Capacity Utilization and Inflation: Is Statistics Canada's Measure an Appropriate Indicator of Inflationary Pressures?†

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[1] The views expressed in this paper are those of the authors and do not reflect those of the Department of Finance. Any and all errors are the responsibility of the authors.

ABSTRACT

Statistics Canada's capacity utilization rate has traditionally been used, by policymakers and economic agents alike, as an indicator of future changes in inflation. Recently, however, domestic inflation pressures have remained subdued despite near record levels of capacity use. This raises the question of whether the link between high capacity utilization and inflation has been broken.

This paper explores the issue econometrically by testing the stability over time of two alternative specifications – a standard Phillips curve and one that incorporates changes in inflation regimes. Both specifications indicate that although there existed a positive and stable relationship between capacity use and inflation prior to the mid-1980s, this relationship breaks down after that time. Indeed, after 1986, econometric tests reject the hypothesis that capacity utlitization rates can provide any information about changes in inflation.

RÉSUMÉ

La mesure du taux d'utilisation de la capacité industrielle de Statistique Canada a traditionnellement été employée comme indicateur avancé de pressions inflationnistes. Cependant, on observe présentement des taux d'utilisations élevés jumelés à une inflation basse. Ceci remet en question la relation traditionnelle entre le taux d'utilisation de la capacité industrielle et l'inflation.

La présente étude explore la question de façon empirique en examinant la stabilité temporelle de deux courbes de Phillips - une courbe de Phillips traditionnelle et une courbe de Phillips dotée de changement de régime. Les résultats pour les deux spécifications indiquent qu'il existait une relation positive et stable entre le taux d'utilisation de la capacité et l'inflation avant 1986 mais que cette relation n'est plus significative par la suite. En effet, après 1986, on peut rejeter l'hypothèse que le taux d'utilisation de la capacité est un bon indicateur des variations du taux d'inflation.

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I. Introduction

In September, Statistics Canada reported that industrial output in the second quarter reached 87.9% of capacity. This figure is just shy of the record high of 88% reached in the mid-1960s. Typically, utilization rates above 82 percent suggested higher future inflation. As excess demand builds, firms tend to incur higher production costs in order to increase output. They are forced to put their less efficient factors of production to work - hire inexperienced workers, pay overtime, or bring mothballed plants and equipment back into service - and pass on the resulting higher production costs to consumers in the form of higher prices.[2] Recently, however, the link between inflation and capacity use has come under scrutiny. In Canada capacity utilization rates have remained above the 82% benchmark but prices have failed to accelerate.

This note explores the issue of whether Statistic Canada's capacity utilization series is an appropriate indicator of changes in future inflation, with a focus on whether the relationship is stable over time. Two alternative Phillips curve specifications are explored. First, a standard price mark-up model, that assumes inflation follows a unit-root process, is used to estimate a short-run Phillips curve. Second, to test the robustness of the results, the unit-root assumption is relaxed and an alternative Phillips curve specification is estimated. The findings from both models suggest that, although there existed a positive and stable relationship prior to the mid-1980s, this relationship is no longer significant. Indeed, after 1986, econometric tests reject the hypothesis that capacity utilization rates predict changes in consumer price inflation. This is not to say that excess demand in final product markets is no longer inflationary. Rather, the evidence suggests that inflation no longer accelerates above an 82% benchmark. Unfortunately no new standard has emerged to replace the old, leaving us with a crippled indicator.

There are many hypotheses as to why the link between inflation and capacity use has weakened. The most common are an increasingly global economy, rapid technological progress, a more pre-emptive monetary policy, and mismeasurement. Although the resolution of the high capacity — low inflation conundrum is beyond the scope of this text, this note presents some possible explanations.

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[2] This is equivalent to saying that firms production processes exhibit diminishing returns-to-scale in the short run.

The following section lays out the model and provides a literature review. Section 3 provides some descriptive statistics. Section 4 lays down the details of the equation being estimated and discusses the findings. Section 5 relaxes the conventional assumption that inflation is I(1) and the robustness of the results from section 4 are investigated. The penultimate section explores the validity of the standard explanations. Section 6 concludes.

II. Model and Literature Review

Traditionally, the rationale for using the capacity utilization gap rather than the unemployment rate gap as a measure of inflationary pressure was that the NAICU (non-accelerating inflation rate of capacity utilization) may be more structurally stable. Until recently, studies on the topic agreed that the NAICU was somewhere around 82% and was stable.[3]

There are two main channels through which capacity utilization is thought to affect inflation. First, high rates of CU are associated with rising costs (through decreasing returns to scale), and increasing pricing power (when supply is scarce relative to demand, producers can increase prices without serious loss in sales). These forces directly affect goods prices but will be important for a broader price index if either goods prices dominate the index or if inflation in the goods market affects the price of services (which seems quite plausible). Second, mounting capacity constraints induce firms to invest in new plant and equipment, stimulating economic expansion and further capacity pressures, giving birth to additional inflationary pressures. It is generally thought that capacity pressures will take longer to impact inflation through the latter channel because of delays associated with planning and executing capital investment projects.

The model used to test the validity of the above hypotheses is similar to that of Emery and Chang (1997), which is itself a modified version of the standard price mark-up model used in estimates of the short-run Phillips curve.[4] The starting point is the canonical empirical Phillips curve:

$$(1)\quad \pi_t = A + B\,cu_t + C\,\pi_t^*$$

where π is inflation, π^* is expected inflation, and CU is a measure of capacity utilization. Further assume that the expected inflation rate is equal to a weighted average of lagged inflation rates and that the sum of the weights are equal to one (i.e. expectations follow a unit root process). This implies that there is a permanent and stable relationship between *changes* in the inflation rate and capacity utilisation. Rewriting equation (1) we obtain

$$(2)\quad \pi_t = A + B\,cu_t + \sum_{i=1}^{n} \lambda_i \pi_{t-i}$$

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[3] For the United States see McElhattan (1978, 1985), Bauer (1990), Franz and Gordon (1993), and Garner (1994). For Canada see Fougère (1993).
[4] See McElhattan (1985) or Fougère (1993) for the complete derivation of the Phillips curve using capacity utilization as a measure of excess demand.

with $\Sigma\lambda = 1$, we can rewrite (2) as

$$(3) \quad \pi_t - \pi_{t-1} = A + Bcu_t + \sum_{i=1}^{n-1}((\sum_{j=1}^{i}\lambda_j) - 1)(\pi_{t-i} - \pi_{t-i-1})$$

Therefore the change in inflation is related to the capacity utilization rate and past changes in inflation. In equilibrium, when lagged changes in inflation are zero, this equation is an upward sloping line which crosses the horizontal axis (where $\pi_t - \pi_{t-1} = 0$) at CU = -A/B. This point is known as the NAICU or the equilibrium rate of capacity utilization (CU^e).

Measures of excess demand and past inflation are not the only determinants of inflation. Various exogenous events, such as supply shocks, also significantly affect prices. Changes in oil prices and changes in the real exchange rate can affect prices directly and indirectly. In addition, given the Canadian economy's relatively large reliance on raw materials, changes in their world price can also affect aggregate domestic prices. In order to avoid misspecification, control variables for the aforementioned need to be incorporated. Adding a vector of variables to control for supply-side shocks yields the final specification of the model:

$$(4) \Delta\pi_t = A + Bcu_t + \sum_{i=1}^{n} c_i \Delta\pi_{t-i} + \sum_{j=1}^{m} d_j z_{jt} + \varepsilon_t$$

where the Z_js are control variables and ε_t is the error term.

Estimating the above model with US data (and using the CPI as their measure of inflation) over the 1967-1996 period, Emery and Chang (1997) obtain the usual result that there is a stable NAICU around 82%. However, breaking their sample into two sub-samples (1967-82 and 1983-96) they discover that while the relationship holds strongly in the former it does not hold in the latter. Hence, they conclude that "…after 1982 there is no evidence that high capacity utilization rates forecast increases in consumer price inflation."[5] However, if the PPI is used as a gauge instead of the CPI, they find that although there is some deterioration in the relationship after 1982, there is still evidence of a significant positive relationship.

A different strand of research explores the question of whether capacity utilization is a reliable inflation indicator over and above economy-wide indicators of inflationary pressures. De Kock and Nadal-Vicens (1996) use variants of Granger-causality tests based on estimated vector-autoregression models to test whether capacity utilization predicts inflation and whether a particular channel is responsible for its predictive power. For Canada and the US, they show that manufacturing capacity utilization provides a signal about future inflation above and beyond current and past inflation rates, GDP gap, and unemployment deviation from trend. However, in the case of Canada, they are unable to identify the channel through which capacity use feeds into inflation, a puzzle,

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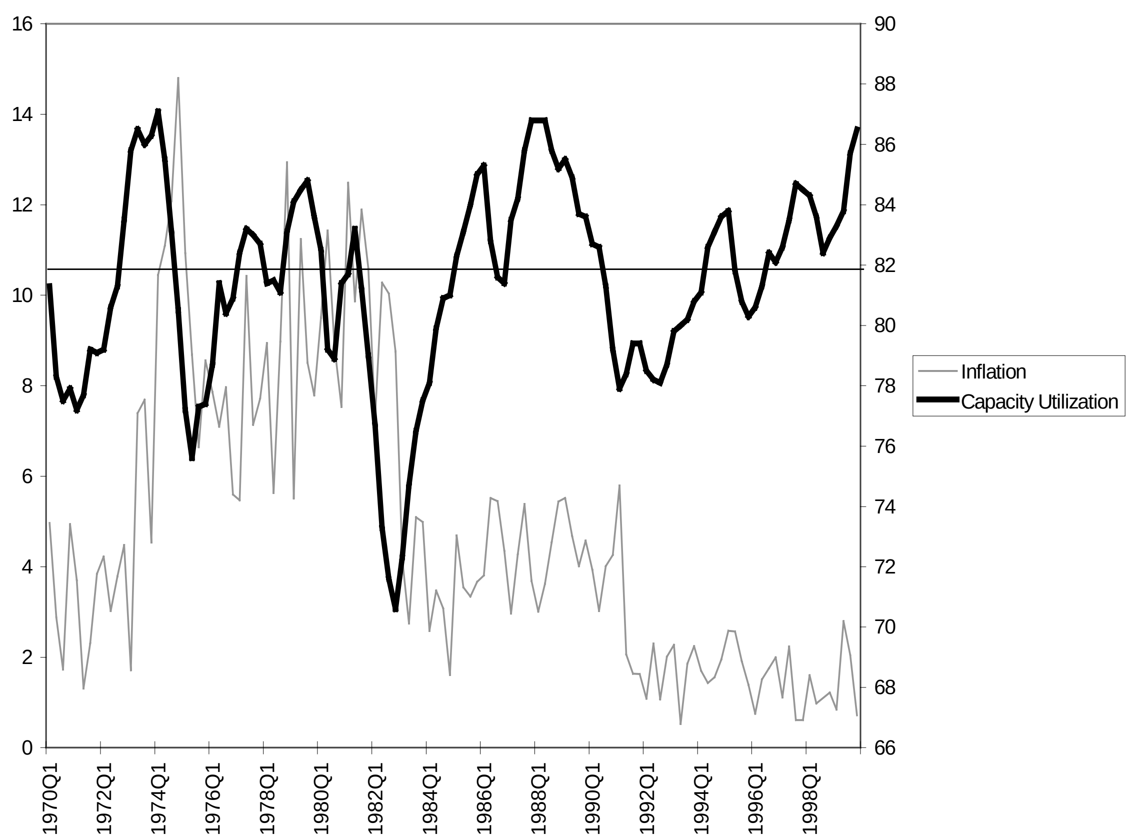
[5] Emery and Chang (1997), p.19

they conclude, deserving further exploration.[6] Unfortunately, they only estimate their model for the 1970-95 period. The problem is that if, as Emery and Chang claim, the relationship breaks down after the mid-1980s it seems possible that different results would be obtained over different sub-periods. In fact, using U.S. data, Cecchetti (1995) finds that before 1982 capacity utilization adds significant information to out-of-sample forecasts of inflation but that it vanishes thereafter.

Finally, using a Phillips curve estimated with US data, Stock and Watson (1999) find that capacity utilization outperforms the unemployment rate when conducting out-of-sample forecasts of inflation, over both the 1970-83 and 1984-96 periods. Furthermore, they find evidence, in both sub-periods, that capacity use contains useful information above and beyond that contained in the unemployment rate and past inflation. Although it is unclear whether the unemployment rate is an adequate benchmark, their results suggest that capacity utilization based Phillips curves remain a valid forecasting tool.

Figure 1: Core CPI Inflation and Capacity Utilization



[6] For the US they find evidence that manufacturing activity impacts on inflation through unit labour costs and producer prices.

III. Descriptive Statistics

A snapshot of the relationships between utilization rates and the core CPI is provided in Figure 1. The figure reveals that capacity rates above 82% tended to presage acceleration in prices prior to the mid-1980s. Thereafter inflation seesawed, but did not increase, during two periods (the 1987-1990 period and the 1996 to present period) where capacity use remained above the 82% line throughout. However, it is noteworthy that, even after the mid-1980s, capacity utilization rates below 82% tended to be associated with falling inflation.

IV. Tests and Results

The general form of the model is expressed in equation (4). Substituting in the relevant variables we obtain the following functional form:

(5) $CHCPIC_t = a_1 + a_2{*}CU_{t-1} + \Sigma b_i{*}CHCPIC_{t-i} + \Sigma c_i{*}CHRELWTI_{t-i} + \Sigma d_i{*}CHRELRM_{t-i} + \Sigma e_i{*}CHREALXR_{t-i} + \varepsilon_t$

where the subscript t denotes time. All estimations in this paper use quarterly data. CHCPIC is the change in core inflation, CU is the capacity utilization rate, CHRELWTI is the change in relative oil price inflation, CHRELRM is the change in relative raw materials (excluding energy) price inflation, and CHREALXR is the acceleration of the real exchange rate.[7] Nonstationarity is not a concern as ADF tests indicate that changes in inflation and capacity utilization are stationary.[8] The model was estimated by OLS for both the core CPI and the IPPI (replacing CHCPIC in (5) with CHIPPI) over the 1973Q1-1999Q1 period[9]. The Akaike and Scharwtz information criterions were used to determine the appropriate number of lags.

Equation (5) was first estimated over the whole sample period 1973Q1-1999Q1. The results are reported in Tables 1 and 2, column I, for the CPI and IPPI regressands respectively. The results are satisfactory; all coefficients are significant (or jointly significant when more than one lag is included) and of expected sign. For the CPI specification, both oil and exchange rate shocks have their greatest impact after 3 quarters[10]. The capacity utilization term enters with a one-period lag and has a significant coefficient of 0.22, implying that a one percentage point increase in the utilization rate leads to a 0.22 percentage point increase in inflation at an annual rate. The NAICU is estimated at 82.0%.

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[7] The precise definitions of the variables, as well as descriptions and sources for each data series, are given in Appendix A.
[8] The results of the ADF test are reported in Appendix B.
[9] Tests for serial correlation were conducted. The null of no autocorrelation was accepted for both tests conducted. The full details are given in Appendix B.
[10] The inclusion of the raw materials variable in the CPI specification yielded insignificant coefficients.

TABLE 1: Regression Results
(Dependent Variable: Change in core CPI)

	I	**II**	**III**	**IV**
TIME PERIOD	**73:1-99:4**	**73:1-86:4**	**87:1-99:4**	**73:1-99:4**
CONSTANT (C)	-17.803	-25.638	-4.112	
	(4.35)	(4.05)	(1.11)	
CU(-1)	0.217	0.317	0.049	
	(4.34)	(4.05)	(1.08)	
DUM1				-24.733
				(5.08)
DUM2				-7.572
				(-1.05)
DUM1*CU				0.306
				(5.09)
DUM2*CU				0.090
				(1.03)
CHCPIC(-1)	-0.657	-0.764	-0.021	-0.690
	(7.80)	(6.64)	(0.14)	(8.31)
CHCPIC(-2)	-0.481	-0.538	-0.490	-0.514
	(5.61)	(4.56)	(3.63)	(6.09)
CHRELWTI(-1)	0.001	0.001	-0.001	0.001
	(0.96)	(0.54)	(0.56)	(0.73)
CHRELWTI(-2)	0.003	0.002	0.005	0.002
	(2.04)	(1.11)	(3.16)	(1.83)
CHRELWTI(-3)	0.005	0.005	-0.0001	0.004
	(3.39)	(2.57)	(0.07)	(3.10)
CHRELWTI(-4)	0.004	0.004	0.004	0.003
	(3.04)	(2.33)	(2.13)	(2.83)
CHREALXR(-1)	0.036	0.040	0.008	0.032
	(1.73)	(1.07)	(0.54)	(1.57)
CHREALXR(-2)	0.019	0.050	-0.018	0.015
	(0.90)	(1.29)	(1.15)	(0.71)
CHREALXR(-3)	0.048	0.075	0.045	0.043
	(2.27)	(1.92)	(2.83)	(2.08)
Summary Statistics				
CU^e = (-C/CU)	82.0	80.9	83.9[1]	Period 1: 80.8
(NAICU)				Period 2: 84.1[1]
R-Squared	0.50	0.60	0.56	0.53
# of observations	108	56	52	108

Absolute values of t-statistics are given in parentheses.
DUM1 is a dummy taking on the value of 1 for data points before 1987:1 and 0 thereafter.
DUM2 is a dummy taking on the value of 1 for data points after (and including) 1987:1 and 0 before.
[1] The low t-statistics suggest coefficients of zero and should be interpreted as such. There is no evidence of the existence of a Phillips curve. Oddly enough, the ratio of the two wholly insignificant coefficients is stable.

TABLE 2: Regression Results
(Dependent Variable: Change in IPPI)

	I	II	III	IV
TIME PERIOD	73:1-99:4	73:1-84:4	85:1-99:4	73:1-99:4
CONSTANT C	-14.100	-27.83	2.871	
	(1.97)	(2.46)	(0.27)	
CU	0.172	0.345	-0.035	
	(1.96)	(2.46)	(0.27)	
DUM1				-26.918
				(2.97)
DUM2				4.336
				(0.35)
DUM1*CU				0.334
				(2.97)
DUM2*CU				-0.054
				(0.36)
CHIPPI(-1)	-0.366	-0.404	-0.269	-0.391
	(3.62)	(2.34)	(1.84)	(3.90)
CHIPPI(-2)	-0.186	-0.284	-0.141	-0.216
	(1.90)	(1.60)	(1.09)	(2.21)
CHRELWTI(-1)	0.011	0.008	0.012	0.011
	(4.95)	(2.46)	(2.69)	(4.73)
CHRELWTI(-2)	0.006	0.009	-0.001	0.006
	(2.56)	(2.64)	(0.28)	(2.42)
CHRELWTI(-3)	0.009	0.011	-0.001	0.009
	(3.56)	(3.36)	(0.10)	(3.44)
CHRELWTI(-4)	0.003	0.005	-0.001	0.004
	(1.70)	(1.62)	(0.18)	(1.58)
CHRELRM	0.112	0.128	0.111	0.113
	(5.91)	(3.92)	(4.39)	(6.04)
CHRELRM(-1)	0.082	0.099	0.075	0.084
	(3.90)	(2.48)	(2.72)	(4.08)
CHRELRM(-2)	0.073	0.068	0.060	0.076
	(4.21)	(2.36)	(2.37)	(4.46)
CHREALXR	0.130	0.024	0.166	0.126
	(3.87)	(0.34)	(4.40)	(3.78)
CHREALXR(-1)	0.067	0.091	0.060	0.066
	(1.88)	(1.39)	(1.34)	(1.88)
Summary Statistics				
CU^e = (-C/CU) (NAICU)	82.0	80.7	82.0[1]	Period 1: 80.6 Period 2: 80.3[1]
R-Squared	0.54	0.63	0.59	0.56
# of observations	108	48	60	108

Absolute values of t-statistics are given in parentheses.
DUM1 is a dummy taking on the value of 1 for data points before 1987:1 and 0 thereafter.
DUM2 is a dummy taking on the value of 1 for data points after (and including) 1987:1 and 0 before.
[1] The low t-statistics suggest coefficients of zero and should be interpreted as such. There is no evidence of the existence of a Phillips curve. Oddly enough, the ratio of the two wholly insignificant coefficients is stable.

A similar story holds for the IPPI specification, although there is evidence that the producer price index reacts more rapidly than its retail counterpart. Indeed, capacity use, CHRELRM, and CHREALXR all enter the equation contemporaneously and the coefficients on CHRELWTI are greater (and significant) earlier on. The coefficient on CU is somewhat lower, at 0.17, implying slower price acceleration. The NAICU is estimated at 82.0%, identical to Fougère (1993). These results are entirely consistent with findings in the literature. They do not, however, address the issue of stability.

Stability of the utilization-inflation relationship over time.

Three separate tests are used to examine the stability of the relationship. Each test was conducted for a multitude of possible break points. First, the Chow break point test is conducted. Second, allowing the coefficients on the constant and the CU term to vary but restricting all other coefficients to remain the same, Wald tests are used to determine whether the two coefficients vary between samples. Third, the second test is repeated but with all coefficients allowed to vary. The results reveal substantial instability beginning in the mid-1980s. The transition most likely occurred progressively but also unevenly. A transition period rather than a breakpoint seems a more appropriate concept. In the case of the CPI, based on analysis of Figure 1 and on the results of the tests described above, January 1987 seems most appropriate. For the IPPI, January 1985 is the prime candidate. The results of the estimation of equation (5) for the two sub-samples are reported in columns II and III of Tables 1 and 2. Column IV reports the results when all coefficients except the ones on the constant and CU terms are restricted to be equal over both periods. The results of the various stability tests (the associated probabilities for the log likelihood ratio for the Chow tests and the associated probabilities for the chi-square statistic for the Wald tests) are reported in Table 3.

Table 3: Stability Tests

	CPI (Table 1) Associated Probability	IPPI (Table 2) Associated Probability
Chow break point test		
(Log likelihood ratio test)	0.01	0.12
Wald tests with restricted coefficients (Specification IV)		
(Chi-square)		
DUM1=DUM2	0.05	0.04
DUM1*CU = DUM2*CU	0.04	0.04
DUM1/DUM1*CU = DUM2/DUM2*CU	0.28	0.98
Wald tests with unrestricted coefficients		
(Chi-square)		
DUM1=DUM2	0.01	0.05
DUM1*CU = DUM2*CU	0.01	0.05
DUM1/DUM1*CU = DUM2/DUM2*CU	0.52	0.98

* The results are for assumed break points in January 1987 for the CPI and January 1985 for the IPPI.

In the case of the core CPI specification, the results for the 1973-86 period (Table 1) are consistent with the standard result of a stable NAICU. All coefficients are significant (or jointly so) and the equilibrium rate of capacity use is estimated at 80.9%. This is not so for the 1987-1999 sample. The coefficients on both the constant and the

CU term are insignificant (regardless of whether the other variables are allowed to vary). Therefore inferences drawn from them are unreliable and potentially misleading. However, if anything, they suggest a flattening of the Phillips curve. In other words, a one percentage point increase in the utilization rate leads to a 0.32 percentage point increase in inflation prior to 1987 but only a 0.05 percentage point increase thereafter. Although the tentative NAICU appears to have increased, one cannot reject the hypothesis that it is equal in both periods. The results in Table 3 indicate that, in all instances, one can reject the null of no change across samples in the constant and CU coefficients (at the 5% confidence level) but cannot reject the hypothesis that CU^e is equal across both samples. This suggests that the Phillips curve has rotated around its equilibrium point (CU^e) or has only shifted slightly. Clearly, since 1987 capacity use does not have predictive power for changes in consumer price inflation. Hence, the traditional hypothesis of rising inflation when capacity use exceeds 82% is no longer supported by the data. This is not to say that high capacity use is no longer inflationary, only that data since the mid-1980s no longer support such a hypothesis. One possibility is that the relationship has somehow been altered but that more time and data are required to establish statistical significance.

The results for the IPPI specification are similar. Unlike the CPI, there is a noticeable shift with respect to the control variables. Note that the coefficients on CHRELWTI (the change in relative oil price inflation), CHRELRM (the change in relative raw materials, excluding energy, price inflation), and CHREALXR (the acceleration of the real exchange rate) exhibit stronger significance on earlier lags. These variables seem to have a more immediate effect in the latter period. This may reflect greater openness and more efficient markets.

Second, in the 1985-1999 period the t-statistics for the constant and CU coefficients are close to zero, indicating a complete lack of correlation. This finding of a complete breakdown between producer prices and inflation since 1985 contrasts sharply with that of Emery and Chang, who find the relationship still holds in the United States (when quarterly data is used). This incongruence and the extent of the breakdown are worthy of further research.

<u>V. Robustness to the assumption that inflation is I(1).</u>

Since the early 1990's, the assumption that inflation follows a unit-root process has come under attack. The public's belief concerning the objectives of the Central Bank and the fashion in which monetary policy is conducted can have an impact on the way inflation expectations are formed. Agents' reaction to a change in inflation are different in a world where the Central Bank has credibly signalled its dedication to price stability to agents than in a world where it has not. For the case of Canada, this idea was formalized by Laxton, Ricketts, and Rose (1994) and Ricketts and Rose (1995). Using a Markov switching model these studies present evidence that although inflation seemed to follow a unit-root process over the 1974-1982 period this is not the case before or after this period. Instead, in other periods, inflation would have been characterised by different stationary processes. One conclusion they draw from these findings is that the formation of expectations is influenced by monetary policy regimes.

If these shifts in regimes reflect the impact of monetary policy on the formation of inflation expectations, ignoring them would lead to mis-specification of the Phillips curve. Fillion and Léonard (1997) incorporate the idea of inflation regime shifts into the Phillips curve. Using a Markov switching model they estimate the probabilities of being in one of three inflation regimes: low inflation, moderate inflation, or high and unstable inflation. Then they introduce a set of dummy variables into the Phillips curve, with each dummy corresponding to a specific regime. Lastly, the dummies are weighted by the probability of being in the given regime at that time. Taking the dummy variables constructed by Fillion and Léonard an alternative Phillips curve, resembling theirs, is estimated:

$$(6)\ INFCPIC = a_1P2 + a_2P3 + a_3P4 + P2*\Sigma bi*INFCPIC_{t-i} + P34*c_i*INFCPIC_{t-1} + \Sigma d_i*CHRELWTI_{t-i} + \Sigma e_i*CHREALXR_{t-i} + f_1*CUGAP_{t-1} + \varepsilon_t$$

The dummy variables P2, P3, and P4 are taken directly from Fillion and Léonard (1997)[11] and represent the unit-root inflation regime, the moderate inflation regime, and the low inflation regime respectively. INFCPIC is core CPI inflation, CUGAP is the capacity utilisation gap[12], and the remaining variables are identical to those in equation 5.

TABLE 3: Regression Results
(Dependent Variable: INFCPIC)

	I		II	
	Coefficient	t-statistic	Coefficient	t-statistic
CONSTANT (P2)	0.29	1.17	0.27	1.09
CONSTANT (P3)	2.57	3.05	2.37	2.74
CONSTANT (P4)	1.15	2.87	1.00	2.34
Σ LAGS INFCPIC (P2)	1.0	(imposed)	1.0	(imposed)
INFCPIC (-1) (P34)	0.31	1.57	0.37	1.82
Σ LAGS CHRELWTI	0.014	12.8*	0.013	10.82*
Σ LAGS CHREALXR	0.088	3.24*	0.082	2.83*
CUGAP (-1)	0.17	3.31		
DUM1*CUGAP (-1)			0.21	3.29
DUM2*CUGAP (-1)			0.09	0.96

*F-statistic

Equation (6) is estimated over the 1973Q1-1999Q4 period for core CPI[13]. The results are reported in Table 3. Column I reports the results when the coefficient on CUGAP is restricted to be equal over the entire sample. Column II reports the results when the coefficient on the CUGAP term is allowed to vary over the pre-1987 and post-1987 samples.

The conclusions drawn from Table 3 are all but identical to those drawn earlier. The coefficient for the 1973-1986 period is 0.21 and significant, while that for the 1987-

[11] See Fillion Léonard (1997), p. 24. P2 is extended to include the four quarters in 1973 and P4 is extended to include the years 1995-1999. P34 combines P3 and P4 as one dummy.
[12] Constructed as capacity utilization at time t minus its average over the appropriate time period (i.e. either the average over 1973Q1-1986Q4 or the average over 1987Q1-1999Q4).
[13] The results for the IPPI added no insight beyond what was gained in section 4.

1999 period is insignificant. Further, the results suggest an equilibrium inflation rate of 3.7% during the moderate inflation era (approximately 1983-1991) and 1.7% during the low inflation era (approximately 1992-1999). These are lower than, but fairly consistent with, previous findings.

VI. Comments on Possible Explanations

As alluded to earlier there are many hypotheses as to why the relationship might have weakened. We do not find support for two commonly stated possibilities. First, as detailed in Appendix A, it does not seem that Statistics Canada's change in methodology in 1988 is at fault. Second, the idea that capacity utilization (which measures excess demand in the goods market) is less relevant because the goods producing portion of the economy has been shrinking over time is not supported empirically. Estimating equation (5) using the goods component of the CPI yielded results qualitatively similar to those obtained when the service component of the CPI was used.

This leaves us with the usual suspects: mismeasurement, an increasingly global economy, rapid technological progress, and a more pre-emptive monetary policy. Mismeasurement is always a possibility, especially when dealing with recent data. It is possible that recent observations are overstated and that, in hindsight, we will find that the relationship was stable after all. However, given that core inflation did not increase in the 1987-1990 period and given the current high rates of capacity use (which would require substantial downward revision to arrive in non-inflationary territory), this explanation seems tenuous.

The globalization argument emphasises increased competition as an explanation. However, increased competition alone cannot explain our findings. Increased competition decreases prices because, since there are more firms, each firm does not need to move as far along its supply curve to satisfy the increase in aggregate demand. But then firms would not be operating at a high rate of capacity utilization. There is, however, the possibility that international competition has reduced the mark-up charged by domestic producers in periods of excess demand. According to this theory, mark-ups are pro-cyclical and increase in periods of peak demand, reflecting non-competitive pricing behaviour by firms who believe they can raise prices without a serious loss in sales. The advent of international competition limits non-competitive behaviour and would thus restrict price increases. The problem with this argument is that one would expect corporate profits to be lower if international competition is allowed; but corporate profits today are near record highs. Admittedly, the issue is not so simple and thus globalization remains a possible explanation.

Another possibility is that technological progress and innovation have modified (i.e. lowered) firms' cost structures. That is, producing more still increases costs but not by as much as was previously the case. This translates into a flattening of the Phillips curve, which is consistent with our results. It is also possible that technological progress has increased the complementarity between factors of production. The argument being that the new technologies that began to emerge in the mid-1980s (i.e. the microcomputer and accompanying innovations) enable unskilled workers to perform tasks that had hitherto been executed by skilled workers. Whereas, in the past, producers ran out of people to operate machinery when they were around 82% of capacity, sparking inflation as the price of skilled labour rose, this is no longer the case. Moreover, increased dissemination of knowledge and information arising from technological progress, as well as a deeper understanding of production processes, may have contributed to lowering costs.

Although this may be part of the answer it is implausible that it is the whole answer. It is inconceivable that firms' supply curves have flattened to the extent suggested by the results. Therefore other phenomenon must be at play. One candidate that has attracted attention recently is the pre-emptive nature of monetary policy. As espoused by Beaudry and Doyle (2000) and summarized by James (2000), the recent flattening of the observed Phillips curve[14] in Canada could be the result of "improved understanding by the monetary authorities of the role played by supply shocks."[15] An alternative hypothesis (rejected by Beaudry and Doyle) is that downward nominal wage rigidity exists and is binding at low rates of inflation. Beaudry and Doyle use a more sophisticated model than the one laid out above and an exposition of their results is beyond the scope of this text. The point is that the apparent shift in the Phillips curve is not a trivial issue and no straightforward explanation seems to exist.

V. Future work and extensions

Our results raise a number of questions. First, is it capacity use that is no longer an appropriate indicator of excess demand or is excess demand itself no longer inflationary (or less inflationary than in the past)? Establishing that the relationship between the output gap and inflation still holds would greatly strengthen the case in favour of abandoning capacity use as an indicator of inflation. Second, which model is the better predictor of inflation? Out-of-sample forecasts, using both capacity utilization and the output gap, could be conducted with standard Phillips curve models and regime switching models to determine which performs best. Lastly, could output gap models shed light on the causes of the demise of capacity use as an indicator of inflation? If so, these could then be investigated further.

VII. Conclusion

For the past five years, Statistics Canada's measure of capacity utilization has been above the traditional inflationary threshold, yet inflation has not risen. This has cast doubt on the usefulness of the capacity utilization rate as an indicator of future inflation. Prior to the mid-1980s the NAICU was stable at 82%. After 1986, one can reject the hypothesis that capacity utilization rates contain information on consumer price inflation (core CPI). A similar conclusion holds for the IPPI after 1984.

The practical implications of our finding are twofold. First, analysis of the data over the past 14 years suggests that the traditional 82% utilization rate benchmark is no

[14] Their excess demand variable is the output gap.
[15] James (2000), p. 1.

longer reliable. Second, until we discover the new mechanism through which capacity use affects prices, because in the end it must, we are left with a demagnetised compass.

Appendix A: The Data

The following provides the mnemonics, descriptions, and sources of the data series used in the estimation of equation (5). Quarterly data was collected from 1969Q1-1999Q4 for all series. To allow for the required lags the regressions were estimated from 1973Q1 to 1999Q4. Percentages are expressed in units rather than decimals (i.e. inflation of 4%, for example, is recorded as 4 rather than 0.04)

Raw Data:

Capacity Utilization (CU): Industrial capacity utilization rate of non-farm goods producing industries. CANSIM D883644. A discussion regarding the appropriateness of using Statistic Canada's measure for capacity use is provided below.
Note: The model was also estimated using the capacity utilization rate of manufacturing industries (CANSIM D883647). The results were similar to those for the capacity utilization rate of non-farm goods producing industries.

Core CPI (CPIC): Consumer price index excluding food, energy, and indirect taxes, seasonally adjusted. CANSIM B3323 for 1984-1999. Observations prior to 1984 were obtained from Martin Charron of the Economic and Fiscal Policy Branch at the Department of Finance.
Note: The model was also estimated using the CPI (P1000000), the goods component of the CPI (P100270), and the service component of the CPI (100274). The results were not qualitatively different from those reported for the core CPI.

Industrial product price index (IPPI): Industrial product price index - all commodities. CANSIM P2000.

Canadian price deflator (CANDEF): Implicit price index of gross domestic product at market prices. CANSIM D15612.

American price deflator (USDEF): Implicit price index of gross domestic product at market prices. RFABASE PDIGDPUS.

West Texas Intermediary (WTI): Spot price per barrel of crude petroleum, in US dollars. RFABASE CPWTIUS. To obtain the relative (or real) price I divide by the American price deflator (USDEF). This yields the variable RELWTI.

Raw materials price index excluding energy (RM): Price index for commodities and aggregation of commodities that are considered raw materials, in US dollars. The series is courtesy of Maxime Fougere of the Economic and Fiscal Policy Branch at the Department of Finance. To obtain the relative price of raw materials I divide by USDEF. This yields the variable RELRM.

Exchange rate (XR): US dollar noon spot rate in Canadian dollars. CANSIM B3400. To obtain the real exchange rate I multiply by the American price deflator (USDEF) and divide by the Canadian price deflator (CANDEF).

Most of the variables used in equation (5) are the difference of the annualised one-period percentage change (second difference). If X is the raw data variable (CPI, say) then the difference of the annualised one-period percentage change (the change in inflation) is given by:

$$F(X) = [4(\ln X - \ln X(-1))*100] - [4(\ln X(-1) - \ln X(-2))*100]$$

Variables used in equation (5):

CHCPIC: F(CPIC)

CHIPPI: F(IPPI)

CHRELWTI: F(RELWTI)

CHRELRM: F(RELRM)

CHREALXR: F(REALXR)

<u>Statistics Canada's measure of capacity utilization</u>

In 1989 Statistics Canada adopted a new survey method for estimating capacity utilization rates. Consequently, there is the possibility of a structural break in the series in 1989. If such is the case, comparisons between capacity utilization rates before and after 1989 are invalid. However, Statistics Canada asserts that they have taken measures to smooth the series and that no structural break exists. In light of the result that the relationship between capacity use and inflation weakens after the mid-1980s, one might wonder whether this merely reflects a structural break in the underlying series.

To remedy the situation a capacity utilization series constructed using the pre-1989 Statistics Canada methodology over the entire period was obtained[16]. All equations were re-estimated using this series. Surprisingly, the series constructed using Statistics Canada's old methodology faired worse (as exhibited by lower t-statistics) than Statistics Canada's current measure. This finding held for both the CPI and IPPI and across all sample periods. In addition, the finding of a tentatively higher NAICU for the CPI in the second period persisted when the constructed series was used. Hence, in all respects, Statistics Canada's adaptation does not appear to be the culprit.

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[16] The series was provided by Bing Song Wong of the Economic and Fiscal Policy Branch at the Department of Finance.

Appendix B: Tests for Stationarity and Serial Correlation

Unit Root Tests

Unit root tests conducted for the two inflation variables (industrial product price index and core consumer price index) and for the Statistics Canada's capacity utilisation variable rejected, in all cases, the null hypothesis of non-stationarity. Hence, cointegration is not a concern. The results for the various variables are given in table A.

Table A: Results of the augmented Dickey-Fuller Unit Root Tests

	# of lagged difference terms	ADF test statistic
Change in core cpi inflation	1	-12.36*
Change in IPPI inflation	0	-14.51*
Statistic Canada's capacity utilization rate	1	-3.77*

*significant at the 1% confidence level

Serial correlation tests

Correlogram analysis and the Breusch-Godfrey LM test were conducted to test for autocorrelation. The results are given in table B. Figures for correlogram analysis are the p-values associated with the Ljung-Box Q-statistic on the eight lag. The LM test was conducted with eight lagged residuals, the results reported in table B are the probabilities associated with the $n*R^2$ term. At the 5% confidence level none of the tests can reject the null of no autocorrelation.

Table B: Results of tests for autocorrelation

Specification using CPI (Table 1)	Correlogram analysis	LM test
Equation I (1973-99)	0.27	0.25
Equation II (1973-86)	0.33	0.08
Equation III (1987-99)	0.57	0.46
Specification using IPPI (Table 2)		
Equation I (1973-99)	0.76	0.39
Equation II (1973-84)	0.81	0.47
Equation III (1985-99)	0.32	0.24

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