Markups and Oil Prices in Canada*

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Abstract

The markup (the ratio of price to marginal cost) in Canada has risen steadily since the early 1990s suggesting a widening gap between the actual and the efficient level of output and a declining share of labour income in GDP. It exhibits non-stationary movements over the sample period 1982Q1 to 2009Q4, allowing us to identify a permanent markup shock. We provide evidence that oil price movements are important for understanding the behaviour of the markup, and separately identify both oil price shocks and permanent non-oil markup shocks. Our key findings are: (1) oil price shocks and non-oil markup shocks account for 50 to 80 percent of the variation in the markup, with the former dominating at shorter horizons; (2) the role of oil price shocks is prominent in accounting for the upward trend in the markup since the mid-1990s; (3) the direct effects of oil prices on the markup in the mining sector (which includes the oil-producing sector) have contributed the most to the upward trend in the aggregate markup; and (4) other explanations such as market structure shifts, trend inflation movements and the falling relative price of investment do not appear to account for the behaviour of the markup.

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1 Introduction

The markup (the ratio of price to marginal cost) has risen steadily in Canada since the early 1990s. This evidence points to two evolving issues for the Canadian economy. First, since the markup represents the difference between the actual and the efficient (higher) level of output, it suggests a widening gap between the two. Second, since the measured markup is the inverse of the labour share of income, the distribution of income appears to be shifting away from labour towards capital. So far the underlying reasons behind the rising markup have not been sufficiently investigated for the Canadian economy.[1] We conduct an empirical analysis of measured markups to shed some light on this issue.

We begin by constructing several measures of the markup using quarterly Canadian business sector data for the 1982Q1 to 2009Q4 period. We show that all the measures have risen significantly since the early 1990s. Traditionally, the markup is thought to exhibit stationary movements. However, there is strong evidence for the non-stationarity of the markup based on three types of unit root tests. Specifically, the augmented Dickey-Fuller and the Phillips-Perron tests do not reject the null of unit root, and the Kwiatkowski-Phillips-Schmidt-Shin test rejects the null of stationarity.[2]

The literature points to several factors that can, in theory, contribute to permanent changes in the markup. First, shifts in market structure caused by changes in the price elasticity of demand, market concentration, and entry-exit of firms. While such shifts in market structure can induce stationary markup variation over the business cycle (see, for example, Jaimovich and Floetotto (2008)), they can also induce non-stationarity in the markup, as shown in Kim (2010). Second, higher inflation can induce greater competition and thus lead to a lower markup (see, for example, Benabou (1992)). Banerjee and Russell (2001) find evidence that higher inflation is related with a lower markup in the long run based on an analysis for G7 economies and Australia. Recently, Karabarbounis and Neiman (2012) point out that a global decline in the labour share of income is driven in part by a

[1] In previous empirical research on markups in the Canadian context, Morrisson (1994) examines the cyclicality of markups in Canadian manufacturing. More recently, Leung (2008) studies how import competition growth has affected the markup growth in Canada, and Boulhol (2008) examines the issue of convergence in the price-cost margins in thirteen OECD countries, including Canada, at the aggregated manufacturing level between 1970 and 2000.

[2] Our findings of non-stationary markups over the 1982Q1-2009Q4 period are also consistent with the evidence presented in Banerjee and Russell (2001) for the 1962Q1-1997Q1 period.

fall in the relative price of investment. Since the labour share of income is the inverse of the markup, changes in the relative price of investment are a potential factor that explains the movement of the markup. We will, however, argue that oil price movements are relatively more important in understanding the behaviour of the markup in Canada.

Data show that the markup and oil prices have become highly related and moved together since 1994. Since Canada is a net exporter of crude oil, there are both direct and indirect effects of oil price movements on the markup. When oil prices rise in the international market, the producers of crude oil in Canada earn more as long as there is no change in cost conditions in this sector. This leads to a rise in the markup in the oil-producing sector which can in turn raise the aggregate markup (the *direct effect*). At the same time, a rise in oil prices raises production costs for sectors that use crude oil and petroleum products. Since oil is not immediately substitutable with other materials, the rise in oil prices induces an increase in the share of intermediate inputs (including oil), which in turn results in a rise in the value-added based markup even when there is no change in the desired markup at the firm level (the *indirect effect*). Thus changes in oil prices create a wedge between the price of value-added output and primary input costs.[3]

The evidence of non-stationarity of the markup implies the presence of a permanent markup shock that induces variations in the markup in the long run. To identify this shock, we adopt the empirical methodology developed by Kim (2010) who studies the effects of a permanent markup shock in the U.S. using the structural vector autoregression (SVAR) framework. As shown in Kim (2010), the key identifying restriction is that only a markup shock can affect the level of the markup in the long run. Furthermore, we use other restrictions to identify the effects of shocks to technology and monetary policy at the same time, which implement the long-run restriction proposed by Galí (1999), and the recursiveness assumption of Christiano et al. (1999). Estimation results show that the real wage, output and per-capita hours decline after a permanent positive markup shock. Moreover, inflation rises immediately, but the effect of the markup shock on inflation dissipates quickly.

Considering that oil prices are determined in the international market, our discussion

[3]As is pointed out by Rotemberg and Woodford (1993), under imperfect competition environment the increase in the price of gross output is bigger than the increase in production costs, thus leading to a rise in the markup measured in value-added terms (difference between the price of gross output and intermediate input costs).

above suggests that the identified markup shocks may in part reflect oil price movements. Indeed, results from the Granger causality test and a regression of identified markup shocks on current and lagged changes in oil prices confirm this point. We, therefore, construct an extended VAR model that can separate permanent markup shocks into oil price shocks and non-oil markup shocks. Both variance decomposition and historical decomposition analyses show that oil price shocks account for nearly half of the variation in the markup over a 12 quarter horizon. Beyond this horizon, the non-oil markup shocks become more important, accounting for nearly 47 percent of the variation at the 20 quarter horizon. Taken together, both shocks account for 50 to 80 percent of the variation in the markup. Other shocks, namely, technology and monetary policy are not important for the markup variation at any horizon. The historical decomposition analysis reveals that the role of non-oil markup shocks gets muted in the late 1990s whereas that of oil shocks is prominent in accounting for the upward trend in the markup.

We conduct a sectoral analysis which complements the analysis based on the aggregate data. To this end, we classify Canadian industries into six aggregated sectors: agriculture, forestry and fishing; mining; manufacturing; utilities (electricity, gas and water); construction; and services. The sectoral analysis reveals three interesting findings and, in addition, allows us to check robustness using an alternative measure of the markup, namely, the price-cost margin. First, we find that changes in the value-added based markup largely reflect changes in the gross output based markup. In other words, changes in the share of intermediate inputs in gross output, which can drive a wedge between these two markup measures, are of relatively small magnitude. Second, we are able to assess the direct and indirect effects of oil prices and their implication for both sectoral and aggregate markups. We find that the direct effect of oil price changes is relatively larger than the indirect effect. In the mining sector (which includes the oil-producing sector), the markup exhibits a strong upward trend driven by the direct effects of oil prices. This upward trend has contributed the most to the upward trend in the aggregate markup. Third, oil prices appear to have a distinct role in driving markups relative to shifts in market structure that influence the degree of competition within the mining sector. As Boulhol (2008) points out, markups can increase when entrants are efficient-high markup firms and exiting firms are inefficient with low markups.

However, Ciobanu and Wang (2012) find that the entry rates - whether based on number of firms or employment - did not surpass the exit rate in the Canadian mining sector during the 2000-2008 period. This suggests that the role of market structure shifts is likely to be limited relative to the role of oil prices in driving the markup in the mining sector. Sectoral markups in the remaining five sectors either show a less robust upward trend (for example, manufacturing and construction) or a decline (agriculture, forestry and fishing, utilities, and services). While the role of changes in market structure may perhaps be more relevant in these sectors, their respective markups do not appear to drive the upward trend in the overall aggregate markup observed since the mid-1990s.

The rest of the paper is organized as follows. In Section 2, we construct several measures of the markup and conduct tests on whether the markup is non-stationary in Canada. In Section 3, we describe the empirical methodology and estimate the effects of permanent markup shocks. Section 4 presents evidence for the linkage between markups and oil prices. Section 5 presents the sectoral analysis. Finally, Section 6 concludes.

2 Markup trend in Canada

2.1 Methodology

Since the markup (the inverse of real marginal cost) is unobservable, researchers usually employ assumptions to measure the markup. A common empirical strategy in the macroeconomic literature is to make assumptions about the production technology and a variable input to link the unobserved real marginal cost to observable variables. For example, with a Cobb-Douglas production function and labour as the variable input, the labour income share serves as the proxy for real marginal cost, and hence, the markup. Two strands of empirical research use this approach. First, the literature examining the cyclicality of markup over the business cycles (see, for example, Bils (1987), Rotemberg and Woodford (1991), Rotemberg and Woodford (1999), and Nekarda and Ramey (2010)). Second, the literature on estimating New Keynesian Phillips curves (see, for example, Galí and Gertler (1999), Sbordone (2002), and Galí et al. (2001)).

An alternative approach taken mostly in the industrial organisation literature is to use the price-cost margin (PCM) defined as the difference between sales and variable costs over sales. Variable costs usually include expenditures on intermediate inputs and labour. Thus the PCM is measured by the following formula:

$$PCM_t = \frac{GO_t - INT_t - CE_t}{GO_t} \tag{2.1}$$

where GO_t, INT_t and CE_t denote the nominal values of gross output, intermediate inputs and compensation of employees, respectively. Examples of this approach are Domowitz et al. (1986) and, more recently, Boulhol (2008, 2010).

In contrast to these approaches measuring the markup directly, Ellis (2006) applies the state space model to estimate the markup indirectly. Assuming a constant elasticity of substitution (CES) production function, Ellis derives two first-order conditions with respect to labour and capital (factor-demand equations) for a typical firm's profit maximization problem, and then jointly estimates the markup and the elasticity of substitution between labour and capital using U.K. data. He finds that the markup has fallen since the early 1970s, which is quite different from what is found when other approaches are applied to U.K. data.

We measure the markup following the standard macroeconomic approach. We think that this approach is more appropriate than Ellis's approach for several reasons. In the standard macroeconomic approach, the markup can be derived based on cost minimization conditions. In contrast, Ellis's approach is based on static profit maximization conditions, which are more restrictive than cost minimization conditions as one must impose strong restrictions on the nature of market structure and demand. Moreover, Ellis's approach can estimate only the long-term trend of the markup while the standard macroeconomic approach can capture the cyclical behaviour of the markup as well. In addition, Ellis's method may work well when the data on capital costs are accurate. However, capital costs include opportunity costs which are not easy to compute. When capital costs are not well measured, this leads to the poor measurement of the markup. Using the PCM has also strengths and weaknesses. While it seems that this approach does not make restrictive assumptions, it becomes valid only when average variable cost is equal to marginal cost. It should also be noted that capital costs are not reflected in equation (2.1), and so this may create distortions when measuring the markup. Although we focus on the standard macroeconomic approach, we also provide PCMs to examine changes in sectoral markups in section 5.

As is mentioned above, the standard measure of the markup is proportional to the inverse of the labour income share. However, Rotemberg and Woodford (1999) point out that this measure of the markup is too procyclical and hence problematic from the standpoint of theoretical models in which business fluctuations are driven by countercyclical markups. They suggest modifications to the labour share due to the presence of overhead labour and the constant elasticity of substitution (CES) production function which tend to lessen the procyclicality of the markup. Kim (2010) shows that the output response to a positive markup shock after some periods is positive when the standard measure of the markup is used in structural VARs, which is inconsistent with theoretical predictions of most macroeconomic models. Thus Kim (2010) incorporates overhead labour to construct a less procyclical measure of the markup, and finds it to be the preferred measure in determining the effects of markup shocks in the U.S. economy. Previously, Gagnon and Khan (2005) find that the CES-based proxy is preferred relative to a Cobb-Douglas-based proxy when estimating the new Keynesian Phillips curve for Canada. More recently, however, Nekarda and Ramey (2010) show that markups in the U.S. are either procyclical or acyclical. This finding raises a challenge for sticky price based models in which countercyclical markups play an important role. Reflecting both sides of arguments, we construct several measures of the markup to be flexible about the cyclical properties of the markup. We stress that the identification of permanent markup shocks based on Kim (2010), which we describe in section 3.1 below, does not require that the markup be countercyclical. However, considering overhead labour and the CES production function enables us to obtain meaningful effects of the identified shocks.

Consider the following CES production function with (time-varying) overhead labour:

$$Y_t = F(K_t,\ L_t) \equiv \left[a_K K_t^{\frac{\sigma-1}{\sigma}} + a_L \left(A_t \left(L_t - \bar{L}_t\right)\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \tag{2.2}$$

where Y_t, K_t and L_t are output, capital input and labour input, respectively; A_t is labour-augmenting technology and $\bar{L}_t$ is the amount of overhead labour; and the parameter σ denotes the elasticity of substitution between capital and labour, and a_K and a_L are the share parameters. The expression for real marginal cost (with respect to optimal labour adjustment) is

$$\frac{MC_t}{P_t} = \frac{W_t/P_t}{F_L(.)} \tag{2.3}$$

where MC_t is nominal marginal cost, P_t is the price level, W_t denotes the nominal wage rate, and $F_L(.)$ is the marginal product of labour. Using (2.2) and (2.3), we can express the markup (the ratio of price to marginal cost) as

$$\frac{P_t}{MC_t} = S_t^{-1}\left(1 - a_K\left(\frac{Y_t}{K_t}\right)^{\frac{1-\sigma}{\sigma}}\right)\left(\frac{L_t}{L_t - \bar{L}_t}\right) \quad (2.4)$$

where S_t is the labour income share. This will be our benchmark measure of the markup. However, results for other measures incorporating either overhead labour or the CES production function will also be reported.

2.2 Measured markups

We use quarterly Canadian business sector data from 1982Q1 to 2009Q4. The data on the labour income share and total labour are from Statistics Canada Table 383-0008, with index 2002 = 100. Real GDP is used for output. We obtained annual data on the capital stock series from the OECD STAN database, and combined quarterly data on the real fixed investment series to construct quarterly series of the capital stock.[4] The value for a_K is set at 0.384 which corresponds to the capital share in production. We set σ to 0.5 as in Gagnon and Khan (2005). This value is slightly bigger than the one that Ellis (2006) estimates based on U.K. data. However, different values for σ had almost negligible effects on the results of this paper. Overhead labour is not directly observable. So we proceed by making assumptions as in Rotemberg and Woodford (1991) and Rotemberg and Woodford (1999), and write $\left(\frac{L_t}{L_t-\bar{L}_t}\right) = \left(\frac{L_t/L_t^{ss}}{L_t/L_t^{ss}-\bar{L}_t/L_t^{ss}}\right)$ where L_t^{ss} is total labour input at the steady state, estimated by a regression with a linear time trend. Kim (2010) uses 29 percent as the steady state share of overhead labour in total labour following Rotemberg and Woodford (1999).[5]

[4]Specifically, assuming that the quarterly depreciation rate (δ) in a year is the same for all four quarters, we have the following relationship between the capital stock at the end of year t (K_t) and the capital stock at the end of year $t-1$ (K_{t-1}):

$$K_t = I_{t,4} + (1-\delta)I_{t,3} + (1-\delta)^2 I_{t,2} + (1-\delta)^3 I_{t,1} + (1-\delta)^4 K_{t-1}$$

where $I_{t,1}$, $I_{t,2}$, $I_{t,3}$ and $I_{t,4}$ denote the real fixed investment of the first, second, third and fourth quarters in year t, respectively. After solving for δ, we can compute the capital stock for each quarter.

[5]Assuming that the steady state labour and overhead labour grow at the same rate along the balanced growth path, the elasticity of $\left(\frac{L_t}{L_t-\bar{L}_t}\right)$ with respect to L_t is $\eta_o \equiv -s_o/(1-s_o)$ where s_o is the steady state share of overhead labour in total labour. Rotemberg and Woodford (1999) assume an average markup of 25% and a labour income share of 0.7, which gives $\eta_o = -0.4$. Thus $s_o = 0.286$ or 29%.

However, the overhead labour share of this size may be too high in that Nekarda and Ramey (2010) report the share of fixed costs is at most 10 percent based on the U.S. data. Thus we assume that the steady state share of overhead labour in total labour, $\bar{L}_t/L_t^{ss}$, is 10 percent. Although results are not reported in this paper, we also tested with the 29 percent steady state share of overhead labour. This alternative parameterization, however, yielded qualitatively no different result.

Panel (a) of Figure 1 shows the labour income share of the Canadian business sector. After a big swing in the 1980s, the labour income share has kept declining since the early 1990s, although there have been cyclical fluctuations. We also observe a spike in 2008 coinciding with the recent global financial crisis. Panel (b) of Figure 1 presents measures of the markup for the Canadian economy. The solid line is the measure of the markup that is standard in the literature. Because the standard markup measure is the inverse of the labour income share, it shows an upward trend over the 1992-2007 period after a rise and a subsequent fall in the 1980s. Other lines are markup measures constructed to take into account either overhead labour or the CES production function, or both. Although the cyclical properties of alternative measures are not apparent in this figure, all measures exhibit an upward trend since the early 1990s, suggesting the presence of a markup shock that shifts the desired markup ratio permanently.

The cyclical properties of measured markups are shown in Table 1. In panel (a), cross correlation coefficients between cyclical components of both real GDP and the markup as computed by the HP filter (with a smoothing parameter, λ, of 1600) are provided for alternative measures of the markup. In panel (b), cross correlation coefficients between the growth of real GDP and the growth of the markup are presented. Focusing on the contemporaneous correlation between the two variables, the standard markup measure turns out to be quite procyclical regardless of whether the coefficient is computed using cyclical components or the growth rate. This is similar to the results found for the U.S. economy in many studies. However, the combination of overhead labour and the CES production function reduces the degree of procyclicality to some extent. The CES production function alone mitigates it only slightly. But when the overhead labour setup is applied, the procyclicality of the markup is reduced more than the CES production function setup. Nekarda and Ramey (2010) show that the correlation between current output and the future markup turns negative based on U.S. data. However, this pattern is not apparent for the Canadian economy. The correlation turns slightly negative after two quarters only when it is computed using the growth rate. Taken together, the evidence suggests that markups are not countercyclical in Canada.

We conduct formal tests to see whether the markup follows a non-stationary process. Table 2 shows the results of unit root tests. We use three types of unit root tests. In the first two columns, the results of augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are reported while the last column is the results of the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. In the first two tests, results do not reject the null hypothesis that the log of the markup follows a unit root process at any conventional significance level irrespective of the measure of the markup. Moreover, the KPSS test rejects the null hypothesis that the log of the markup is stationary even at the one percent significance level for all measures of the markup. Thus, there is strong evidence for the non-stationarity of the markup in the Canadian economy. This is also consistent with the findings of Boulhol (2008). He presents estimates of the PCM trends in thirteen OECD countries. Especially for Canada, the PCM at the aggregated manufacturing level has tended to rise between 1970 and 2000.

3 Effects of permanent markup shocks

In this section we present the empirical methodology for the identification of markup shocks and examine their effects on Canadian macroeconomic variables.

3.1 Identification scheme

In order to analyze the effects of the permanent markup shock, we employ the methodology developed by Kim (2010). In a structural VAR framework, he uses two long-run restrictions: (1) only the markup shock affects the price/marginal cost ratio in the long run, and (2) only shocks to the markup and technology affect the real wage in the long run. As an auxiliary short-run restriction to identify a monetary policy shock, he also uses the recursiveness assumption of Christiano et al. (1999). We consider a six-variable VAR, similar to that in Kim (2010), to identify a markup shock, along with technology and monetary policy shocks.

The structural moving average representation is

$$[\Delta\mu_t,\ \Delta w_t,\ \Delta y_t,\ u_t,\ \Delta p_t,\ r_t]' = C(L)\xi_t \tag{3.1}$$

where $\Delta\mu_t = \Delta\log(P_t/MC_t)$ is the growth of the markup ratio, $\Delta w_t = \Delta\log(W_t/P_t)$ the growth of real wages, $\Delta y_t = \Delta\log Y_t$ the growth of per-capita output, $u_t = \log U_t$ the log of the product of the overhead labour factor and the CES factor in equation (2.4),[6] $\Delta p_t = \Delta\log P_t$ inflation, and r_t the bank rate. $C(L)$ is a matrix of lag polynomial and ξ_t is a vector of structural shocks. The first element of ξ_t is a permanent shock to the desired markup ratio (ξ_t^p), the second element is the technology shock (ξ_t^a), and the last element is the monetary policy (or the policy rate) shock (ξ_t^r). We can express the two long-run restrictions for identifying the markup and technology shocks using the long-run multiplier matrix as the following:

$$C(1) = \begin{pmatrix} c_{11} & 0 & 0 & 0 & 0 & 0 \\ c_{21} & c_{22} & 0 & 0 & 0 & 0 \\ c_{31} & c_{32} & c_{33} & c_{34} & c_{35} & c_{36} \\ c_{41} & c_{42} & c_{43} & c_{44} & c_{45} & c_{46} \\ c_{51} & c_{52} & c_{53} & c_{54} & c_{55} & c_{56} \\ c_{61} & c_{62} & c_{63} & c_{64} & c_{65} & c_{66} \end{pmatrix}. \tag{3.2}$$

The zeros in the first row of the above matrix show the restriction that only the markup shock affects the level of the desired markup in the long run. The zeros in the second row show the restriction that only the markup and the technology shocks affect the real wage in the long run. With these two long-run restrictions, and the recursiveness assumption of

[6]Since the log of the markup is

$$\begin{aligned} \log\frac{P_t}{MC_t} &= \log S_t^{-1}\left(1 - a_K\left(\frac{Y_t}{K_t}\right)^{\frac{1-\sigma}{\sigma}}\right)\left(\frac{L_t}{L_t - \bar{L}_t}\right) = \log\frac{P_tY_t}{W_tL_t}U_t \\ &= -\log\frac{W_t}{P_t} + \log Y_t - \log L_t + \log U_t, \end{aligned}$$

and the factor U_t is stationary, there exists a cointegrating relationship among the logs of the markup, the real wage, per-capita output and per-capita hours (L_t). So if the growth of per-capita hours ($\Delta\log L_t$) is included directly in the VAR, there will be cointegration among the levels of the variables, and thus there will be no VAR representation for equation (3.1). To avoid this problem, $\log U_t = \log\frac{P_t}{MC_t} + \log\frac{W_t}{P_t} - \log Y_t + \log L_t$ is included in the VAR. In this case, the response of per-capita hours is computed by $\log L_t = \log U_t - \log\frac{P_t}{MC_t} - \log\frac{W_t}{P_t} + \log Y_t$.

Christiano et al. (1999) to identify the monetary policy shock, we can estimate three sets of impulse responses. Note that one advantage of using a relatively large VAR as in (3.1) is that it helps reduce biases due to omitted variables as recommended, for example, by Faust and Leeper (1997) and Erceg et al. (2005).

3.2 Estimation results

We use the quarterly population and business sector data of the Canadian economy from 1983Q1 to 2009Q4. The resident population is computed as the total population (series v1) less non-permanent residents (series v494880) of Statistics Canada Table 051-0005. The business sector data are from Statistics Canada Table 383-0008, with index 2002 = 100. The markup ratio is the one constructed in the previous section using these data. The real wage is the compensation per hour worked divided by the GDP deflator. Per-capita output is real GDP divided by the resident population. The price level is the GDP deflator. Finally, the bank rate is the quarterly average (in percent per year) from Statistics Canada Table 176-0041. To be conformable with the inflation rate that is measured as a quarterly change, the bank rate is also converted to a quarterly interest rate by dividing the bank rate (percent per year) by 400. The number of lags in the VAR is set to four as the usual practice.

Depending on the choice of the markup measure, there can be four sets of impulse response functions (IRFs) corresponding to each measure of the markup shown in panel (b) of Figure 1. It turns out that the standard markup and the markup incorporating only the CES production function are problematic because the output response to either a markup shock or a technology shock is hard to reconcile with theoretical predictions.[7] This is consistent with Kim's (2010) finding that the standard markup measure does not lead to theoretically meaningful IRFs for the U.S. economy. This exercise also shows that taking into account the CES production function only does not make significant improvements. In the following, we report only two meaningful sets of IRFs just to save space.

IRFs to three structural shocks are presented in Figures 2 and 3. Figure 2 is IRFs under the overhead labour set up while Figure 3 displays IRFs under both overhead labour and

[7] When the standard markup is used, output increases in response to a positive markup shock both in the short and the long run. When the markup incorporating only the CES production function is used, output decreases in response to a positive technology shock both in the short and the long run.

the CES production function. As is shown in these figures, two sets of IRFs are very similar. For IRFs to the markup and technology shocks, they are impulse responses to a positive one standard deviation shock. For IRFs to a policy rate shock, they are impulse responses to an expansionary one standard deviation shock. The solid lines in the figure are point estimates while the shaded areas denote the 90 percent confidence interval, computed by bootstrap simulations with 200 random draws. The vertical axes denote percent changes for all variables except inflation and interest rates. The latter two variables are in terms of percentage points. The horizontal axes show the number of quarters after a particular shock.

Panel (a) is IRFs to a markup shock. After a positive markup shock, the real wage decreases in the short run. In the long run, by construction, there is a permanent effect on the markup ratio and the real wage. The responses of output, per-capita hours, inflation, and the bank rate are unrestricted. Output and per-capita hours decline after the markup shock. However, their long-run response is not significantly different from zero.[8] Inflation rises immediately upon impact, and the effects dissipate quickly. The bank rate declines for an extended period of time in response to the positive markup shock.

Panel (b) shows the effects of a positive technology shock. Output and the real wage increase both in the short run and in the long run. Per-capita hours decline in the short run, and then rise slowly. But the long-run response of per-capita hours is not significantly different from zero. The short-run inflation response does not exhibit inertia. Inflation declines immediately and then gradually builds up reaching the peak effect at about four quarters. The technology shock appears to have a persistent effect on the bank rate. However, in view of the wide confidence intervals, there is a great deal of uncertainty regarding the responses of the variables to a technology shock.

Panel (c) shows the effects of an expansionary monetary policy shock. The effects on output and per-capita hours are hump-shaped, with peak effects occurring eight to nine quarters after the shock. The real wage does not react much in the short run but increases

[8]Unlike the U.S. case examined in Kim (2010), the long-run response of output to a positive markup shock is not negative. Assuming the 29% steady state share of overhead labour in total labour does not yield better results. We find that it becomes slightly negative under the overhead labour setup when we include a third long-run restriction - only shocks to price and wage markups and technology affect the output level in the long run - in the VAR as in Kim (2010). However, in view of the wide confidence intervals, we think that the small sample makes it difficult to have a more accurate assessment. All these IRFs are available from the authors upon request.

after about nine quarters. Real marginal cost displays persistent negative effects, but turns positive after around three years. There is a 'price puzzle' observed in the short run in that inflation first drops before turning positive.

One concern with these results is that markup shocks may not be properly identified considering that they are estimated with a short sample (27 years). Theoretical models as in Comin and Gertler (2006) and Holden (2010), which endogenize movements in productivity, suggest that markups may exhibit very persistent movements within this short period of time even if they are in fact stationary. However, in view of studies based on even longer sample periods, we think that evidence is in favor of non-stationary markups. For example, Kim (2010) provides evidence that the markup is non-stationary after a careful examination of the U.S. markup for the period 1960-2005. Boulhol (2008) reports that markups at the aggregated manufacturing level in many OECD countries have indeed risen between 1970 and 2003. Moreover, as will be explained later, findings from our strategy of identifying markup shocks are quite consistent with results from sectoral analyses. Rather, if the mechanism of endogenous technological progress is crucial, this poses more problems for the identification of technology shocks since they may not be truly exogenous. This may be related to more or less unsatisfactory long-run effects of technology shocks on the interest rate (panel (b) of Figures 2 and 3). Although this is not a big concern for estimating markup shocks, it is likely that the small sample bias is inherent in this exercise, so caution needs to be taken in interpreting results.

4 Markup shocks and oil price movements

4.1 Overall linkage between the markup and oil prices

In this section we present a detailed analysis of how oil price movements are relevant for understanding the behaviour of markups in Canada. Specifically, we focus on how oil prices affect the identified permanent markup variation.

Before we turn to the formal analysis, it is useful to consider the relevance of other potential factors that may account for the upward trend in the markup and contribute to its non-stationarity. These factors are, namely, changes in trend inflation, the relative price of investment and market structure. Considering trend inflation first, we find that it is unlikely to have contributed to the rise in the markup in Canada since the early 1990s. Panel (a) of Figure 4 shows that after the Bank of Canada adopted the inflation targeting regime in 1991, the inflation rate dropped from a little over 6 percent to around 2 percent, and remained stable since then. However, the markup kept increasing after 1991, suggesting that the markup trend may be driven by factors other than the stable low inflation environment. A second potential source of the upward trend in the markup is the falling relative price of investment. Recently, Karabarbounis and Neiman (2012) have pointed out that a global decline in the labour share of income is driven in part by a fall in the relative price of investment.[9] They argue that, if the economy has the CES production function with the elasticity of substitution between labour and capital greater than one, a fall in the relative price of investment induces high capital accumulation. But at the same time, it greatly reduces labour demand, which leads to a decline in the labour income share. Since the markup is the inverse of the labour income share, the rising markup may have been caused by the falling relative price of investment according to their argument. However, as is shown in panel (b) of Figure 4, this possibility is not likely for the Canadian economy. Although the markup and the relative price of investment somehow moved in the opposite direction since the late 1990s, the behaviour of the two observed before that period does not support their argument. The markup and the relative price of investment moved in the same direction between 1984 and 1991. Since then, the relative price of investment remained stable up to the late 1990s whereas the markup increased substantially during the same period.

Turning to shifts in market structure, we note that over the past two decades influences of free trade agreements, increased globalization, and industrial deregulation are likely to have affected the overall competitive environment in Canada.[10] One may view these changes as enhancing the overall degree of competition among firms in Canada, and hence lowering markups.[11] Boulhol (2008), however, argues that the effect of enhanced competition on the markup is uncertain since there may be two countervailing forces at work. On the one hand,

[9]Rodriguez and Jayadev (2010) document declining labour shares in the manufacturing sector since the 1980s using annual United Nations National Accounts data from 129 countries.

[10]Examples include the Canada-United States Free Trade Agreement (1988), NAFTA (1994), and the deregulation of electricity, telephone and airlines industries since the late 1990s (see, for example, Maher and Shaffer (2005) and Iacobucci et al. (2006)).

[11]Due to unavailability of a time series index of industrial concentration or mobility indices (as suggested by Baldwin (1995)) at the aggregate level, we cannot directly examine the relationship between the markup and industrial concentration to see if they have moved together over the past two decades.

it leads to a lower markup for every firm. On the other hand, a decrease in domestic and foreign barriers induces the exit of the least efficient/low markup firms and the entry of the most efficient/high markup firms. Overall, Boulhol (2008) finds that markups at the aggregated manufacturing level in many OECD countries have risen between 1970 and 2003, which implies that the latter effect is more prevalent. In a related paper, Boulhol (2010) also presents evidence that the pro-competitive effect of trade liberalization is offset by financial deepening which may increase capital mobility.

However, if the markup is substantially affected by oil price movements as we argue in this paper, caution needs to be taken when investigating the relationship between the degree of competition and the level of the markup. In order to understand the relationship between oil price movements and the markup, we first focus on the strong association of oil prices with the steady rise of the observed markup. Panel (c) of Figure 4 compares the markup variation and movements of both nominal and real oil prices.[12] Nominal and real oil prices behave in a similar way except that real oil prices were much higher than nominal oil prices during the early 1980s. This figure shows that the markup was not particularly related to oil prices before 1994. Although they moved in the same direction between 1984 and 1988, they moved in the same direction between 1989 and 1993. Overall, the correlation between the growth of the markup and the growth of oil prices is -0.036 for the period before 1994. However, since 1994 the two appear highly related. The correlation between the two (growth rates) is 0.677 for this latter period. Considering that there can be other factors such as changes in market structure that affect the markup, this result suggests that oil price movements have played a relatively bigger role in the variation of the markup since 1994.

Next we examine the relationship between oil price movements and identified markup shocks from the VAR. To this end, we first perform the Granger causality test for the period 1983:Q1-2009Q4 using 4 lags. Table 3 presents test results on the relationship between the (log) change in oil prices (Δp_t^o) and the identified markup shocks (ξ_t^p) from our benchmark VAR. The null hypothesis that the markup shock does not Granger cause oil prices is not rejected at all conventional significance levels while the hypothesis that oil prices do not

[12]Nominal oil prices are the price of Brent (U.S. dollar per barrel) which is available from International Financial Statistics of the IMF. Real oil prices are the price of Brent divided by the Canadian GDP deflator (2002=1).

Granger cause the markup shock is rejected at the 10 percent level. Since the Granger causality test includes only lags of explanatory variables other than lags of the dependent variable, the contemporaneous effect is not taken into account. So we ran a regression of the markup shocks on oil prices including current oil price changes, the result of which is shown in Table 4. As shown in the table (Regression 1), oil price movements seem to affect the markup contemporaneously and with a one-period lag. The hypothesis that coefficients on oil price changes in the current and previous quarters equal zero is rejected at the 10 percent significance level (t-statistics are 1.933 and 1.937, respectively). Moreover, the hypothesis that all the slope coefficients equal zero (*F-test*) is rejected at the 5 percent level. These exercises clearly show that the identified permanent markup shocks in Canada are linked to oil price movements.

We also check whether the movements of the markup are associated with changes in the relative price of investment. For this, we regressed the identified markup shocks on the current and lagged values of (log) changes in both oil prices and the relative price of investment (Δrpi_t).[13] As shown in Table 4 (Regression 2), the coefficients on the relative price of investment are all statistically insignificant while the coefficients on oil price changes continue to be statistically significant. The coefficients on the lagged values of the relative price investment are even estimated to be positive, which is the opposite of what Karabarbounis and Neiman (2012) predict. In addition, the hypothesis that coefficients on the current and lagged values of the relative price of investment are all zero (*F-test*) is not rejected at all conventional significance levels. This finding further confirms our main point that markup movements are linked to oil prices movements in Canada.

4.2 VAR analysis

Since Canada is a small oil exporter, we can reasonably assume that Canada has very little impact on oil prices. Combined with the previous analysis, this means that some portion of the permanent markup shocks can be attributed to oil price movements. Considering that there are other sources of markup shocks such as changes in market structure, it is possible

[13] The relative price of investment is measured by the ratio of the price index of machinery and equipment (CANSIM series V62307272) to the price index of final consumption expenditure (CANSIM series V62307258).

to divide permanent markup shocks into two factors, that is, oil price shocks and non-oil markup shocks. To separate the effects of both types of markup shocks, we modify our benchmark VAR by including oil price changes in the VAR.

Assuming that oil price changes are exogenous to the Canadian economy, we attempt to identify oil price shocks as unanticipated changes in oil prices. Since unit root tests on oil prices unambiguously show that oil prices are non-stationary, oil price shocks lead to permanent changes in the level of oil prices.[14] At the same time, we can modify long-run restrictions in the benchmark VAR to identify other structural shocks: (1) only oil price shocks and non-oil markup shocks lead to permanent changes in the markup, (2) only oil price shocks, non-oil markup shocks and technology shocks affect the real wage in the long run. These long-run identifying restrictions together with the recursiveness assumption of Christiano et al. (1999) enable us to estimate the effect of each structural shock.

Now the structural moving average representation is

$$Z_t = C(L)\xi_t \tag{4.1}$$

where Z_t is the vector that consists of seven variables, and ξ_t is the vector of structural shocks. Specifically, $Z_t = [\Delta p_t^o,\ \Delta\mu_t,\ \Delta w_t,\ \Delta y_t,\ u_t,\ \Delta p_t,\ r_t]'$ where Δp_t^o is the (log) change in oil prices and the other six variables are the same ones as in the benchmark VAR in equation (3.1). The first element of ξ_t is an oil price shock (ξ_t^o), the second is a non-oil markup shock (ξ_t^{no}), the third is a technology shock (ξ_t^a), and the last is the policy rate shock (ξ_t^r).

Usually, equation (4.1) is estimated by converting it to the VAR representation which can be written

$$A_0 Z_t = \Gamma(L) Z_{t-1} + \xi_t \tag{4.2}$$

where A_0 is a matrix that shows contemporaneous relationships among variables in Z_t, and is normalized to have ones along the diagonal; $\Gamma(L)$ is a matrix of lag polynomial. The first

[14] Based on data on oil prices (the price of Brent) for the period 1982:Q1-2009:Q4, both ADF and PP tests do not reject the existence of a unit root at all conventional significance levels. Moreover, the KPSS test rejects the null hypothesis of stationarity at the five percent level. The test statistics are

$$ADF(2) = -0.846, \quad PP(5) = -0.952, \quad KPSS(9) = 0.610$$

where statistics are t-statistics for ADF and PP tests, and an LM-statistic for the KPSS test; numbers in parentheses are optimal lags.

equation in (4.2) is

$$\Delta p_t^o = \Gamma_{oo}(L)\Delta p_{t-1}^o + \Gamma_{o\mu}(L)\Delta\mu_t + \Gamma_{ow}(L)\Delta w_t + \Gamma_{oy}(L)\Delta y_t \\ +\Gamma_{ou}(L)u_t + \Gamma_{op}(L)\Delta p_t + \Gamma_{or}(L)r_t + \xi_t^o \tag{4.3}$$

where $\Gamma_{ij}(L)$'s are lag polynomials corresponding to each variable. Under the assumption that only oil price shocks lead to permanent changes in the level of oil prices, lag polynomials in equation (4.3) except $\Gamma_{oo}(L)$ are restricted to have a unit root. But it should be noted that, when oil prices are exogenous, all the terms except $\Gamma_{oo}(L)\Delta p_{t-1}^o$ and ξ_t^o vanish from the equation. Thus we can simply estimate the first equation by the following:

$$\Delta p_t^o = \Gamma_{oo}(L)\Delta p_{t-1}^o + \xi_t^o. \tag{4.4}$$

The other equations in (4.2) are estimated by the standard method that implements long-run restrictions and the recursiveness assumption of Christiano et al. (1999).

The estimated IRFs from this extended VAR are shown in Figure 5. Panel (a) is IRFs to an oil price shock. When there is a positive oil price shock, oil prices overshoot in the short run, but then approach a new level in the long run. The response of the markup ratio is similar to that of oil prices. Real wages decline both in the short and long run. Inflation jumps up immediately, which is consistent with two oil shock experiences in the 1970s and early 1980s. One interesting thing to note is that the responses of output and per-capita hours are positive in the short run, but then turn negative. We think that this feature may be associated with two possibilities. One possibility is that a rise in oil prices may act as a favorable terms of trade shock because Canada is a net oil-exporter. The other is that the oil price shock in the VAR may not capture pure supply-side effects. As Kilian (2009) reports, changes in oil prices in the 2000s are likely to be primarily affected by global aggregate demand shocks unlike the 1970s. Thus if the rise in oil prices is associated with world-wide economic expansions, then Canada's export may increase after the oil price shock leading to positive responses of output and per-capita hours. Panel (b) displays IRFs to a non-oil markup shock. Since oil prices are exogenous, there is no change in oil prices after the shock. IRFs for other variables are qualitatively similar to IRFs to a (combined) markup shock in the benchmark VAR (panel (a) of Figure 3) except that no initial jump in inflation is now observed. Finally, panels (c) and (d) are IRFs to a technology shock and a policy rate shock, respectively. Except that oil prices do not respond, the qualitative features of IRFs are similar to those in the benchmark VAR.

To examine how much of the variation in the markup is explained by each shock, we provide results for the variance decomposition of forecast errors. Table 5 shows the fraction of forecast error variance of the markup that can be attributed to each shock. As is shown in the table, oil price shocks account for the variation in the markup by about 40 to 50 percent for the first three years. But after that, the contribution of oil price shocks gradually diminishes. Non-oil markup shocks explain only little for the first two years, but the contribution of non-oil markup shocks increases substantially after that, reaching about 47 percent after five years. The markup variation due to technology and monetary policy shocks are very small. Taken together, both oil price shocks and non-oil markup shocks can account for the variation in the markup by a substantial amount. Their contribution is over 50 percent after one year, and increases over time, reaching around 80 percent after five years.

We also carry out a historical decomposition analysis to see the contribution of oil price movements to variations in the actual markup since the early 1980s. We assume that the economy was at a steady state before 1983Q1, and that only markup shocks (either of oil and non-oil factors or both factors) impinge on the economy from 1983Q1 onward. We then do a dynamic simulation and compute the path for the endogenous variables in the VAR. The result from this dynamic simulation is shown in Figure 6. In panel (a), the solid line is the log of the actual markup ratio scaled to be zero at 1982Q4.[15] The dotted line is the variation of the markup ratio caused by two permanent markup shocks, that is, oil price shocks and non-oil markup shocks. The dashed line is the difference between the actual markup and the markup variation due to two permanent markup shocks. We interpret this difference as cyclical fluctuations of the markup which can be caused by any other structural shocks in the economy. In panel (b), we break down the contribution of permanent markup shocks into two parts: one induced by oil price movements (solid line), and the other due to non-oil markup shocks (dotted line).

As is shown in panel (a), after falling up to 1993, the markup variation caused by the two

[15] As is shown in Figure 4, there is a slight upward trend in the actual markup during the sample period. In the dynamic simulation, all constants in the VAR are left out. To make an adjustment for this discrepancy, the actual markup in panel (a) of Figure 6 is displayed after eliminating the upward trend.

permanent markup shocks started to rise since then. Although the steady rise in the markup in the second half of the 1990s is affected by both oil price shocks and non-oil markup shocks, the contribution of non-oil factors is larger. However, since the late 1990s non-oil markup shocks have reduced the markup ratio whereas oil price movements have kept raising it. In this respect, the role played by markup shocks coming from changes in market structure seems less important in accounting for the trend in the markup in Canada since the late 1990s.

Finally, from this historical decomposition, it appears that the weak correlation between oil price movements and the markup that we have seen in panel (c) of Figure 4 arises from the opposite forces at work especially between 1989 and 1993. Oil prices rose during the period 1989-1990, and then declined up to 1993. However, both non-oil markup shocks and cyclical factors moved in the opposite direction between 1989 and 1993, as a result of which the actual markup and oil prices exhibited very different behaviour.[16]

5 Sectoral analysis

We complement our analysis in section 4 by conducting a sectoral analysis. This analysis helps (a) to examine the role of intermediate inputs in driving a potential wedge between the value-added and gross output based markups and (b) to shed light on how the relationship between oil prices and sectoral markups have evolved over the 1982 to 2006 period via potential direct and indirect effects of oil price changes.

5.1 Value-added vs. gross output based markups

Previously, we have dealt with the markup of value-added output (hereafter, value-added markup). In this subsection, we shift attention to the markup of gross output (hereafter, gross markup). This is for two reasons. First, to see how changes in market structure affect the markup, it is more appropriate to focus on the gross markup. Even though there is no change in the desired markup at the firm level, changes in the share of intermediate inputs in gross output can lead to changes in the value-added markup. Second, constructing the gross markup facilitates the analysis of the effects of oil price movements on the Canadian

[16] During 1983, both oil price shocks and non-oil markup shocks caused the markup to decline slightly. However, the actual markup rose during this period. This turns out to be mainly due to cyclical factors.

markup. Since Canada is a net exporter of crude oil, there are both direct and indirect effects of oil price movements on the markup. When oil prices rise in the international market, the producers of crude oil in Canada earn more as long as there is no change in cost conditions in this sector. This leads to a rise in the markup in the oil-producing sector (the *direct effect*), and in turn in the mining sector at a more aggregated level. At the same time, a rise in oil prices raises production costs for sectors that use crude oil and petroleum products. Since oil is not immediately substitutable with other materials, the rise in oil prices induces an increase in the share of intermediate inputs (including oil), which in turn results in a rise in the value-added markup even when there is no change in the desired markup at the firm level (the *indirect effect*). Thus changes in oil prices create a wedge between the price of value-added output and primary input costs.

To compute gross markups, we assume the following fixed proportions production technology as in Rotemberg and Woodford (1993), Basu (1996), and Conley and Dupor (2003).

$$Q_t = \min\left[\frac{M_t}{\phi_t},\ \frac{F(K_t,\ L_t)}{1-\phi_t}\right] \tag{5.1}$$

where Q_t is gross output, M_t is the amount of materials, and ϕ_t is the variable that represents the quantity of materials needed to produce one unit of gross output. It can be easily shown that there exists a value-added production function of the form in equation (2.2). However, here we assume that the value-added production function is Cobb-Douglas ($Y_t = K_t^\alpha (A_t L_t)^{1-\alpha}$) simply because we are interested in markup trends rather than in its cyclical behavior. Incorporating overhead labour and the CES production function would not matter for this analysis. Thus, the real marginal cost of producing one unit of gross output is

$$mc_t = \phi_t \frac{P_t^m}{P_t} + \frac{1}{1-\alpha}\frac{W_t L_t}{P_t Q_t} \tag{5.2}$$

where P_t and P_t^m are the price of gross output and the price of materials, respectively. In this case, the real marginal cost of producing one unit of value-added output is proportional to the labour income share, that is, $mc_t^v = (1/(1-\alpha))(W_t L_t / P_t^v Y_t)$ where P_t^v is the price of value-added output. So we have

$$mc_t = \phi_t \frac{P_t^m}{P_t} + \frac{1}{1-\alpha}\frac{W_t L_t}{P_t Q_t} = S_t^m + (1 - S_t^m) mc_t^v \tag{5.3}$$

where S_t^m is the share of materials in gross output. Equivalently, we have the following because the markup is the inverse of real marginal cost.

$$\frac{1}{\mu_t} = S_t^m + (1 - S_t^m)\frac{1}{\mu_t^v} \tag{5.4}$$

where μ_t and μ_t^v are gross and value-added markups, respectively. Finally, we have the following relationship between the value-added markup and the gross markup.

$$\mu_t^v = \frac{1 - S_t^m}{1/\mu_t - S_t^m} \tag{5.5}$$

The above equation shows that changes in the share of materials in gross output induce variations in the value-added markup (μ_t^v) even though there is no change in the markup that firms face in their product markets (μ_t).

We use the annual data from the OECD STAN database to compute gross markups for each sector. For this, we set the capital share parameter, α, to the same value that we have used in Section 2 (i.e., $\alpha = a_K = 0.384$). In addition, we assume that this parameter is the same across all sectors although it may differ in the actual economy. This is simply because we do not have enough information on sectoral production functions. To check whether there is a significant problem arising from this assumption, we also provide the PCM measure defined in equation (2.1). It turns out that the two measures exhibit similar trends, and so this assumption seems to be innocuous for our analysis.

Do the changes in the value added markup reflect changes in the share of intermediate inputs in gross output or do they reflect changes in the gross markup? Panel (a) of Figure 7 presents the trend of gross and value-added markups of the entire economy for the period 1982-2006. The trend of both gross (solid line) and value-added (dotted line) markups is similar to the one that we have seen in Section 2. After a rise and a subsequent fall in the 1980s, both markups have increased persistently since the early 1990s. The gross markup exhibits the lowest level of 2.2 percent in 1992 and the highest level of 6.6 percent in 2005. Even with the gross markup, we see that variations in the markup are very persistent, and this suggests that permanent shifts in the value-added markup are not simply explained by changes in the share of intermediate inputs in gross output. As a further check, we examine a trend of the value-added markup that would have occurred if there were no change in the share of intermediate inputs in gross output. As panel (b) of Figure 7 shows, the actual share of intermediate inputs has risen over time although there were some periods of decline. We assumed that this share is unchanged at the 1982 level. Then by using equation (5.5), we computed the value-added markup corresponding to this scenario, which is represented by the dashed line in panel (a). As is apparent from the figure, the rise in the share of intermediate inputs induces only a minor degree of variations in the value-added markup. Thus changes in the value-added markup mainly reflect changes in the gross markup.

5.2 Oil prices and sectoral markups

Sectoral trends of gross markups are displayed in Figure 8. We classified Canadian industries into six aggregated sectors: agriculture, forestry and fishing; mining; manufacturing; utilities (electricity, gas and water); construction; and services. Figures 8 (a)-(c) show gross markups based on equation (5.2) while Figures 8 (d)-(f) provide the PCM measures to check the robustness of the results. It turns out that both measures show a similar trend. Markups in agriculture, forestry and fishing have declined steadily over time. Markups in the mining sector were high in the early 1980s and in the 2000s. This is consistent with the movements of real oil prices that we have already seen in panel (c) of Figure 4. Markups in this sector reached the lowest level in 1998 reflecting a decline in oil prices due to reduced demand for oil after the Asian currency crises. This feature of Canadian markups in the mining sector being highly influenced by the movements of oil prices since the early 1980s may reflect the fact that Canada became a net oil exporter since the early 1980s (see, for example, Jiménez-Rodríguez and Sánchez (2004)). Markups in the manufacturing sector have kept rising over time, which is consistent with Boulhol's (2008) analysis. However, they have decreased somewhat since 2000, and so markups in 2006 remain at about the same level as in 1993. Markups in the utilities sector have gone through dramatic fluctuations. However, we observe a decline since the late 1990s. The construction sector has exhibited a big swing in markups, falling and then rising since the mid-1990s. Markups in the service sector are relatively stable. However, they have declined somewhat since the mid-1990s.

Since oil price movements affect markups in the mining sector directly, a simple way of examining the effects of oil prices on the aggregated markups is to exclude the mining sector. The result from this exercise is shown in panel (a) of Figure 9. Although the gross markup for the entire Canadian economy (solid line) has risen since 1994, it has decreased during the same period when we exclude the mining sector (dotted line). Panel (b) of Figure 9 shows the trend of the value-added markup. Reflecting the gross markup trend, the value-added markup for the entire economy (solid line) has risen since 1994 whereas the value-added markup excluding the mining sector (dotted line) has declined. We also note that the movements of the value-added markup excluding the mining sector are by and large similar to the permanent variation in the markup due to non-oil factors (see panel (b) of Figure 6). A rise in oil prices also induces an indirect effect on the value-added markup in that it increases the share of intermediate inputs in gross output through the cost channel. To get a sense of the size of the indirect effect, we constructed a value-added markup (excluding the mining sector) by assuming that the share of intermediate inputs remains at the 1982 level. The result from this exercise is shown by the dashed line in panel (b). Although oil price increases have raised the value-added markup since 1994, this exercise shows that the indirect effect is small. In sum, these analyses show that oil price movements were a big factor in determining the markup trend in Canada since 1994 through both direct and indirect effects. However, the indirect effect through the cost channel is small, and most changes in the aggregated markup are driven by the direct effect of oil price movements on markups in the mining sector.

6 Conclusions

In this paper, we conducted an empirical analysis of the observation that the markup in the Canadian economy has risen steadily since the early 1990s. The rising markup suggests a widening gap between the actual and the efficient level of output and a declining share of labour income in GDP. We construct several markup measures for the period 1982Q1 to 2009Q4 to confirm that this is a robust pattern. Econometric tests unanimously point to the evidence for the non-stationarity of the markup. This feature allows us to use long-run restrictions within the structural vector autoregression framework to identify permanent markup shocks and determine the effects on macroeconomic variables. We find that oil price movements are especially important for understanding the behaviour of the markup, and separately identify both oil price shocks and permanent non-oil markup shocks. Both oil price and non-oil markup shocks account for 50 to 80 percent of the variation in the markup, with the former dominating at shorter horizons. Moreover, the role of oil price shocks is prominent in accounting for the upward trend in the markup since the mid-1990s. Our sectoral analysis reveals that oil prices have a direct effect on the markup in the mining sector (which includes the oil-producing sector) and have been relatively more important in accounting for the upward trend in the aggregate markup. Other potential explanations such as shifts in market structure, changes in trend inflation and the falling relative price of investment do not appear to be important in accounting for the behaviour of the markup in Canada.

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Table 1

Cyclicality of Markups

(a) Cross correlation between cyclical components

	-2	-1	0	+1	+2
Markup, standard	0.427	0.520	0.493	0.331	0.161
	(0.078)	(0.069)	(0.072)	(0.085)	(0.092)
Markup under CES, $\sigma = 0.5$	0.405	0.493	0.462	0.302	0.140
	(0.079)	(0.072)	(0.075)	(0.086)	(0.093)
Markup under OHL	0.380	0.450	0.404	0.240	0.082
	(0.081)	(0.076)	(0.079)	(0.089)	(0.094)
Markup under OHL & CES, $\sigma = 0.5$	0.354	0.418	0.367	0.207	0.058
	(0.083)	(0.078)	(0.082)	(0.091)	(0.095)

(b) Cross correlation between log differences

	-2	-1	0	+1	+2
Markup, standard	0.191	0.321	0.446	0.105	-0.003
	(0.091)	(0.085)	(0.076)	(0.094)	(0.095)
Markup under CES, $\sigma = 0.5$	0.183	0.309	0.424	0.090	-0.011
	(0.092)	(0.086)	(0.078)	(0.094)	(0.095)
Markup under OHL	0.172	0.279	0.389	0.049	-0.035
	(0.092)	(0.088)	(0.081)	(0.095)	(0.095)
Markup under OHL & CES, $\sigma = 0.5$	0.164	0.266	0.365	0.033	-0.044
	(0.092)	(0.088)	(0.082)	(0.095)	(0.095)

Note: Correlation coefficient between real GDP at period t and the markup at period $t + j$. Numbers in parentheses are standard errors.

Table 2

Unit Root Tests on Markups

	ADF		PP		KPSS	
Markup, standard	-2.077	[1]	-1.847	[3]	0.809***	[9]
Markup under CES, $\sigma = 0.5$	-2.126	[1]	-1.896	[3]	0.802***	[9]
Markup under OHL	-2.083	[1]	-1.883	[3]	0.824***	[9]
Markup under OHL & CES, $\sigma = 0.5$	-2.137	[1]	-1.936	[3]	0.816***	[9]

Note: The statistics are t-statistics for ADF and PP tests, and an LM-statistic for the KPSS test. The numbers in brackets are optimal lags. These lags are selected based on Schwarz Information Criterion in the ADF test, and by using Newey-West automatic bandwidth in PP and KPSS tests. Bartlett kernel is used to estimate the long-run variance of error term for PP and KPSS tests. *** denotes that the null is rejected at the one percent significance level.

Table 3

Granger Causality Test

Null hypothesis	P-value
Markup shocks do not Granger cause oil prices ($\xi^p \nrightarrow \Delta p^o$).	0.358
Oil prices do not Granger cause markup shocks ($\Delta p^o \nrightarrow \xi^p$).	0.084

Note: Markup shocks are estimated from the benchmark VAR.

Table 4

Regression of Markup Shocks on Oil Prices and Relative Price of Investment

	Regression 1			Regression 2		
	Coefficient	Std. error	t-statistic	Coefficient	Std. error	t-statistic
Constant	-6.82E-05	0.0002	-0.243	0.0003	0.0003	0.980
Δp_t^o	0.0037*	0.0019	1.933	0.0040*	0.0020	1.949
Δp_{t-1}^o	0.0038*	0.0020	1.937	0.0046**	0.0021	2.169
Δp_{t-2}^o	5.94E-05	0.0021	0.027	0.0017	0.0022	0.773
Δp_{t-3}^o	0.0025	0.0020	1.264	0.0040*	0.0022	1.810
Δp_{t-4}^o	0.0017	0.0019	0.857	0.0022	0.0022	1.035
Δrpi_t				-0.0047	0.0169	-0.278
Δrpi_{t-1}				0.0133	0.0169	0.787
Δrpi_{t-2}				0.0248	0.0169	1.468
Δrpi_{t-3}				0.0184	0.0170	1.079
Δrpi_{t-4}				0.0109	0.0171	0.639
R^2	0.112			0.162		
D-W	2.134			2.202		
P-value (F-test)	0.031			0.339		

Note: * and ** denote that the null is rejected at the ten and five percent significance level, respectively. The null hypothesis of the F-test in Regression 1 is that coefficients on the current and lagged values of oil price changes are all zero whereas the null hypothesis of the F-test in Regression 2 is that coefficients on the current and lagged values of the relative price of investment are all zero.

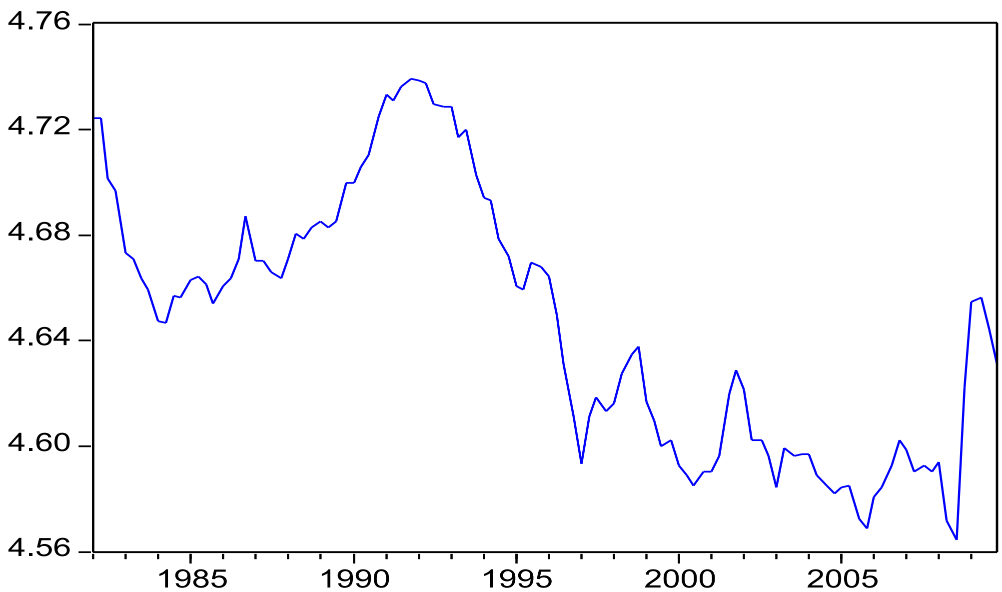
Table 5

Variance Decomposition of Markups (Extended VAR)

	Quarters after shock				
	4	8	12	16	20
Oil price shock	0.507	0.473	0.434	0.377	0.332
Non-oil markup shock	0.008	0.087	0.233	0.373	0.466
Technology shock	0.010	0.007	0.012	0.020	0.025
Policy rate shock	0.036	0.039	0.027	0.026	0.032
Sum of oil price and non-oil markup shocks	0.515	0.560	0.667	0.750	0.798

Figure 1: **Labor Income Share and Measures of Markup (Log Scale)**

(a) Labour income share



(b) Measures of markup

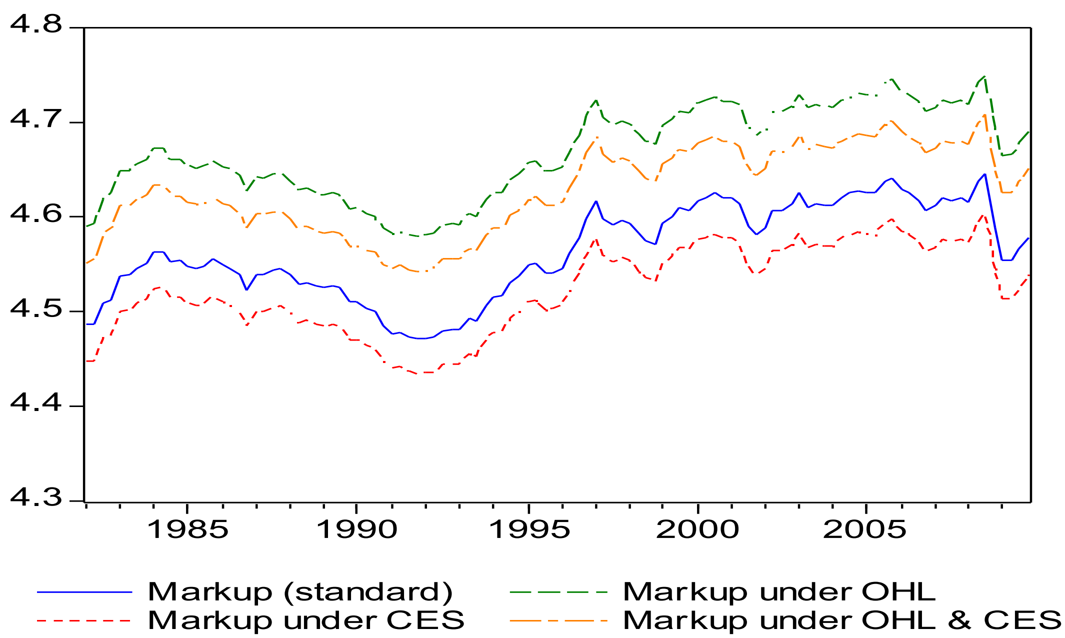
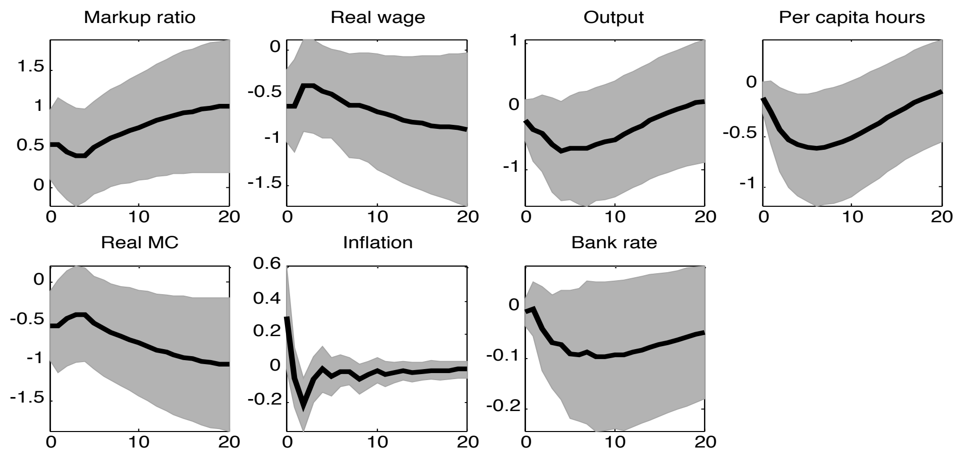
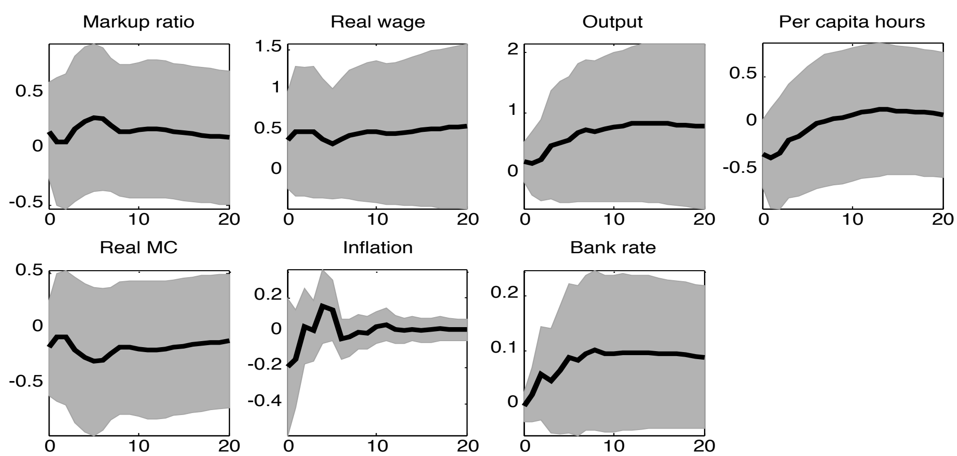


Figure 2: **IRFs in the VAR (Overhead Labour)**

(a) IRFs to a markup shock



(b) IRFs to a technology shock



(c) IRFs to a monetary shock

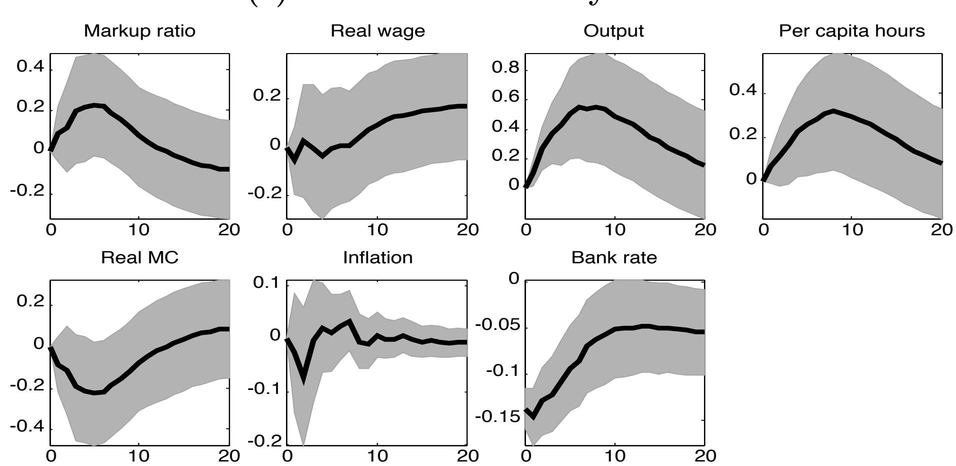
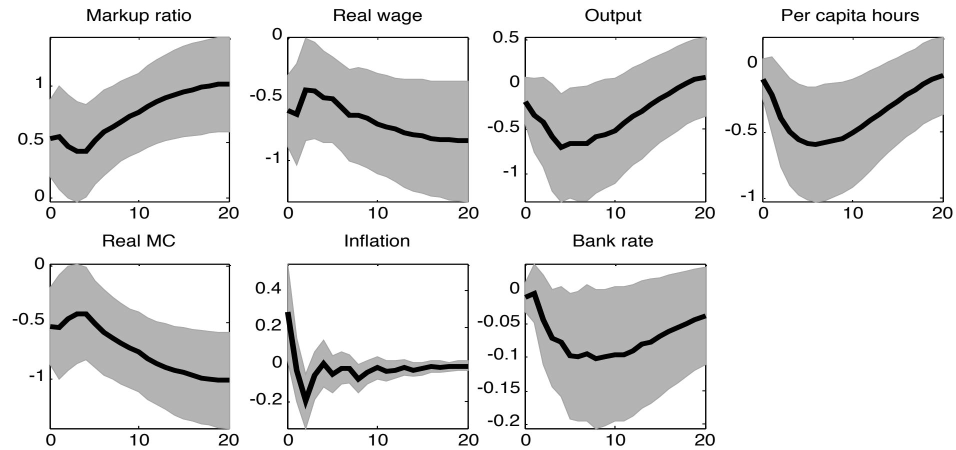
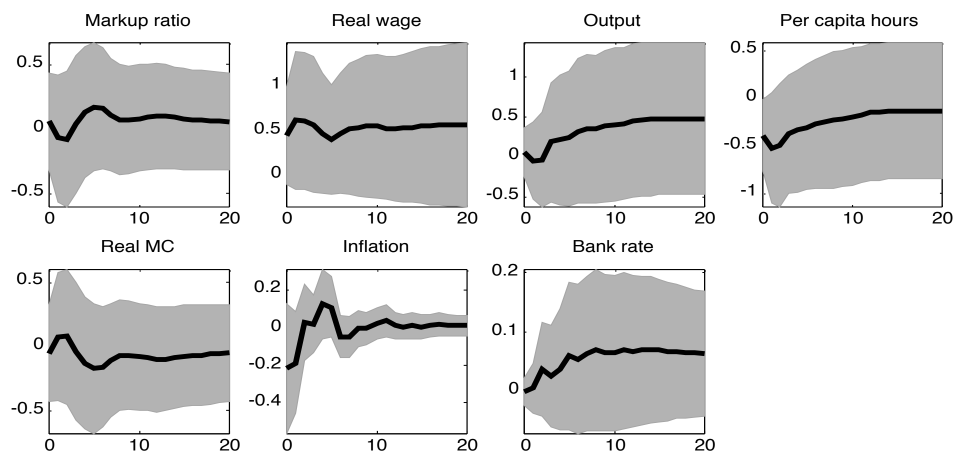


Figure 3: **IRFs in the VAR (Overhead Labour and CES)**

(a) IRFs to a markup shock



(b) IRFs to a technology shock



(c) IRFs to a monetary shock

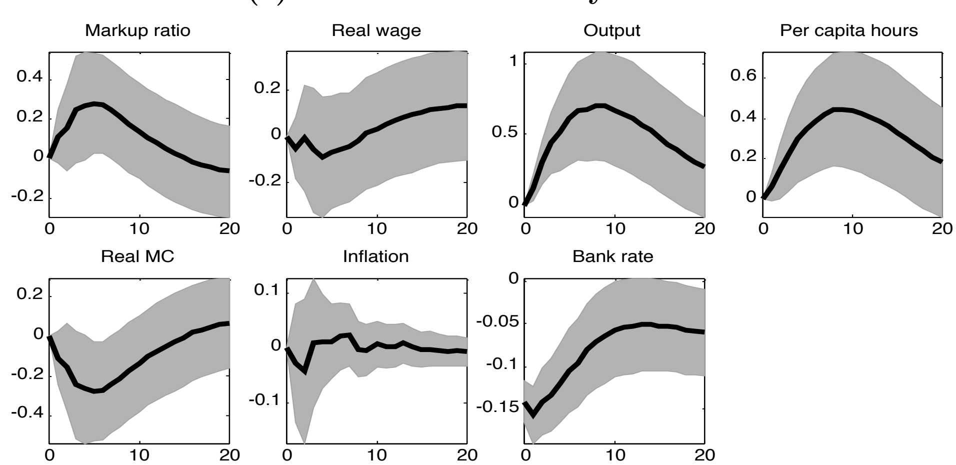
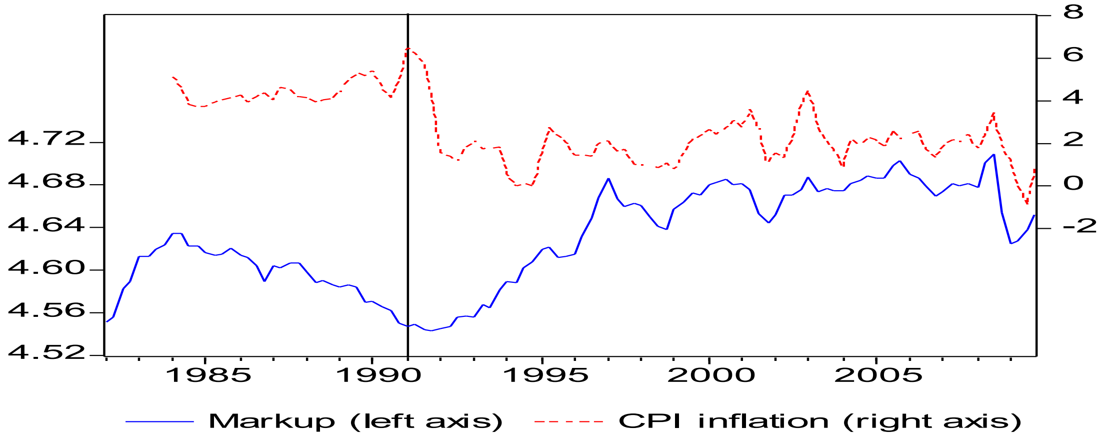
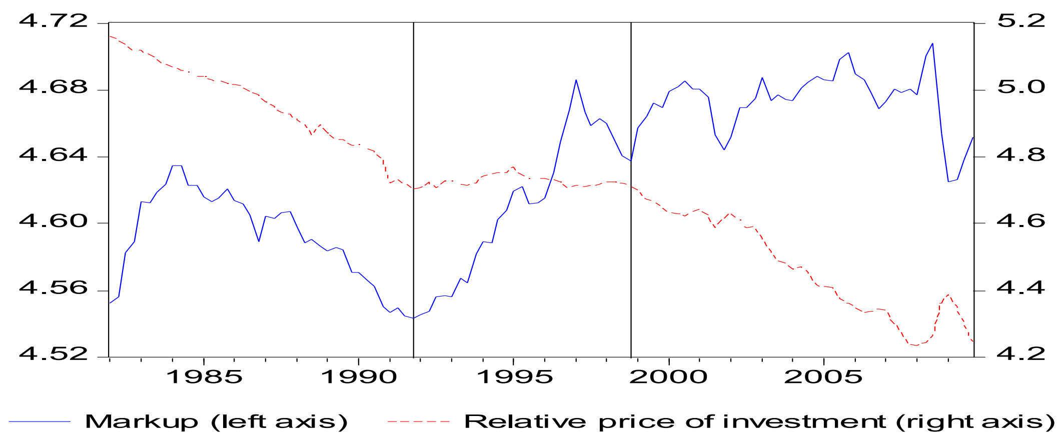


Figure 4: **Potential Factors Explaining Markups**

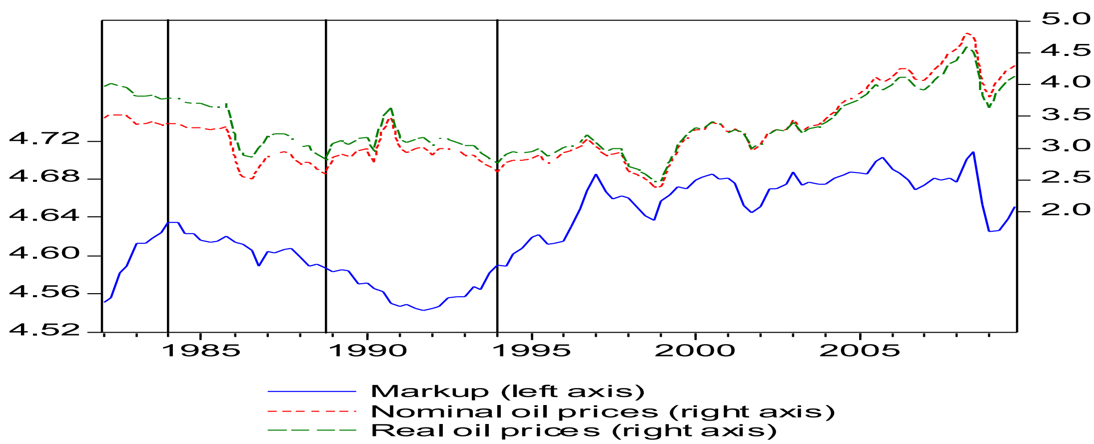
(a) Markup and trend inflation



(b) Markup and relative price of investment



(c) Markup and oil prices



Note: The markup, the relative price of investment, and oil prices are expressed in logs. CPI inflation is percentage changes from a year ago.

Figure 5: **IRFs in the VAR with Oil Prices Included**

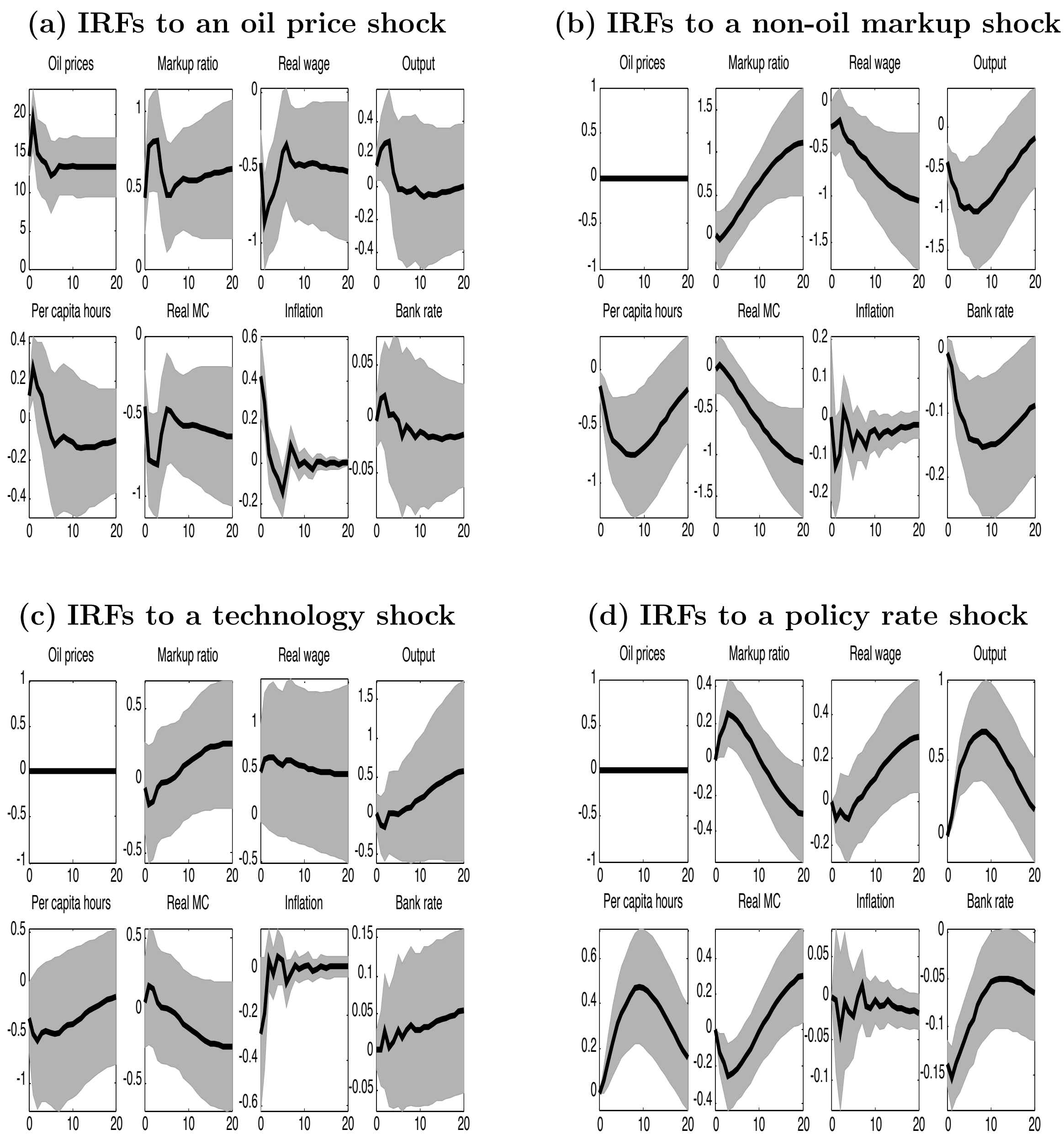
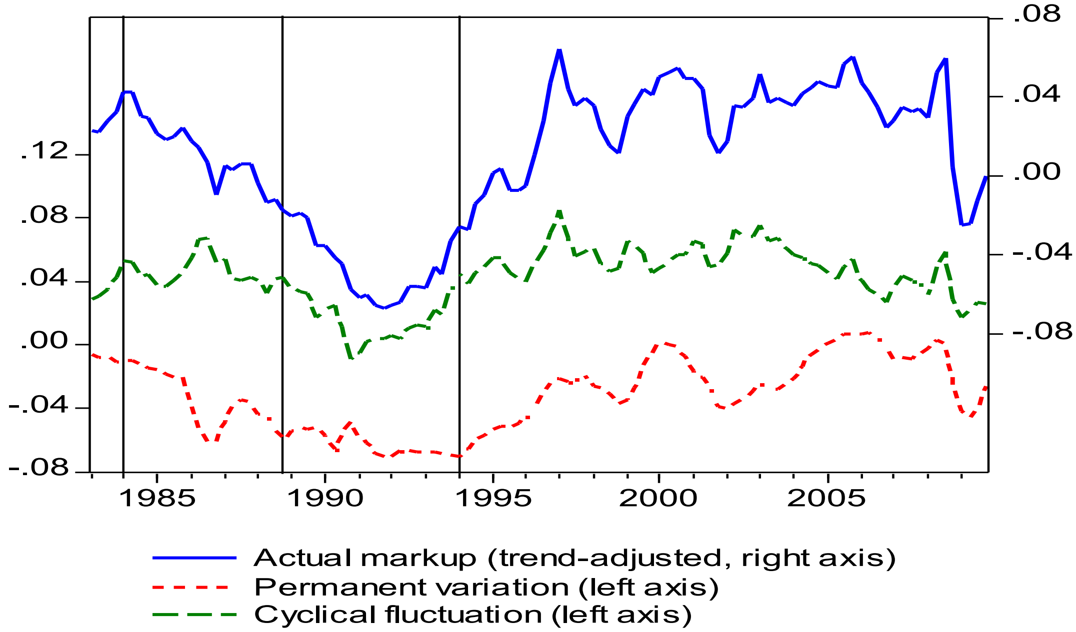


Figure 6: **Historical Decomposition of Markup Variation**

(a) Permanent variation vs. cyclical fluctuation



(b) Oil prices vs. non-oil factors

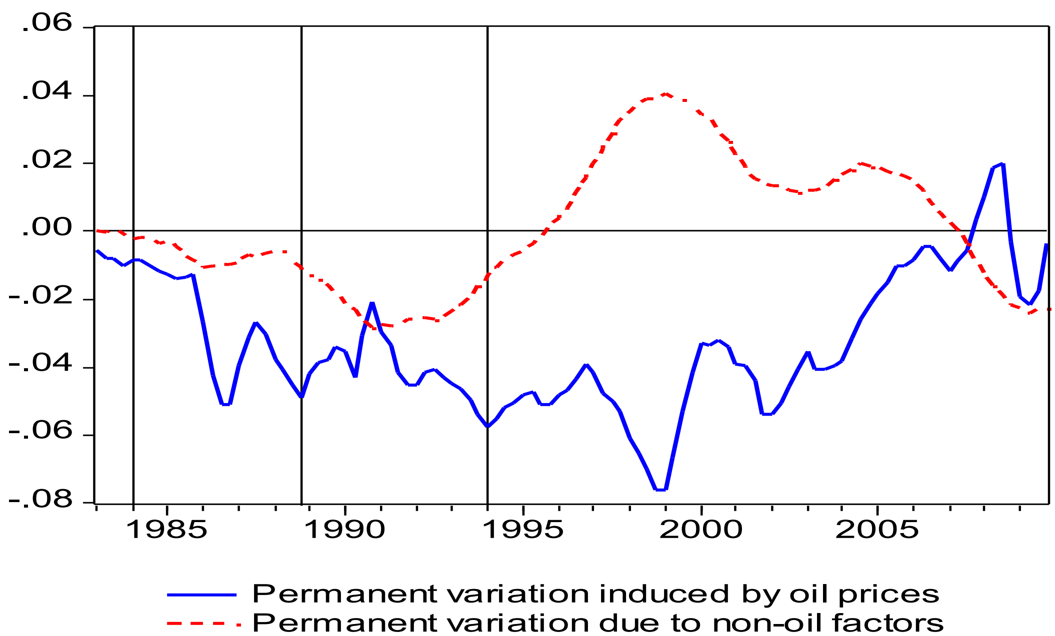
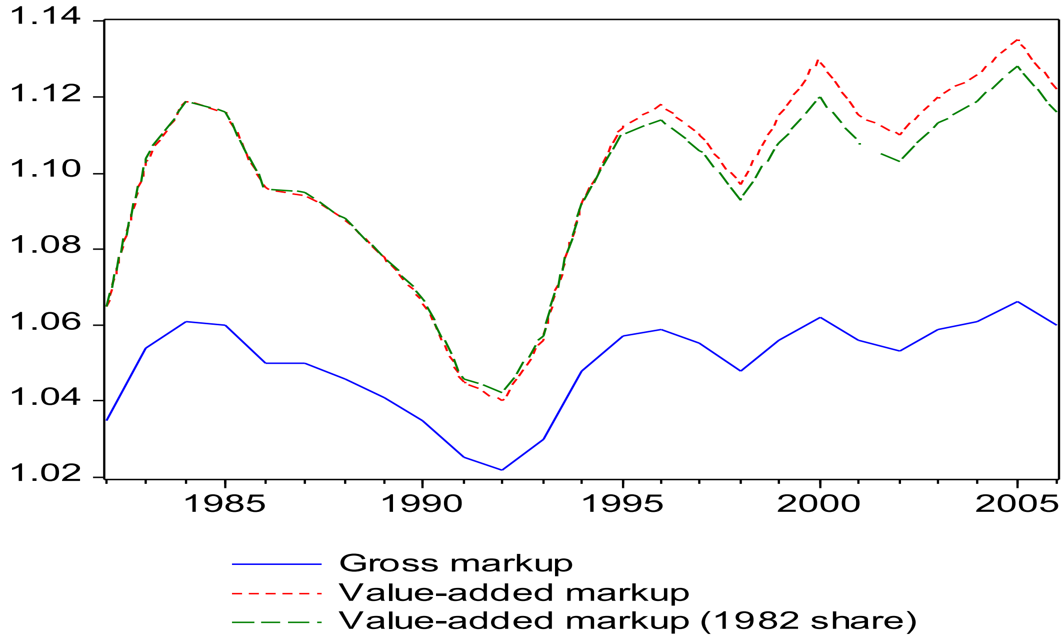


Figure 7: **Trend of Gross Markup and Value-Added Markup**

(a) Gross markup vs. value-added markup



(b) Share of intermediate inputs

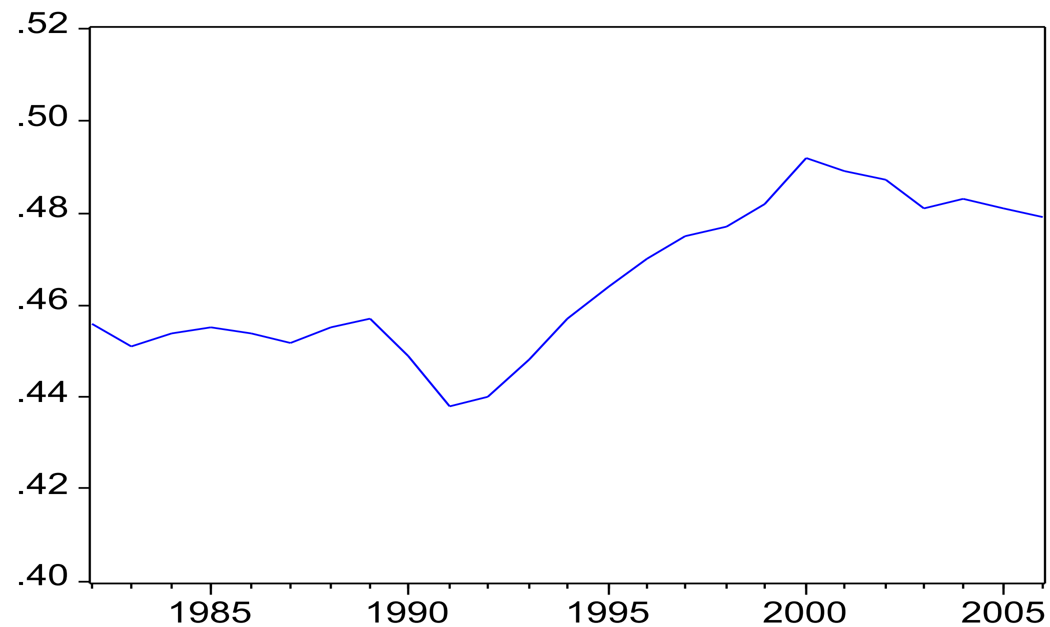
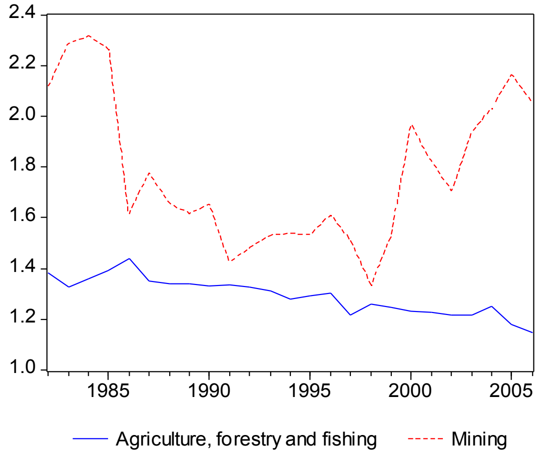
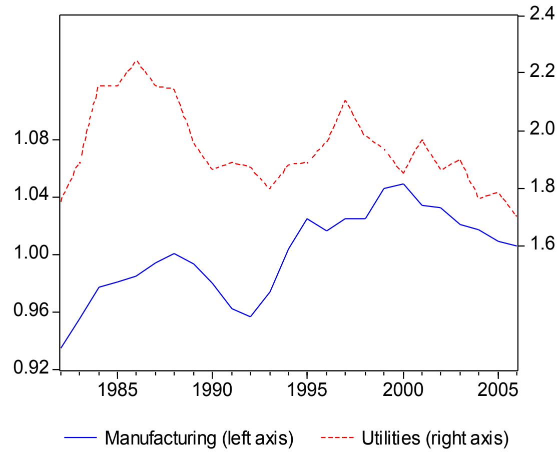


Figure 8: **Sectoral Gross Markups**

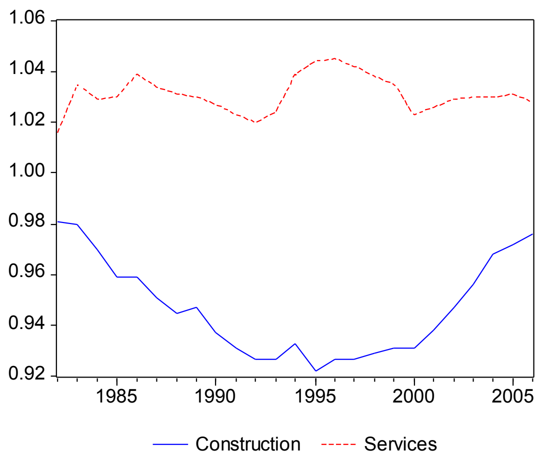
(a) Prod. function-based measure



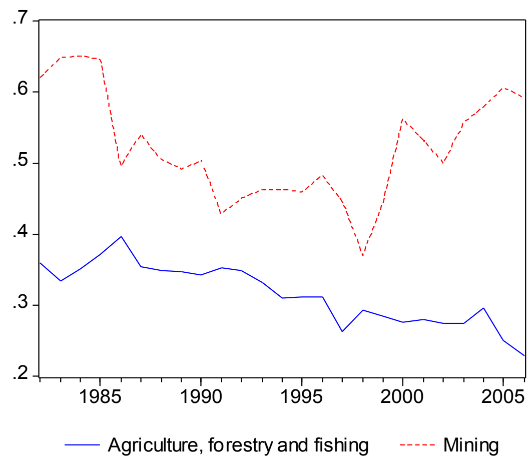
(b) Prod. function-based measure



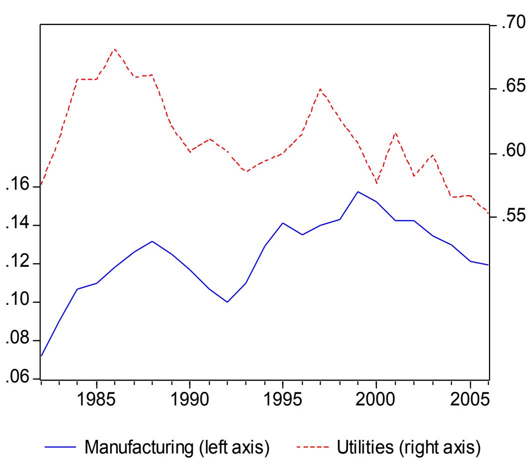
(c) Prod. function-based measure



(d) PCM measure



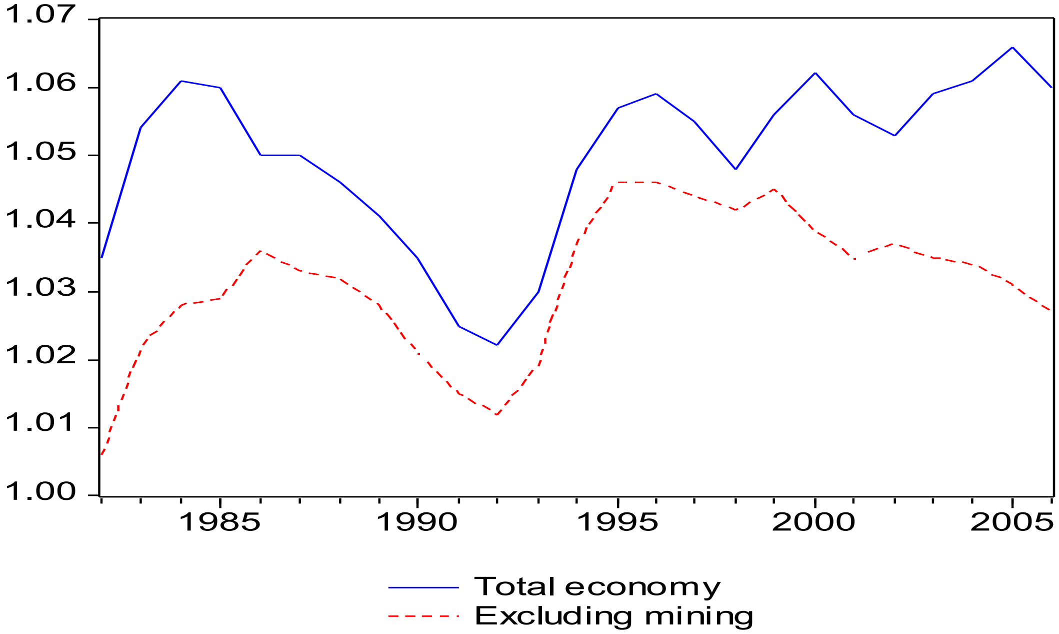
(e) PCM measure



(f) PCM measure

Figure 9: **Markups Excluding Mining**

(a) Gross markups



(b) Value-added markups