The NIRCU and the Phillips Curve–

An Approach Based on Micro Data*

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Abstract

In this paper we propose a straightforward method to derive a non-inflationary rate of capacity utilisation (NIRCU) based on micro data. We condition the current capacity utilisation of firms on their current and planned price adjustments. The non-inflationary capacity utilisation rate is then defined as the rate where a firm feels no price adjustment pressure. One of the main advantages is that this methodology uses structural aspects and does not make it necessary to operate with –often rather arbitrary– statistical filters. We show that our aggregate NIRCU performs remarkably well as an indicator of inflationary pressure in a Phillips curve estimation.

JEL classification: E31; E32; E52

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1 Introduction

The Phillips curve, which is the relationship between the deviation of unemployment from its natural rate and inflation, is at the heart of monetary economics. Based on this relationship, Modigliani and Papademos (1975) created the acronym NIRU, which stands for the non-inflationary rate of unemployment. It is defined as the rate of unemployment that is consistent with a stable price level. It is important to note that in practice the NIRU is a short-run concept and is distinct from the long-run natural rate of unemployment. This is because the long-run natural rate captures the long-run real equilibrium determined by the structural characteristics of labour and product markets. However, the NIRU is defined solely in relation to the level of unemployment that is consistent with a stable price level in the short run, and so it may be affected by the adjustment of the economy to past economic shocks. As the effects of adjustment to shocks fade away, the NIRU will tend towards the long-run natural rate (Batini and Greenslade, 2006). In economies where central banks target a stable price level, NIRU is of interest for monetary policy makers. It allows them to measure the rate of unemployment that could sustain a stable price level. This differs from the NAIRU (non-accelerating inflation rate of unemployment), which is consistent with a stable *inflation* rate. However, the difference between the NAIRU and the NIRU is arguably small in a low-inflation environment and zero in an environment with a stable price level. What is important is that both are short-run concepts of the natural rate. Estrella and Mishkin (2000) and Woodford (2002) emphasise that the short-run concept should be the main focus of monetary policy, not the long-run natural rate. This is because the variability in the short-run NAIRU and NIRU contain information on future inflationary pressures that is disregarded when targeting the long-run natural rate. Hence, the deviation of the current rate of unemployment from the NAIRU or NIRU, the unemployment gap, contains information on upcoming inflationary pressure. Therefore, the Phillips curve relationship is one of the key ingredients for monetary policy making. Nowadays, the term "Phillips curve" is employed as a synonym for the short-run relationship between any measure of excess demand and inflation.

While the unemployment gap has been found to be a useful indicator in the Phillips curve relationship, Staiger et al. (1997) show that "some other variables are at least as valuable as unemployment for predicting inflation" (p.46). Stock and Watson (1999) suggest that, amongst some other measures of real activity, the rate of capacity utilisation is a reliable indicator for upcoming inflationary pressures. Therefore, it would be desirable to obtain an estimate of the current NAICU – the Non-Accelerating Inflation Rate of Capacity Utilisation (McElhattan, 1985) or the NIRCU – the Non-Inflationary Rate of Capacity Utilisation. In spite of the NIRCU being a theoretically appealing concept, it is unobservable in empirical macro data. Most traditional approaches estimate the non-inflationary rate of capacity utilisation as the long-term average of utilisation (i.e., it is simply assumed to be constant over time). However, due to structural change in the manufacturing sector, the NIRCU is rather expected to be time-varying (Gordon, 1997).[1] Other, more sophisticated statistical methods, such as the Kalman filter, typically impose strong priors on the smoothness of the trend or cycle, and generally assume that trend and cycle shocks are uncorrelated.[2] These restrictions lack support in theory, and, moreover, tend to shape the estimated components (Basistha and Nelson, 2007).

Furthermore, output figures tend to be heavily revised and real-time estimates are often flawed (e.g. Orphanides and Williams, 2002). This is especially problematic as the end-point estimates are most important for central banks to make forward-looking monetary policy decisions. For example, Orphanides and Williams (2005) show that the combination of monetary policy directed at tight stabilisation of unemployment near its perceived natural rate and large real-time errors in estimates of the natural rate contributed to poor macroeconomic performance in the U.S. during the 1970s.

Offering a NIRCU measure that is directly observable, not subject to revisions and based on the theoretical idea of the non-inflationary rate is the focus of this paper. To derive the NIRCU in a theory-consistent way, we rely on micro data information. More precisely, we use the KOF survey data, which allows us to observe the capacity utilisation rate and currently conducted and expected price adjustments at the firm level.[3] Hence, we can link the utilisation rate to the knowledge of whether, at that given utilisation rate, a firm has adjusted prices or expects to adjust prices. If a given firm in the data set indicates that it does not adjust prices and does not expect to adjust prices in the next period, the utilisation rate the firm currently reports can be considered to reflect the firm-specific NIRCU, defined as the rate of utilisation that is consistent with no change in prices.

Our measure has advantages over previous estimates. First, it is available in real time on a quarterly basis and is not subject to revisions. Second, it is derived from micro data and explicitly

[1]For example, Nahuis (2003) provides some explanations for an upward shift in the NAICU, which equally apply to the NIRCU: innovations, better management techniques and improved functioning of product and labour markets may have increased efficiency. Furthermore, increased competition stimulated by the establishment of the internal market and deregulation of product markets may have reduced entrepreneurs pricing power, resulting in prices being increased by a higher level of demand.

[2]For example, the majority of the estimates employing a Kalman filter approach assume that the natural rate follows an AR(1) process. As the natural rate is unobserved, such assumptions are rather arbitrary.

[3]The exact data source is the KOF Swiss Economic Institute's quarterly Business Tendency Survey in the manufacturing sector.

takes into account the theoretical idea that the NIRCU should reflect the rate of capacity utilisation that is consistent with a stable price level. Third, it is derived from very simple methods that are not subject to end-point adjustments or priors on the smoothness of the trend or cycle. Fourth, it takes into account heterogeneity at the firm level to some extent and, fifth, allows for time variation.

As this is the first measure of the NIRCU that is directly observable, the illustration of the figure already covers valuable information. In particular, it proves to be quite volatile and time-varying, which are the characteristics that Estrella and Mishkin (2000) expect from the theoretical idea of the short-run concept of the natural rate. We test the performance of the micro based NIRCU as a measure of real activity in a hybrid version of the New Keynesian Phillips curve for Switzerland. We show that our measure performs remarkably well, yielding estimates close to the Galí et al. (2001) estimates for other countries using ex-post marginal cost or output gap data. The latter, however, are often subject to huge revisions in real time, which our measure is not. The results are robust to specifying the Phillips curve alternatively, using survey data as a measure for inflation expectations, and to estimating the Phillips curve in first differences.

This paper is structured as follows. Section 2 describes the survey data used in the calculation of the NIRCU, which is given in section 3. The performance and informational content of the NIRCU is tested in section 4. Section 5 presents robustness checks, and section 6 concludes.

2 Data Description

In our analysis, we use firm-level micro data for Switzerland. The data source is a business tendency survey in the Swiss manufacturing industry collected by the KOF Swiss Economic Institute. It covers the years 1985 Q1 to 2007 Q2 on a quarterly basis. The purpose of the survey is to construct business tendency indicators. There are about $1,500$ firms in the survey panel, which represents about 12.6% of all registered Swiss manufacturing firms and about 30% of employment in the manufacturing sector. Manufacturing value-added accounts for about 20% of GDP in Switzerland. On average $1,140$ firms responded to the quarterly survey in our sample. However, as firms respond on a voluntary basis, the number of firms responding varies, which gives us $102,682$ observations in an unbalanced panel.[4] Firms receive the questionnaire on the first working day after the end of a quarter and the results of the survey are released by KOF

[4] We have already excluded the firms that did not respond to the questions relevant for the construction of the indicator in this paper. Therefore, the figures do not exactly fit those reported in Lein (2010).

at the end of the same month.[5] Thus, the data is available far earlier than GDP figures, which are released only at the end of the following quarter. Furthermore, GDP data are usually revised substantially, even after up to eight years after the first release (Cuche-Curtis et al., 2009).[6] This is not the case for the capacity utilisation data.

There are several qualitative questions about prices in the survey. Firms are asked whether their selling prices (i) have changed in the previous three months (denoted by $Price_{it}$ for firm i at period t) and (ii) are expected to change in the following three months, $E_t(Price_{i,t+1})$. The answering options for both questions are *increase* (+1), *decrease* (-1) or *left unchanged* (0), whereas a non-response is treated as missing value. Relating to capacity utilisation, the firms are asked to quantify their capacity utilisation ($Utilisation_{it}$) within the past three months in percentage points, where the firms can choose from a range of 50% to 110% in five-percent steps.

To obtain a measure for the current pressure to invest into new equipment, firms are queried about their current technical capacities. The question in the survey reads: *technical capacities in your firm are...?"* and the firm has three response options: *more than sufficient (+1); sufficient(0); not sufficient(-1).*[7] This indicator, which we label *Investment Gap* henceforth, allows us to identify firms that are running at high (low) capacity because of a need to adjust their capital stock. These are the firms that report that their technical capacities are not (more than) sufficient. These firms should not determine the NIRCU, even though they might keep their prices unchanged, because their utilisation rate may be systematically biased by a positive (negative) investment gap.[8] Thus, we use only firms in the NIRCU that report that their current technical capacities (their capital stock) are *sufficient*.

The distribution of capacity utilisation rates across firms shows a fair amount of heterogeneity, which we show in the left panel in Figure 1. For this example, we choose one point in time, here

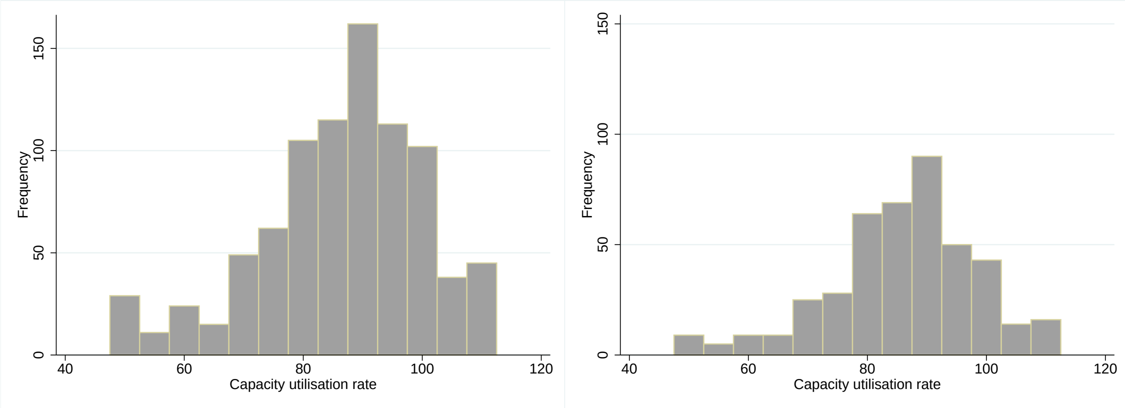
[5] See Lein (2010) for more details on the survey and the survey procedure.

[6] For example, Cuche-Curtis et al. (2009) show that the mean revision of GDP growth rates amounts to 0.82 to 0.64pp even five to eight years after the initial release.

[7] Note: technical capacity is defined in the survey questionnaire as the amount and quality of equipment (incl. buildings). Technical capacities are more than sufficient if they currently cannot be utilized as desired due to insufficient demand for the product. They are not sufficient if expected demand for the product cannot be met without an increase in delivery lags due to shortage of technical capacity.

[8] There may be a systematic deviation of the NIRCU of firms that are changing prices from the NIRCU of firms that are not changing prices. This is the case when firm i's capital stock (k_t) is lower than its desired capital stock (k_t^*), i.e. the stock of capital it would hold if it did not face capital adjustment cost. The difference between the two is labelled the *investment gap* (Caballero et al., 1995), which measures the pressure to invest ($investment\ gap_t = k_t^* - k_t$). Thus, with costs of adjusting capital, the gap is closed completely by an investment and the investment rate is exactly the size of the $investment\ gap_t$. See Caballero et al. (1995) for the theory and Doms and Dunne (1998) for empirical evidence. In our context, this implies that firms, to meet higher demand in a period with a positive investment gap, most likely have to raise their utilisation rates. After the firm has invested, the utilisation rate will fall back again to a lower level. If this firm does not adjust prices, it seems as if the NIRCU first increases and then falls. However, this movement in the NIRCU is not due to a movement in the rate of utilisation that is consistent with price stability, but to the adjustment of the capital stock.

Figure 1: Distribution of capacity utilisation rates across firms



The left panel in the figure shows the distribution of capacity utilisation rates across all firms in 2007 Q1. The right panel shows the distribution of capacity utilisation rates across firms that report that their current technical capacities are sufficient, did not change prices in the current quarter and do not expect to change prices in the upcoming quarter in 2007 Q1. KOF Quarterly Industry Survey.

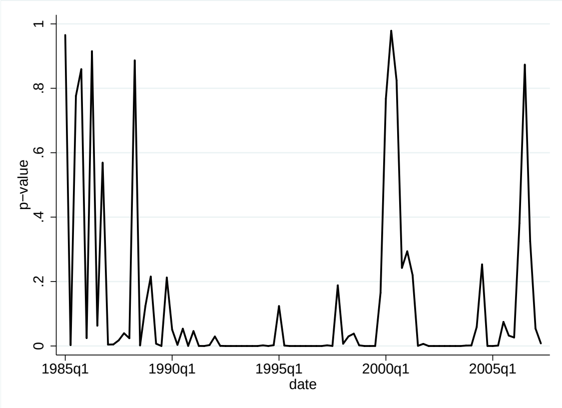
it is the first quarter in 2007.[9] It can be seen that 162 firms in the sample currently use 90% of their capacity. 105 use 80%, 102 use 100% and 45 use 110%.

The main idea behind our micro data-based NIRCU is that we build upon the theoretical requirement that the non-inflationary rate is associated with a stable price level. Hence, firms operating at the NIRCU should not feel any pressure to adjust prices. Thus, we define the NIRCU as the rate of capacity utilisation that is consistent with a zero investment gap and associated with *no change in prices and no expected change in prices.*[10] The advantage of the data set is that we can directly link the information on price adjustments or expected price adjustments to the rate of capacity utilisation. In this way, we can control for the unobserved heterogeneity across firms to some extent, as we can observe at the firm level which firm-specific capacity utilisation rate is related to price changes and which is not. The right panel in Figure 1 shows the distribution of capacity utilisation rates including only firms that indicate no investment gap and that state that they left their selling prices unchanged in the previous quarter and do not expect to change their prices in the upcoming quarter. When we exclude the firms that changed prices or expect to change prices, or that indicate an investment gap, only 90 firms in the sample currently use 90% of their capacity, compared to the 162 observed before. 64 use 80%, 43 100% and only 16 utilise 110%. Hence, for roughly 55% of the firms with a capacity utilisation of 90% prices change. For

[9] 2007 was a year with favourable economic conditions and high average utilisation rates.

[10] It should be borne in mind that the measure proposed in this paper is not necessarily a measure of the natural rate in the New Keynesian sense. Prices we observe are final selling prices and not measures for the mark-up. If input prices are falling but a firm holds output prices constant, the New Keynesian approach would classify this firm as being above the natural rate, while our measure defines it as being at the NIRCU.

Figure 2: p-values of the Wilcoxon-Mann-Whitney test on equality of distributions



P-values of the Wilcoxon-Mann-Withney test, which tests whether the distribution of capacity utilisation rates of firms in the NIRCU at quarter t is significantly different from the distribution of capacity utilisation rates of firms not in the NIRCU at quarter t for t=*1985 Q1,...,2007 Q2*.

the other 45%, a utilisation of 90% is not associated with pressure to raise prices in the short run. This already shows that the NIRCU is very heterogeneous and shows substantial variation at the firm level. In order to test whether the distribution of capacity utilisation rates of firms having no price pressure is significantly different from those reporting price pressure we perform a two-sample Wilcoxon-Mann-Whitney test. It uses the rank of data from two independent sample sizes to test the hypothesis that the samples of observations come from the same distribution (Mann and Whitney, 1947 and Wilcoxon, 1945). In our case it assumes that we draw the NIRCU firms' capacity utilisation rates from a distribution of all firms, and then test whether the utilisation rates in the NIRCU are different from those that remain undrawn, i.e., which are not in the NIRCU. This allows us to test whether the distributions are significantly different from each other. We ran the test for each quarter from 1985 Q1 to 2007 Q2. Figure 2 shows the associated p-values. We can reject the null hypothesis of equality of the samples in 75.6% of the time periods at the 10% level of significance. In other words, in 24.4% of the time periods, there is no significant difference between the distributions of firms determining the NIRCU and the distributions of firms that do not determine the NIRCU. In these time periods, the gap between the NIRCU and the other firms' utilisation is very low, suggesting that there are indeed not many shocks. Thus the output gap is more or less zero in that case. Indeed, as shown in the following section, inflation was very low in the sample period, so it seems reasonable that the firms in the NIRCU are not significantly different from those that are not included in the NIRCU.[11]

For these reasons, we find it important to take into account the heterogeneity in the level

[11]CPI inflation was below 1% in 18% of the quarters in the sample and PPI inflation in 31%.

of utilisation associated with no price adjustments when deriving a NIRCU on the macro level. Furthermore, the firm-specific NIRCU can be time-varying due to several structural changes in the manufacturing sector over the two decades under review. See Gordon (1998, 1999) for a discussion. The following chapter describes the details of the construction of our NIRCU variable.

3 The NIRCU Based on Micro Data

As mentioned in the introduction, the measure for the NIRCU we propose has several advantages over other statistical measures derived from macro data. We use a bottom-up approach, first constructing a firm-specific NIRCU, which we then aggregate up to obtain a macro level NIRCU.

We define the capacity utilisation rate of firm i that is not biased by an investment gap and that is consistent with no price adjustments conducted by firm i at quarter t as

$$NIRCU_{it} = (Utilisation_{it} \mid Price_{it} = 0, E_t(Price_{i,t+1}) = 0, Investment\ Gap = 0.) \quad (1)$$

Thus, the current rate of utilisation is equal to the NIRCU for firm i in t if it is associated with no price adjustments in the current or the upcoming quarter and if the firm is not facing an investment gap. We chose to condition on both the current and the next period's price adjustments, as some firms might not be able to adjust prices immediately, but still feel price pressure. Other firms might be able to adjust prices instantaneously.[12]

In a second step, we aggregate these firm-level rates of capacity utilisation up to obtain a macro-level time series. We weight the utilisation rates by firm size. As a measure of firm size we use the number of employees in firm i ($employee_{it}$).[13] Furthermore, we define an indicator variable NR_{it}, which is one if firm i at time t is at its NIRCU and zero otherwise. The sum of all employees in all firms which currently operate at the NIRCU is then

$$MaxweightNIRCU_t = \sum_i employee_{it} * NR_{it}. \quad (2)$$

To obtain the macro-level NIRCU, we weight the firms which operate at their natural rate

[12] Conditioning only on expected price changes or only on current price changes does not change any of the results substantially. The two series conditioning only on current and only on expected price adjustments are available from the authors upon request.

[13] Unfortunately, the number of employees is the only quantitative variable in the survey that allows us to construct firm weights for the aggregate indicator. Arguably, using weights from firms' fixed capital or value-added would be more appropriate. However, such data on the firm level is unfortunately not available.

with their respective firm size

$$NIRCU_t = \sum_i \frac{employee_{it} * NIRCU_{it}}{MaxweightNIRCU_t}. \tag{3}$$

To derive the current capacity utilisation rate in the economy at the macro level, we similarly use all capacity utilisation rates weighted by firm size and compute an aggregate measure

$$CU_t = \sum_i \frac{employee_{it} * Utilisation_{it}}{MaxweightCU_t} \tag{4}$$

where $MaxweightCU_t$ is defined as

$$MaxweightCU_t = \sum_i employee_{it}. \tag{5}$$

We thus allow for a firm-specific NIRCU by taking into account that different firms have different utilisation rates they associate with no price pressure. We assume that the firms are otherwise identical *on average*, thus that –after aggregation– the firms running at the NIRCU can identify the NIRCU of the firms that do not.

To obtain a time series for the capacity utilisation gap, we simply use the difference between the natural rate $NIRCU_t$ and the current aggregate utilisation CU_t

$$GapCU_t = CU_t - NIRCU_t. \tag{6}$$

We plot the series in Figure 3. It can be seen that the utilisation rate (CU) in the Swiss economy was on average around the NIRCU at the beginning of the sample, whereas during the early nineties, utilisation rates are below the NIRCU. From the end of the nineties to 2006, the average utilisation in Switzerland fluctuates around the NIRCU. In the last two quarters of 2006 and 2007, the current average utilisation rate even lies above the NIRCU. Another striking feature of the NIRCU is that it appears to be more volatile than other measures of the natural rate. However, the usual smoothness of the natural-rate measures is a result of rather arbitrary statistical smoothing (Ball and Mankiw, 2002). There is no theoretical reason for expecting the natural rate to be very smooth. For example, real shocks should affect the natural rate, which may cause the volatility in the NIRCU series. Given that we focus on a short-run concept with the NIRCU, it may also be expected to be more volatile. It might be worth recalling what the NIRCU is: it is the level of capacity utilisation at which inflation would be zero. Theoretically, the level of

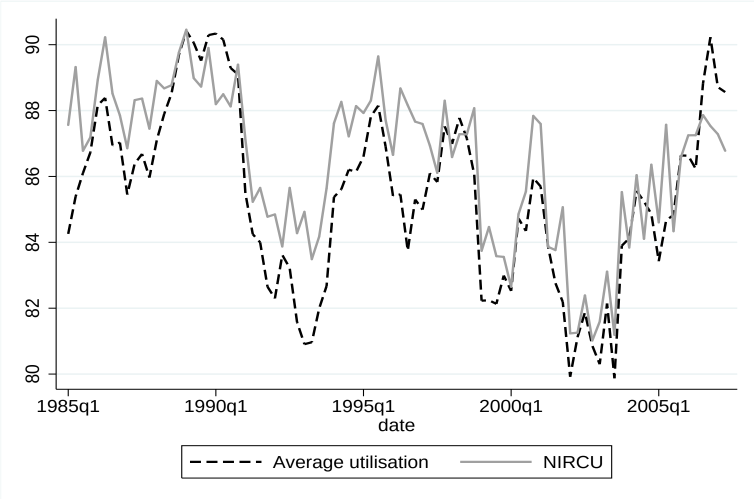


Figure 3: Capacity utilisation rates
Dashed line average utilisation rate CU_t, grey solid line $NIRCU_t$, not seasonally adjusted. Source: KOF Quarterly Industry Survey.

the NIRCU is not only affected by the long-run natural rate but also by all inflationary pressures due to short-term supply shocks or expectations (see Estrella and Mishkin, 2000 or Camarero et al., 2005).[14]

Our measure of the NIRCU is, during some periods, even more volatile than the average utilisation rate.[15] Note that we have not yet seasonally adjusted. Hence, the volatility might partially be caused by the seasonality and staggered price setting found in earlier studies (Lein, 2010). Furthermore, as Lein and Köberl (2009) show, firms that are constrained to adjust their capacity in the short run are more likely to adjust prices. Hence, the firms are those that are included in the average utilisation rate but not in the NIRCU. Arguably, these are firms that have a stable utilisation rate, otherwise they would not report that they are constrained in terms of capacity. Firms that are not constrained and can adjust their capacity in response to shocks are those that are included in the NIRCU. As these are more likely to adjust to shocks by adjusting utilisation, the NIRCU can be expected to display more volatility it the presence of shocks.

Furthermore, the volatility of such a structural measure is in line with a growing recent empiri-

[14]Note that firms that are hit by a shock to their prices which does not affect their utilisation rate should have the same utilisation rate as otherwise identical firms that are not hit by that shock. Thus, even though the former firms do not enter the NIRCU, the difference between the NIRCU and the average utilisation should be zero and thus not indicate inflationary pressure. Moreover, the NIRCU takes into account possible assymmetries in the impact of over- and under-utilisation of capacity. If under-utilisation does not lead to price reductions, whereas overutilisation does, the NIRCU would show no difference to the average utilisation in the case of under-utilisation (and thus indicate no price pressure) but it would be below the average utilisation during a period when many firms report over-utilisation (and thus indicate upward pressure on prices).

[15]The standard deviation of the NIRCU is slightly lower than the standard deviation of average utilisation, as shown in the summary statistics reported in Table A.1.

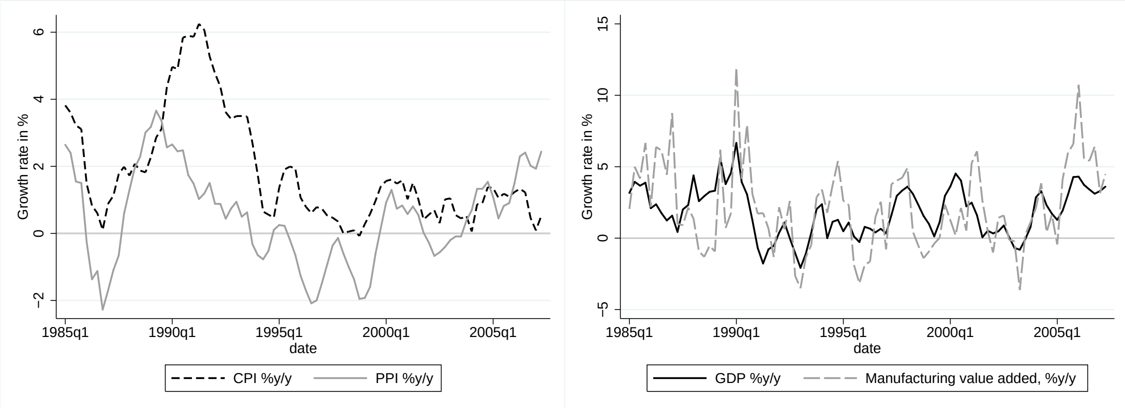
cal literature. For example, the structural output gap series estimated by Neiss and Nelson (2005) is more volatile than HP filtered series. Basistha and Nelson (2007) derive the unemployment gap based on the forward-looking New Keynesian Phillips Curve. In addition, their estimates of the natural rate show a fairly volatile natural rate of unemployment. King and Morley (2007) come to a similar conclusion. They measure the natural rate of unemployment as the time-varying steady state of a structural vector autoregression (SVAR). Their findings show that its movements account for most of the variation in the unemployment rate, as well as substantial portions of the variation in aggregate output and inflation.

However, there are clearly some shortcomings of our measure that have to be borne in mind. First, while we can construct a measure of the NIRCU, we cannot construct a measure of the NAICU. However, the goal of the monetary policy framework of the Swiss National Bank (SNB) is long-term price stability.[16] Thus, the NIRCU is an interesting concept for monetary policy makers, too. This is especially true for such a low-inflation country as Switzerland. As shown in the left panel in Figure 4, inflation was relatively low in Switzerland over the observation period and the growth rate of the producer price index (PPI) and the CPI are highly correlated. The right panel in Figure 4 shows the growth rate of GDP and the growth rate of manufacturing value added. Both GDP and manufacturing grew by 1.83% on average over the sample. They are also highly correlated, the regression slope including a constant is 1.02 and the correlation coefficient 0.68. Thus, the cycle in the manufacturing sector is quite representative for the aggregate business cycle.

Moreover, we look only at pricing behaviour and utilisation rates of the manufacturing sector. As shown in Lein (2010), about 30% of prices in the manufacturing sector change per quarter, which suggests that firms change prices slightly more often than once a year. Meanwhile, prices in other sectors are likely to change more or less often due to a heterogeneity in price setting documented in the price-setting literature. For example, Kaufmann (2008), using prices underlying the calculation of the Swiss CPI, shows that prices of services change less often (13.7% per quarter) and prices of unprocessed food change rather frequently (38.7% per quarter). On average, 23.5% of all prices change per quarter in the Swiss CPI, which is relatively close to the average price changes in the manufacturing sector. Nevertheless, it should be borne in mind that we do not exactly measure the NIRCU that is consistent with no price changes in the overall economy but proxy for it by measuring the NIRCU of the manufacturing sector.

[16] The SNB defines price stability as a rise in the national consumer price index (CPI) of less than 2% per year. It is recognised that the CPI probably overstates actual inflation to some extent. Consequently, price stability is equated with a slightly positive measured inflation rate (Baltensperger et al., 2007).

Figure 4: Macroeconomic data for Switzerland



The left panel shows Swiss CPI and PPI inflation, both % y/y. The right panel shows the growth rate of Swiss GDP (black solid line) and value added in the manufacturing sector (grey dashed line), both % y/y. Sources for CPI and PPI: Swiss Federal Statistical Office (SFSO); GDP and manufacturing value added: Quarterly National Accounts, State Secretariat for Economic Affairs (SECO).

Second, if such a huge shock hit the economy that all firms raised prices in the same period, we would not be able to identify a NIRCU at that point in time. In the current sample, at least one fourth of the firms are at the NIRCU. On average about half of the firms (48.7%) determine the NIRCU. Even though it is highly unlikely that the economy were to be hit by such a large shock, that only few or even no firms were left to identify the NIRCU, such a case cannot be ruled out completely.[17]

4 Phillips Curve Estimates

The estimation of a NIRCU is only an advantage if the indicator is at least as good as other indicators for inflationary pressures. Therefore, in this section, we test for the informational content of the capacity utilisation gap by including it in a Phillips curve regression. We compare the indicator with a measure of the capacity utilisation gap, where the NIRCU is assumed to be equal to the long-term average of capacity utilisation rates, measures of the output gap, and unit labour costs.

Our empirical equation is a hybrid Phillips curve with a forward looking and a backward looking component

[17] We assume that such a large shock seems quite unlikely in a low-inflation country given recent findings on price setting behaviour in high-inflation contries. For example, even in Mexico, where inflation reached 86% in 1995, the share of prices changed in the Mexican CPI was 64.7% in that month (Gagnon, 2009). Similar findings for high-inflation periods in Israel, Argentina, and Poland are provided by Eden (2001), Burstein et al. (2005), and Konieczny and Skrzypacz (2005), respectively. Thus, even in such a situation not all prices changed in a given month. Arguably, looking at quarterly data might change this picture slightly, but, at least to our knowledge, no study looking at pricing behaviour in extreme situations found a quarter in which *all* prices changed.

$$\pi_t = \lambda Gap_t + \gamma^f E_t\{\pi_{t+1}\} + \gamma^b \pi_{t-1} \tag{7}$$

where π_t is inflation of the Swiss CPI, $E_t\{\pi_{t+1}\}$ is expected inflation, and Gap_t the output gap, for which we include different proxies.

We use two approaches to estimate equation (7). First, we follow Galí and Gertler (1999) and employ generalised method of moments (GMM). Second, we estimate the equation with inflation expectations derived from survey data in the robustness section. For the former we use the orthogonality conditions that can be derived from rational expectations where the forecast error of π_{t+1} should be uncorrelated with the available information dated at t. It follows from equation (7) that

$$E_t\{(\phi\pi_t - (1-\omega)(1-\theta)(1-\beta\theta)\kappa GapCU_t - \theta\beta\pi_{t+1})Z_t\} = 0 \tag{8}$$

where Z_t is a vector of variables dated at t and earlier and thus orthogonal to the inflation surprise in $t+1$. This condition forms the basis of the GMM estimation, where we use three lags of the inflation rate, two lags of the import price inflation, the lagged real wage inflation and the lagged measure of the output gap as instruments.[18] Additionally, we include the lagged real-time HP filtered output gap measure in the set of instruments. Dufour et al. (2006) suggest that the real-time output gap is an appropriate instrument, instead of an output gap based on detrending GDP up to the end of the sample period. We therefore use the real-time output gap as an instrument, as provided by the Swiss National Bank (SNB). The inflation rate and the import price inflation rate are obtained from the Swiss Statistical Office (BFS).[19] Summary statistics are given in Table A.1 in the Appendix. To check for the robustness of the results with respect to the GMM methodology we also run a separate regression using OLS with Newey West corrected standard errors and a survey measure of inflation expectations, which are reported in the following section.

Our GMM estimates are reported in Table 1. In column (1) we employ the NIRCU gap $GapCU_t$ derived in this paper as a measure for real activity. We find parameter values that are close to the values for the euro area found in Galí et al. (2001). The coefficient on $GapCU_t$ is 0.04, and it is significant at the five percent level. Galí et al. (2001) find coefficient estimates of

[18] We have tried different instrument specifications, also including interest rate spreads and more lags of the respective instruments. As long as the instruments were valid and we did not include too few instruments, the results remained robust.

[19] The CPI inflation rate was adjusted for a change in the treatment of sales prices from 2000 onwards.

Table 1: GMM parameter estimates, 1985Q1-2007Q2

	(1)	(2)	(3)	(4)	(5)
$E_t[\pi_{t+1}]^{GMM}$	0.50***	0.54***	0.53***	0.54***	0.56***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)
π_{t-1}	0.51***	0.48***	0.48***	0.47***	0.46***
	(0.06)	(0.06)	(0.06)	(0.05)	(0.06)
$GapCU_t$	0.03**				
	(0.02)				
$GapAvgCU_t$		-0.01			
		(0.01)			
$GapGDP_t$			0.00		
			(0.01)		
ULC_t				0.02	
				(0.04)	
$GapGDPHP_t$					0.01
					(0.02)
Constant	0.00	-0.03	-0.03	-0.03	-0.04
	(0.03)	(0.03)	(0.06)	(0.02)	(0.03)
Observations	86	86	86	86	86
Hansen J-Stat	0.02	0.02	0.02	0.02	0.01
p-value Hansen	(0.70)	(0.55)	(0.73)	(0.72)	(0.79)
p-value AR	0.66	0.98	0.99	0.99	0.98
p-value AR-K	0.19	0.77	0.88	0.96	0.77

Standard errors in parentheses. *** p<0.01 ** p<0.05 * p<0.1. Columns (1)-(5) report GMM estimates, where the expected inflation rate $E_t[\pi_{t+1}]^{GMM}$ is instrumented by three lags of the inflation rate, the two lags of the import price index, the lagged output gap, and the lagged output gap in real time ($GapGDPHP_t^{RT}$). The import price index is taken from the Swiss Federal Statistical Office (BFS). In column (1) the measure for the Phillips curve relationship is $GapCU_t$ as proposed in this paper. Column (2) employs the deviation of capacity utilisation from its constant long-run average $GapAvgCU_t$ as measure for real activity. Column (3) employs the output gap $GapGDP_t$ calculated by the KOF. Column (4) uses the unit labor cost measure ULC_t calculated by the KOF. Column (5) uses the output gap based on an HP filter ($GapGDPHP_t$). P-values of the Hansen J-Statistic are reported in brackets. P-values for the Anderson Rubin (AR) test and the Kleibergen (AR-K) test proposed by Dufour et al. (2006) are reported in the last two rows.

0.04 for the euro area and 0.16 for the U.S. The estimates for the coefficients on expected and lagged inflation are 0.53 and 0.50 respectively. The estimates in Galí et al. (2001) for the euro area are 0.27 and 0.69, and 0.36 and 0.60 for the U.S. In columns (2) to (5) we replicate the estimations from (1), with the only difference being that we include other proxies for the output gap in the regressions. In column (2) we use the deviation of capacity utilisation from the long-run average (which is around 85.5 percent) $GapAvgCU_t$. This measure is commonly used as a measure for real activity with capacity utilisation data.[20] When using this variable, the coefficient on the estimated Phillips curve relationship is insignificant and wrongly signed. In column (3) we use the output gap constructed by the KOF ($GapGDP_t$). The coefficient estimate is correctly signed and the size is comparable to other Phillips curve estimates. However, it is statistically

[20]E.g., Nahuis (2003) assumes that the NAICU is constant. He obtains estimates of the NAICU for Germany, France, the Netherlands, Belgium and Italy. His estimates vary between 78.1 for Italy and 86.4 for France for the period 1986 to 1996.

insignificant. We also use a measure of unit labour cost as an explanatory variable for the Phillips curve equation. The data is taken from a KOF calculation (ULC_t). The estimate reported in column (4) is correctly signed but also not significant. Column (5) uses the output gap based on an HP filter ($GapGDPHP_t$). Again, the output gap is insignificant. Based on the Hansen test, we do not reject the models. However, as noted by Dufour et al. (2006) and Nason and Smith (2008), amongst others, the GMM may be biased in the presence of weak instruments, which leads to potentially spurious overrejections of the Hansen test. We therefore applied the two tests based on the Anderson and Rubin (1949) (AR) pivotal F-statistic developed in Dufour et al. (2006). One is the AR procedure, which is robust to both weak and missing instruments, and to the formulation of a model for endogenous explanatory variables. The shortcoming of the procedure is that it may lead to a large number of identifying instruments, reducing the degrees of freedom and therefore affecting the test power. Dufour et al. (2006) therefore suggest using in addition the statistic developed in Kleibergen (2002). The statistic overcomes the deficiencies of the Anderson-Rubin statistic, whose limiting distribution has a degrees of freedom parameter equal to the number of instruments, because it has a degrees of freedom parameter equal to the number of structural parameters. The p-values of the two test statistics are shown in the last two rows of Table 1. Neither the AR nor the AR-K tests reject the models, suggesting that our instrument choice is valid. The results from these regressions suggest that the NIRCU is indeed a good indicator for inflationary pressure. We find that the NIRCU does indeed perform better than the other measures of the output gap and that this result is very robust. Thus, even though the other indicators have already been corrected by revisions, the NIRCU performs better in the Phillips curve. Consequently, the NIRCU is both available early and is even more reliable than already revised alternative measures of the output gap. However, the fact that other measures of the output gap are insignificant does not necessarily mean that they are flawed or wrong. For example, Mourougane and Ibaragi (2004) show that the capacity utilisation-inflation trade off in Japan becomes insignificant when inflation is low. Mihailov et al. (2009) do not find a significant coefficient on the output gap for Switzerland either. This might be explained by findings in the literature that the output-inflation trade-off becomes lower in a low-inflation environment (e.g., Ball et al., 1988). This might explain why in very low-inflation environments, such as in Switzerland or Japan, it is hard to find a significant relationship between the output gap and inflation, because the trade-off is close to zero. The insignificant relationship between the other output gap measures and inflation may therefore be explained by the fact that it is hard to reject the null of a zero coefficient, rather than by the fact that the measures themselves are flawed. The NIRCU displays more variation, which might make it easier to identify a relationship.

5 Robustness

In this section, we provide robustness checks for our results for the Phillips curve estimates. The GMM procedure proposed by Galí and Gertler (1999) has been criticized by Dufour et al. (2006) or Nason and Smith (2008), amongst others, on the grounds that weak instruments may undermine GMM based inference and cause spurious rejections of the Hansen test. We therefore use an alternative to assuming rational expectations and applying GMM. We replace the proxy for expected inflation by a direct measure of inflation expectations, following for example Henzel and Wollmershäuser (2008) for European countries and Adam and Padula (2003) or Zhang et al. (2009) for the US. This allows us to estimate the equation by OLS.[21]

Table 2: OLS parameter estimates, 1990Q1-2007Q2

	(1)	(2)	(3)	(4)	(5)
$E_t[\pi_{t+1}]^{Forec}$	0.29**	0.18	0.28**	0.20	0.22*
	(0.12)	(0.14)	(0.14)	(0.13)	(0.13)
π_{t-1}	0.79***	0.84***	0.81***	0.81***	0.80***
	(0.00)	(0.09)	(0.09)	(0.09)	(0.09)
$GapCU_t$	0.10***				
	(0.03)				
$GapAvgCU_t$		0.00			
		(0.02)			
$GapGDP_t$			-0.05		
			(0.05)		
ULC_t				0.16	
				(0.11)	
$GapGDPHP_t$					0.07*
					(0.04)
Constant	-0.09***	-0.10***	0.06	-0.11	-0.09
	(0.10)	(0.12)	(0.15)	(0.11)	(0.11)
Observations	70	70	70	70	70
F-Statistic	461.3	398.5	417.9	216.6	416.1
R^2	0.95	0.95	0.95	0.95	0.95

Newey-West corrected standard errors in parentheses *** p<0.01 ** p<0.05 * p<0.1. Columns (1)-(5) report OLS estimates with Newey West corrected standard errors. The expected rate of inflation ($E_t[\pi_{t+1}]^{Forec}$) is the real-time forecast for Switzerland from Consensus Economics, which is available from 1990 onwards only. In column (1) the measure for the Phillips curve relationship is $GapCU_t$ as proposed in this paper. Column (2) employs the deviation of capacity utilisation from its constant long-run average $GapAvgCU_t$ as measure for real activity. Column (3) employs the output gap $GapGDP_t$ calculated by the KOF. Column (4) uses the unit labor cost measure ULC_t calculated by the KOF. Column (5) uses the output gap based on an HP filter.

[21] Henzel and Wollmershäuser (2008) show that OLS is valid and that the estimated parameters are very stable over time.

To measure expected inflation, we employ the median forecast of professional economists for the next twelve months collected by Consensus Economics ($E_t[\pi_{t+1}]^{Forec}$).[22] As consensus economics data for inflation expectations is only available from 1990 onwards, the number of observations drops to 70. The OLS estimates with Newey-West corrected standard errors can be found in Table 2. As in Table 1, columns (1) to (5) report the estimates employing the different proxies for the output gap. In column (1) we report our estimates for the NIRCU gap constructed in this paper. The estimated coefficient for the gap has a value of 0.10 and is therefore higher than the GMM estimate. Also with OLS, the measure of the ouput gap is significant at the ten percent level. The coefficient on expected inflation is lower than the GMM coefficient, while the coefficient for lagged inflation is higher. This finding is in line with the results reported in Henzel and Wollmershäuser (2008) for Germany. They estimate a coefficient on expected inflation of 0.24, a coefficient of 0.79 on lagged inflation and a coefficient of 0.08 on the measure of the output gap. Furthermore, the estimates are close to the estimates in Galí et al. (2001) for Europe. As for the GMM results for the average utilisation gap, the KOF output gap and the unit labour costs, they are not significant at the ten percent level. However, using an HP filter (ex post) of GDP, we find that the output gap measure is significant and correctly signed when using the survey-based expectations. This measure was insignificant in the GMM estimation, which suggests that either the survey-based measures of expectations are indeed better than the assumption of rational expectations, or that there was a change in potential output or the inflation-output trade-off before 1990, where the OLS sample starts, which can be captured by the NIRCU but not by the HP filter.

As a second robustness test we estimate equation (7) in first differences. Unit root tests are reported in Table A.2 in the Appendix. We ran four unit root tests: the augmented Dickey Fuller (Dickey and Fuller, 1979) test (ADF), the Phillips-Perron (Phillips and Perron, 1988) test (PP), the Dickey-Fuller GLS (Elliott and Stock, 1996) test (DFGLS), and the Kwiatkowski-Phillips-Schmidt-Shin (Kwiatkowski et al., 1992) test (KPSS). We find that while the tests suggest that the output gap measures and the instruments used in the regressions are all I(0), the results for inflation are indeed mixed. While we cannot reject the null of a unit root using the PP and the ADF test, we can reject the null of a unit root using the DFGLS test. The KPSS test, which tests the null hypothesis of a stationary series, could not be rejected either. Thus, two tests suggest

[22] Consensus Economics conducts monthly surveys among professional economists from banks and public institutions. The survey asks them about their expectations regarding inflation and other macroeconomic aggregates for the current and the upcoming year. The consensus forecast is the mean of these forecasts for the Swiss CPI. The data have been transformed to obtain a fixed, one-year ahead forecast horizon. The exact transformation proceeds as follows: for month m of a given year t, the expectation of inflation is defined as $(13-m)/12$ times the forecast for year t plus $(m-1)/12$ times the forecast for year $t+1$. We then employ the monthly series and aggregate it to a quarterly series by employing simple averages.

Table 3: GMM parameter estimates in first differences, 1985Q2-2007Q2

	(1)	(2)	(3)	(4)	(5)
$\Delta E_t[\pi_{t+1}]^{GMM}$	0.28***	0.31***	0.29***	0.29***	0.30***
	(0.05)	(0.07)	(0.06)	(0.06)	(0.05)
$\Delta\pi_{t-1}$	0.39*	0.32	0.38*	0.33	0.34
	(0.21)	(0.23)	(0.21)	(0.22)	(0.22)
$\Delta GapCU_t$	0.12***				
	(0.03)				
$\Delta GapAvgCU_t$		-0.03			
		(0.03)			
$\Delta GapGDP_t$			-0.02		
			(0.05)		
ΔULC_t				0.01	
				(0.06)	
$\Delta GapGDPHP_t$					0.00
					(0.08)
Constant	-0.04	-0.03	-0.04	-0.04	-0.04
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Observations	85	85	85	85	85
Hansen J-Stat	0.08	0.07	0.07	0.07	0.07
p-value Hansen	(0.11)	(0.13)	(0.11)	(0.10)	(0.11)
p-value AR	0.20	0.72	0.63	0.67	0.66
p-value AR-K	0.11	0.83	0.78	0.83	0.82

Standard errors in parentheses *** p<0.01 ** p<0.05 * p<0.1. Columns (1)-(4) report GMM estimates, where the change in the expected inflation rate $\Delta E_t[\pi_{t+1}]^{GMM}$ is instrumented by three lags of the inflation rate, two lags of the import price index and the lagged output gap (all in first differences). In column (1) the measure for the Phillips curve relationship is $GapCU_t$ as proposed in this paper. Column (2) employs the deviation of capacity utilisation from its constant long-run average $GapAvgCU_t$ as the measure for real activity. Column (3) employs the output gap $GapGDP_t$ calculated by the KOF. Column (4) uses the unit labor cost measure ULC_t calculated by the KOF. Column (5) uses the output gap based on an HP filter. P-values of the Hansen J-Statistic are reported in brackets. P-values for the Anderson Rubin (AR) test and the Kleibergen (AR-K) test proposed by Dufour et al. (2006) are reported in the last two rows.

that inflation has a unit root, while two tests suggest the opposite. We have therefore added a robustness check and used the inflation series in first differences. Table 3 reports the results for equation (7) in first differences using GMM. While the expected inflation rate is highly significant with a coefficient of around 0.3, lagged inflation is significant in only two equations. The change in the capacity utilisation gap derived from the NIRCU ($\Delta GapCU_t$) is again significant and correctly signed. The coefficient is higher than in the level specification. Again, all other measures of the output gap are insignificant. However, some of the tests for the equation including $GapCU_t$ are close to rejecting the validity of the instruments. Therefore, we also estimated the OLS equation with the survey forecasts in first differences. Table 4 shows the results. Expected inflation is now insignificant in all specifications while lagged inflation is always significant and displays a coefficient of around 0.7. Our results remain unchanged with regards to the output gaps. The capacity utilisation gap is significant and the size of the coefficient is 0.09, which is close to the

Table 4: OLS parameter estimates in first differences, 1990Q2-2007Q2

	(1)	(2)	(3)	(4)	(5)
$\Delta E_t[\pi_{t+1}]^{Forec}$	0.13	0.09	0.08	0.08	0.08
	(0.13)	(0.13)	(0.14)	(0.14)	(0.13)
$\Delta \pi_{t-1}$	0.71**	0.79***	0.73**	0.72**	0.73**
	(0.27)	(0.28)	(0.29)	(0.29)	(0.28)
$\Delta GapCU_t$	0.09**				
	(0.04)				
$\Delta GapAvgCU_t$		-0.05			
		(0.03)			
$\Delta GapGDP_t$			-0.02		
			(0.06)		
ΔULC_t				0.02	
				(0.08)	
$\Delta GapGDPHP_t$					0.08
					(0.10)
Constant	-0.03	-0.03	-0.03	-0.03	-0.03
	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)
Observations	69	69	69	69	69
F-Statistic	6.87	5.17	4.21	4.19	4.45
R^2	0.24	0.19	0.16	0.16	0.17

Newey-West corrected standard errors standard errors in parentheses *** p<0.01 ** p<0.05 * p<0.1. Columns (1)-(5) report OLS estimates with Newey West corrected standard errors. The expected rate of inflation ($E_t[\pi_{t+1}]^{Forec}$) is the real-time forecast for Switzerland from Consensus Economics, which is available from 1990 onwards only. In column (1) the measure for the Phillips curve relationship is $GapCU_t$ as proposed in this paper. Column (2) employs the deviation of capacity utilisation from its constant long-run average $GapAvgCU_t$ as measure for real activity. Column (3) employs the output gap $GapGDP_t$ calculated by the KOF. Column (4) uses the unit labor cost measure ULC_t calculated by the KOF. Column (5) uses the output gap based on an HP filter.

GMM estimate of 0.12. Overall, the results for the capacity utilisation gap derived from the NIRCU remain robust.

6 Conclusions

This paper proposes a straightforward method to derive an indicator of the Non-inflationary rate of Capacity Utilisation (NIRCU). We employ firm-level survey data collected by the KOF Swiss Economic Institute, where we can directly observe a firm's current capacity utilisation rate *and* its current and desired price adjustments. Following the definition of the non-inflationary rate, we construct the NIRCU by conditioning the capacity utilisation rate on no price adjustments. Compared to previous estimates of the NIRCU, which usually assume that the NIRCU is the long-term average of capacity utilisation rates across time, we see several advantages in this approach. First, it is available in real time and not subject to revisions. Second, it is based on the theoretical idea of a natural rate. Third, to some extent, it is able to take into account firm level heterogeneity. Fourth, it takes into account the time variability of the natural rate. Fifth, it does not require statistical methods for smoothing that imply end-point problems or other forms of uncertainty. Included in a Phillips curve regression as an indicator for real activity, the NIRCU is shown to outperform other measures such as unit labour costs or the output gap. The results are robust to the choice of the methodology, to the measure of survey expectations, and they hold both in levels and first differences specifications of the Phillips curve.

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Appendix

Table A.1: Summary statistics

Variable	Obs.	Mean	Std:Dev.	Min	Max
π	90	1.827	1.635	-0.078	6.249
π^{Forec}	71	1.741	1.125	0.555	4.416
CU	90	85.503	2.687	79.175	90.625
$NIRCU$	90	86.348	2.556	79.675	91.586
$GapCU$	90	-1.002	1.387	-4.412	2.696
$GapAvgCU$	90	0.000	2.687	-6.328	5.121
$GapGDP$	90	0.206	1.964	-4.190	4.416
ULC	90	0.030	0.063	-0.111	0.112
$GapGDPHP_t$	90	0.0314	1.259	-2.201	3.778
π^{Import}	90	-0.215	4.161	-12.459	9.3662
Wage growth	90	1.296	1.498	-1.751	4.630

Table A.2: Unit root tests

Variable	ADF	PP	DFGLS	KPSS
π	-1.998	-1.968	-1.650*	0.292
π^{Forec}	-1.616	-1.165	-0.645	0.31
$GapCU$	-4.541***	-4.462***	-2.885***	0.224
$GapAvgCU$	-2.41	-2.580*	-2.298**	0.249
$GapGDP$	-2.818*	-2.113	-2.707***	0.16
ULC	-3.990***	-6.798***	-3.904***	0.332*
$GapGDPHP_t$	-3.523***	-2.383	-3.566***	0.094
π^{Import}	-3.257**	-3.595***	-2.012**	0.125
Wage growth	-3.299**	-2.922**	-3.292***	0.164

The table reports four unit root tests: the augmented Dickey Fuller (Dickey and Fuller, 1979) test (ADF), the Phillips-Perron (Phillips and Perron, 1988) test (PP), the Dickey-Fuller GLS (Elliott and Stock, 1996) test (DFGLS), and the Kwiatkowski-Phillips-Schmidt-Shin (Kwiatkowski et al., 1992) test (KPSS).*** p<0.01 ** p<0.05 * p<0.1.