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Essays on Real Wages and Money: Cross-Country and Cross-Industry Evidence
(Under the Direction of WILLIAM D. LASTRAPES)

This dissertation researches on real wage responses to money supply shocks across different countries and different industries. The real wage responses to nominal shocks at aggregate-level still remain an unsettled issue. Thus, I have built empirical models that can identify the real wage responses across Group-of-7 countries to find any general tendencies implicit in data as a first research. I have extended the estimation beyond the U.S. since not many economists have researched on the real wage responses for other countries. To this end, vector autoregression representations (VARs) of those 7 countries are built, from which relative stickiness of output price and wage is expected to be identified.

As a second research, I have built a model for the estimation of sectoral real wage responses to the same money supply shocks across U.S. industries. Recently, a lot of economists have shown models in which supply-side channel of monetary shocks are more dominant over demand-side channel empirically. Using a similar VARs with longrun neutrality restrictions, I have found an empirical results that support those views on the monetary transmission.

INDEX WORDS: Vector Autoregression, Long-Run Neutrality Restrictions, Impulse Response Functions, Supply-Side Channel

ESSAYS ON REAL WAGES AND MONEY : CROSS-COUNTRY AND CROSS-INDUSTRY EVIDENCE

by

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CHAPTER 1

INTRODUCTION

This dissertation consists of two essays on the effects of money on labor markets, and in particular on real wages. In both essays, the focus of the research is on identifying the dynamic response of real wages to money supply shocks - innovations in the money stock that emanate primarily from the behavior of the central bank and the banking system - as opposed to other sources of fluctuations such as the demand for money. The reasons for this focus are twofold: a) in some ways, identifying money supply shocks is easier than identifying other shocks; and b) we are ultimately interested in understanding how exogenous changes in the supply of money are transmitted to the real economy.[1]

In the first essay, I focus my attention on the effects of money on the aggregate labor market. How the aggregate real wage responds to money supply shocks is an important distinguishing feature of many theories of the business cycle. For example, aggregate demand theories of aggregate fluctuations that rely on rigid nominal wages imply that aggregate real wages will respond negatively to positive money supply shocks: an increase in the money supply that increases aggregate demand will put upward pressure on the price level, reducing real wages and inducing firms to increase employment and thus output. On the other hand, sticky-price theories suggest that increases in the money supply will raise the effective demand for labor at a given

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[1] See the discussion in Christiano, Eichenbaum and Evans (1999).

price level, generating an increase in the real wage and a movement along the labor supply curve. Furthermore, equilibrium theories of the cycle based on financial market rigidities (e.g. Christiano, Eichenbaum and Evans 1997) typically imply a positive response of the real wage due to “limited participation” in financial markets ; in this case, the liquidity effect of an increase in the money supply on the real interest reduces the cost of labor, thus increasing the demand for labor and the real wage. Clearly, being able to isolate the response of aggregate wages to money supply shocks can help us to refine our understanding of how money is transmitted to the economy.

This issue has been studied before, as noted in the literature in chapter 2. Most of this research has relied on the use of vector autoregression (VAR) techniques to estimate the impact of money supply shocks on aggregate real wages. However, there remains a lack of consensus on how aggregate real wages respond to such shocks due to the lack of robustness of many of the findings (Lastrapes 2001). In chapter 3, I revisit this evidence from VARS by providing at least two improvements to the extant studies. First, most of the previous work has attempted to identify the broader concept of aggregate demand shocks, rather than the more narrow money supply shocks. In this context, I specifically identify money supply shocks by including money, interest rates and prices in the systems that I estimate, and exploit long-run monetary neutrality as the main identifying restriction. Second, whereas most of these studies pay attention only to data from the US, I utilize observations from the G-7 countries.

In sum, I find that the real wage, in general, responds positively to positive money supply shocks for most of the countries except for Italy and Japan, which show negative responses when the real wages are deflated by producer price index. The real wage responses tend to vary as the price deflator shifts from PPI to CPI and GDP deflator, though, from which no robust responses are found. For the most part, then, these findings provide some support for sticky-price and limited participation models.

In the second essay, I move from aggregate real wages to industry-level wages. The motivation is to help refine the understanding of why money supply shocks affect real activity. Specifically, I follow Barth and Ramey (2000) and ask whether money shocks are transmitted to disaggregated markets primarily through demand side effects or supply side effects. For example, if money works primarily through market demand (and sticky prices), then industry level real wages will tend to fall with a positive money supply shock (i.e. the industry-level price will rise more than the industry-level wage).[2] If a cost channel predominates, such as the financing effect of Christiano, Eichenbaum and Evans (1997), the opposite will occur. As in Barth and Ramey, I identify the response of industry level real wages to money supply shocks in the context of a VAR. Unlike in their paper, I use long-run monetary neutrality as an identifying restriction to gauge the robustness of their results.

The industry level real wages generally respond positively to aggregate money supply shocks, which supports the hypothesis that supply side channel plays more dominant role as opposed to traditional way of transmission of the shocks. Moreover, the price of output for more than half of the industries considered falls, which tends to rule out the sticky-price explanations. The findings by Barth and Ramey are, therefore, robust to different model specification.

More literatures and articles are reviewed in the following chapter followed by the first research on the real wage responses across G-7 countries in chapter 3. Chapter 4 has a research on the real wage responses across different industries in the U.S. and conclusions are added in the last chapter.

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[2] Barth and Ramey (2000) provide a simple illustrative model.

CHAPTER 2

LITERATURE REVIEW

2.1 Real Wage Responses across G-7 Countries

From neoclassical theory of employment, it is typically predicted that there is a negative correlation between real wages and the employment or output due to diminishing returns to labor in the short run. Thus, if there is a growth rate of current output in the short-run that exceeds a normal growth rate of output in the long-run, that growth is attributable to an increase in employment relative to the normal trend which will result in a decline in real wages below the normal level of wages.(Otani, 1978) But not many statistical studies have confirmed the relationships to support the theories. Some have shown a negative correlation while others have shown a positive relationship or no specific relationship between them.[3]

Early studies by Dunlop (1938) and Tarshis (1939) show that real wages move rather positively that is not consistent with the theories. Kuh (1966) and Bodkin (1969) later found a statistically insignificant but a positive relation between real wages and employment. Bils (1985) employed disaggregated data, panel data, to show highly positive responses of real wages whose results differ sharply from those

[3] Negative correlations are shown by Neftci(1978), Sargent(1978), Otani(1978), Chirinko(1980), Cushing(1990), Ramey and Shapiro(1998), and Spencer(1998). However, Dunlop(1938), Tarshis(1939), Kuh(1966), Bodkin(1969), Bils(1985), McCallum(1986), Gamber and Joutz(1993), Solon, Barsky and Parker(1994), Christiano, Eithenbaum Evans(1997) have all shown positive correlations while no specific correlation is found by Geary and Kennan(1982), Sumner and Silver(1989), Abraham and Haltiwanger(1995).

neoclassical and Keynesian theories as well.[4] This difference is partly explained by incorporating overtime earnings into their real wage measure. Bils indicated that the use of aggregate time-series data for the analysis of real wage responses contains a serious limitation for several reasons. The composition of the work force does not remain the same over the business cycle, and the aggregate data over the cycle may contain negative or positive biases. McCallum (1986) describes a model that is consistent with non-negative movements of real wages arguing nominal stickiness of product prices. Real wage responses to aggregate demand shocks, according to another paper by Gamber and Joutz (1993), is either positive or insignificantly different from zero, which is consistent with the sticky-price models of McCallum (1986) and the real business cycle models.[5] Similar to Bils (1985), Solon, Barsky, and Parker (1994) have also shown substantially positive real wage responses using longitudinal microdata since 1960s. They show that the positive real wages are obscured in aggregate time series because of a composition bias : the aggregate statistics are constructed in a way that gives more weight to low-skill workers during expansions than during recessions. Substantial evidence in support of the positive real wage movements is also found by Christiano, Eithenbaum and Evans (1997). Aggregate price level initially responds very little to monetary shocks implying that aggregate price is stickier than wages. In addition to all empirical work above, the

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[4] Aggregate time series for the same period also display strong positive responses.

[5] A possible explanation for such a result is that the identification procedure employed in their article underestimates the movements in aggregate supply (labor demand and labor supply) shocks.

(weak) positive correlations or responses of real wages have been supported by many other economists.[6]

A positive correlation between output (or employment) and real wage over the business cycle implies that price is stickier than wage, which is consistent with sticky-price model (McCallum 1986) or recent RBC model (Christiano, Eichenbaum and Evans (CEE), 1997) with supply shocks excluded. According to a limited participation model explained by CEE (1997), an unexpected expansionary money supply shock can cause a positive real wage response stemming from a lower production cost thanks to a lower interest rate (liquidity effect). The price level has been found steady for some period of time empirically.(CEE, 1997). The sticky-price level[7] is attributable to the positive response to the shock. However, a negative correlation implies that wage is stickier than price whose correlation is consistent with neoclassical and Keynesian sticky-wage theories.

Neftci (1978) and Sargent (1978) show that past employment levels do not Granger cause the real wages while past wages do Granger cause employment negatively. Neftci insists that when appropriate distributed lags are estimated the data suggest that employment and real wages are negatively correlated. In the presence of distributed lags, simple regression will not, in general, detect lagged responses and thus could give the erroneous impression that real wages and employment are positively correlated. An application of the appropriate time-series methodology reveals that real wages and employment are negatively related and that the puzzling positive correlation reported by Bodkin (1969) is a result of ignoring the dynamics of the

[6] Prescott (1986), Greenwald and Stiglitz (1988), Blanchard and Fischer (1989), Hall and Taylor (1991), Abel and Bernanke (1992), Christiano and Eichenbaum (1992).

[7] The price level has been found steady for some period of time empirically. (CEE, 1997)

underlying problem. Similar results have been drawn in a model by Cushing (1990) using band spectrum regression.[8] He finds that product real wages move negatively over the period 1947-1970,[9] which reflects the preponderance of aggregate demand shocks in that period.[10] Ramey and Shapiro (1998)[11] also conclude a negative response of real wage to an aggregate demand shock (a shock to government expenditure, military buildup)

In a regime where output prices and wages are assumed to be perfectly flexible, there is no effect on real wages by nominal aggregate demand shocks leaving only nominal wages and prices changed. Thus, no output is expected to be affected. But many business cycle theories assume some existence of wage and price stickiness in their explanations regarding the movements of real economic variables in response to nominal disturbances in the short-run. (Spencer 1998) Such disturbances will cause those output and real wages to deviate from their normal long-run growth trend temporarily due to the failure of proper adjustment by nominal wages and output prices to such shocks over the short period of time. Aggregate demand disturbances may have a positive or negative real wage responses depending on magnitude in relative stickiness of the wage and price. However, if no specific shocks are mentioned in the model, there is nothing much a positive correlation between employment and real wage can tell about the relative stickiness of the wage and price

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[8] The band spectrum regression is introduced by Engle, which provides a direct technique for isolating the purely cyclical relationship.

[9] No consistent cyclical pattern was found for the period of 1971-1986.

[10] Supply shocks since 70s have disrupted the pre-70s negative responses.

[11] They argue that real product wage using producer price index is more appropriate argument for the labor-demand function.

since a general growing economy may experience both AS and AD shocks.[12] In this manner, Spencer (1998)[13] reports that the overall evidence strongly supports the conclusion that sticky wages have been more important than sticky prices in transmitting aggregate demand shocks to real economic activity in the post-war U.S. with a temporary fall in real wages responding to a positive aggregate demand shock.

However, according to the most recent paper by Lastrapes (2001), the real wage responses to the aggregate demand shocks using vector autoregression framework with long-run identifying restrictions have not been found clearly robust. The results he derived are quite different depending on the model specification (e.g., lag length), data transformation to induce stationarity, the choice of proxy for real wage and the choice of variables to include in the (VAR) model. One of the points he addressed is that more precise identification of different sources of aggregate demand shocks, such as shocks to money supply, is needed for the identification of real wage dynamics.

Abraham and Haltiwanger (1995) summed up similarly that it is unlikely to have any systematically consistent positive and negative real wage responses to exogenous shocks. Any empirical analysis of the cyclicality of real wages is clouded by a host of measurement and specification issues : How to measure the real wage? Consumption real wage (using CPI) or production wage (using PPI)? How to detrend the data set? The frequency or sample period of the data for the analysis.

Earlier, Geary and Kennan (1982) were not able to reject a null hypothesis that real wages and employment were statistically independent over the business cycle using

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[12] A general growing economy is to have a positive trend growth in both real wage and output reflecting increases in the capital stock and technical progress.

[13] He has used a nominal wage contracting model.

the data for 12 OECD countries.[14] They found that the differences between their results and those other results (negative or positive responses) are due primarily to the choice of deflator[15] and sample period rather than to differences in statistical technique. Sumner and Silver (1989) have found that real wages were either positive or negative depending on the sample period selected. Employment changes generated by aggregate supply shocks were associated with positive real wage movements, while during years dominated by shifts in aggregate demand, real wages were highly negative.

Some of these papers have attempted to shed light on the transmission mechanism of aggregate demand shocks to real term fluctuations in the business cycles in the short-run while the rest tried to identify the relationship between real wages and employment (or output) over the business cycles. Most of these works have developed models using U.S. data only and few (e.g., Geary and Kennan, 1982) have extended the work beyond the U.S.

Thus, the purpose of first research is to verify the movements of real wage to demand shocks, specifically to a shock to money supply (as opposed to more general aggregate demand shocks), and extend to more industrialized countries. To this end, I will build models for not only the US but several more advanced countries, Group of 7 (G-7),[16] in hopes of finding more general tendencies since most of those previous works have focused on the responses in the US economy only and few have carried

[14] They tested independence of employment and real wages by Haugh's S-test and by F-test proposed by Geweke (1981) in a dynamic regression model.

[15] Wage variable using PPI is more relevant for the labor demand curve.

[16] G-7 countries : Canada, France, Germany, Italy, Japan, United Kingdom, United States

out similar studies across other countries. (Otani 1978, Geary and Kennan 1982) Thus, the VAR models of 6 variables will be built up for the estimation for each country, and the models are expected to provide a better identification of the real wage responses and relative stickiness of the wage and price. Furthermore, long-run neutrality restrictions are imposed to better isolate money supply shocks from other supply shocks as claimed by many others like Gali (1992), Kim (1999) and Lastrapes (2001).

2.2 Dynamic Effects of Money on Industry-Level Labor Markets

Many economists have shown short-run dynamics of real wage and output or employment to aggregate demand shocks like money supply shocks in a traditional way. The aggregate demand shocks effect the real variables through a demand channel of transmission in the short-run with some type of rigidity in the economy. Aggregate price, in general, is believed to move positively following expansionary monetary shocks, from which a negative real wage response is expected.

However, some other economists developed empirical models that show positive real wage responses using sectoral U.S. data, which stresses the importance of supply-side channel of monetary shocks. Christiano, Eichenbaum and Evans (hereinafter CEE, 1997) have built an empirical model with an assumption that firms should borrow in order to finance and pay their production factors before they receive their revenues from sales. One of the stylized facts with an expansionary monetary shocks is lower initial interest rate, liquidity effect. Even though some researchers (Bernanke and Blinder 1990, Strongin 1991) have argued that the liquidity effect is not consistent with empirical data insisting that innovations to broad monetary aggregates mostly reflect shocks to money demand rather than shocks to money supply. However, the liquidity effect is found to be persistent empirically by many others like Christiano and Eichenbaum (CE,1992, 1995)[17], CEE (1997),[18] Lastrapes and Selgin (1995) and Barth and Ramey (2000). With liquidity effects, CE (1995) and CEE (1997) have shown more positive real wage responses across the U.S. industries that stresses the importance of supply side channel of monetary transmission. CEE (1997) claim that the aggregate price is unresponsive to the monetary shocks for a substantial period of time implying that supply-side channel has played a dominant role, which is supported by many others. (Bernanke and Mihov 1998, Keating and Nye 1999) The confirmation of positive real wage response across the industries has recently been supported by Barth and Ramey (2000). They argue that a cost-channel is a dominant mechanism of transmission in the short-run after monetary shocks. They further insist that any price puzzle may not be an enigma at all since the puzzle ignores the possibility that the monetary transmission mechanism itself has cost effects. Prices should rise in the short-run following an unanticipated monetary contraction if the cost effects of the monetary transmission mechanism dominate the demand effects.

The importance of credit conditions are well documented empirically by Kashyap, Lamont and Stein (1994). They have tried to find empirical evidence of interest rates that effect inventory investment, which was claimed by Blinder and Maccini (1991). As interest rate rises following an contractional monetary shock, industries are

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[17] Christiano and Eichenbaum (1992) have built a model that show that any expansionary monetary policy shocks generate persistent lower interest rates with positive effects on real economic activities.

[18] CE(1995) and CEE(1997) assume that firms are forced to borrow working capital in advance (firms must finance their variable inputs like labors) on a pay-as-you-go basis with cash since the revenues do not accrue until the end of the production period.

expected to cut back on their inventory volumes as financing or lending becomes more expensive. Thus, the monetary shocks are transmitted to real variables through a cost-channel assuming a significant number of industries are bank-dependent and their real economic activities are a lot sensitive to credit conditions (or bank lending conditions). They found that industries cut their inventories significantly as the access to public debt markets is more tightly constrained, which is also supported by Barth and Ramey (2000).

Gertler and Gilchrist (1994) also found a prominent role of financial factors (supply-side channel) in the slowdown of aggregate inventory demand in their analysis small versus large-firm reaction to monetary shocks. The large firms initially borrow to accumulate inventories while small firms shed inventories at a relatively quick pace, which implies that the small firms are more sensitive in their reaction to the shocks (more credit conditioned). Thus, there are more liquidity constraints on small firms.

Earlier, Farmer (1985, 1988) has shown the effect of monetary shocks on sectoral labor market dynamics arguing that higher interest rate leads to more layoffs with inefficiency of the optimal employment contract. The model in this paper predicts a higher rate of unemployment as the high interest rate has negative effects on aggregate supply especially during recession (due to imperfect financial markets). The high interest rate cause industries to write labor contracts in which workers (or other factors of production) are laid off more frequently than would otherwise be the case assuming that firms have superior information (in a world of asymmetric information). Thus, his work suggests that supply-side effects of interest rates can account for much of the employment variation in U.S. data.

Thus, the purpose of second research is to identify the real wage responses to the monetary shocks, from which the relative importance of demand-side channel and supply-side channel is expected to be better explained. The ultimate goal of this research is to gain some empirical sense of the importance of supply-side channel of monetary shocks on real economic activities. Although the underlying theories are divided, demand-side channel and supply-side channel, a common prediction is that differences in cyclical behavior should emerge across firms, depending on their respective access to capital markets (or their credit conditions). This prediction leads this research to identify the real wage responses (and relative price ratio), from which the supply-side and demand-side channels are better identified in its role in the transmission of the nominal monetary shocks to real economic variables (since the money affects the economy not only through its effect on aggregate demand but also on aggregate supply). I focus on monetary shocks because a number of researchers have identified it as an important source of aggregate demand disturbances in the postwar period. (Romer and Romer 1989, Bernanke and Blinder 1992) Long-run neutrality restrictions are used to better trace out the effect of such monetary shocks across the industries and to discriminate money supply shocks from other aggregate supply shocks.

CHAPTER 3

MONEY AND REAL WAGES : TIME-SERIES EVIDENCE ACROSS G-7 COUNTRIES

3.1 Introduction

The real wage response to nominal money supply shocks can be an important indicator of the source of aggregate fluctuations. Keynesian sticky- wage theories of the business cycle argue that the transmission of nominal shocks to real activity causes countercyclical aggregate real wage movements along the labor demand curve in the short-run.(Gray 1976, Fischer 1977, Otani 1978, Ramey and Shapiro 1998, Spencer 1998) On the other hand, sticky-price models imply a procyclical response of the real wage to demand shocks (e.g., limited participation model by Christiano, Eichenbaum and Evans 1997), in which the demand for labor depends on the interest rate implying positive responses of the real wage. It is, therefore, important to understand how wages actually respond to such shocks since their responses can help determine the relative importance of these competing theories.

Many economists, including Gamber and Joutz (1993), Christiano, Eichenbaum and Evans (1997), Spencer (1998), and Lastrapes (2001) have tested and estimated the dynamic responses of real wages to aggregate demand shocks using aggregate post-war U.S. data. But the empirical evidence is mixed, with contradictory conclusions about the real wage responses to the shocks even when identical statistical techniques are used. Gamber and Joutz (1993) find a positive response of real wages to aggregate demand shocks. Their finding on the real wage is consistent with sticky-price models.(McCallum 1986, Christiano and Eichenbaum 1992) CEE (1997) also find positive real wage responses to money supply shocks.

Spencer (1998), however, using techniques identical to Gamber and Joutz (1993) finds a negative real wage response insisting that sticky wages have been more important than sticky prices in transmitting aggregate demand shocks to real economic activity in the post-war U.S. Lastrapes (2001) points out the sensitivity of these results to model specification and measurement issues. Clearly, additional research is needed.

The purpose of this chapter is to identify the real wage responses to specific aggregate demand shocks, namely, money supply shocks, using vector autoregression techniques. To this end, a VAR representation of 6 variables (real wage, real output, interest rate, real exchange rate, real money stock and nominal money stock) will be built up for the estimation in this research. Furthermore, I will estimate models for not only the US but also for the remaining G-7 countries : Canada, France, Germany, Italy, Japan and United Kingdom. Only a few studies have considered using real wage data in different countries to analyze those issues. (Otani 1978, Geary and Kennan 1982) The VAR representation of those variables for each country will be a useful vehicle to identify the short-run real wage responses to such demand shocks assuming a plausible identifying restrictions imposed on the model. Numerous macroeconomic studies have shown that impulse response functions of the VAR could provide a helpful information regarding the dynamic movements of the variables of interest to exogenous shocks in a system.

3.2 Empirical Methods

3.2.1 VAR and Identification

Let vector Z_t contain 6 variables, which are generated by the following structural model,

$$A_0 Z_t = A_1 Z_{t-1} + A_2 Z_{t-2} + ... + A_p Z_{t-p} + u_t \qquad (1)$$

where Z_t contains real output (ΔY_t), real wage (Δw_t), interest rate (Δr_t), real exchange rate (Δe_t), real money supply (Δm_t), and nominal money supply (ΔM_t), and u_t is 6 × 1 vector of mutually uncorrelated white-noise disturbances with $E u_t u_t$ = I. The variables are differenced to impose stationarity, a valid transformation if the elements of Z_t have a single unit root. Since equation (1) is a structural VAR, it is not directly estimable and the model to be estimated using OLS is a reduced VAR representation as follows:

$$Z_t = B_1 Z_{t-1} + B_2 Z_{t-2} + ... + B_p Z_{t-p} + \varepsilon_t \qquad (2)$$

where $B_t = A_0^{-1} A_t$, $\varepsilon_t = A_0^{-1} u_t$, and $E e_t e'_t = \Sigma = A_0^{-1} A_0^{-1'}$.

From (1),

$$Z_t = (A_0 - A_1 L - .... - A_p L^p)^{-1} u_t$$

$$= (D_0 + D_1 L + D_2 L^2 + ...) u_t$$

$$= D(L)\, u_t \; ; \qquad (3)$$

and from (2),

$$Z_t = ((I - B L - B_2 L^2 - .... - B_p L^p) e_t$$

$$= (I + C_1 L + C_2 L^2 + ...)\varepsilon_t$$

$$= C(L)\varepsilon_t \qquad (4)$$

C(L) and Σ are obtained from the estimation of the VAR in (2), as seen by equation (2). However, the structural coefficients in (1) and (3) can not be recovered from the reduced form estimates without restrictions on the structural system, since the mapping from structure to reduced form is not unique. The restriction employed here is long-run monetary neutrality : a permanent shock to the level of nominal money, or a temporary shock to the growth rate, has no permanent effect on the levels of real variables at the infinite horizon.[19] Let's see how this set of restrictions identify D(L)

$$C(L)\varepsilon_t = C(L)A_0^{-1}u_t$$

which implies that

$$D(L) = C(L)A_0^{-1} \cdot \qquad (6)$$

where $D_0 = A_0^{-1}$.

Note from (6) that

$$D(1) = C(1)\, D_0 \qquad (7)$$

and $D(1) = \sum_{i=0}^{\infty} D_i$

Finally,

$$D(1)\, D(1)' = C(1)\, D_0 D_0' C(1)' = C(1)\, \Sigma C(1)' \qquad (8)$$

[19] The use of restrictions at the infinite horizon was pioneered by Shapiro and Watson (1988), and Blanchard and Quah (1989). It has been used extensively in the VAR literature with regards to aggregate real wages. (Gamber and Joutz 1993, Spencer 1998, Lastrapes 2001)

The purpose of the empirical strategy is to identify D(L), the dynamic multipliers showing the responses of the system variables to the money supply shocks. Equation (8) shows how this identification can be achieved by imposing restrictions on D(1), the infinite-horizon responses of the levels of the variables, $\lim_{k\to\infty}\frac{\delta z_t}{\delta u_{t-k}}$.[20] Long-run neutrality restricts the last column of D(1) to be all zeroes except for the last element. That is,

$$\lim_{k\to\infty}\frac{\delta y_t}{\delta u_{6t-k}}=\lim_{k\to\infty}\frac{\delta w_t}{\delta u_{6t-k}}=\lim_{k\to\infty}\frac{\delta r_t}{\delta u_{6t-k}}=\lim_{k\to\infty}\frac{\delta e_t}{\delta u_{6t-k}}=\lim_{k\to\infty}\frac{\delta m_t}{\delta u_{6t-k}}=0, \qquad (9)$$

where u_6 is defined to be the money supply shock. Lastrapes (1998) has shown how this restriction is sufficient to identify the response of each variable to money supply shocks. The scale of the money supply shock is identified from the Cholesky factor of $C(1)\ \Sigma C(1)'$.

3.2.2 Data

The data used in this paper are selected to be as close to each other as possible across the G-7 countries. The quarterly data range from 1960 through 1998 depending on the availability. The data were obtained from 'OECD Main Economic Indicators' : GDP at constant prices (or industrial production), hourly earnings in manufacturing sector, money supply (M1), long-term interest rates (government bond), and exchange rate against the U.S. Thus, the VAR model for the US has 5 variables. Currently, the hourly earnings does not include any overtime payment in order to avoid any potential

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[20] For example, if D(1) is lower triangular, then it can be uniquely identified as the Cholesky factor of $C(1)\ \Sigma C(1)'$.

procyclical bias in the estimation as explained by Spencer (1998).[21] I have used a producer price index (PPI), consumer price index (CPI) and GDP deflator, respectively, in an attempt to acquire more general fluctuations of the real wage to money supply shocks even though some economists (e.g. Geary and Kennan, 1982, Sumner and Silver, 1989, Spencer, 1998) claim that using real product wage with PPI is more appropriate since the employment is demand determined along labor-demand function. Ramey and Shapiro (1998) who find a negative response of real wage to the demand shocks also argue that real product wage that uses PPI is more appropriate argument for the labor-demand function. They show that real wage using GDP deflator has no statistically significant cyclicality in the model.

3.3 Dynamic Responses

The empirical model with long-run neutrality restrictions imposed is built on the assumption that the variables in the system are difference stationary and there is no cointegration according to Engle-Granger method. I used augmented Dickey-Fuller test coupled with Phillips-Perron test (1988) in an attempt to test the presence of unit roots in the variables and confirmed the existence of single unit roots in levels for all variables in 7 countries. I have a table 3.1 that shows the results of the tests for the G-7 countries. Deterministic component of the VAR contains constant, seasonal dummy variables and exogenous energy price to control for any potential supply-side shocks during the post-OPEC period. For this measure, I have used producer prices of petroleum products and consumer prices of fuel and electricity for each country.

[21] A model with overtime payment will be estimated later to see any potential procyclical bias.

(source : OECD Main Economic Indicators) The lag length for all the countries is 4, which is proven to be proper for these quarterly data analysis to whiten the residuals by likelihood ratio and Akaike Information Criterion /Schwartz Bayesian Criterion tests. According to table 3.2, only Canada has AIC and SBC select lag 4 and the rest countries have mixed selection. When the AIC and SBC select different lag length, I adopt the parsimony principal and proceed with a model that has a smaller lag length. Ljung-Box Q-statistic is adopted to see if the residuals from an estimated VAR model behave as a white-noise process and no significant autocorrelation is found. I have a table 3.3 for Ljung-Box Q-test for variable residuals. Furthermore, each figure displays the estimated response function along with simulated standard error bands to account for the precision of the estimates. Standard errors are obtained using conventional Monte Carlo integration techniques to estimate the posterior density of the response coefficients. 1000 replications are generated using the antithetic acceleration method of Geweke (1988) to enhance the efficiency of the simulation.

Each figure has the responses of each variable in all 7 countries to nominal money supply shocks. Each country is located in alphabetical order along the columns in following figures while the impulse response functions of variables can be identified in the order of as follows : real wage, real GDP (or employment), interest rate, real money supply, nominal money supply and real exchange rate for each row for the figures imposing long-run restrictions.

The responses of all variables (real wage, real output, interest rate, real exchange rate, and real money supply) are fading away as the time variable, k, increases, which is due to the long-run monetary neutrality restriction imposed on this model. The impulse response functions are shown in following figures. (Figure 3.1-3.6, Figure 3.10-3.12) According to the figures, procyclical responses are generally identified across the countries except Italy and Japan which show strong countercyclical responses when it comes to real wage responses using PPI. However, the responses may change as the price deflator shifts from PPI to either CPI or GDP deflator, which indicates that no robust fluctuation of the real wage is present. Only Japan, UK and the US show strong countercyclical/procyclical responses with robustness no matter what the price deflator is used. Now let me further describe the responses of variables along several crucial dimensions.

3.3.1 Producer Price Index

Let me explain the responses of each variable to money supply shocks starting with producer price index (PPI). As I have mentioned, 6 variables with 4 lag-period are employed in its VAR model. Nominal wage, exchange rate, and nominal money supply are all deflated using PPI for real effects by the nominal money supply. No price deflator is used for the GDP variable since real GDP itself is available in the data.

I will spend more time describing the responses of the variables deflated by PPI to conserve space since the responses of the same variables deflated by CPI and GDP deflators can be identified from the figures. I have normalized the nominal money supply responses of all countries at 1.0 to better compare the responses of the variables among the countries. Let me first start with the responses in Canada. When there is an unanticipated positive money supply shock, its initial effect will be an increase in nominal money supply by 0.36% one quarter (one lag-period or k-1) after the shock. Its effect on the nominal money supply will reach the maximum level at almost 1.0% five quarters after the shock with a steady state converged at 1.0%

thereafter. The real wage responds positively with a 0.30% increase one quarter after the shock, and the response dies down to zero as time elapses. Real GDP also shows a positive response with its maximum level at 0.24% and fades away thereafter due to the neutrality condition. The interest rate, however, moves negatively to a positive money supply shock, which is in line with a liquidity effect (Christiano and Eichenbaum 1992,[22] Lastrapes and Selgin 1995). In addition, the responses of the real GDP and interest rate in Canada support stylized facts about the effects of expansionary money supply shocks shown by previous research (CEE 1997, Bernanke and Mihov 1998).

The real value of the Canadian currency decreases for some period of time in response to a positive money supply shock with its peak around 0.22% one year after the shock, which is confirming some of previous studies (e.g. Lastrapes, 1992). Lastrapes has shown a similar response of real exchange rate to money supply shocks with a conclusion that both nominal and real exchange rates are affected primarily by the real shocks. There are some positive effects on real money stock for some period of time which may imply that the price level does not respond immediately. This is consistent with findings, sticky-price, by many studies like CEE (1997).

France, United Kingdom and the US also show positive real wage responses to the shock and the ways the other variables respond are almost identical to what Canada has shown before. The real wage response of the US is more positively sensitive with its peak at 0.52% than the rest countries. Germany shows positive real wage responses with a lag of almost one year after the shock. However, Italy and Japan show quite strong negative responses to such shocks. Thus, no general tendency of the real wage

[22] They have built a model that show that any expansionary monetary policy shocks generate persistent lower interest rates with positive effects on real economic activity.

is found here even though the responses of the remaining variables for all 7 countries are consistent with the empirical stylized facts. The responses of the real wage may vary across the countries when the PPI is used for real terms.

3.3.2 Consumer Price Index and GDP Deflator

Now let me move on to the responses of the variables when consumer price index (CPI) and GDP deflators are used. Again, the responses may vary depending on the price deflator across the countries and even within a country for Canada, France, Germany and Italy. The real wage response in Canada moves negatively to the same money supply shocks, which may imply that PPI is more stable (or more slow to adjust) than the CPI and GDP deflator in Canada. The real wage in France also respond negatively to the shocks with the lowest level at -0.40% and -0.36%, respectively, one quarter after the shocks. However, the real wage in Germany shows a negative response for more than a year when the variables are deflated by the CPI and a strong positive response when GDP deflator is used. Only Japan (negative), United Kingdom and the US (positive) show consistent responses to the shocks no matter what price deflator is used. Japan shows the most highly negative responses to the shocks with the lowest level at -0.56%, -0.80%, -0.92%, respectively.

3.3.3 Employment

I have reestimated the models adopting employment in manufacturing sector in place of nominal GDP to better account for labor market dynamics, and to see if any changes of the real wage responses are found. The employment in manufacturing sector is used mainly due to the longest availability across the countries. As the figures show (Figure 3.4-3.6), I have a lot similar real wage responses even with employment variable for these 7 countries. The positive real wage response in Canada changes to negative responses as the price deflator changes from PPI to CPI and GDP deflator while the responses of the remaining variables are consistent with economic theory. Thus, as far as the real wage response is concerned, there is almost no difference between using nominal GDP and employment in manufacturing sector. The real wage responses still vary across the countries even though the behaviors of the remaining variables are almost identical to the models employing nominal GDP with long-run neutrality restrictions.

3.3.4 Forecast Error Variance Decomposition

Finally, forecast error variance decomposition tells us the proportion of the movements in a sequence due to its own shocks versus shocks to the other variables. I have figures (Figure 3.7-3.9) for the relative variance contribution of money supply shocks across the price deflators to see the importance of the nominal shocks over time. The vertical orders of variables in the figures are as follows : real wage, real GDP, interest rate, real money supply, nominal money supply and real exchange rate. As many previous studies have shown, the real effects of nominal money supply is generally existed for short-period of time and it fades away eventually as the wage and output price adjust to the shocks. I have a table 3.4 that may show how much and how long the money supply has real effects for each country.

3.4 Conclusion

The theoretical arguments for a countercyclical responses of real wage to an exogenous shock are well documented. But it is generally believed that real wages show procyclical movements over the business cycles due to many previous empirical evidence[23] that do not support the neoclassical and Keynesian theories of employment in the short run. Keynesian theories that are based on wage inflexibilities tend to have a negative correlation between real wages and employment, so is neoclassical economics that is based on a production function that follows downward labor demand curves. With this production function, changes in labor and output will be highly positively correlated and the real wage rate will move countercyclically. Recently, Spencer (1998) has shown that there is a negative real wage response to demand shocks that supports the theories. However, a limited participation model (Christiano, Eichenbaum and Evans, 1997) along with sticky-price model (McCallum, 1986) claims that the real wage responds procyclically in the short-run with a steady price level for a substantial period of time in response to the exogenous monetary shocks.

But no consistent real wage responses have been drawn from the cross country studies here.[24] The responses may vary depending on the price deflators and the countries selected, which supports the previous research of Lucas (1977), Sumner and Silver (1989), Abraham and Haltiwanger (1995), and Lastrapes (2001).

[23] Some of the findings are found to be statistically insignificant, though.

[24] The U.S. and U.K. show positive real wage responses consistently while Japan shows a negative real wage response to the shocks with all the price deflators. However, no consistent real wage response is found for the rest of G-7 countries. They are varying depending on the price deflator.

Table 3.1 Augmented Dickey-Fuller and Phillips-Perron Test for the 7 Countries

	Test	Real Wage	Real Output	Interest Rate	Real Money Supply	Nominal Money Supply	Exchange Rate
Canada	Dickey-Fuller Test	-1.249 (-11.877)	-1.446 (-9.939)	-0.785 (-8.651)	-0.490 (-7.918)	-1.433 (-9.154)	-2.179 (-8.801)
	Phillips-Perron Test	-2.005 (-25.228)	-1.023 (-30.894)	-0.857 (-14.721)	-0.444 (-21.467)	-1.465 (-23.147)	-2.195 (-18.538)
France	Dickey-Fuller Test	-2.632 (-5.420)	-2.393 (-5.044)	-2.182 (-6.793)	-2.088 (-5.461)	-0.970 (-7.043)	-2.607 (-5.868)
	Phillips-Perron Test	-2.259 (-15.780)	-2.120 (-17.246)	-1.986 (-14.367)	-2.278 (-20.623)	-0.998 (-26.071)	-2.523 (-11.184)
Germany	Dickey-Fuller Test	-0.097 (-8.409)	-1.987 (-6.457)	-2.506 (-7.136)	-1.484 (-6.760)	-1.711 (-7.495)	-1.954 (-7.758)
	Phillips-Perron Test	-2.244 (-19.199)	-2.740 (-12.137)	-2.154 (-11.392)	-1.636 (-15.533)	-1.716 (-16.948)	-1.881 (-12.542)
Italy	Dickey-Fuller Test	-0.817 (-8.482)	-0.678 (-7.823)	-1.936 (-5.095)	-1.262 (-5.837)	-1.003 (-7.103)	-1.691 (-6.165)
	Phillips-Perron Test	-1.564 (-20.137)	-0.865 (-21.116)	-1.640 (-9.127)	-1.417 (-16.749)	-1.170 (-18.623)	-1.929 (-10.125)
Japan	Dickey-Fuller Test	-1.121 (-14.819)	-1.769 (-7.660)	-2.593 (-8.920)	-2.172 (-5.725)	-2.531 (-6.253)	-2.321 (-7.042)
	Phillips-Perron Test	-2.278 (-19.356)	-2.122 (-17.886)	-2.802 (-15.142)	-1.722 (-13.734)	-3.502 (-16.738)	-2.024 (-12.574)
UK	Dickey-Fuller Test	-2.880 (-12.236)	-2.872 (-11.932)	-1.553 (-8.659)	-0.927 (-4.851)	-0.658 (-3.548)	-2.782 (-8.836)
	Phillips-Perron Test	-3.662 (-25.953)	-3.845 (-30.484)	-1.339 (-14.311)	-0.587 (-12.644)	-0.118 (-12.656)	-2.631 (-13.916)
US	Dickey-Fuller Test	-2.241 (-11.663)	-1.974 (-8.991)	-1.044 (-8.406)	-1.448 (-8.082)	-2.354 (-8.440)	
	Phillips-Perron Test	-2.487 (-28.823)	-1.832 (-26.168)	-1.078 (-14.732)	-1.354 (-20.112)	-2.405 (-20.396)	

The numbers in parenthesis indicate t-value for first differenced variables and each t-value in the upper row accepts the unit root hypothesis while the t-value in parenthesis rejects the hypothesis. Thus, the figures show that all countries have single unit roots in their variables.

Table 3.2 AIC/SBC Test for Lag Length

	Canada	France	Germany	Italy	Japan	UK	USA
AIC/SBC (lag 8)	-4974 -4338	-2393 -1947	-5803 -5595	-1667 -1445	-3788 -3200	-4326 -3713	-5203 -4567
AIC/SBC (lag 4)	-4997 -4650	-2250 -2007	-5784 -5671	-1664 -1488	-3776 -3456	-4304 -3969	-4956 -4610

AIC test barely selects lag length 8 for the countries but Canada while SBC test definitely selects 4 as a lag length for all countries.

Table 3.3 Ljung-Box Q-Test for Variable Residuals : PPI and 4-lag

	Canada(38)	France(28)	Germany(36)	Italy(17)	Japan(32)	UK(35)	USA(38)
Real Wage	32.991	26.825	52.469	9.786	40.135	37.778	42.506
Real GDP	53.106	48.035	39.983	15.634	36.060	44.612	38.586
Interest Rate	51.486	34.051	34.265	13.894	23.193	38.455	38.875
Real Exchange Rate	28.713	36.112	45.584	16.268	49.682	56.925	n/a
Real Money Supply	25.292	30.201	17.865	16.844	25.907	31.874	15.729
Nominal Money Supply	54.020	35.313	17.615	21.040	27.578	24.690	7.942

Q tests for variable residuals (4 lag) : If the calculated value of Q exceeds the appropriate value in a Chi-square table, we can reject the null of no significant autocorrelations. (refer to the table in Hamilton textbook)

Table 3.4 Forecast Error Variance Decomposition : PPI and 4-lag

Canada

	Real Wage	Real GDP	Interest Rate	Real Exchange Rate	Real Money Supply	Nominal Money Supply
1	18.137	0.018	44.588	0.249	28.056	26.721
2	16.648	0.266	40.144	1.276	42.985	44.165
3	14.420	1.522	36.270	2.608	50.843	55.575
4	10.035	2.883	31.468	3.118	53.338	59.054
5	7.859	3.904	27.502	2.760	51.839	62.055
…	…	…	…	…	…	…
36	0.771	0.934	3.625	0.403	6.429	64.195
37	0.748	0.905	3.504	0.392	6.178	64.185
38	0.725	0.878	3.390	0.381	5.943	64.175
39	0.704	0.852	3.282	0.371	5.724	64.166
40	0.685	0.828	3.181	0.362	5.519	64.158

France

	Real Wage	Real GDP	Interest Rate	Real Exchange Rate	Real Money Supply	Nominal Money Supply
1	3.660	17.383	10.452	1.249	9.460	25.981
2	7.075	13.537	5.899	0.545	10.314	28.525
3	7.330	9.736	3.271	0.317	6.896	25.092
4	6.224	8.344	2.217	0.416	6.314	25.303
5	4.963	7.201	1.938	0.464	5.504	26.247
…	…	…	…	…	…	…
36	0.703	1.393	0.548	0.142	0.694	46.765
37	0.683	1.355	0.533	0.138	0.675	46.935
38	0.664	1.320	0.520	0.134	0.657	47.094
39	0.647	1.287	0.507	0.130	0.640	47.242
40	0.630	1.255	0.495	0.126	0.623	47.381

Germany

	Real Wage	Real GDP	Interest Rate	Real Exchange Rate	Real Money Supply	Nominal Money Supply
1	1.214	60.471	5.592	10.813	13.388	19.122
2	2.165	53.360	2.052	12.986	10.298	22.460
3	1.411	49.745	1.359	10.677	6.812	20.343
4	0.973	45.466	1.103	8.454	4.743	17.804
5	0.787	40.190	0.838	6.481	3.315	14.512
…	…	…	…	…	…	…
36	0.366	3.759	0.309	0.822	0.332	16.005
37	0.356	3.658	0.301	0.800	0.322	16.021
38	0.347	3.561	0.293	0.779	0.314	16.037
39	0.338	3.469	0.286	0.759	0.305	16.052
40	0.329	3.381	0.280	0.740	0.297	16.068

Italy

	Real Wage	Real GDP	Interest Rate	Real Exchange Rate	Real Money Supply	Nominal Money Supply
1	0.220	12.105	13.826	45.969	24.375	44.089
2	0.110	11.095	10.079	28.644	17.195	43.363
3	0.184	10.429	9.283	23.173	10.578	37.725
4	0.566	7.475	8.294	18.559	7.134	34.611
5	0.655	7.739	6.307	13.572	5.642	32.255
…	…	…	…	…	…	…
36	0.563	1.965	1.635	1.545	0.552	10.809
37	0.545	1.891	1.596	1.503	0.536	10.769
38	0.529	1.822	1.558	1.463	0.521	10.732
39	0.513	1.757	1.523	1.425	0.507	10.698
40	0.498	1.696	1.489	1.389	0.494	10.666

Japan

	Real Wage	Real GDP	Interest Rate	Real Exchange Rate	Real Money Supply	Nominal Money Supply
1	8.999	30.562	1.655	0.014	3.537	15.283
2	4.813	22.890	1.117	0.062	2.269	15.985
3	3.329	15.777	0.778	0.214	1.210	14.608
4	2.666	11.349	0.543	0.206	0.691	11.424
5	2.266	7.559	0.534	0.158	0.452	9.124
…	…	…	…	…	…	…
36	0.267	0.672	0.182	0.048	0.045	2.399
37	0.257	0.651	0.177	0.047	0.044	2.377
38	0.247	0.632	0.172	0.046	0.042	2.355
39	0.238	0.613	0.167	0.044	0.041	2.335
40	0.230	0.596	0.162	0.043	0.040	2.316

UK

	Real Wage	Real GDP	Interest Rate	Real Exchange Rate	Real Money Supply	Nominal Money Supply
1	28.888	8.526	23.240	1.805	23.427	25.270
2	26.317	13.388	18.987	3.208	26.508	34.750
3	27.013	15.757	16.752	4.114	28.071	39.294
4	28.024	16.820	15.000	4.681	26.204	38.385
5	30.450	18.388	13.358	5.447	25.727	38.266
…	…	…	…	…	…	…
36	18.321	10.387	2.276	4.981	12.691	29.091
37	17.854	10.170	2.214	4.890	12.391	28.818
38	17.400	9.957	2.215	4.800	12.099	28.522
39	16.958	9.749	2.098	4.712	11.815	28.294
40	16.528	9.547	2.044	4.626	11.539	28.044

USA

	Real Wage	Real GDP	Interest Rate	Real Money Supply	Nominal Money Supply
1	22.507	40.955	17.425	1.506	0.108
2	24.683	38.195	15.138	1.712	0.366
3	24.292	37.909	13.732	2.657	1.123
4	23.137	37.010	11.913	3.021	1.544
5	18.549	34.315	10.097	3.007	1.987
…	…	…	…	…	…
36	1.409	1.940	1.191	0.317	2.888
37	1.360	1.859	1.150	0.307	2.921
38	1.314	1.784	1.113	0.298	2.953
39	1.271	1.714	1.078	0.290	2.984
40	1.231	1.649	1.044	0.281	3.014

Forecast error variance decomposition with CPI and GDP deflators can be identified in the figures.

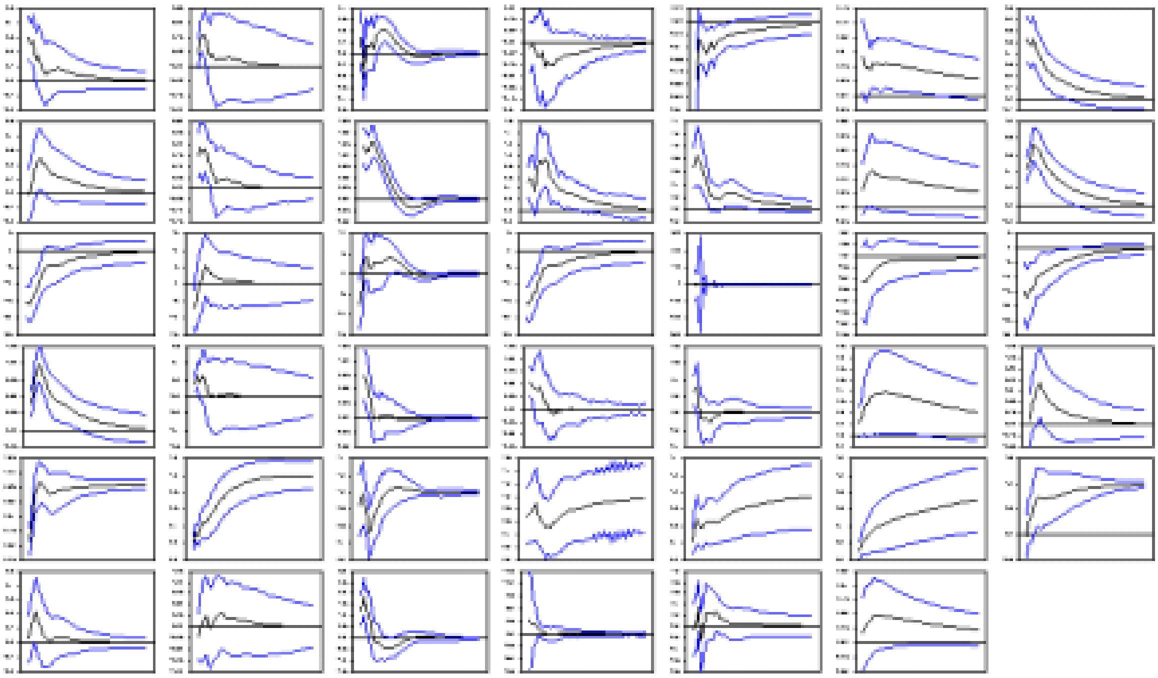

Figure 3.1 Response to Money Supply Shocks - PPI, Output, Lag-4
Canada, France, Germany, Italy, Japan, UK, USA

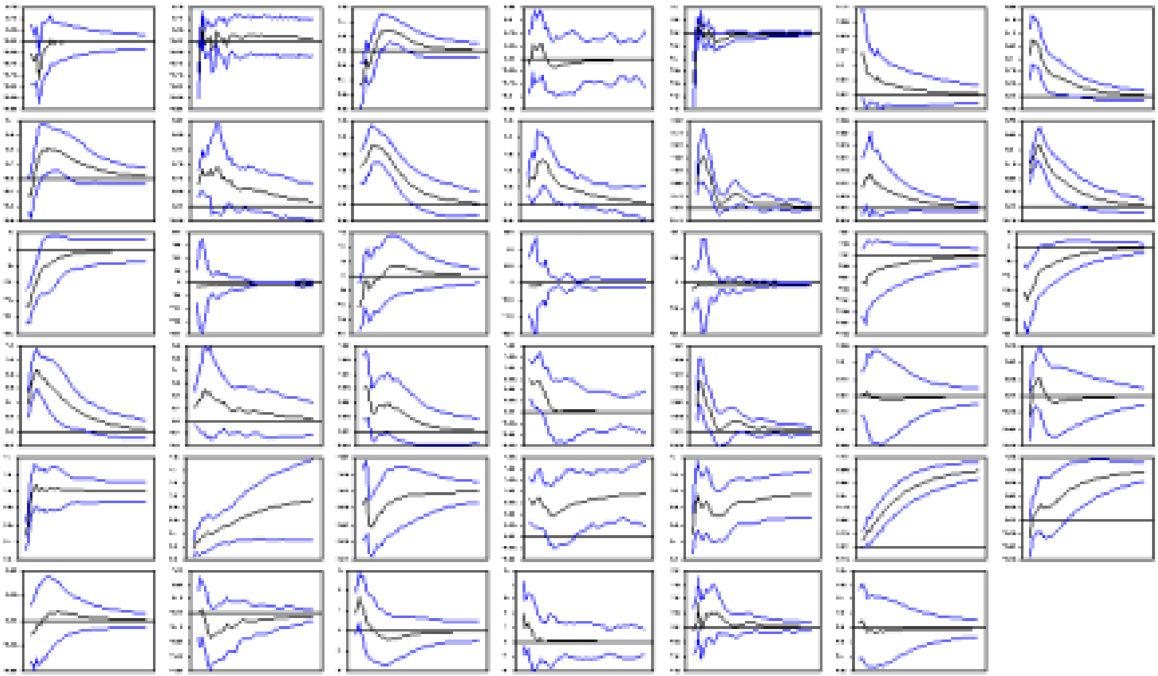

Figure 3.2 Response to Money Supply Shocks - CPI, Output, Lag-4
Canada, France, Germany, Italy, Japan, UK, USA

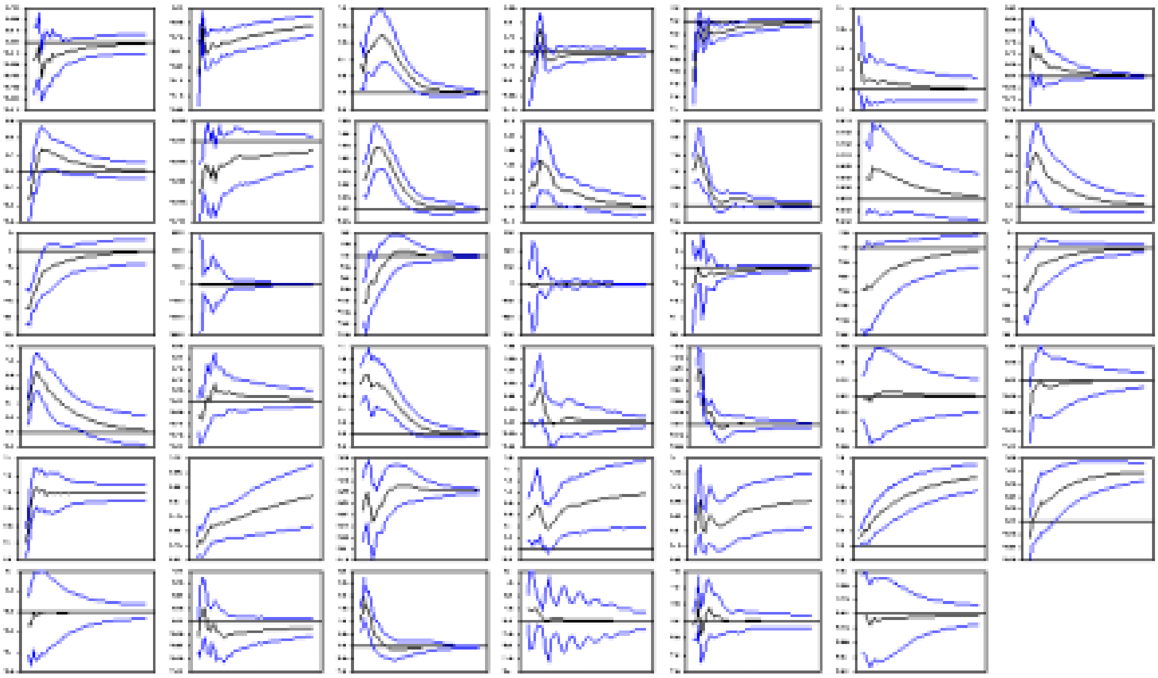

Figure 3.3 Response to Money Supply Shocks - GDP Deflator, Output, Lag-4
Canada, France, Germany, Italy, Japan, UK, USA

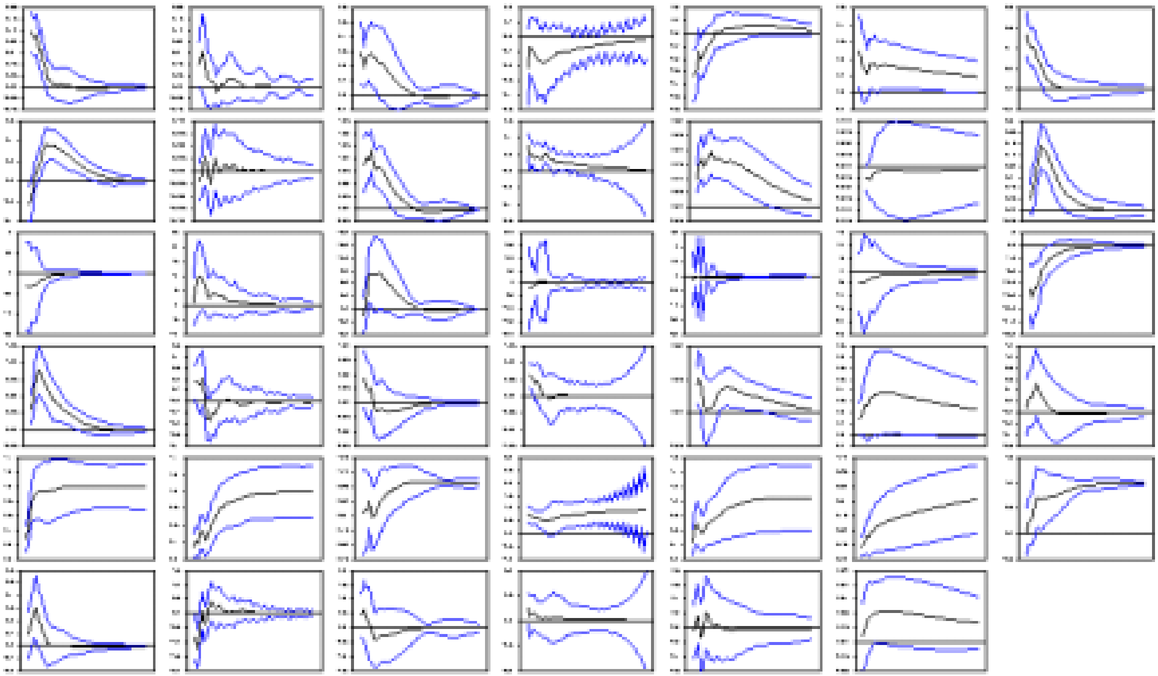

Figure 3.4 Response to Money Supply Shocks - PPI, Employment, Lag-4
Canada, France, Germany, Italy, Japan, UK, USA

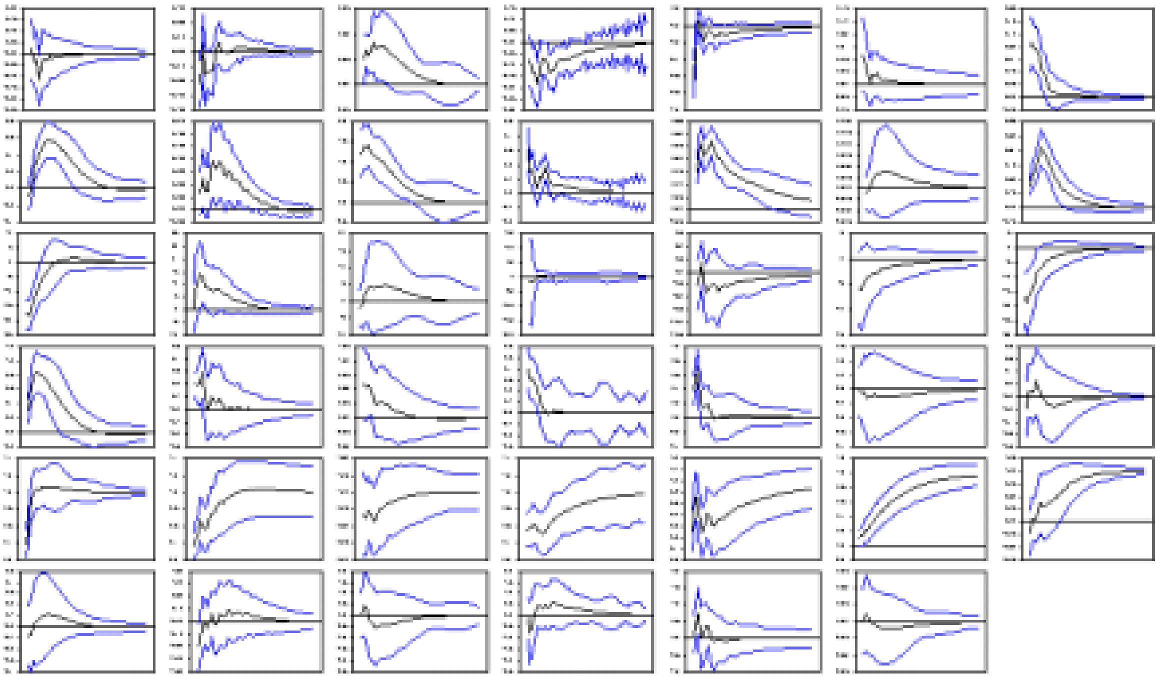

Figure 3.5 Response to Money Supply Shocks - CPI, Employment, Lag-4
Canada, France, Germany, Italy, Japan, UK, USA

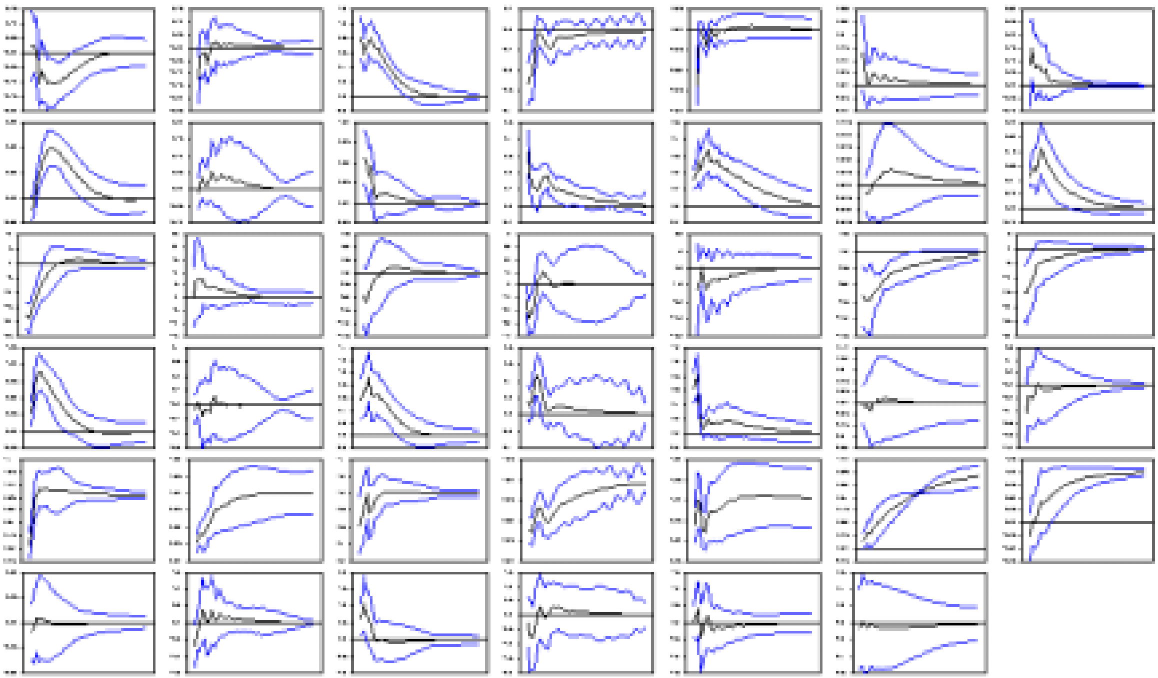

Figure 3.6 Response to Money Supply Shocks - GDP Deflator, Employment, Lag-4
Canada, France, Germany, Italy, Japan, UK, USA

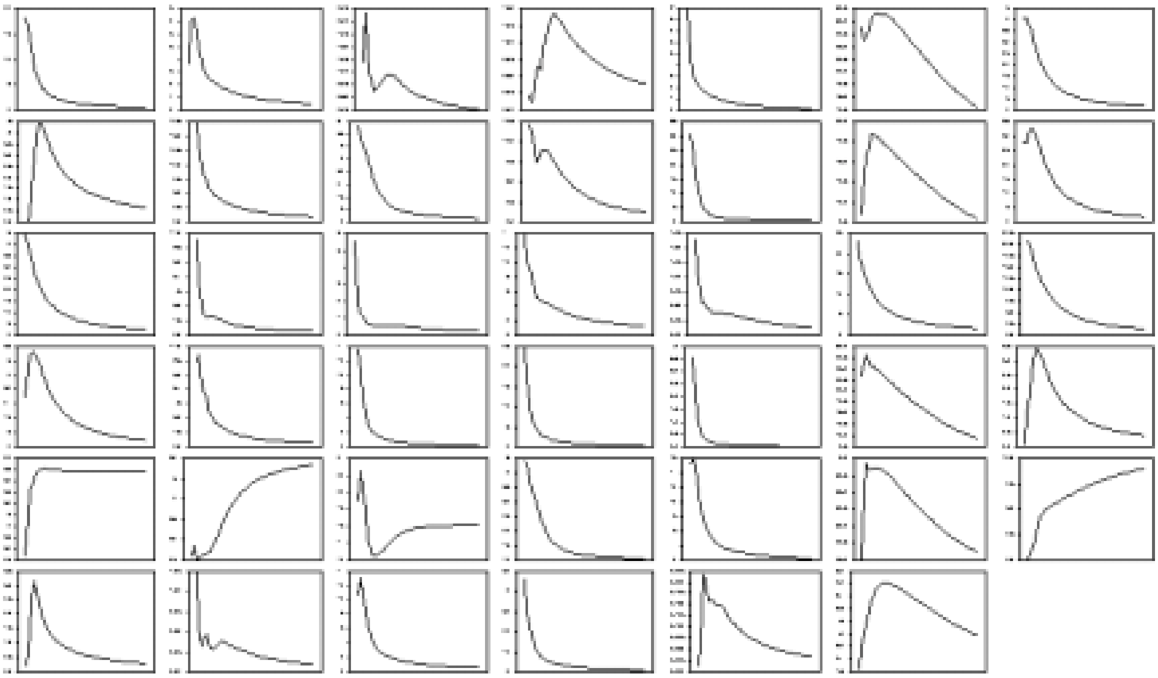

Figure 3.7 Relative Variance Contribution of Money Supply Shocks - PPI
Canada, France, Germany, Italy, Japan, UK, USA

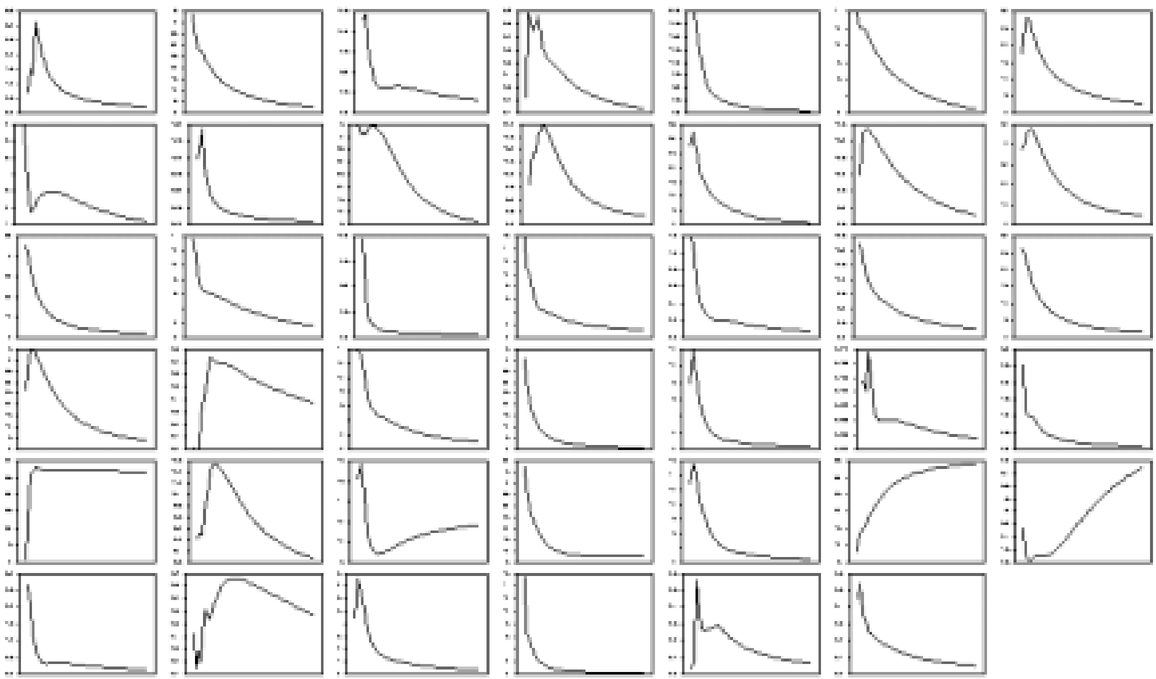

Figure 3.8 Relative Variance Contribution of Money Supply Shocks - CPI
Canada, France, Germany, Italy, Japan, UK, USA

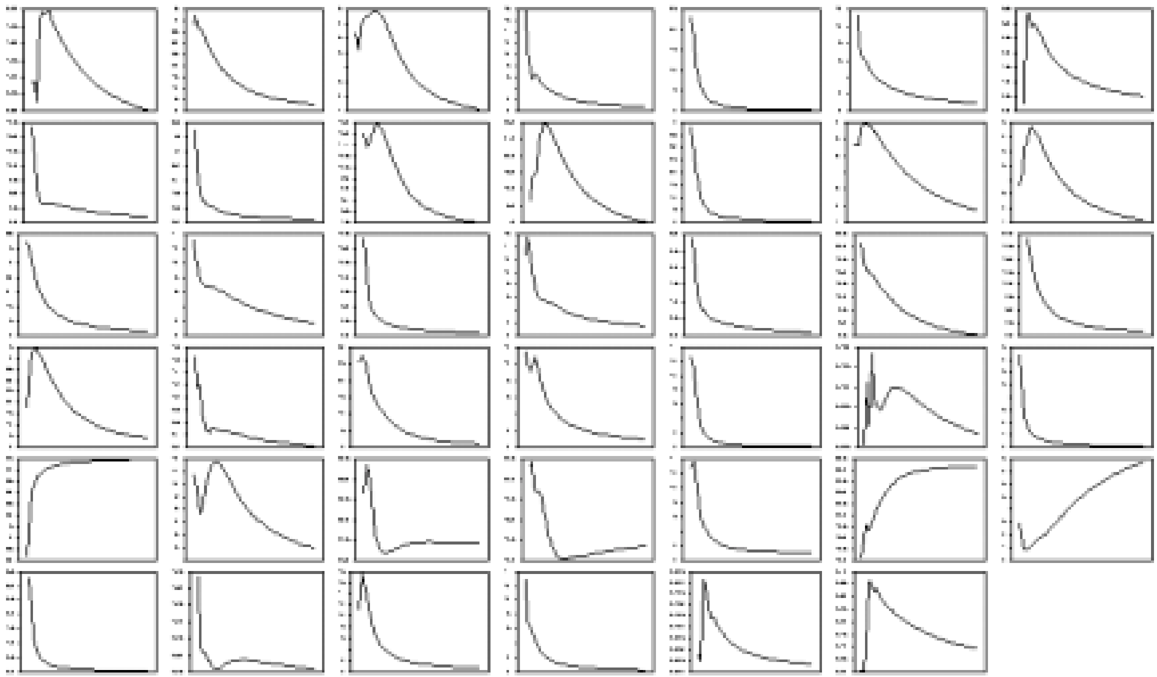

Figure 3.9 Relative Variance Contribution of Money Supply Shocks - GDP Deflator
Canada, France, Germany, Italy, Japan, UK, USA

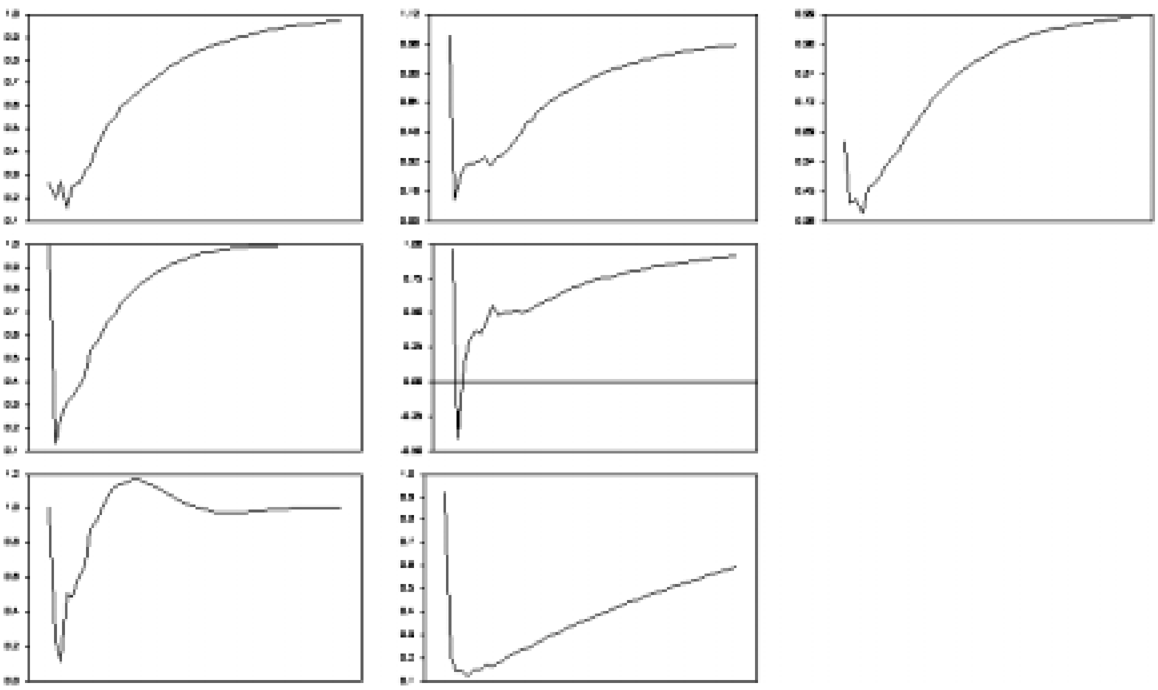

Figure 3.10 Response of Nominal Wage - PPI, Output, Lag-4
Canada, France, Germany, Italy, Japan, UK, USA

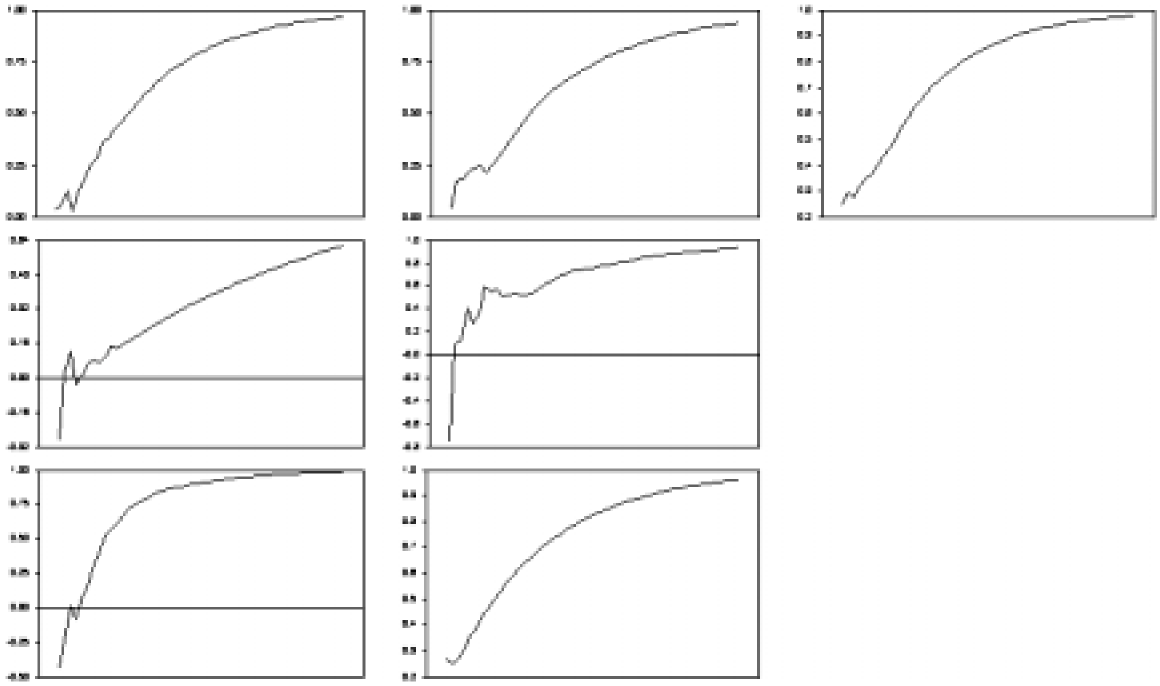

Figure 3.11 Response of Nominal Wage - CPI, Output, Lag-4
Canada, France, Germany, Italy, Japan, UK, USA

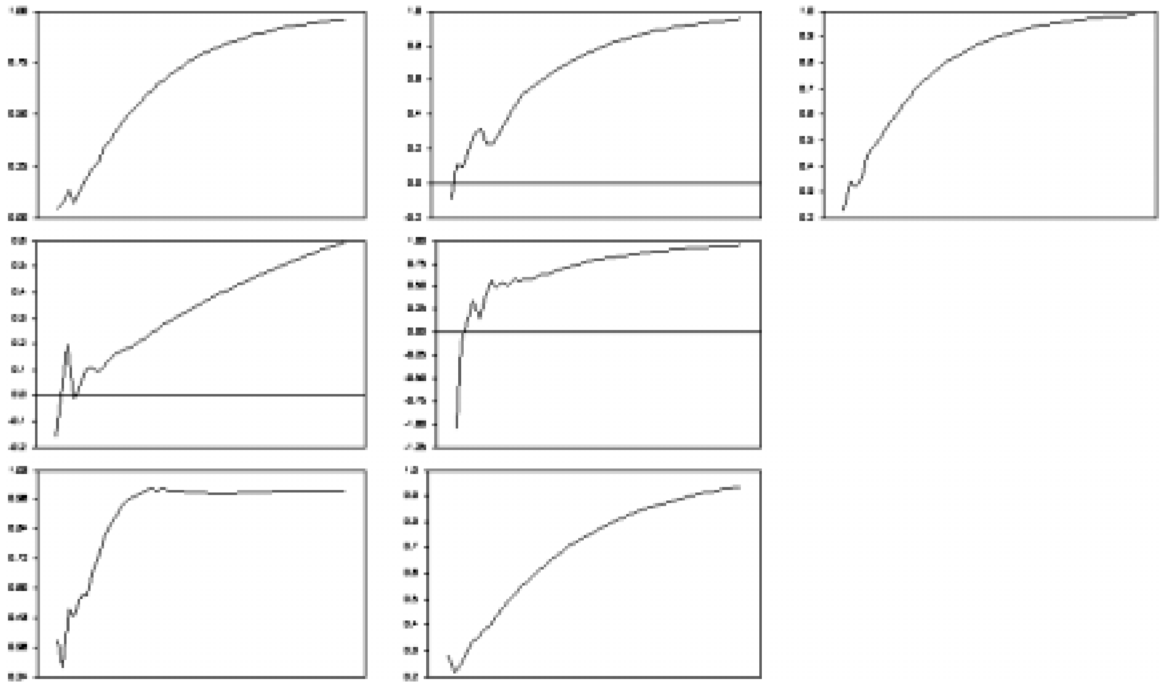

Figure 3.12 Response of Nominal Wage - GDP Deflator, Output, Lag-4
Canada, France, Germany, Italy, Japan, UK, USA

CHAPTER 4

THE DYNAMIC EFFECTS OF MONEY ON INDUSTRY-LEVEL LABOR MARKETS

4.1 Introduction

There are many economists who have shown short-run dynamics of real variables (e.g. real wage and output) in response to nominal aggregate demand shocks like money supply shocks in a traditional way, demand-side channel of monetary shocks. The monetary shocks affect the real variables through a demand channel of transmission in the short-run with some type of rigidity in the economy.

However, some other economists (Blinder 1987, Kashyap, Lamont and Stein 1994, Christiano, Eichenbaum and Evans (CEE) 1997, Barth and Ramey 2000) proposed empirical models that focused on supply-side effects of the monetary shocks. As explained by CEE (1997), one of the stylized facts about the expansionary monetary transmission is a positive real wage response to monetary shocks across U.S. industries. According to their model, 'sticky price and limited participation model',[25] a positive real wage response to the money supply shocks is more identified. Positive money supply shocks are followed by a negative interest rate, liquidity effect, which may increase the demand for labors by firms stemming from lower production cost of

[25] CEE (1997) built an empirical model with an assumption that firms should borrow in order to finance and pay their production factors, labors and capitals, before they receive their revenues from sales.

hiring labors.[26] Thus, they have confirmed more positive real wage responses across the industries in their empirical U.S. industry-level study, which shows more relative importance of the supply-side channel of the shocks. In addition, the importance of supply-side channel are also well documented empirically by others like Kashyap, Lamont and Stein (1994). They found that industries cut their inventories significantly as the access to public debt markets is more tightly constrained, which is supported by Barth and Ramey (2000). Barth and Ramey (2000) recently support the view of much research focused on the supply-side channel of monetary shocks like CEE (1997) by insisting that a cost channel (or supply-side effect)[27] is the primary mechanism of transmission for short period of time after monetary shocks for many manufacturing industries in the U.S. They further show that the real wages across the industries move positively in response to the monetary shocks even with sticky wages.

The purpose of this chapter is to estimate and identify labor market dynamics at the industry-level waged, prices, and employment or output, to money supply shocks, from which the relative importance of the demand-side channel and supply-side channel can be examined. To the extent that money is non-neutral in the short-run, it can affect individual markets in two ways : by causing a shift in the demand for a product, and by causing a shift in the supply of the product.[28]

[26] They have stressed the importance of supply side channel of monetary transmission as labor demand curve shifts to the right in wage-employment space.

[27] There are many other studies which focus on the supply-side effect of monetary transmission including "Wright Patman Effect." (e.g., Shapiro (1981), Farmer (1985, 1988), Fuerst (1991), Gertler and Gilchrist (1994),) Key indication of the supply-side effect is an increase of sectoral price and decrease of sectoral output following monetary contraction.

[28] Barth III and Ramey (2000) call the latter the cost channel of monetary transmission.

As Barth and Ramey (2000) show, if the demand channel is of primary importance, then a positive monetary shock should cause activity, employment and output, in each industry to rise and the real product wage to fall, due primarily to a rise in the price.[29] On the other hand, if the cost channel is paramount, then the real product wage should rise, as output price falls, in response to a money supply shock. Thus, I will examine the response of industry-level labor markets to money supply shocks to better shed light on this issue.

To this end, a vector autoregressions (VAR)[30] of industry-level real wage (including nominal wage and sectoral price level), employment/output and aggregate variables will be built imposing long-run monetary neutrality restrictions on the model. Lastrapes and Selgin (1995), Bernanke and Mihov (1998) show that the long-run neutrality of money is consistent and robust within the context of an economically interpretable model of money market. They further argue that the long-run neutrality can play a good role as a device for identifying the effects of shocks to monetary policy.[31] This is a key identifying method that is different from the models of CEE (1997) and Barth and Ramey (2000) who have all employed short-run recursive

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[29] The industrial wages are deflated by the sectoral producer price index and aggregate producer price index, respectively.

[30] Like much of the recent literature (CEE 1997, Loo & Lastrapes 1998, Barth and Ramey 2000), I investigate the responses in the context of VARs representation of policy and the economy. VARs are now widely used to identify reaction of various aggregates to monetary policy changes.

[31] The findings by Boschen & Mills (1995) and King & Watson (1997) support the long-run monetary neutrality as an empirical feature of the U.S. economy. Bernanke and Mihov (1998) also add that the long-run neutrality restriction can be sufficient enough to identify the monetary shocks.

restrictions.[32] However, I am not arguing that the long-run neutrality restrictions are preferred to the contemporaneous restrictions and it is not the purpose of this chapter to degrade the short-run restrictions in identifying the monetary shocks. Rather, the empirical model using the long-run restrictions in this chapter may provide robustness of the findings, supply-side channel of monetary shocks with procyclical real wage responses at industry-level, of CEE (1997), and Barth and Ramey (2000).[33] I show significantly procyclical real wage responses across the US industries that confirm the supply-side effect of the monetary transmission even with long-neutrality restrictions imposed.

Section 2 describes the empirical framework and the long-run neutrality restrictions to identify the money supply shocks. Section 3 reports the results with industry-level real wages, responses of nominal wage and sectoral price, sectoral output/employment responses, and responses of aggregate variables to the money supply shocks. Section 4 has a conclusion with brief comments on future research.

4.2 Empirical Framework

Numerous macroeconomic studies have used vector autoregression (VAR) systems to identify dynamic fluctuations of the endogenous variables to exogenous money

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[32] CEE (1997) assume that the Fed has at its disposal monthly data on aggregate employment, industrial output and other indicators of aggregate real economic activity while Kim (1999) assumes differently.

[33] Gali (1992), Loo & Lastrapes (1998), Kim (1999) are among the economists who argue that more appropriate identification of money supply shocks is needed in empirical analysis since the conclusion of previous studies may vary depending on the source of relevant shocks. Furthermore, Gali (1992) and Kim (1999) show that both short-run and long-run restrictions need to be imposed to better isolate the money supply shocks from other shocks.

supply shocks. They have shown that impulse response functions associated with the VAR provide crucial information about the dynamic movements of the variables of the system. In this chapter, I build a structural VAR model following the work of Loo and Lastrapes (1998) for real wage responses across U.S. industries. Since I consider many industries, a VAR that contains industry-level variables for each industry is not tractable. To conserve degrees of freedom the empirical model exploits two sets of overidentifying restrictions ; 1) the industry-level variables, conditional on a set of aggregate variables (or common factors) are independent, and 2) the macro variables are independent of industry-level variables. These restrictions in effect impose diagonality and block recursive restrictions that allow the large VAR system to be estimated.

Let $y_{ti} = \{w_i, p_i, n_i\}$ be a vector containing the wage (w_i), price (p_i), and employment or output (n_i) for industry i and x_t be a vector of macro variables (real wage, output or employment, interest rate, real money stock and nominal money stock). Define $y_t = \{y_{to}\}$ and $z_t = \begin{bmatrix} y_t \\ x_t \end{bmatrix}$, where z_t is n × 1 matrix, y_t is 3m × 1 matrix, m is the number of industries, and x_t is $n_t \times 1$ matrix with nominal money ordered the last. Note that n = 3m + n_2 .

If each process has a unit root and there is no cointegration, then we can write the dynamic structural model as follows, by which those macro and real wage variables are represented assuming first order for convenience ;

$$\tilde{A}\Delta Z_t = \tilde{B}\Delta Z_{t-1} + \tilde{u}_t \qquad (1)$$

where $\tilde{u}_t$ is a vector of white noise shocks, with covariance matrix equal to identify matrix.

Note that this system is large. We therefore assume that labor markets are related only through their joint dependence on macro variables, so that each labor market can be considered separately, conditional on the macro system.

Furthermore, we assume that causation runs from shocks of aggregate variables to industry-level real wages at all lag-periods, but not vice versa. After appropriately partitioning the coefficient matrices, those assumptions imply that (1) can be rewritten as a block recursive system for each industry (i = 1, 2, ... , m).

$$\begin{bmatrix} iA_{11} & iA_{12} \\ 0 & A_{22} \end{bmatrix} \begin{bmatrix} \Delta y_{it} \\ \Delta x_t \end{bmatrix} = \begin{bmatrix} iB_{11} & iB_{12} \\ 0 & B_{22} \end{bmatrix} \begin{bmatrix} \Delta y_{it-1} \\ \Delta x_{t-1} \end{bmatrix} + \begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix} \qquad (2)$$

In this partitioned representation, matrices with subscript (1,1) are 3×3, those with (1,2) are 3 × n_2 and those with subscript (2,2) are $n_2 \times n_2$. In effect, the overidentifying restrictions reduce the large scale VAR to m trivariate VARs with n_2 exogenous variables and macro VAR with n_2 variables. We assume that the last element in u_{2t} has nominal money supply shocks. We ultimately want the response of y_{t+k} to this shock.

The structural model is not estimable directly from the data. Thus, the equation needs to be transformed to a reduced form that can be estimated from the data. Drop the i subscript for notational convenience, so it is understood that we are looking at one industry.

We then have

$$A^{-1} = \begin{bmatrix} A_{11}^{-1} & -A_{11}^{-1}A_{12}A_{22}^{-1} \\ 0 & A_{22}^{-1} \end{bmatrix} \equiv D_0 = \begin{bmatrix} D_{11}^{0} & D_{12}^{0} \\ 0 & D_{22}^{0} \end{bmatrix} \qquad (3)$$

and

$$\begin{bmatrix} \Delta y_t \\ \Delta x_t \end{bmatrix} = \begin{bmatrix} D_{11}^{0} & D_{12}^{0} \\ 0 & D_{22}^{0} \end{bmatrix} \begin{bmatrix} B_{11} & B_{12} \\ 0 & B_{22} \end{bmatrix} \begin{bmatrix} \Delta y_{t-1} \\ \Delta x_{t-1} \end{bmatrix} + \begin{bmatrix} D_{11}^{0} & D_{12}^{0} \\ 0 & D_{22}^{0} \end{bmatrix} \begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix}$$

$$= \begin{bmatrix} D_{11}^{0}B_{11} & D_{11}^{0}B_{12} + D_{12}^{0}B_{22} \\ 0 & D_{22}^{0}B_{22} \end{bmatrix} \begin{bmatrix} \Delta y_{t-1} \\ \Delta x_{t-1} \end{bmatrix} + \begin{bmatrix} D_{11}^{0}u_{1t} \quad D_{12}^{0}u_{2t} \\ D_{22}^{0}u_{2t} \end{bmatrix} ,$$

which implies

$$\begin{bmatrix} \Delta y_t \\ \Delta x_t \end{bmatrix} = \begin{bmatrix} \pi_{11} & \pi_{12} \\ 0 & \pi_{22}^{0} \end{bmatrix} \begin{bmatrix} \Delta y_{t-1} \\ \Delta x_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$$

or

$$\Delta Z_t = \pi \Delta Z_{t-1} + \varepsilon_t \,. \qquad (4)$$

where $\varepsilon_t = A^{-1}u_t = D_0 u_t$, $\pi = A^{-1}B = D_0 B$.

Note that π maintains the block recursivity of the structural model.

The covariance matrix of the residuals is

$$\Sigma = E\ \varepsilon_t \varepsilon_t' = E \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \begin{bmatrix} \varepsilon_{1t}' & \varepsilon_{2t}' \end{bmatrix} = \begin{bmatrix} E\varepsilon_{1t}\varepsilon_{1t}' & E\varepsilon_{1t}\varepsilon_{2t}' \\ E\varepsilon_{2t}\varepsilon_{1t}' & E\varepsilon_{2t}\varepsilon_{2t}' \end{bmatrix}$$

$$= \begin{bmatrix} \Sigma_{11} & \Sigma_{12} \\ \Sigma_{12} & \Sigma_{22} \end{bmatrix}$$

$$= E\,(A^{-1}u_t u_t' A^{-1'}) = A^{-1}A^{-1'} \text{ since } Eu_t u_t' = I \,. \qquad (5)$$

Now, the block recursive structure implies that u_{2t} can be fully identified from the macro block :

$\Delta x_t = \pi_{22}\Delta x_{t-1} + \varepsilon_{2t}$ is the reduced form from (4),

$$\varepsilon_{2t} = D^0_{22}u_{2t}\ ,\ \ \Sigma_{22} = E\ \varepsilon_{2t}\varepsilon^{'}_{2t} = D^0_{22}u_{2t}u^{'}_{2t}D^{0'}_{22} = D^0_{22}D^{0'}_{22}\ , \qquad (6)$$

and

$$\Delta x_t = (I - \pi_{22}L)^{-1}D^0_{22}u_{2t} = C_{22}(L)\ D^0_{22}u_{2t}$$

$$= D_{22}(L)\ u_{2t}\ , \qquad (7)$$

where $C_{22}(L) = (I - \pi_{22}L)^{-1}$ and $C_{22}(L)D_{22} = D_{22}(L)$.

Assume that $D_{22}(1)$ is lower triangular ; since, $D_{22}(1)$ measures the long-run impact of the structural shocks on the levels of the macro variables and money is last in the ordering due to the long-run neutrality restrictions. Then $D_{22}(1)$ is the Cholesky factor of $C_{22}(1)\ \Sigma_{22}C_{22}(1)^{'}$, say $\tilde{D}^0_{22}(1)$.

From equation (7),

$$\tilde{D}^0_{22} = C_{22}(1)^{-1}\tilde{D}_{22}(1)$$

$$\tilde{D}_{22}(L) = C_{22}(L)\ \tilde{D}^0_{22} \qquad (8)$$

By estimating the macro system, we obtain efficient estimates of $\tilde{\varepsilon}_{2t}$, $C_{22}(L)$, $C_{22}(1)$, Σ_{22} , $D_{22}(L)$ and D^0_{22} using long-run neutrality restrictions. The lower triangular restriction is just sufficient to identify the responses of all variables in the system to monetary shocks, which is the main object of this chapter. The last column of the first 3 rows of the accumulated lag polynomial, $(I-L)^{-1}D(L)$, now tells about the movements of industry-specific variables to the money supply shocks.

To see how the restriction identifies industry level shocks, consider the responses of y_{t+k} to u_{2t} . Using equation (4),

$$\Delta y_t = \pi_{11}\Delta y_{t-1} + \pi_{12}\Delta x_{t-1} + \varepsilon_{1t}$$

and

$$\Delta y_t = (I-\pi_{11}L)^{-1}\pi_{12}D_{22}(L)u_{2t-1} + (I-\pi_{11}L)^{-1}\varepsilon_{1t}$$

$$= (I-\pi_{11}L)^{-1}\pi_{12}D_{22}(L)u_{2t-1} + (I-\pi_{11}L)^{-1}(D^0_{11}u_{1t} + D^0_{12}u_{2t}) \qquad (9)$$

where $\Delta x_{t-1} = D_{22}(L)u_{2t-1}$.

The response, $\frac{\delta y_{t+k}}{\delta u_{2t}}$ now depends on π_{11} , π_{12} , $D_{22}(L)$ and D_{12} .

Note that

$$\Sigma = \begin{bmatrix} \Sigma_{11} & \Sigma_{12} \\ 0 & \Sigma_{22} \end{bmatrix} = \begin{bmatrix} D^0_{11} & D^0_{12} \\ 0 & D^0_{22} \end{bmatrix} \begin{bmatrix} D^{0'}_{11} & 0 \\ D^{0'}_{12} & D^{0'}_{22} \end{bmatrix}$$

$$= \begin{bmatrix} D^0_{11}D^{0'}_{11} + D^0_{12}D^{0'}_{12} & D^0_{12}D^{0'}_{22} \\ 0 & D^0_{22}D^{0'}_{22} \end{bmatrix}$$

$$\Rightarrow \Sigma_{12} = D^0_{12}D^{0'}_{22} .$$

Finally,

$$D^0_{12} = \Sigma_{12}D^{0'-1}_{22} .$$

Thus, once we have identified D_{22}^0, we know D_{12}^0 and the relevant impulse responses are identified with respect to shocks to u_{2t}. We do not need to impose identifying restrictions on the industry-level equations. In effect, this is because we are estimating the equilibrium response of the labor market variables to macro variable, money supply shocks.

The last issue is how to estimate efficiently the coefficients, π_{11}, π_{12}, and Σ_{12}. The simplest approach to program is probably SUR with the block recursive restrictions. However, we can also use OLS by regressing y_t on contemporaneous values of x_t.[34]

$$y_t = F_0 x_t + F_{11} y_{t-1} + F_{12} x_{t-1} + v_{1t}$$

$$E v_{1t} v_{1t}' = \text{H}$$

Then use mapping from F_0, F_{11}, F_{12}, H to obtain original parameterization. Both approaches to estimation are identical.

4.3 Estimation and Responses

4.3.1 Data and estimation

[34] Equation (4) can be estimated efficiently using OLS, from which π and Σ are derived from the data set, z_t. As shown by Loo and Lastrapes (1998), the system that contains macro variables can be efficiently estimated independently of the industry-level equations. Furthermore, each industry-level real wage equations can also be estimated separately with no efficiency loss using OLS conditioning on the contemporaneous values of aggregate values.

The empirical estimation focuses on monthly data for 26 private disaggregated industries according to the 2-digit and 3-digit Standard Industrial Classification (SIC) code. The data primarily come from DRI/Citibase, and range from January 1959 through December 1999. They are industry-level real wage (nominal wage and price), employment, industrial output and following macro variables : money supply (M1, fm1), 3-month treasury bill (R, fygm3) (or effective federal funds rate , fyff), producer price index for all commodities (P, pw).[35]

The variables in the system are all first-differenced,[36] since all the industrial variables (real wage, industrial output and employment) have single unit roots according to augmented Dickey-Fuller test and Phillip-Perron test. (table 4.6) Furthermore, I have found no cointegrating relationships among the variables using Engle-Granger method. The VAR equations include a constant, seasonal dummies, energy prices and 8 common lags sufficient to whiten the residuals by eliminating serial correlation in the residuals. (table 4.7) In addition to the point estimates, simulated standard error bands using Monte-Carlo methods with 500 replications are added to account for the precision of the estimates.

4.3.2 Responses

4.3.2.1 Response of Aggregate Variables

[35] See table 1 for sources and description.

[36] As shown by Loo and Lastrapes (1998), imposing a unit root on the stationary series has no important effect on the results.

Figure 4.1 and 4.2 show macro variable responses to the nominal money supply shocks, which are again consistent with those stylized facts. I can confirm liquidity effect as the interest rate responds negatively, which may contribute to the supply-side channel of the nominal shocks.(Christiano and Eichenbaum 1992, Lastrapes and Selgin 1995) The real money stock responds positively that confirms that aggregate price level does not respond proportionately for a certain period of time. The real wage at aggregate level moves positively to the shocks which is consistent with those sticky-price and supply-side channel models. (Bernanke and Gertler 1995, CEE 1997, Barth and Ramey 2000)

The responses of all macro variables are fading away as the time variable increases because of the long-run monetary neutrality restrictions imposed on this model.

4.3.2.2 Real Wage Response

Figure 4.3 shows industrial real wage responses deflated by industrial producer price index to positive money supply shocks. The graphs are ordered in alphabetical order starting with apparel industry. All the industries except leather industry show positive real wage responses to the shocks implying that sectoral producer price is stickier than sectoral nominal wage.[37] As we can see, chemical, fabricated metal, lumber and wood, and printing industries have huge responses for early period of time while finance sector and whole trade sector have relatively small and oscillatory responses followed by negative responses. The real wage responses for most of the industries remain consistently positive for longer period of time, though. As figure 4.5 shows,

[37] I have limited the maximum and minimum to easily compare the amplitude of the responses across the industries.

almost all of the industries show strong procyclical nominal wage responses to the expansionary money supply shocks.[38] However, sectoral producer price generally responds negatively for early period to one-standard deviation of money supply shocks. (figure 4.6) More than two-thirds of the industries show strong supply-side effect of the shocks, which is consistent with one of the stylized facts about the expansionary monetary shocks.[39] Figure 4.7 shows relative dynamics of sectoral prices (Pi/P). As the figure shows, sectoral producer prices are believed to have more persistent supply-side effect than aggregate price from the long lasting negative responses of Pi/P. (Barth and Ramey, 2000)

Figure 4.4 shows the real wage responses deflated by aggregate producer price index to the shocks. Again, the real wages, in general, respond positively to the shocks (except for food and kindred, lumber and wood industries that have oscillatory responses) which confirm many previous studies like CEE (1997) and Barth and Ramey (2000) who have focused on the supply-side channel of the nominal shocks.[40]

As we can identify the industrial real wage and output responses to the shocks, the real wage responds differently across the industries in size. Some industries respond positively and stay for a long period of time while some other respond positively for a shorter period of time and fade away and even followed by negative response.

[38] 4 industries (apparel, finance, leather and whole trade) show negative wage responses for short-period of time ranging from 3 to 5 months.

[39] The stylized facts about the effects of an expansionary money supply shock : (1) Output increases for a couple of years. (2) The interest rate falls down initially followed by gradual recovery. (3) Price level is sticky for a couple of years to the shocks.

[40] If the demand channel plays more dominant role, then the higher demand should pull up the price level. If the supply channel plays more important role over the business cycle, then both demand and supply will respond in the same direction. Thus, even though the demand is increased, the price may stay unchanged for a certain period of time due to higher supply level thanks to lower interest rate.

(construction, finance, lumber and wood, retail trade, stone, whole trade). Thus, the monetary shocks have differential impacts on industries according to the importance of credit conditions for their demand and supply as shown by Kashyap, Lamont and Stein (1994), and Barth and Ramey (2000).

4.3.2.3 Employment Response

Figure 4.8 shows the employment responses to the money supply shocks. Even though the aggregate employment level responds positively to the shocks (figure 4.1), the sectoral responses slightly differ across the industries. I have used sectoral and total employees (lpnag) on nonfarm industry for the sectoral and aggregate employment variables. More than half of the industries show positive responses (eventually) while less than half (7 industries) show negative responses. Those industries that show negative employment responses behave according to the economic theory. As the real wage of the labors increases the demand for the labors will decrease, thus the employment in those industries will decrease to the shocks in the short-run. But in general, the positive money supply shocks have positive employment responses at industry-level, which is again consistent with empirical stylized facts of money supply shocks.

4.3.2.4 Output Response

Figure 4.9 shows output responses to the shocks at industry-level. In general, most of the industries show positive output responses, which is consistent with one of the stylized facts shown by previous research. (CEE 1997, Bernanke and Mihov 1998)

Not all of the industries show positive output responses even though it moves positively at aggregate level. Construction, electrical equipment, industrial machinery, leather, mining, primary metal, textile show negative or oscillatory output responses to the shocks.

4.4 Conclusion

Several economists have recently provided empirical models that can support the contention that supply-side effects play more important role in the transmission of monetary innovations. This chapter also shows nominal monetary shocks on real variables across key U.S. industries. Real wages at industry-level and industrial output move positively following an unanticipated monetary expansion, which support the studies of CEE (1997) and Barth and Ramey (2000) and many others who have all shown supply-side channel of nominal shocks to real economic activities. (Shapiro 1981, Blinder 1987, Fuerst 1991, Bernanke and Gertler 1995) The supply-side channel of monetary transmission to real economic activities dominate the demand-side channel over business cycle even though the responses are different across the industries depending on the importance of credit conditions. (Kashyap, Lamont and Stein 1994, Gertler and Gilchrist 1994) Thus, the demand-side channel does not play as important role over business cycle as explained by traditional economic theories, from which a negative real wage response is expected. This chapter also confirms that industry-level prices responds much more quickly with persistent supply-side effect than the aggregate price level, which is consistent with the findings by Blanchard's (1987) and Barth and Ramey (2000).

Table 4.1 DRI/Citibase Data Code for Aggregate Variables

Aggregate wage
Total Private : le6h
Good-Producing : le6gp
Total output
Industrial production : ip (seasonally adjusted)
Total employment
Total employees on non-farm industry : lpnag
Aggregate price
Producer price index for all commodities : pw
Interest rate
3-month treasury bill : fygm3
Money supply
M1 : fm1 (seasonally adjusted)
Energy price
Refined petroleum products : pw557

Table 4.2 Average Hourly Earnings

1. Apparel and other textile products : le6m23
2. Chemicals and allied products : le6m28
3. Construction : le6hcc
4. Durable goods : le6hmd
5. Electronic and other electrical equipment : le6m36
6. Fabricated metal products : le6m34
7. Finance, insurance, real estate : le6hfr
8. Food and kindred products : le6m20
9. Furniture and fixtures : le6m25
10. Industrial machinery and equipment : le6m35
11. Instruments and related products : le6m38
12. Leather and leather products : le6m31
13. Lumber and wood products : le6m24
14. Manufacturing : le6hm
15. Mining : le6hmi
16. Miscellaneous Manufacturing : le6m39
17. Nondurable goods : le6hmn
18. Paper and allied products : le6m26
19. Primary metal industries : le6m33
20. Printing and publishing : le6m27
21. Retail trade : le6htr
22. Stone, clay and glass products : le6m32
23. Textile mill products : le6m22
24. Transportation equipment : le6m37
25. Transportation and public utilities : le6htu
26. Wholesale trade : le6htt

Table 4.3 Employees on Nonfarm Industry

1. Apparel and other textile products : lpn23
2. Chemicals and allied products : lpn28
3. Construction : lpcc
4. Durable goods : lped
5. Electronic and other electrical equipment : lpd36
6. Fabricated metal products : lpd34
7. Finance, insurance, real estate : lpfr
8. Food and kindred products : lpn20
9. Furniture and fixtures : lpd25
10. Industrial machinery and equipment : lpd35
11. Instruments and related products : lpd38
12. Leather and leather products : lpn31
13. Lumber and wood products : lpd24
14. Manufacturing : lpem
15. Mining : lpmi
16. Miscellaneous Manufacturing : lpd39
17. Nondurable goods : lpen
18. Paper and allied products : lpn26
19. Primary metal industries : lpd33
20. Printing and publishing : lpn27
21. Retail trade : lptr
22. Stone, clay and glass products : lpd32
23. Textile mill products : lpn22
24. Transportation equipment : lpd37
25. Transportation and public utilities : lptu
26. Wholesale trade : lpt

Table 4.4 Industry-Level Output

1. Apparel and other textile products : ipnt3
2. Chemicals and allied products : ipnch2
3. Construction : ip353
4. Durable goods : ipd
5. Electronic and other electrical equipment : ipdma4
6. Fabricated metal products : ipdm5
7. Finance, insurance, real estate : ipc
8. Food and kindred products : ipnfo2
9. Furniture and fixtures : ipdf2
10. Industrial machinery and equipment : ipdma3
11. Instruments and related products : ipdi
12. Leather and leather products : ipnt4
13. Lumber and wood products : ipdcl3
14. Manufacturing : ipmfg
15. Mining : ipmin
16. Miscellaneous Manufacturing : ipdetc
17. Nondurable goods : ipn
18. Paper and allied products : ipnpr2
19. Primary metal industries : ipdm2
20. Printing and publishing : ipnpr3
21. Retail trade : ipcn
22. Stone, clay and glass products : ipdcl2
23. Textile mill products : ipnt2
24. Transportation equipment : ipdt
25. Transportation and public utilities : ipcd
26. Wholesale trade : ipn

Table 4.5 Industry Producer Price Index

1. Apparel and other textile products : pw381
2. Chemicals and allied products : pwch
3. Construction : lwcc6
4. Durable goods : lphrd
5. Electronic and other electrical equipment : pw117
6. Fabricated metal products : pw102
7. Finance, insurance, real estate : lwfr6
8. Food and kindred products : pwfe
9. Furniture and fixtures : pwfh
10. Industrial machinery and equipment : pwme
11. Instruments and related products : lphr38
12. Leather and leather products : pwsk
13. Lumber and wood products : pwlu
14. Manufacturing : lphrm6
15. Mining : pw1192
16. Miscellaneous Manufacturing : pwmis
17. Nondurable goods : lphrnd
18. Paper and allied products : pwpa
19. Primary metal industries : pw101
20. Printing and publishing : lphr27
21. Retail trade : lwtr
22. Stone, clay and glass products : lphr32
23. Textile mill products : pwtex
24. Transportation equipment : pwti
25. Transportation and public utilities : lwtu
26. Wholesale trade : lwtwr

Table 4.6 Augmented Dickey-Fuller Test and Phillips-Perron Test for 26 Industries

Test	Industry	Real Wage	Output	Employ-ment	Industry	Real Wage	Output	Employ-ment
Dickey-Fuller Test	Apparel	-1.196 (-5.993)	-2.810 (-7.312)	-1.429 (-6.671)	Food and Kindred	-2.577 (-7.610)	-1.248 (-8.282)	-1.152 (-6.713)
Phillips-Perron Test		-1.286 (-20.492)	-3.036 (-27.695)	-1.107 (-18.701)		-2.370 (-19.116)	-1.564 (-34.573)	-1.334 (-25.844)
Dickey-Fuller Test	Chemical	-2.121 (-4.967)	-2.214 (-6.802)	-2.270 (-5.349)	Furniture	-1.249 (-5.238)	-3.456 (-6.627)	-3.284 (-6.171)
Phillips-Perron Test		-1.930 (-21.273)	-1.698 (-23.140)	-1.678 (-14.596)		-1.134 (-21.695)	-2.896 (-23.295)	-2.517 (-12.705)
Dickey-Fuller Test	Construc-tion	-2.162 (-6.342)	-2.527 (-5.131)	-3.497 (-4.925)	Industrial Machinery	-2.050 (-5.727)	-3.756 (-4.833)	-2.897 (-5.306)
Phillips-Perron Test		-2.246 (-21.119)	-1.746 (-25.506)	-2.435 (-23.626)		-2.002 (-21.607)	-2.010 (-21.421)	-1.718 (-13.574)
Dickey-Fuller Test	Durable	-2.222 (-5.530)	-3.285 (-5.436)	-3.088 (-5.117)	Instru-ments	-1.349 (-5.782)	-0.933 (-6.061)	-1.467 (-5.385)
Phillips-Perron Test		-2.079 (-22.266)	-2.150 (-15.848)	-2.008 (-14.043)		-1.326 (-20.985)	-0.309 (-22.972)	-0.727 (-12.558)
Dickey-Fuller Test	Electrical Equip-ment	-2.018 (-5.302)	-1.220 (-4.961)	-2.815 (-5.380)	Leather	-0.710 (-5.730)	-2.773 (-7.833)	-1.956 (-6.714)
Phillips-Perron Test		-1.875 (-21.127)	-0.259 (-23.765)	-2.025 (-16.346)		-0.657 (-20.403)	-2.364 (-25.940)	-1.687 (-21.261)
Dickey-Fuller Test	Fabrica-ted Metal	-2.261 (-5.087)	-3.271 (-5.979)	-2.800 (-5.080)	Lumber and Wood	-2.051 (-7.447)	-3.580 (-7.155)	-3.926 (-5.420)
Phillips-Perron Test		-2.131 (-22.499)	-2.273 (-20.220)	-1.961 (-15.770)		-2.649 (-18.812)	-3.471 (-22.576)	-3.087 (-13.592)
Dickey-Fuller Test	Finance	N/A	-3.052 (-5.697)	N/A	Manufac-turing	-2.104 (-5.538)	-3.425 (-5.837)	-2.980 (-5.424)
Phillips-Perron Test			-2.162 (-19.188)			-1.927 (-22.081)	-2.319 (-15.591)	-2.036 (-12.117)

The numbers in parenthesis indicate t-value for first differenced variables and each t-value in the upper row accepts the unit root hypothesis while the t-value in parenthesis rejects the hypothesis. Thus, the figures show that all countries have single unit roots in their variables.

Test	Industry	Real Wage	Output	Employ-ment	Industry	Real Wage	Output	Employ-ment
Dickey-Fuller Test	Mining	-2.618 (-7.036)	-2.146 (-7.621)	-1.061 (-5.622)	Retail Trade	N/A	-2.534 (-6.856)	-1.561 (-4.525)
Phillips-Perron Test		-2.850 (-23.594)	-2.230 (-23.121)	-0.953 (-20.842)			-2.025 (-20.927)	-0.716 (-22.426)
Dickey-Fuller Test	Miscell. Manufac-turing	-1.239 (-6.218)	-2.954 (-6.197)	-2.517 (-5.670)	Stone	-2.359 (-5.657)	-2.973 (-5.953)	-2.778 (-5.139)
Phillips-Perron Test		-1.232 (-19.173)	-2.579 (-26.249)	-2.086 (-18.364)		-2.236 (-20.345)	-2.481 (-23.859)	-1.912 (-18.150)
Dickey-Fuller Test	Non-durable	-1.963 (-5.243	-2.473 (-6.912)	-2.541 (-6.176)	Textile	-1.295 (-6.462)	-3.191 (-7.668)	-2.326 (-6.611)
Phillips-Perron Test		-1.779 (-22.470)	-1.815 (-19.858)	-2.038 (-13.328)		-1.381 (-17.933)	-2.604 (-21.134)	-1.878 (-12.740)
Dickey-Fuller Test	Paper	-2.158 (-5.777)	-3.163 (-7.757)	-3.039 (-6.536)	Transpor-tation Equip-ment	-2.218 (-6.820)	-3.024 (-7.028)	-2.990 (-5.683)
Phillips-Perron Test		-2.239 (-22.750)	-3.003 (-25.877)	-2.512 (-17.510)		-2.480 (-22.718)	-3.125 (-20.407)	-2.595 (-24.150)
Dickey-Fuller Test	Primary Metal	-3.189 (-6.118)	-3.393 (-7.047)	-2.632 (-5.783)	Public Utilities	N/A	-2.377 (-8.095)	-2.900 (-6.656)
Phillips-Perron Test		-2.689 (-24.068)	-2.919 (-17.912)	-1.783 (-10.788)			-1.987 (-29.066)	-4.267 (-35.588)
Dickey-Fuller Test	Printing	-1.786 (-5.029)	-1.730 (-6.166)	-2.252 (-4.086)	Whole Trade	N/A	-2.534 (-6.856)	-2.036 (-4.573)
Phillips-Perron Test		-1.723 (-21.058)	-1.275 (-25.673)	-0.890 (-18.112)			-2.025 (-20.927)	-0.999 (-14.761)

The numbers in parenthesis indicate t-value for first differenced variables and each t-value in the upper row accepts the unit root hypothesis while the t-value in parenthesis rejects the hypothesis. Thus, the figures show that all countries have single unit roots in their variables.

Table 4.7 AIC/SBC Test for Lag Length

Industry	AIC/SBC (lag 12)	AIC/SBC (lag 8)	Industry	AIC/SBC (lag 12)	AIC/SBC (lag 8)
apparel	-7596 -5838	-7363 -6162	manufacturing	-8250 -6488	-8082 -6881
chemical	-7756 -5994	-7588 -6387	mining	-7417 -5655	-7187 -5986
construction	-7256 -5494	-7191 -5990	miscellaneous manufacturing	-7489 -5727	-7415 -6213
durable	-7975 -6214	-7833 -6632	nondurable	-8037 -6275	-7842 -6641
electrical equipment	-7501 -5739	-7377 -6176	paper	-7804 -6043	-7546 -6345
fabricated metal	-7879 -6117	-7667 -6466	primary metal	-7406 -5644	-7139 -5938
finance	-7658 -5916	-7407 -6219	printing	-7791 -6029	-7601 -6400
food and kindred	-7800 -6038	-7666 -6465	retail trade	-7721 -5979	-7451 -6263
furniture	-7689 -5927	-7465 -6264	stone	-7619 -5857	-7435 -6233
industrial machinery	-7660 -5898	-7569 -6368	textile	-7551 -5790	-7316 -6115
instruments	-7424 -5662	-7342 -6140	transportation equipment	-7265 -5504	-7168 -5966
leather	-7407 -5645	-7248 -6047	transportation and public utilities	-7363 -5621	-7071 -5883
lumber and wood	-7488 -5726	-7329 -6128	whole trade	-7787 -6044	-7559 -6371

When the AIC and SBC select different lag length, I adopt parsimony principal and proceed with a model that has fewer lag length, lag 8.

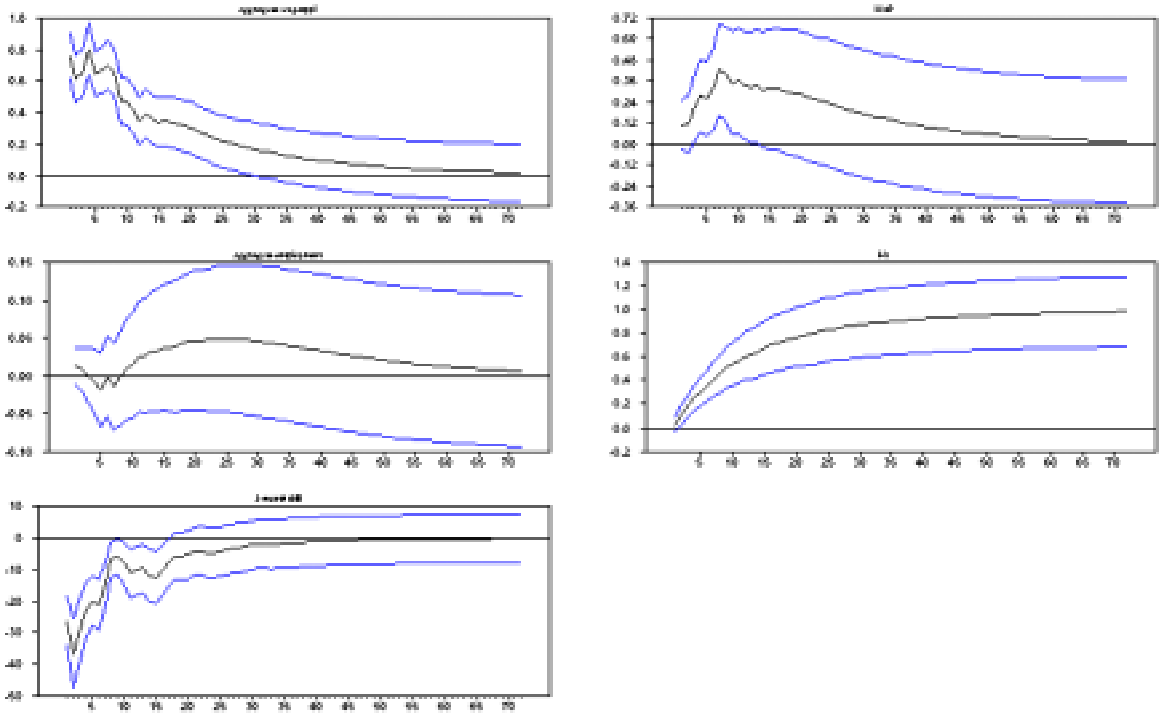

Figure 4.1 Macro Variable Response to Money Supply Shocks

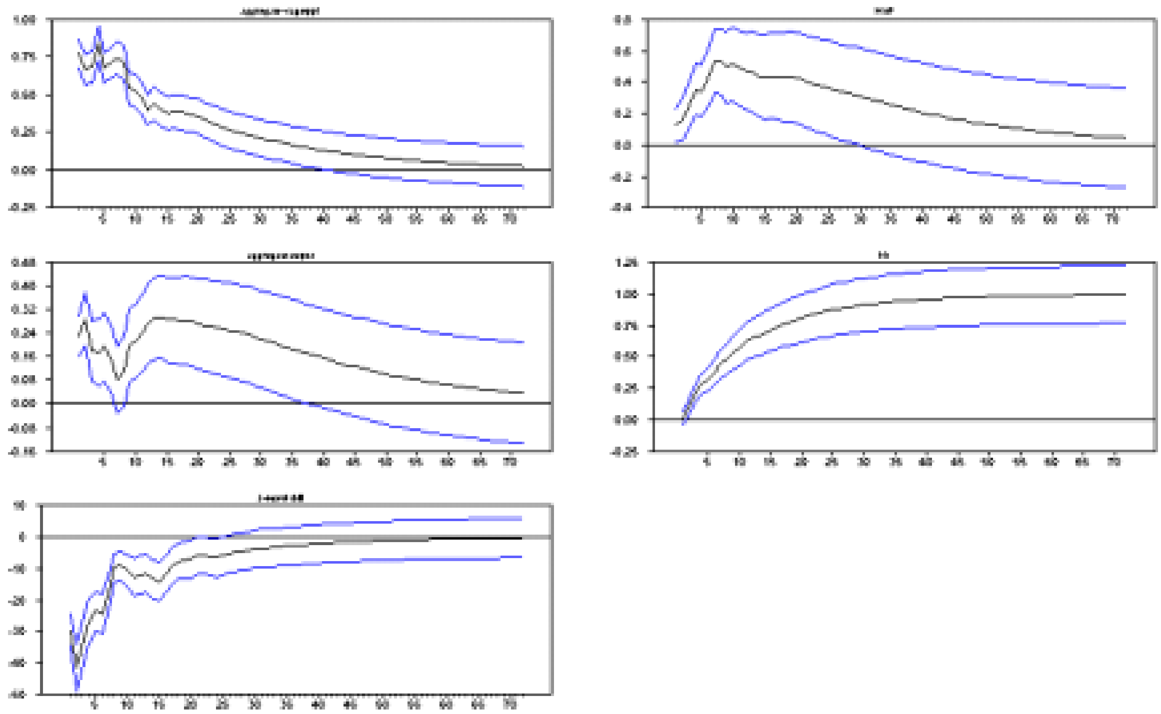

Figure 4.2 Macro Variable Response to Money Supply Shocks

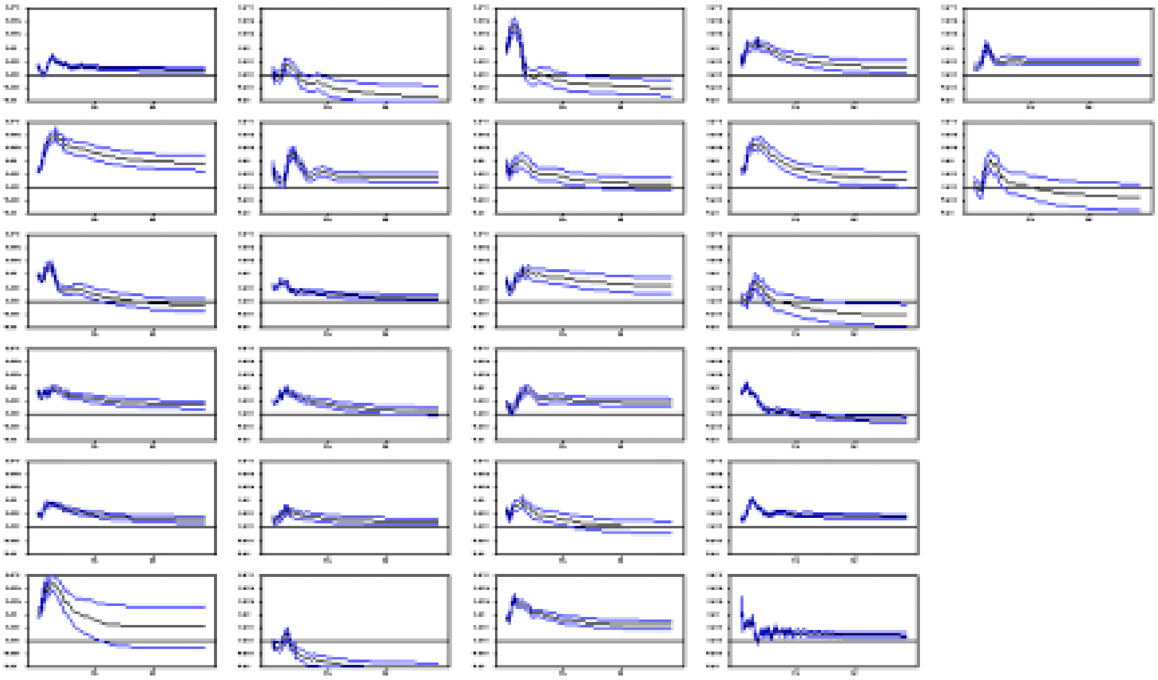

Figure 4.3 Real Product Wage Response to Money Supply Shocks - (Wi/Pi)

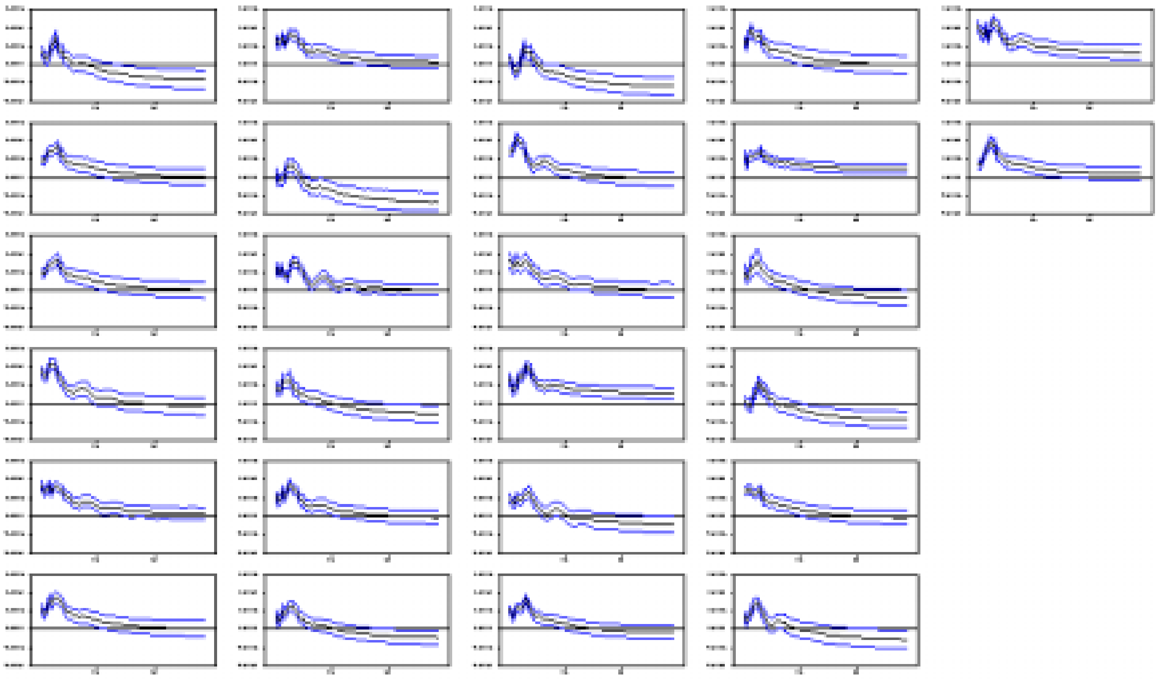

Figure 4.4 Real Product Wage Response to Money Supply Shocks - (Wi/P)
26 Industries in Alphabetical Order

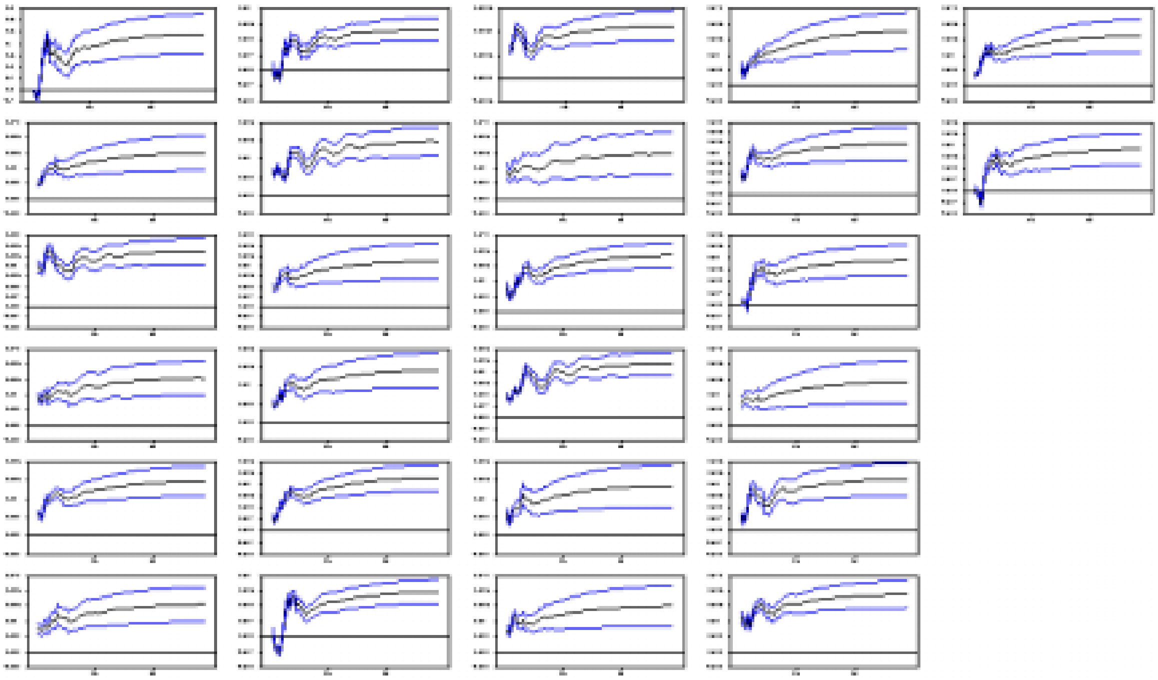

Figure 4.5 Nominal Wage Response to Money Supply Shocks - (Wi)
26 Industries in Alphabetical Order

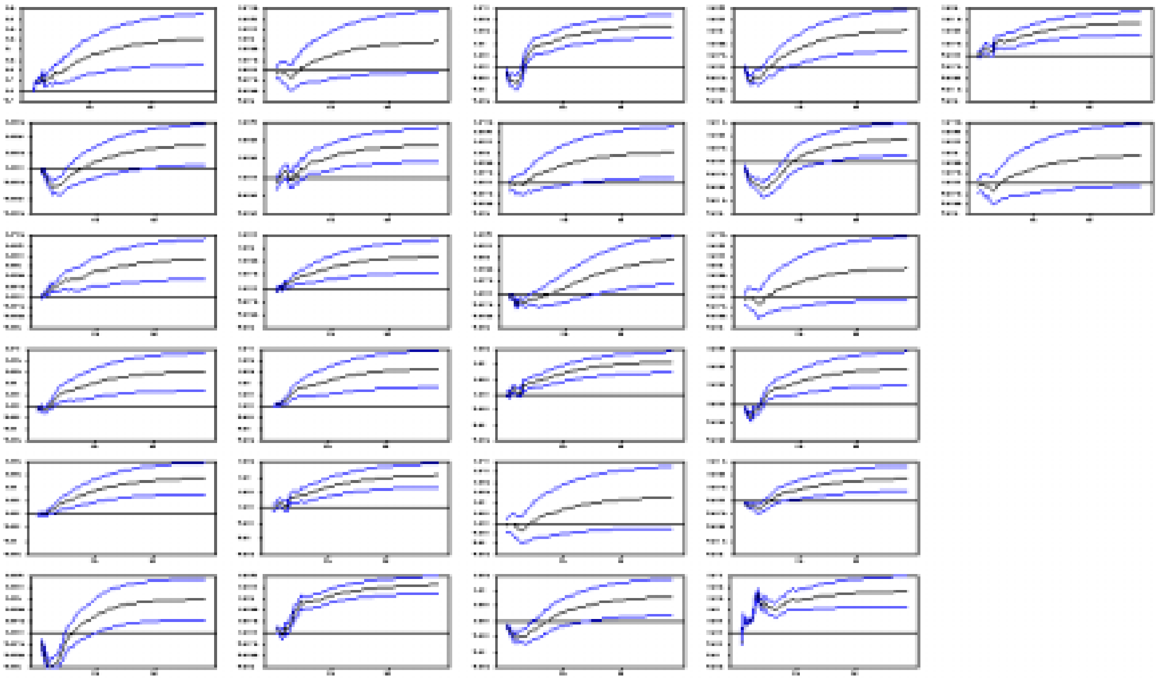

Figure 4.6 Sectoral Price Response to Money Supply Shocks - (Pi)
26 Industries in Alphabetical Order

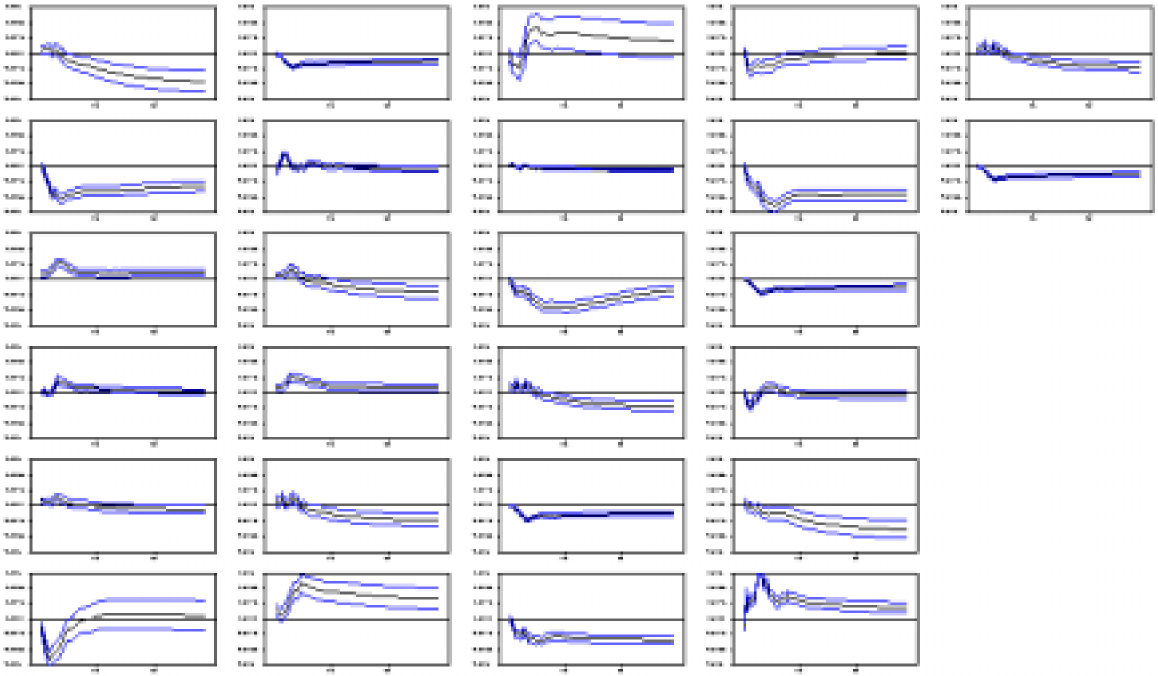

Figure 4.7 Relative Price Response to Money Supply Shocks - (Pi/P)
26 Industries in Alphabetical Order

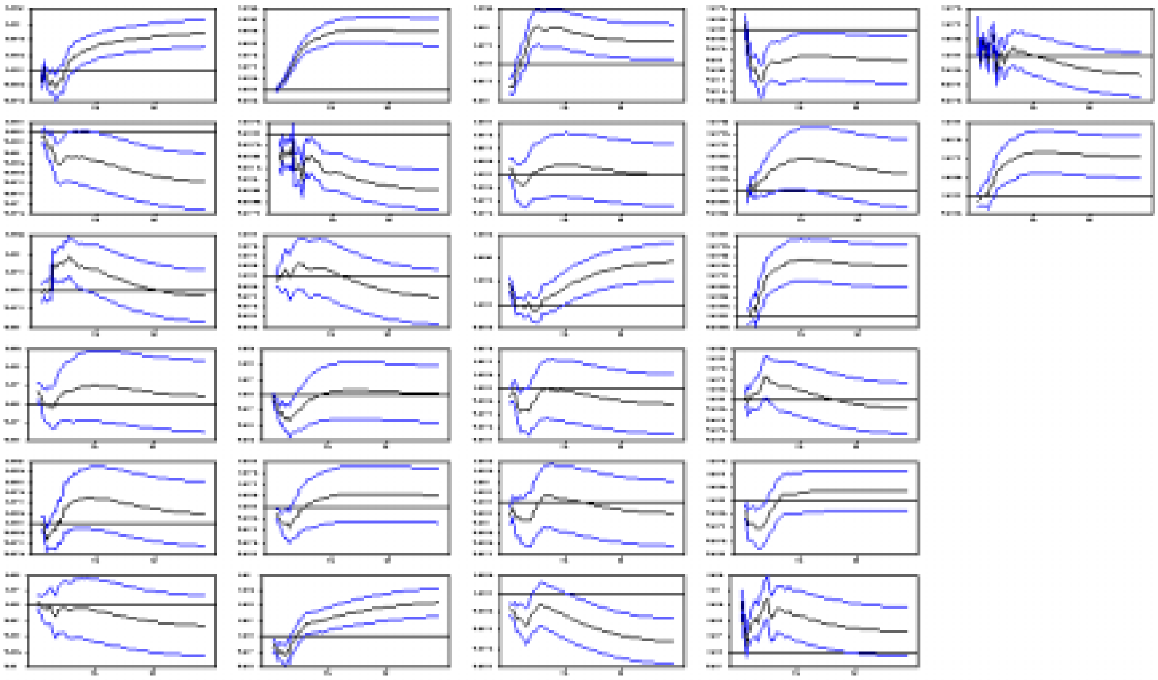

Figure 4.8 Employment Response to Money Supply Shocks
26 Industries in Alphabetical Order (employees on nonfarm industry)

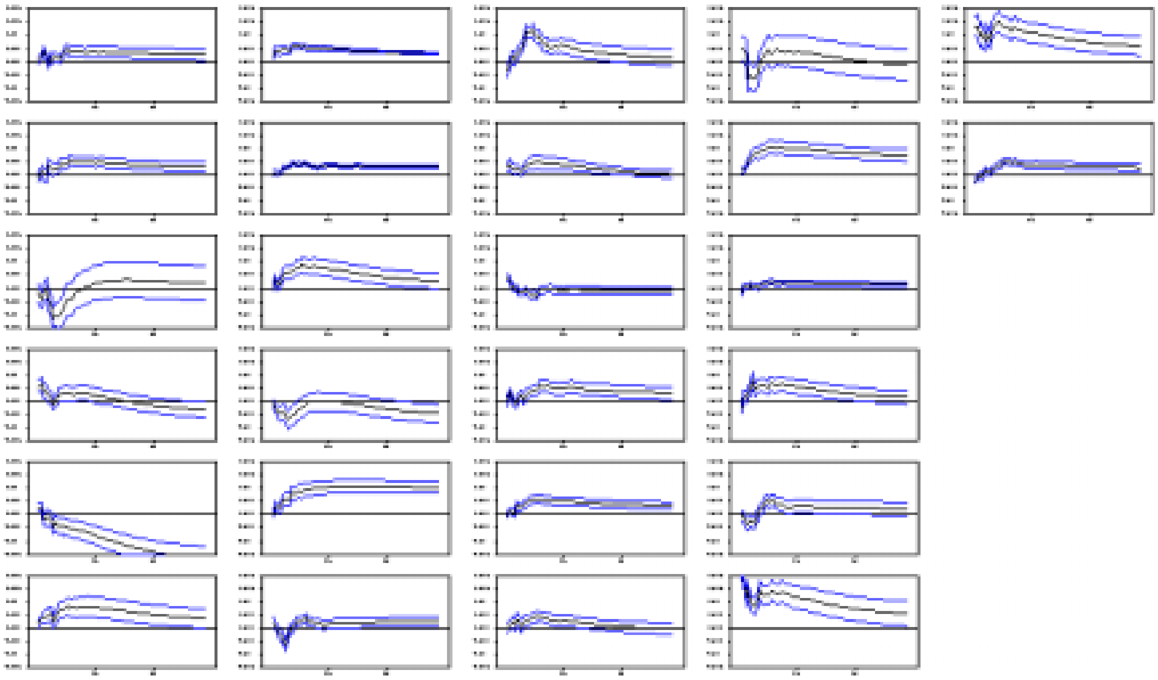

Figure 4.9 Output Response to Money Supply Shocks
26 Industries in Alphabetical Order (industrial output)

CHAPTER 5

CONCLUSION

The theoretical arguments for a countercyclical responses of real wage to an exogenous shock are well documented. But it is generally believed that real wages show procyclical movements over the business cycles due to many previous empirical evidence[41] that do not support the neoclassical and Keynesian theories of employment in the short run. Keynesian theories that are based on wage inflexibilities tend to have a negative correlation between real wages and employment, so is neoclassical economics that is based on a production function that follows downward labor demand curves. With this production function, changes in labor and output will be highly positively correlated and the real wage rate will move countercyclically. However, a limited participation model (Christiano, Eichenbaum and Evans, 1997) along with sticky-price model claims that the real wage responds procyclically in the short-run with a steady price level for a substantial period of time in response to the exogenous monetary shocks.

Most of the previous empirical research was focused on the behavior of real variables to aggregate demand shocks using sectoral and aggregate U.S. data and not many have extended the work beyond the U.S. I have first built empirical vector autoregression models for G-7 countries in an attempt to acquire any general tendencies across the countries in real wage responses to monetary shocks, from

[41] Some of the findings are found to be statistically insignificant, though.

which the relative stickiness of wage and output price can better be explained. But no consistent real wage responses have been found from the cross country studies as a first research. The responses may vary depending on the price deflators and the countries selected, which supports the previous research of Lucas (1977), Sumner and Silver (1989), Abraham and Haltiwanger (1995), and Lastrapes (2001), who have all shown no consistent real wage responses.

In the second research, I have built new VAR models in an effort to identify the relative importance of demand-side channel and supply-side channel in the transmission of nominal shocks to real economic activity across key U.S. industries. Real wages and output at industry-level respond positively to expansionary monetary shocks, which support many studies that have shown supply-side channel of monetary shocks. (CEE 1997, Barth and Ramey 2000) Thus, the supply-side channel plays more dominant role in industrial responses of real variables to nominal money supply shocks, which is consistent with one of the stylized facts about the effects of an expansionary monetary shock.

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