 shows, the explanatory power of the output gaps declines during the later estimation periods. The PcGets variable selection algorithm deselects all output gap estimates, although the production function based output gaps remain borderline significant in non-automated general-to-specific modelling.

5.3 The significance of testing for an accelerationist Phillips curve

What most of the output gap Phillips curve papers for China so far have fallen short of is an adequate analysis of the policy implications of their results. Almost none of the papers so far tests for a long-run vertical Phillips curve, i.e. a Phillips curve where there is no long-run trade-off between inflation and output and a positive output gap would lead to accelerating inflation.[38] Indeed, the estimation of a non-accelerationist Phillips curve would be a strong hint that the Phillips curve relationship is not valid for the country (yet). If production above the long-run sustainable level does not lead to ever-increasing inflation due to the exhaustion

[37] Including up to four lags of all output gaps at the same time results in a final selected model which contains different lags of different output gaps in the same model. The contemporaneous lag has been determined as the dominant lag for the Phillips curve by prior PcGets modelling with four lags of the *same* output gap.
[38] Imai (1997) considers the trade-off explicitly, though not in a formal Phillips curve environment.

of productive capacity, an expansion of the productive capacity - caused by the overstretching of the economy - would be implied and a Phillips curve model would be the wrong representation of the economy. Instead a plausible alternative modelling strategy could follow a Lewis (1954) type setting of a two sector economy, where the industrial sector is the determinant area of economic activity and the agricultural sector serves as the labour pool for the higher productivity manufacturing/industrial sector and hence the binding (labour) constraint in production would be binding temporarily only until new labour pours from the rural areas into the cities.[39] Such a setting would not be non-sensical for the case of China, however it would only be valid if one is content with the assumption that untrained (rather than specialised) labour is required to expand the production possibility frontier in the short-term.[40] Labour would hence be the easily adjustable factor of production, while the standard assumption of a the capital stock as being fixed in the short-run is maintained. This paper is the first to test for a long-run vertical Phillips curve, which the above argument suggests 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 always satisfied.

5.3 The Lucas critique

So what about the Lucas (1976) critique, given the structural change in the economy? Is there any point in estimating a behavioural equation for a gradually changing economy? Lucas' policy invariance argument stresses the *ceteris paribus* assumption in econometric work. In particular, changes in a policy objective or policy instrument change the coefficients in the behavioural equations of an economy as economic agents re-adjust their behaviour to a changed policy environment.[41] Econometric estimations of behavioural equations therefore must stay clear of time periods of policy changes since these would most likely lead to breaks in the behavioural equations. If Lucas' (1976) argument was true, econometric analysis of Chinese data could only be performed on weekly data at best, too many steps of reform would be 'disturbing' the structural working of the economy. Despite its profound impact on

[39] See Vines (2004) for a related two sector model.
[40] The assumption of a fixed (medium-term, potential) labour supply in production has been fed into the construction of the output gap in Scheibe (2003). If the two-sector, flexible labour framework is adopted, the assumptions underlying the output gap calculations would be faulty.
[41] During the 1980s and 1990s the Chinese central bank gradually shifted their main policy instrument from quotas to more indirect measures such as reserve requirements and interest rates.

empirical work, the Lucas critique has been subject to criticism recently. In essence, the validity of the Lucas critique is an empirical question.[42] This applies to backward-looking models as well as those grounded in micro-foundations with forward looking features, and Estrella and Fuhrer find that for US data the backward-looking models (which are thus potentially more deceptive to the Lucas critique) vastly outperform the forward-looking ones in their forecasts. Tests for structural breaks and recursive estimations can show whether policy changes have a quantifiable effect on, say, the Phillips curve. The evidence from the Phillips curve regressions suggests that no such effect is seriously disturbing the estimation results. Second, how meaningful is the Lucas critique under a scenario of constant, gradual change? Possibly, economic agents eventually get the chance to learn about the changes in policy making. This could lead to either constant change in behaviour without any constancy, or a rather stable behavioural pattern as (incomprehensible) change is ignored. Hendry (2000: p. 10-11) makes the point that, in a non-stationary world, economic agents could only arrive at rational, i.e. model consistent, expectations if they knew all the relevant information, including ‘how every component enters the joint data density at each point in time, when many of the events and their consequences, cannot be anticipated’. In such a world, agents would adopt ‘robust forecasting rules’ which do not change with policy changes. If the econometric model incorporates the policy variables, changes in policy can be captured within the model and no change in behavioural equations need occur. In this paper the Phillips curve is estimated with stationary variables only, but the gist of Hendry’s argument applies, especially if the Phillips curve is implanted into a fully specified macro model with non-stationary components. Bergeijk and Berk (2001) find further evidence that policy changes do not necessarily lead to parameter instability in behavioural equations. From this evidence we conclude that it seems ill-advised to take the Lucas critique at face value. From the Lucas critique and its discussion two lessons apply to the estimation of a Chinese Phillips curve. First, empirical tests for parameter constancy are important. Second, despite structural change in the economy, there is a point in estimating a behavioural equation for China.

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 result in stable results across rolling estimation windows. Partially forward-looking Phillips curves

[42] Estrella and Fuhrer (1999)

seem to be important for China, too. The output gap and changes in the exchange rate are important variables for explaining inflation in China. Money supply, on the other hand, does not play any role in the reduced form Phillips curve in our estimations. 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 small literature on inflation in China with more elaborate, production function based output gap estimates, the later kind lead to greatly improved explanatory power. Equally, the careful 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 also important for the identification 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 policy implications of the estimation results are twofold. First, with inflation expectations probably being part of the inflation process, the effectiveness of monetary policy should increase, as 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 exchange rate effects in inflation despite the trend to a more open economy. The Phillips curve estimations lend evidence to the hypothesis of increasing pricing to market of imports in China. In this case, an eventual capital account opening and an exchange rate liberalisation would have a reduced impact on inflation in China.

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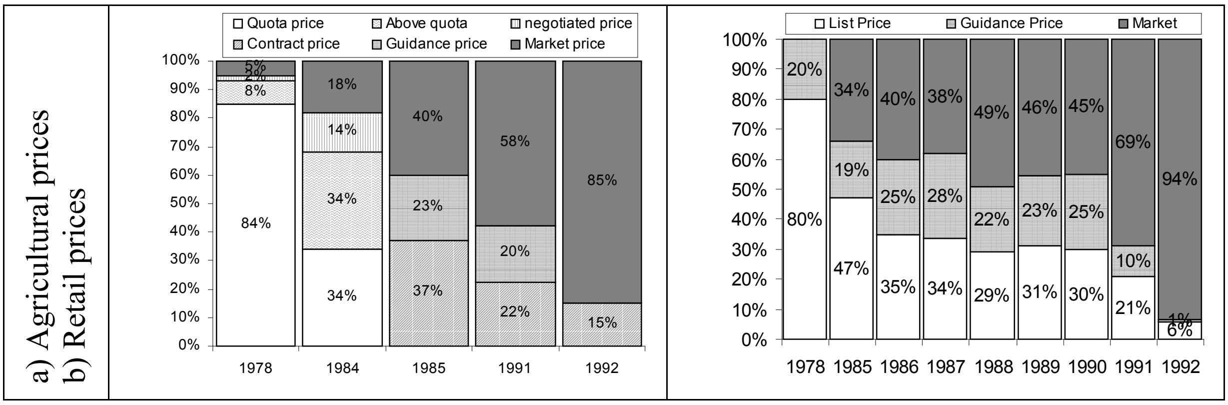
8 APPENDIX

Tables

Figures

8.1 Price liberalisation and adjustment for structural change



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

Figure 1: Price liberalisation

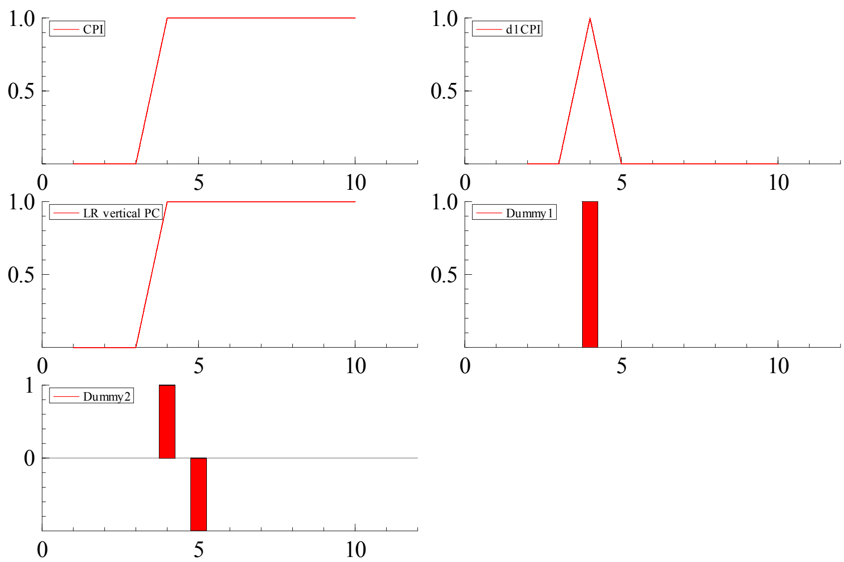


Figure 2: Event dummy in the vertical LR Phillips curve

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 4: Estimation periods

8.2 Data discussion

This section lists the data and its sources, and documents data construction where needed. It follows a discussion of the main variables.

Variable	**Description**		**Source**	**Available from**
π_t	Quarterly change in the CPI	Growth rate	Constructed	1986Q2
	CPI	Index	Constructed, annual inflation data from IMF IFS (92464..XZF)	1987Q1
y_t^{gap}	Output gap, various specifications	level	Constructed, see Scheibe (2003)	1987Q1
m_t	Money M1	Level	IMF IFS (92434...ZF)	1980Q1
p_t^{oil}	Oil price (Brent Crude) in RMB	Level	Datastream	1982Q2
e_t	Nominal effective exchange rate (NEER)	index	IMF IFS (924..NECZF)	1980Q1

Table 5: Variables for the inflation equation

Inflation

There is no officially published quarterly level series of a consumer price index (CPI), wholesale price index (WPI) or GDP deflator.[43] Level data of price indices is available for annual frequencies for more than the last 25 years. However, quarterly data on the CPI exists only as annual CPI inflation since 1987. Since first differenced data of the price level is desirable for avoiding severe AR(4) autocorrelation in the Phillips curve, CPI level data has to be constructed. All that is needed for the construction of the index is an 'index connection base' of four quarters to which the annual growth rates would be linked. Two approaches for the construction of this connection base are followed.

First, we try to build an 'index connection base' (ICB) during the period of most stable annual inflation (index 1). Second, we build an ICB as the series of level data which minimised the

[43] All standard data bases such as the IMF's International Financial Statistics, various Chinese statistical publications, Datastream, or the Economist Intelligence Unit database publish only the annual growth rates of the price level, i.e. annual inflation. The IMF's senior economist at the China desk, Tarhan Feyzioglu, confirmed to me that quarterly price index data is not published by the Chinese authorities. There had been a short attempt of three months when price level data was published in 2001, however due to methodological discrepancies with the construction of the annualised inflation rates the data did not match the existing inflation data series and the Statistics Office ceased the publication of the seemingly contradicting index.

variance of the (quarterly) first difference of the CPI (index 2). Table 6 shows the construction of the four quarter long ICB for both indices. The resulting quarterly inflation rates are displayed in Figure 3e. After seasonal adjustment of the two price indices CPI1 and CPI2, the first differences of the seasonally adjusted data are virtually identical as Figure 3e illustrates.

Quarter	Annual inflation rate	Index 1	Index 2
2000/1	0.10%	100.000	100.000
2000/2	0.10%	100.025	98.465
2000/3	0.27%	100.050	99.588
2000/4	0.50%	100.118	100.475

Table 6: Construction of the CPI

Expected inflation

The Munich IFO Institute has collected survey data on expectations of inflation from 1992 at quarterly intervals, the data is available from Datastream. The data, which is displayed in Figure 3f, shows the currently expected annual rate of inflation in twelve months time, i.e. $E_t\left[\Delta^4 CPI_{t+4}\right]$. Using the same method as described above, an expected inflation index is derived in order to be allow for inclusion of expected quarterly inflation rates in the hybrid Phillips curve. No judgement as to whether these expectations are rational, adaptive, or even backward-looking can be made, however these survey based expected rates of inflation are the representative best guess of Chinese economic agents. The expected inflation seems to lag rather than lead actual inflation. This seems to indicate that the Chinese public have forecasted future inflation as current inflation. Taking into account that it takes time for the public to learn about how to form expectations on inflation and the economy as well as the policy framework have changed over the 1990s, an extrapolative expectations formation appears to be a reasonable strategy.

Output gap

Five output gap estimates are considered in the regressions of the macro-model, namely where potential output is determined by a) a linear trend, b) a trend derived from a Hodrick and Prescott (1997) (HP) filter with $\lambda^{HP} = 1,600$,[44] c) a growth accounting approach on aggregate data with a (slightly) flexible total factor productivity component, d) a growth

[44] 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.

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.[45] It is the aim to tests which of the output gap specifications provides the 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 3a, b, and c show the relevant output gaps. Note the correlation of the different output gaps with inflation.

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.

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

The first difference of the logged index numbers are used for the estimations. A graph of the NEER has been shown in Figure 3h.

[45] 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 allow for the regression residual to be interpreted as an output gap. Effectively, the results from the two methids 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.

Money supply

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

Instruments for the hybrid Phillips curve

For the hybrid Phillips curve, the usual instruments for future inflation in the literature include, apart from lagged inflation and the output gap: marginal production prices, interest rate spreads between short-term and long-term bonds, and commodity prices. While the first kind of variable would have to be estimated, the second type is not very illuminating for inflation expectations as the interest rates are set by the central bank and financial markets are still in the developing stage. Commodity prices at the monthly or quarterly interval are available since 1996 only, two years after the starting point for the last of the rolling estimation windows. Faced with this shortage of potential instruments, the oil price in RMB is used as a representative for commodity prices.

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 $\left(I \sim (0)\right)$. Quarterly inflation data misses the critical value for stationary data by a small margin only, and the conclusion that π_t is indeed stationary is not far fetched given the weaknesses of the augmented DF test.[46] First differenced data of the exchange rate is 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 is overruled on these grounds.

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

Variable	Test period	Const/trend	DF/ADF test lag			
			0	1	4	5
$\pi_t\left[=\Delta^1 CPI_t\right]$	1988q3-2002q4	Const	-2,631	-2,149	-2,149	-1,732
$\Delta^4 CPI_t$ I	1988q3-2002q4	Const	-1,078	-2,753	-2,099	-2,254
y_t^{gap} (lin)	1988q3-2002q4	Const	-1,533	-1,914	-1,893	-2,467
y_t^{gap} (HP)	1988q3-2002q4	Const	-2,829	-3,240*	-2,515	-3,097*
y_t^{gap} (SecGA, flex TFP)	1988q3-2002q4	Const	-1,153	-1,663	-1,710	-2,647
y_t^{gap} (AggrGA, flex TFP)	1988q3-2002q4	Const	-1,626	-1,944	-1,754	-2,484
y_t^{gap} (AggrRgr, fixed TFP)	1988q3-2002q4	Const	-1,613	-1,980	-1,885	-2,724
m_t	1988q3-2002q4	Const Trend	-0,712 -1,035	-0,582 -1,345	-0,547 -1,420	-0,441 -1,481
$\Delta^1 m_t$	1988q3-2002q4	Const	-7,225**	-6,063**	-3,133*	-3,049*
p_t^{oil}	1988q3-2002q4	Const	-2,065	-1,966	-1,801	-1,321
$\Delta^1 p_t^{oil}$	1988q3-2002q4	Const	-8,853**	-8,255**	-5,270**	-4,903**
e_t	1988q3-2002q4	Const	-1,117	-1,117	-1,108	-1,078
$\Delta^1 e_t$	1988q3-2002q4	Const	-5,946**	-5,212**	-4,129**	-3,973**
$\Delta^4 e_t$	1988q3-2002q4	Const	-2,787	-3,396*	-4,884**	-3,375*

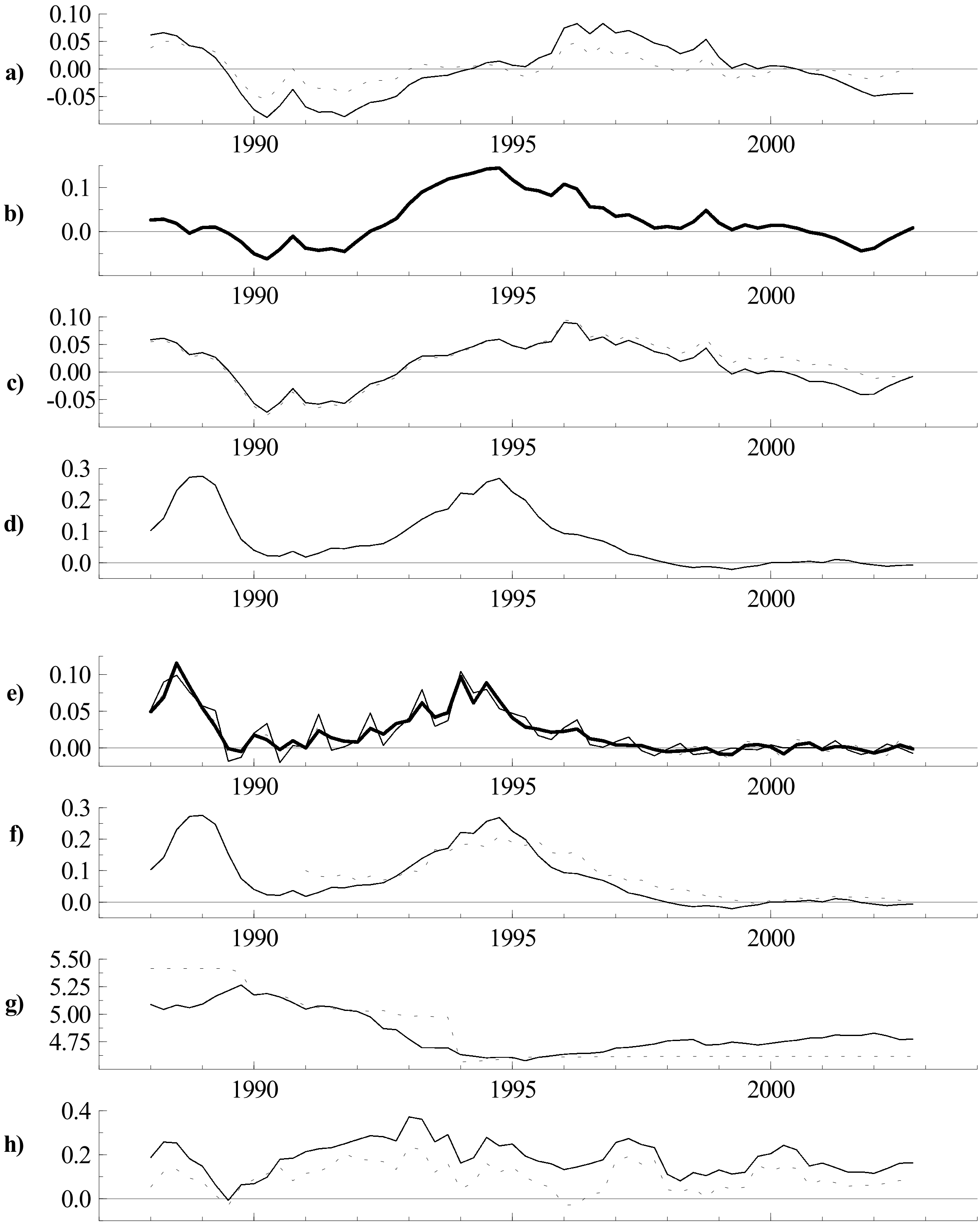
Table 7: Unit root tests

The critical values are -2.91 and -3.55 at the five and one percent level for a test without trend, respectively. Including a trend in the test, the critical values are -3.49 and -4.12. Rejection of the unit root hypothesis at the five and one percent level is indicated with * and **. The inclusion of a trend does not change the results for any of the variables by much.

	Linear trend	HP trend	Aggr - linTFP	Sector based	Aggr - flex TFP	d4CPI
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	1,00
d1CPI	0,22	0,42	0,45	0,55	0,28	0,85

Table 8: Correlation of output gaps and inflation

The correlation of the quarterly and annual inflation rates are high, as are the correlations within the sets of output gaps derived from either a statistical trend or the production function based output gap family as well as all output gaps in general. The correlation of inflation and particular output gaps shows a larger degree of variance.



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 (d4CPI)

e) the first differences of the two constructed price indices CPI1 and CPI2 (dotted) and the first difference of the seasonally adjusted CPI (thick line)

f) annual inflation (again) and expected inflation (dotted, expectation at *t* of inflation at *t+4*)

g) log of NEER and (mean adjusted) USD-RMB exchange rate (dotted)

h) annual growth rate of M1 and annual growth rate of M1 adjusted for real GDP growth

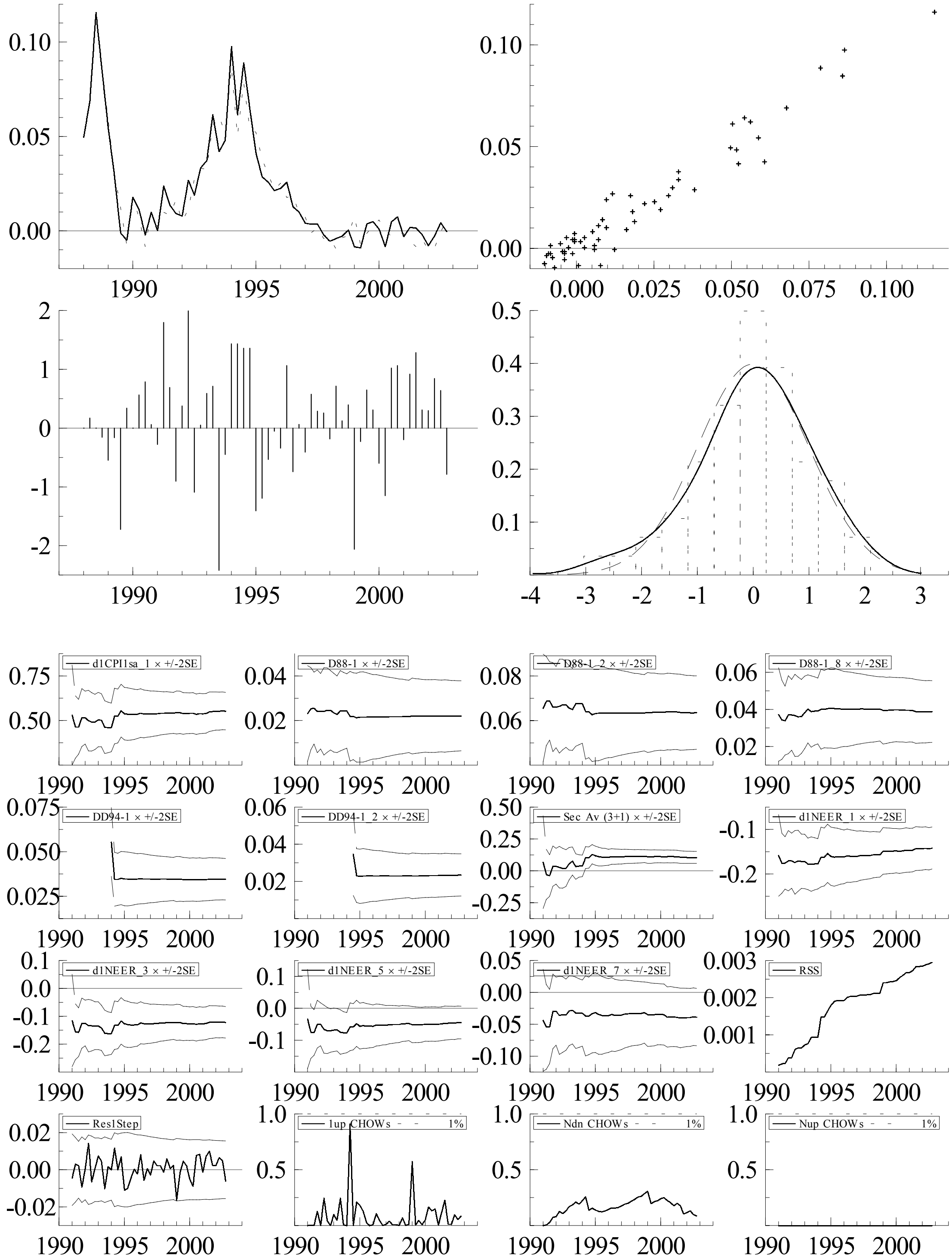
Figure 3: Data overview

8.3 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( )

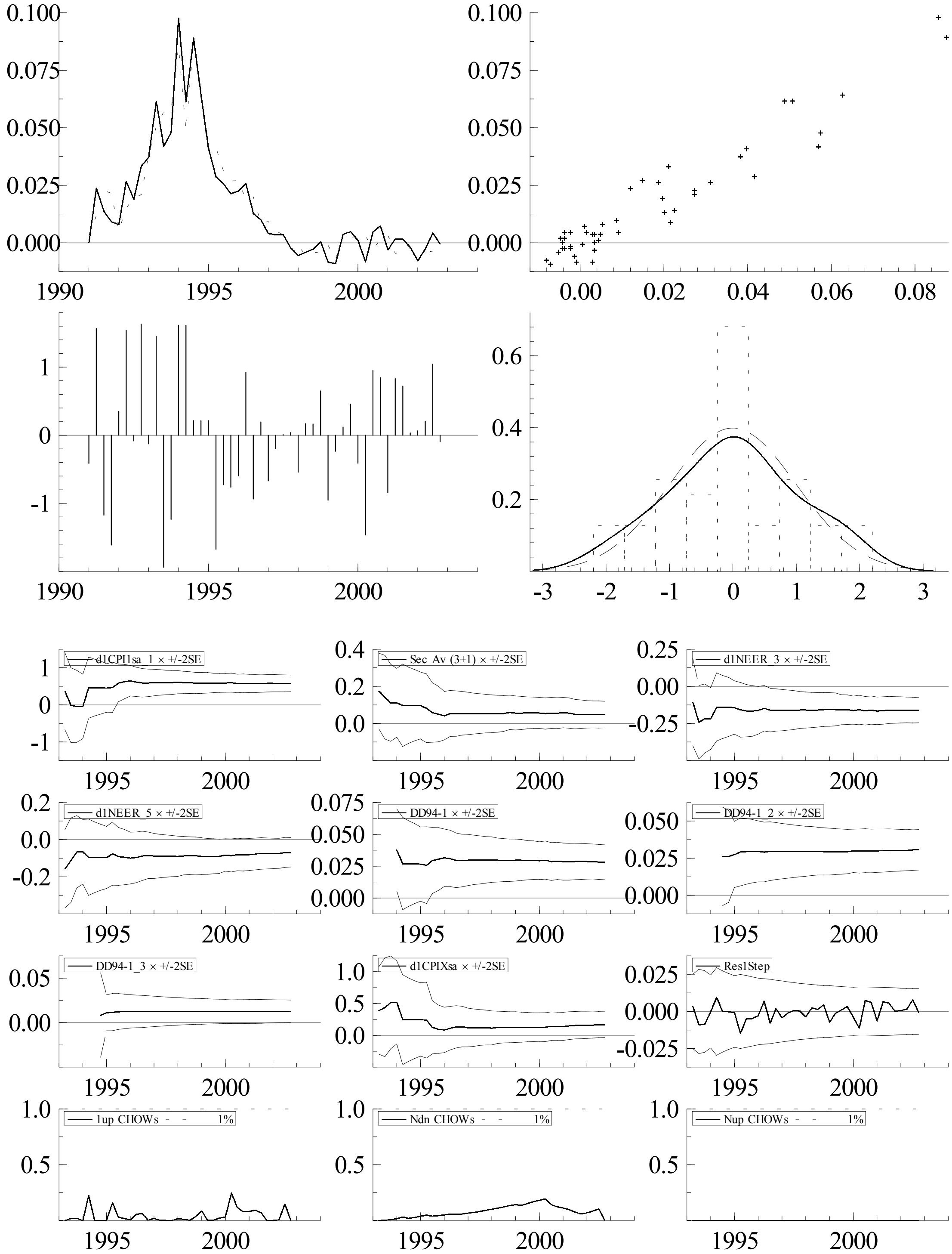
Table 9: Diagnostic tests: explanation and references

Regression estimations are run using the econometrics software PcGive 10 (Hendry and Doornik (2003)). The references manuals are Hendry and Doornik (2001) and Doornik and Hendry (1999). The above 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 are 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.



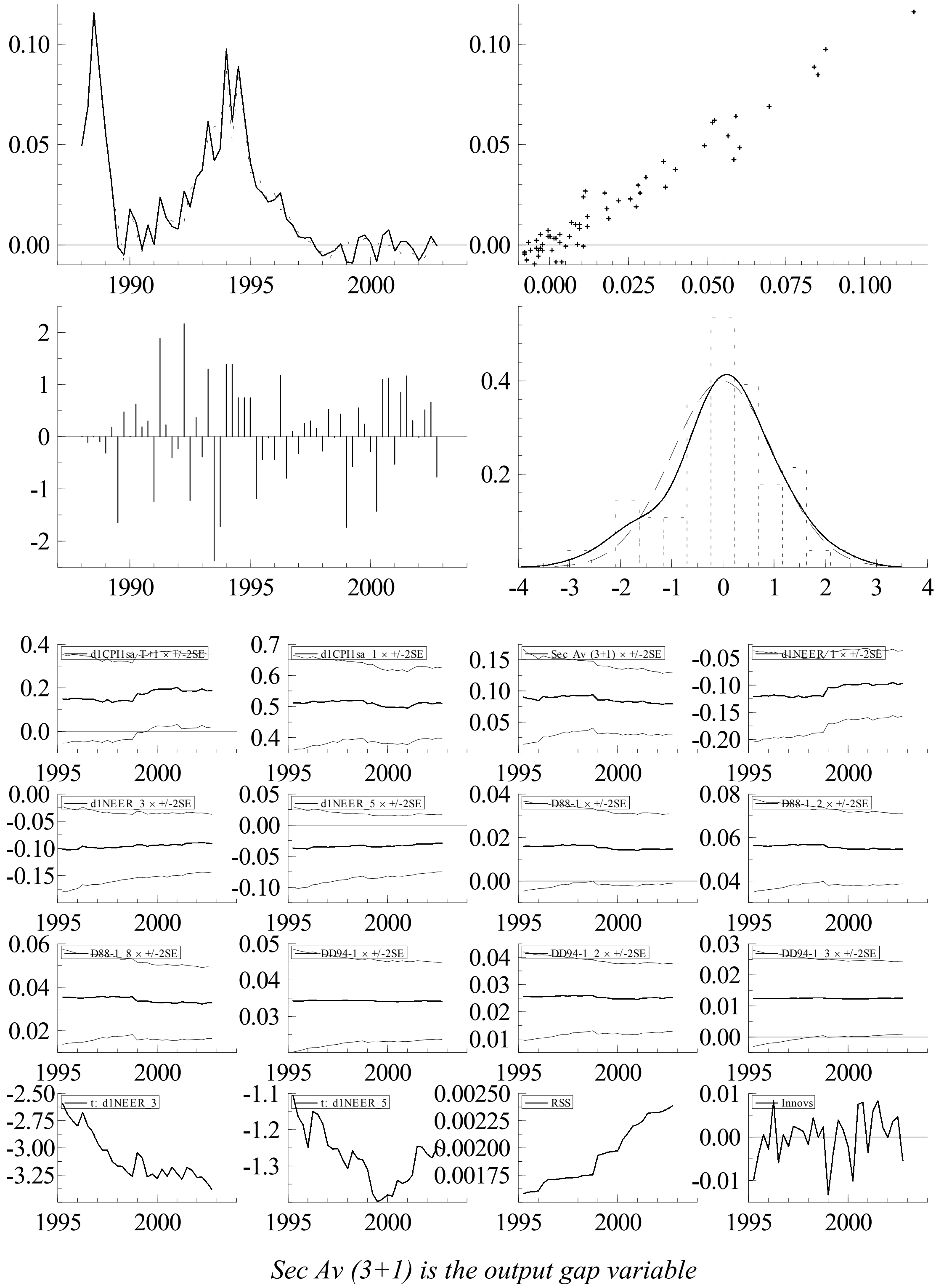
Sec Av (3+1) is the output gap variable

Figure 4: Diagnostic graphics for backward-looking Phillips curve



Sec Av (3+1) is the output gap variable

Figure 5: Diagnostic graphics for hybrid Phillips curve (survey data)



Sec Av (3+1) is the output gap variable

Figure 6: Diagnostic graphics for hybrid Phillips curve (IV method)

partial R-sqr	88-02	88-96	89-97	90-98	91-99	92-00	93-01	94-02	Average*
Linear	1,7%	1,9%	8,0%	9,6%	10,4%	0,3%	2,1%	1,7%	4,8%
HP	0,8%	2,5%	2,3%	12,2%	12,7%	0,4%	8,2%	9,5%	6,8%
Sector based, fixed TFP	29,2%	27,0%	31,8%	13,9%	14,6%	9,7%	12,1%	11,7%	17,3%
Agg data, flex TFP	11,9%	12,7%	12,1%	11,9%	13,1%	0,2%	3,0%	10,8%	9,1%
Aggr data, fixed TFP	9,3%	13,4%	12,6%	13,6%	13,6%	0,1%	1,8%	5,8%	8,7%

sigma									
Linear	0,91%	1,14%	1,06%	0,86%	0,88%	0,89%	0,76%	0,64%	0,89%
HP	0,92%	1,21%	1,09%	0,85%	0,87%	0,89%	0,74%	0,62%	0,90%
Sector based, fixed TFP	0,78%	0,92%	0,92%	0,84%	0,86%	0,86%	0,70%	0,61%	0,81%
Agg data, flex TFP	0,87%	1,10%	1,04%	0,85%	0,87%	0,89%	0,76%	0,59%	0,87%
Aggr data, fixed TFP	0,88%	1,09%	1,03%	0,85%	0,87%	0,89%	0,76%	0,60%	0,87%

t-stat									
Linear	0,93	0,70	1,47	1,66	1,73	-0,27	0,78	0,69	0,97
HP	0,64	0,84	0,79	1,90	1,94	0,34	1,53	1,59	1,28
Sector based, fixed TFP	4,49	3,91	3,48	2,05	2,11	1,64	1,89	1,85	2,42
Agg data, flex TFP	2,57	1,98	1,92	1,88	1,98	0,21	0,93	1,71	1,52
Aggr data, fixed TFP	2,24	2,05	1,98	1,86	2,02	0,13	0,72	1,21	1,43

Schwartz-Criterion									
Linear	-8,84	-8,27	-8,37	-8,84	-8,75	-8,900	-9,22	-9,51	-8,84
HP	-8,83	-8,29	-8,42	-8,87	-8,81	-8,901	-9,14	-9,47	-8,84
Sector based, fixed TFP	-9,17	-8,72	-8,71	-8,89	-8,83	-8,790	-9,25	-9,54	-8,96
Agg data, flex TFP	-8,95	-8,41	-8,53	-8,87	-8,86	-8,899	-9,22	-9,49	-8,90
Aggr data, fixed TFP	-8,92	-8,42	-8,53	-8,87	-8,82	-8,898	-9,21	-9,44	-8,88

Failed diagnostic tests **									
Linear	Het*	--	--	--	--	--	Het*, Reset**	AR*, Reset*	
HP	Het*	--	--	--	--	--	Het*, Reset**	Reset**	
Sector based, fixed TFP	Reset**	Reset*	Reset*	--	--	--	Reset*	Reset**	
Agg data, flex TFP	--	--	--	--	--	--	Het*, Reset**	Reset*	
Aggr data, fixed TFP	Het*	--	--	--	--	--	Het*, Reset**	Reset*	

LR vertical PC ***									
Linear	0,58	0,67	0,09	0,02	0,02	0,24	0,17	0,36	
HP	0,71	0,93	0,48	0,02	0,03	0,24	0,09	0,39	
Sector based, fixed TFP	0,09	0,05	0,09	0,62	0,49	0,40	0,26	0,29	
Agg data, flex TFP	0,95	0,44	0,76	0,10	0,13	0,32	0,45	0,77	
Aggr data, fixed TFP	0,78	0,34	0,90	0,15	0,20	0,34	0,49	0,87	

*) Average values for the rolling estimation windows, excluding the full estimation period.
**) * indicates test failure at the 5 percent level, ** indicates test failure at the 1 percent level.
***) Probability of accepting the hypothesis of a long-run vertical Phillips curve.
The white numbers indicate rejection of the hypothesis where the sum of the relevant coefficients is >1.

Table 10: Selection criteria for the best output gap

Phillips Curve	d1CPI															
Output gap: selected by PcGets (only one particular lag of all output gaps is allowed)																
	88-02	t-stat	**88-96**		**89-97**		**90-98**		**91-99**		**92-00**		**93-01**		**94-02**	
D88-1	0,022	2,74	0,022	2,34												
D88-3	0,063	7,40	0,061	6,23												
D90-1	0,040	4,72	0,045	4,28	0,042	4,42	0,033	3,51								
DD94-1	0,034	5,73	0,034	4,85	0,033	4,83	0,039	5,80	0,037	5,13	0,032	4,91	0,032	5,58	0,040	7,36
DD94-3	0,025	4,42	0,024	3,60	0,024	3,74	0,024	3,65	0,024	3,45	0,030	5,00	0,030	5,82	0,038	7,17
d1CPI-1	0,586	11,65	0,594	9,85	0,601	9,12	0,803	15,17	0,817	14,31	0,869	17,68	0,855	20,8	1,164	11,44
d1CPI-2															- 0,278	-2,92
d1e-1	- 0,142	-5,90	- 0,162	-5,49	- 0,147	-3,73	- 0,087	-2,11								
d1e-3	- 0,112	-1,47	- 0,107	-3,01	- 0,118	-2,79	- 0,123	-2,88	- 0,143	-2,80	- 0,196	-3,83	- 0,204	-4,58	- 0,162	-3,06
d1e-5							- 0,086	-2,05	- 0,103	-2,09						
d1e-7	- 0,033	-1,48														
ygap	0,109	4,58	0,119	3,99	0,115	3,46										
R-sqr	0,936		0,924		0,895		0,907		0,901		0,914		0,940		0,955	
sigma	1,06%		0,93%		0,90%		0,86%		0,89%		0,83%		0,72%		0,60%	
Diagnostic tests																
AR 1-4	0,910	0,47	0,162	0,96	0,208	0,93	0,787	0,54	0,996	0,43	0,623	0,65	1,674	0,18	3,021	0,04
ARCH 1-4	0,607	0,66	0,341	0,85	0,160	0,95	0,078	0,99	1,201	0,34	0,306	0,87	0,384	0,82	1,059	0,40
Normality	3,134	0,21	0,973	0,62	1,070	0,59	3,546	0,17	1,648	0,44	0,697	0,71	2,519	0,28	0,864	0,65
Heteroskedasticity	13,36	0,69														
sum of d1CPI and d1NEER coefficients	0,872		0,863		0,866		1,099		1,063		1,065		1,059		1,048	
Annual output gap effect	0,438		0,477		0,460		-		-		-		-		-	
Exchange rate effect	- 0,254		- 0,269		- 0,265		- 0,296		- 0,246		- 0,196		- 0,204		- 0,162	

Table 11: Search for best output gap - PC Gets results