WELFARE COST OF INFLATION IN THE ECONOMY WITH INFLATION TARGETING: THE CASE OF NEW ZEALAND

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Abstract

The present research estimates the welfare cost of inflation in New Zealand. The size of this cost in the economy with inflation targeting regime deserves much attention as to evaluate the policy towards reduction of inflation-induced welfare losses. I use GMM estimation technique to estimate the parameters characterizing preferences and technology. The calculated cost of the rise of quarterly inflation from 0% to 1% is equivalent to 0.00804% of GNP. This is substantially smaller than those reported in other studies with partial equilibrium approach. The research provides two possible justifications for the minuteness of the estimates: 1) *Reserve Bank of New Zealand*'s credibility lent by the citizens which makes inflation expectations anchored; 2) The actual independence of *Reserve Bank* from the influence of government bodies thus avoiding the inflationary finance.

1. Introduction

High inflation has always been viewed as one of the main deterrents to economic growth and substantially detrimental to the welfare of economic agents. But in fact, only at the beginning of 90s did policymakers of industrialized countries worldwide opt for setting explicit and long-run goals of reducing inflation and keeping it at a low and stable level. New Zealand was a pioneer. In December 1989, the New Zealand Parliament passed the *Reserve Bank Act* representing the first attempt to create and codify a certain monetary policy framework to attain a well-defined economic objective. This framework has been termed *Inflation Targetting* as it is an approach based on official quantitative (usually low) targets or target ranges for the inflation rate to achieve.

The main principle of inflation targeting dictates that low inflation has to be “the primary long-run goal of monetary policy” (Bernanke et al. 1999, pp. 10). The very rationale for keeping prices stable is obvious costs, induced by high inflation starting from the costs of frequent re-pricing by firms and ending with overexpansion of the whole financial system due to unavoidable effect of inflation on cash holdings.

In this research, I focus on the welfare losses incurred by households. In Cash-in-Advance models, money is used for consumption acquisitions that require solely cash (see e.g. Lucas and Stockey, 1983) and since real money balances are reduced by high inflation, so are the purchases of cash goods and services. Inflation here serves as a tax by driving a wedge between the marginal utilities of cash goods and the goods acquired by other means, namely, credit. However, inflation can be viewed as a tax in a different way as well. If the government can freely expand the money stock, it may potentially finance its expenditures by simply printing new money. Increased money supply inevitably forces prices to go up and resulted inflation reduces the rate of return associated with working for money today and carrying it into the next period to purchase consumer goods (Andolfatto, 2008). Moreover, in attempts to avoid negative effects of inflation, consumers prefer holding less cash and make more trips to the bank or ATM machine incurring the cost of time and effort (so-called shoe leather cost). Although the development of internet reduced this particular cost, electronic funds transfers still require significant resources in the economy to be devoted to transacting via these channels. The more these resources are, the less is available for production, resulting in reduced output, consumption and welfare (Marquis 2001).

Intuitively, in the economy where policymakers target low inflation rates, abovementioned costs are expected to be minimal. But this inference is not as clear as it seems. One of the most important features of inflation targeting regime is frequent communications with the public and thorough presentation of the central bank's "view about the past and future performance of inflation and monetary policy" via public speeches and/or publication of summarized reports (Mishkin, 2000, pp. 105). The officially announced quantitative target helps economic agents to form the expectations and make decisions accordingly. However, if the public questions the credibility and commitment of the central bank, the expectations on inflation rate still might not reflect the announced one and cause distortions leading to possible losses on the part of individuals. Thus, without these distortions, welfare costs are expected to be smaller in the country with the credible central bank than in an environment where individuals still doubt what the future inflation will be.

Another issue is a degree of actual independence of the central bank from the government. Politicians, in order to monetize budgetary and fiscal deficits, often resort to inflationary finance thus generating considerable revenues (seigniorage) and as pointed above, inflation here acts as tax and generates welfare loss. Apparently, insulation of policy-making board from politicians can effectively reduce this cost.

My primary claim is that the monetary policy conducted in New Zealand and widely assessed as highly credible and sufficiently independent from the influence of government bodies (Bernanke et al. 1999, Sherwin 1999, Truman 2003 and Horn 2008), does contribute to the small size of inflation-induced welfare costs on money holdings. The costs estimated in my research are incurred as follows. Inflation reduces the real value of the cash balances that are held over periods and negatively affects the purchasing power of them. But for the given rate of inflation, agents equate opportunity cost of holding money (the foregone nominal interest rate) to the marginal productivity of money (measured by the services yielded by cash), and this equality gives rise to a certain level of money demand. When expected rate of inflation rises, agents reduce their demand for money balances thus reducing the amount of services provided by holding cash. Therefore, the increase in the expected inflation rate induces welfare cost since agents part with some liquidity benefit of money. As pointed above, in the country with a low inflation target, these welfare costs, presumably, are to be minimal. But I argue that in New Zealand, due to minor distortions in expectation-forming (i.e. people trust the publicly announced target) and negligible role of inflationary finance (policy-making board is insulated from politicians), the costs are expected to be even smaller.

In order to assess these costs quantitatively, I set up an intertemporal model where the optimal behavior and the decision-making of utility-maximizing agents are determined according to the expected rate of inflation, population growth rate and real interest rate. I impose the budget constraint incorporating past and current money holdings, financial assets, consumption and income[1]. With the aid of Hansen's (1982) Generalized Method of Moments, I estimate the parameters characterizing preference and technology in the model, and calculate the welfare loss as a measure required to compensate the New Zealander household for inflation. I compare the steady states of the model based on different inflation rates and find that the rise of quarterly inflation from 0% to 1% generates on average the welfare loss equivalent to 0.0134% of steady state consumption, or in other terms, the loss amounts to 0.00804% of GNP. To make it comparable with estimates from other studies, I report the welfare cost of 4% annual inflation (around 1% inflation per quarter) as 0.042% of GNP in New Zealand, which is substantially less than 0.12% computed by Fisher (1981) for the same 4% annual inflation rate in the U.S. Lucas (1981) gives even bigger estimate of 0.19%. Eckstein and Leiderman (1991) calculated these costs as equivalent to 0.46% of GNP for Israel.

Of course, I do not intend to claim that this noticeable relative minuteness of the estimate in New Zealand is only due to the special characteristics of the monetary policy run by *Reserve Bank*. Instead, I will provide the rationale for thinking that credible monetary policy can reduce the costs of inflation and argue that the small size of the estimate for New Zealand is partly owing to this. Meanwhile, I will discuss the possible reasons for existing differences.

[1] This set-up follows the approach adopted by Eckstein and Leiderman (1991) to calculate seigniorage and the welfare cost of inflation in Israel.

The paper is organized as follows. Next chapter reviews the related literature. Chapter 3 is devoted to the description of the model and the way of welfare cost calculations. Chapter 4 describes the data, estimation method, and discusses the results along with implications. The last chapter concludes.

2. Literature Review

Since the seminal paper of Bailey (1956), the notion of welfare cost of inflation and its measurement have drawn considerable attention of economists. The line of research has focused on partial and general equilibrium approaches, incorporating different frameworks to provide theoretical justification where the costs are stemming from and the ways they are calculated. I will summarize the major contributions in separate parts.

2.1 Consumer Surplus

Bailey (1956) viewed the welfare cost of inflation as a loss of consumer surplus which could be obtained from the reduction of nominal interest rate from positive value to zero. The nominal interest rate represents for a consumer a private opportunity cost of holding cash instead of deposit. An implicit assumption here is that the foregone interest rate is justified with the benefits brought by holding currency in terms of transaction-facilitating services. Any rise in the nominal interest rate (that reflects the rise in inflation rate) induces a corresponding fall in money demand and a decline of the benefits yielded by cash. This flow of productivity is associated with the area under the curve of "liquidity preference function" relating demand for real cash balances, m, to nominal interest rate, i. More precisely, the area is calculated via integration under the inverse money demand function:

$$w(i) = \int_{m(i)}^{m(0)} \psi(x)dx = \int_{0}^{i} m(x)dx - im(i)$$

where i is nominal interest rate, and $w(\cdot)$, $m(\cdot)$ and $\psi(\cdot)$ denote welfare cost, money demand and inverse money demand, respectively. For numerical estimations of the costs, Bailey (1956) and Friedman (1969) used the semi-log specification of money demand derived by Cagan (1956). However, Lucas (2000) applied the same techniques of calculations to log-log form of the demand function and argued that this set-up performs better in times of moderate inflation.

2.2. Money-in-the-Utility Function Framework

Although money-in-the-utility function specification has often been criticized (as money itself has no intrinsic value), it is a very convenient way enabling to solve numerically for welfare costs. Under certain assumptions, putting money in the utility function ensures that there is a demand for positive amounts of money in equilibrium (Walsh, 2003). Changes in the steady-state values of money demand associated with different rates of inflation (Eckstein and Leiderman, 1991) or interest rate (Lucas, 2000), give rise to a welfare loss. Lucas (2000) finds that this loss, which is calculated via "compensating variation" approach, is very close to the one calculated by the method adopted by Bailey (1956) for small rates of nominal interest. This approach defines welfare cost to be equal to the income compensation required for a consumer to keep him indifferent between positive and zero nominal interest rates[2]. I will provide further description and welfare cost implications of money-in-the-utility function framework while introducing the model under my research in the next chapter.

[2] In Eckstein and Leiderman (1991) and Lopez (2001), the compensation is in terms of consumption a household needs to be indifferent between positive and zero *inflation* rates.

2.3. Shopping-Time Framework

Unlike the money-in-the-utility function framework where money directly yields utility, shopping-time models treat money as a significant time-saving mean for transactions[3]. The development of this approach substantially owes to the work by McCallum and Goodfriend (1987). They motivate the necessity of cash by introducing transactions technology in the model. In particular, the economy is populated by infinitely-lived households having preferences over consumption of goods, c_t, and leisure, l_t, described by increasing and concave within-period utility function:

$$U = \sum_{t=0}^{\infty} \beta^t u(c_t, l_t) \qquad (1)$$

where β is the discount factor. The use of money is incorporated in the model as follows: it is assumed that a household needs cash to facilitate transactions since a shopping process requires a certain amount of time to be spent on it. Although more time devoted to shopping yields more consumption for an agent, time is negatively related to cash balances for a given level of consumption. That is, the bigger the amount of money held, the bigger the leisure (and utility) and the less the consumption. The authors define a function, ψ, to account for this relationship:

$$l_t = \psi(m_t, c_t) \quad \psi_1 > 0, \psi_2 < 0$$

which is a transaction constraint (m_t is real money holdings). Next, using this constraint and the budget constraint of a household, the authors maximize agent's lifetime utility and find a "portfolio-balance" formula relating real money balances, a variable associated with the time and effort spent on transactions and the nominal interest rate

[3] The notion of 'shopping time' was first introduced by Saving (1971)

which represents an opportunity cost of holding money. The “portfolio-balance” formula enables one to define the welfare cost of inflation in shopping-time models. In particular, when inflation rises, purchasing power of money is reduced. For a given amount of cash, individuals are able to purchase less consumption, which forces them to spend more time and effort on shopping to obtain the same quantity of goods as before. As a result, an agent’s leisure (or time for working) decreases, and the welfare loss is incurred. In his simplified version of McCallum-Goodfriend framework, Lucas (2000) shows that for small nominal interest rates, this loss is comparable to that calculated by consumer surplus formula and “compensating variation” approach in money-in-the-utility function framework.

2.4. Cash-in-Advance Framework

Cash-in-advance approach takes its origin from Lucas (1982), Svensson (1985) and Lucas and Stockey (1987). It is based on the assumption that money is the only source to make certain type of acquisitions and therefore, cash balances are required to be held by a consumer. The difference from shopping-time approach is that money holdings here can not be substituted for time. In Lucas (1982), an agent starts each period by allocating its portfolio between cash and interest-bearing assets while taking into account any current shocks, and makes purchases of consumption goods only in the next period. Facing an opportunity cost of holding money, an agent trades off between keeping money to finance future purchases and acquiring assets. Svensson (1985) changed the timing assumption of the original model in a way that he introduced an uncertainty about the money holdings needed for purchases of goods in the next period. It turns out that the positive nominal interest rate (induced by positive inflation rate) acts as a tax on consumption because a household must hold money to purchase it. Thus, a welfare loss is generated. Lucas and Stockey (1987) proposed an idea that in the market, there is a certain type of consumption goods that can be purchased by credit. That is, they applied cash-in-advance constraint only to cash goods thus giving a rise to a difference between marginal utilities of the two types of goods. This difference, in fact, induces tax on cash goods and consequently, higher inflation leads a consumer to undesirable substitution of cash goods by credit goods which generates a welfare loss.

3. The Model

The economy is described by infinitely lived households maximizing expected discounted utility

$$E_0 \sum_{t=0}^{\infty} \beta^t U(m_t, c_t^*) \qquad (1)$$

where E_0 denotes expectations conditional on information set available at time 0, β indicates a subjective discount factor, and $U(\bullet)$ is a concave increasing utility function defined over two arguments: real money balances per capita, m_t, and consumption services per capita, c_t*. Due to the conventional split of consumption into durable and non-durable components, I assume the consumption as a flow of utility yielding services not only from the current actual purchases, but also from those in the previous period. In other words, I relate consumption services to actual purchases as follows:

$$c_t^* = c_t + \delta c_{t-1} \qquad (2)$$

where δ is a fixed parameter that can be interpreted as a degree to which past consumption acquisitions contribute to current consumption services (or disservices).

Each household faces a budget constraint

$$b_t = \frac{b_{t-1}(1+r_{t-1})}{1+n_t} + \frac{m_{t-1}}{(1+n_t)(1+\pi_t)} + y_t - m_t - c_t \qquad (3)$$

where b_t is a real per capita value of one period financial asset and y_t corresponds to real per capita income other than that from capital gains. r_{t-1}, n_t and π_t denote respectively real interest rate, population growth and inflation rates from one quarter to another. Next, I assume that a following approximation of Fisher equation holds:

$$1+r_t = (1+R_t)/(1+\pi_{t+1}) \quad (4)$$

where R_t is a nominal interest rate on assets carried from *(t-1)* to *t*.

I opt for the utility function specification in logarithmic form:

$$U(\bullet) = \gamma \log m_t + (1-\gamma)\log c_t^* = \gamma \log m_t + (1-\gamma)\log(c_t + \delta c_{t-1}) \quad (5)$$

which represents a simplification of that used by Eichenbaum et al (1988) in time series analysis of representative agent models with $\gamma \in (0,1)$ being a preference parameter. As it can be seen from the specification, money directly enters the utility function which is an approach originally adopted by Sidrauski (1967) in studies of critical issues in monetary economics. Although the idea of money-in-the-utility function (MIUF) has often been treated with much criticism due to an intrinsically useless property of money, vast amount of research emphasizes the role of holding money as a substantial time-saving mean for purchasing consumption goods (see e.g. Brock 1974, Feenstra 1986).

In order to solve the maximization problem of (1), I express current actual purchases from (3) in terms of other variables:

$$c_t = \frac{b_{t-1}(1+r_{t-1})}{1+n_t} + \frac{m_{t-1}}{(1+n_t)(1+\pi_t)} + y_t - m_t - b_t \quad (6)$$

and substitute it into (2):

$$\begin{aligned} c_t^* = c_t + \delta c_{t-1} = \frac{b_{t-1}(1+r_{t-1})}{1+n_t} + \frac{m_{t-1}}{(1+n_t)(1+\pi_t)} + y_t - m_t - b_t + \\ \delta\left[\frac{b_{t-2}(1+r_{t-2})}{1+n_{t-1}} + \frac{m_{t-2}}{(1+n_{t-1})(1+\pi_{t-1})} + y_{t-1} - m_{t-1} - b_{t-1}\right] \end{aligned} \quad (7)$$

Finally, I substitute (7) into (5) and differentiate with respect to b_t and m_t to obtain first order conditions:

$$\beta E_t\left[\frac{(1-\gamma)/(c_{t+1}+\delta c_t)}{(1-\gamma)/(c_t+\delta c_{t-1})}\left\{\frac{(1+r_t)}{(1+n_{t+1})}-\delta\right\}\right]+\beta^2\delta E_t\left[\frac{(1-\gamma)/(c_{t+2}+\delta c_{t+1})}{(1-\gamma)/(c_t+\delta c_{t-1})}\frac{(1+r_t)}{(1+n_{t+1})}\right]-1=0 \quad (8)$$

$$\begin{aligned}&\frac{\gamma/m_t}{(1-\gamma)/(c_t+\delta c_{t-1})}+\beta E_t\left[\frac{(1-\gamma)/(c_{t+1}+\delta c_t)}{(1-\gamma)/(c_t+\delta c_{t-1})}\left\{\frac{1}{(1+n_{t+1})(1+\pi_{t+1})}-\delta\right\}\right]+\\ &\beta^2\delta E_t\left[\frac{(1-\gamma)/(c_{t+2}+\delta c_{t+1})}{(1-\gamma)/(c_t+\delta c_{t-1})}\frac{1}{(1+n_{t+1})(1+\pi_{t+1})}\right]-1=0\end{aligned} \quad (9)$$

where I used the fact that marginal utilities of (5) take the form

$$U_m^{'}=\frac{\gamma}{m_t} \qquad U_{c^*}^{'}=\frac{1-\gamma}{c_t^*}=\frac{1-\gamma}{c_t+\delta c_{t-1}} \quad . \quad (10)$$

A difference equation in (8) represents an Euler one – an intertemporal first-order condition characterizing an optimal allocation of consumption between periods *t* and *(t+1).* In particular, by equating expected marginal costs and benefits in the model with uncertainty, expectational Euler equation becomes a condition on moments allowing effective estimation of parameters in the model. Equation (9) can be viewed as another moment condition which equates the expected utility costs and gains of giving up one unit of current consumption and allocating it to real money balances and then to consumption in following periods. More complete justification of using these moment conditions as a tool for estimation will be discussed in the next chapter of the paper.

In order to derive a formula for calculation of welfare costs of inflation, I turn to a discussion of the steady state of the model. Therefore, I assume constant growth rates for population, n, and for consumption and real money balances per capita, φ. Another assumption is the invariance property of real variables to changes in the steady state level of inflation rate, π. The latter assumption is sometimes referred as a neutrality property of the model provided by MIUF approach. It substantially simplifies welfare cost calculations as variations in money holdings and consumption are not necessarily taken into account and in fact, these calculations are based on money demand model derived from Sidrauski-type optimizing framework (Walsh, 2003). With these assumptions, (9) becomes a non-stochastic equation of the following form:

$$\frac{\gamma / m}{(1-\gamma)/((1+\phi)c+\delta c)} + \beta \frac{(1+\phi)c+\delta c}{(1+\phi)c+\delta c}\left\{\frac{1}{(1+n)(1+\pi)} - \delta\right\} + \beta^2 \delta \frac{(1+\phi)c+\delta c}{(1+\phi)c+\delta c}\frac{1}{(1+n)(1+\pi)} - 1 = 0 \qquad (11)$$

After rearranging, a steady state demand for money can be obtained:

$$m^{ss} = c^{ss}\frac{\gamma}{1-\gamma}(1+\varphi+\delta)\frac{1}{1-\beta\left(\frac{1}{(1+n)(1+\pi)} - \delta\right) - \beta^2\delta\frac{1}{(1+n)(1+\pi)}} \qquad (12)$$

Having derived a crucial relationship in (12), I next follow the logic developed by Lucas (1994) to calculate welfare costs of inflation. The idea is to determine the percentage increase in steady-state consumption necessary for keeping an agent indifferent between zero and some positive level of inflation rates. If this increase is denoted by $\theta(\pi)$[4], then the following must hold:

$$U(m^{ss}, c^{ss} + \theta(0)c^{ss}) = U(m^{ss}, c^{ss} + \theta(\pi)c^{ss}) \qquad (13)$$

Substituting (12) into (5) and then into (13) yields:

[4] Of course, $\theta(0) = 0$.

$$\gamma \log\left[\frac{\gamma}{1-\gamma}\frac{(1+\varphi+\delta)c^{ss}}{1-\beta\left(\frac{1}{1+n}-\delta\right)-\beta^2\delta\frac{1}{1+n}}\right]+(1-\gamma)\log\left[(1+\varphi+\delta)c^{ss}\right]=$$

$$\gamma \log\left[\frac{\gamma}{1-\gamma}\frac{(1+\varphi+\delta)(c^{ss}+\theta(\pi)c^{ss})}{1-\beta\left(\frac{1}{(1+n)(1+\pi)}-\delta\right)-\beta^2\delta\frac{1}{(1+n)(1+\pi)}}\right]+(1-\gamma)\log\left[(1+\varphi+\delta)(c^{ss}+\theta(\pi)c^{ss})\right] \quad (14)$$

After simplifying, (14) takes the form:

$$-\gamma \log\left[1-\beta\left(\frac{1}{1+n}-\delta\right)-\beta^2\delta\frac{1}{1+n}\right]=$$
$$\gamma\log(1+\theta(\pi))-\gamma\log\left[1-\beta\left(\frac{1}{(1+n)(1+\pi)}-\delta\right)-\beta^2\delta\frac{1}{(1+n)(1+\pi)}\right]+(1-\gamma)\log(1+\theta(\pi)) \quad (15)$$

From which the percentage increase

$$\theta(\pi)=\left[\frac{1-\beta\left(\frac{1}{(1+n)(1+\pi)}-\delta\right)-\beta^2\delta\frac{1}{(1+n)(1+\pi)}}{1-\beta\left(\frac{1}{1+n}-\delta\right)-\beta^2\delta\frac{1}{1+n}}\right]^{\gamma}-1 \quad (16)$$

In calculations, I will report the welfare loss as a percentage of GNP by multiplying *θ(π)* by the ratio of consumption to GNP.

4. Data Description, Estimation Methodology,

Empirical Results and Discussion

This chapter covers the main features of the data, a theoretical description of the estimation tool used, and a complete report of the results from conducted regressions. The chapter ends with the welfare cost calculations and the discussion of obtained values.

4.1. Data Description

Due to unavailability of the data on New Zealand's population estimates in quarterly frequency before 1992, the sample period spans from 1992:I to 2008:IV. Therefore, the estimation procedure is employed against 68 observations of each variable. A significant part of the data was provided by Statistics New Zealand via *Infoshare* database searching tool[5]. Observations on some variables were retrieved from *OECD.Stat Extracts*[6] and *International Financial Statistics (IFS)*[7].

For estimation purposes I use two alternative measures of money: monetary base (M0) and M1. While the former refers to the physical currency (notes and coins) held by the public, the latter includes not only M0, but also "chequeable deposits, minus inter-

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[5] Available at http://www.stats.govt.nz/infoshare/
[6] Available at http://stats.oecd.org/WBOS/index.aspx
[7] Available at http://www.imfstatistics.org/IMF/imfbrowser.aspx?branch=ROOT

institutional chequeable deposits, and minus central government deposits". [8] Consumption is measured by final consumption expenditure of households. In order to obtain per-capita values of above mentioned variables, I divide the aggregate data by the current population estimate. All nominal variables are at constant (2000) prices. A numerical measure for the real interest rate is calculated according to the assumed relationship (4) where I use the data on money market rate for R_t. Inflation rate, π_t, is defined as a percentage change in Consumer Price Index. Descriptive statistics are summarized in Table 6 in the appendix.

4.2. Estimation Methodology

I checked for the stationarity of the variables and ADF test could not reject the null hypothesis of unit root in the series of money holdings and consumption. I removed the trend from the series via Hodrick-Prescott Filter and tested again for the unit root. At 5% significance level, ADF test rejected the null[9]. The results of these tests are provided in Tables 7-12.

There are three parameters to be estimated in the model: a preference parameter, γ, a subjective discount factor, β, and a parameter relating past actual acquisitions to current consumption services, δ. The estimation procedure is based on Generalized Method of Moments (GMM) approach originally developed by Hansen (1982). The procedure uses the first-order conditions obtained in a discrete-time model of utility-

[8] Reserve Bank of New Zealand. Series description – Monetary and financial statistics. Available at http://www.rbnz.govt.nz/statistics/monfin/c1/description.html#transEFTexcl

[9] Cogley and Nason (1991) provide some of the reasons why de-trending via HP Filter induces stationarity in the series.

maximizing agents in an uncertain environment. Generally, these first-order conditions take the form:

$$\mathrm{E}_t h(X_{t+n}, b_0) = 0 \qquad (1)$$

where X_{t+n} is a k-dimensional vector of variables observable at time $(t+n)$, b_0 is an m-dimensional vector of parameters to be estimated, h denotes the function mapping $R^k \times R^m$ into R^l, and E_t is an expectation operator based on the information set available at time t. Agents are assumed to form expectations rationally.

The relation in (1) is a theoretical one and it includes the true (but unknown to an econometrician) values of the parameters[10]. (1) can be translated into the terms of the model under my research as (8) and (9) Euler equations from the previous chapter. In particular, X_{t+n} (n = -1, 0, 1, 2) corresponds to the vector containing data on per capita values of money holdings and consumption, along with rates of population growth, real interest and inflation. Besides,

$$b_0 = (\beta, \delta, \gamma) \qquad (2)$$

GMM estimation procedure is based on the fact that Euler equations, (8) and (9) from the previous chapter, are orthogonal to any variable (instrument) under consideration which belongs to the current information set. The rationale for this statement is that as soon as expectations are formed, any past information is irrelevant to make further predictions. Thus,

$$\mathrm{E}_t \left[h(X_{t+n}, b_0) \bullet z_t \right] = 0 \qquad (3)$$

where h is a vector-function including right-hand sides of (8) and (9) from the previous chapter, and z_t is an instrument. In order to estimate parameters in (2), the procedure

[10] This relation is also referred as a moment condition.

replaces the theoretical orthogonality condition (3) with its sample counterpart and derives the estimates in such a way that weighted distance between true and sample values is minimal.

In fact, (3) represents a system of equations. It is said to be overidentified if instruments are more than the parameters to be estimated because there is no single solution for $\hat{b}_0$ (the estimate for b_0) in the sample counterpart of (3). To allow for overidentification, GMM estimator is obtained by minimizing the sample counterpart of the criterion function

$$J(b_0) = \left[h(X_{t+n}, b_0)\right]^T A h(X_{t+n}, b_0) \qquad (4)$$

where A is a weighting matrix. The minimized value of the sample counterpart of (4) is used to derive a *J-statistic* which allows testing the validity of overidentifying restrictions.

Yet one of the most important issues is to choose instruments correctly. As Fuhrer (1995) shows, weak and irrelevant instruments negatively affect the unbiasdness and statistical significance of the GMM estimators. He suggests that one should use lags of the variables included in X_{t+n}. The idea is that they are highly correlated with the contemporaneous values of the variables and weakly correlated with $h(\cdot)$.

I employed *Eviews* econometrical software to carry out the empirical part of the research. I accounted for heteroskedasticity and autocorrelation of unknown form by choosing HAC Weighting Matrix tool with Bartlett functional form of the kernel, which is one way to ensure the weighting matrix A in (4) to be symmetric positive definite and yield a consistent estimate for b_0 (Hamilton, 1994). As instruments, I use the following two vectors:

$$Z_t^1 = \left(1, \frac{c_t}{c_{t-1}}, m_{t-1}, \frac{r_{t-1}}{n_t}\right)^T \qquad (5)$$

$$Z_t^2 = \left(1, \frac{c_t}{c_{t-1}}, m_{t-1}, \frac{r_{t-1}}{n_t}, \frac{c_{t-1}}{c_{t-2}}, m_{t-2}, \frac{r_{t-2}}{n_{t-1}}\right)^T \qquad (6)$$

where the notations are the same as before. By looking at the moment conditions in the previous chapter, one can see that (5) and (6) are plausible instruments to be used. Moreover, their validity was never rejected by the corresponding J-statistic in the conducted regressions (see below) at 5% significance level.

4.3. Empirical Results

As pointed above, I use two measures for money aggregates: M0 and M1. In Table 1 below, I report the results of the estimation using M0 and Z_t^1 vector of instruments.

Table 1. The Estimates of the Parameters Using M0 and Z1 Instrument. * - significant at 10% level

	β	***γ***	***δ***	***Number of Observations***
Coefficient (Standard Error)	0.875645 ***** (0.517395)	0.110567 ***** (0.06134)	0.325792 (0.201126)	68
J-statistic	0.057842			
Overid_p	0.152557			

Overid_p is a p-value of the test for the validity of overidentifying restrictions under the null hypothesis that overidentifying restrictions are satisfied. Here, the null hypothesis can not be rejected. While the estimate for *β* is slightly lower than a conventional one, the coefficient for *γ* and *δ* (insignificant, though) seem of a reasonable size[11]. In Table 2 below, I change the money aggregate to M1 and use the same Z_t^1 instrument.

Table 2.The Estimates of the Parameters Using M1 and Z1 Instrument. ** - significant at 5% level

	β	***γ***	***δ***	***Number of Observations***
Coefficient (Standard Error)	0.925984 ****** (0.421766)	0.069871 (0.045827)	0.502481 * (0.293024)	68
J-statistic	0.096684			
Overid_p	0.115510			

As one can see, the estimate for the subjective discount factor became closer to one with statistical significance at 5% level. However, the coefficient for *γ* lost its significance while that of *δ* is significant at 10% level. The overidentifying restrictions are still valid. Table 3 below summarizes the estimation results of the regression using another instrument, Z_t^2, and again, M1.

[11] See Holman (1998) for the estimation results of the quarterly subjective discount factor parameter in MIUF framework.

Table 3. The Estimates of the Parameters Using M1 and Z2 Instrument.

	β	***γ***	***δ***	***Number of Observations***
Coefficient (Standard Error)	0.950120 ***** (0.524557)	0.085794 ** (0.041441)	0.295481 * (0.167599)	68
J-statistic	0.074684			
Overid_p	0.195235			

All the estimates are significant at 10% level and the values are of reasonable size. In addition, the validity of the restrictions can not be rejected at any reasonable significance level. This makes me confident to think that Z_t^2 instrument and M1 measure for money holdings are the most plausible ones to be used in calculations of welfare costs. However, I provide the summary of one more conducted regression below, in Table 4.

Table 4. The Estimates of the Parameters Using M0 and Z2 Instrument.

	β	***γ***	***δ***	***Number of Observations***
Coefficient (Standard Error)	0.860254 (0.565046)	0.354814 (0.249595)	-0.019245 (0.012150)	68
J-statistic	0.205687			
Overid_p	0.086254			

The validity of restrictions are not rejected at 5% level but at 10% they are. Besides, all the estimates are insignificant, and the coefficient for δ has economically meaningless sign. I attribute these failures to the improperness of using M0 (compared to M1) as a measure for money holdings in the model.

4.4. Welfare Cost Calculations

To calculate the welfare cost of inflation, I use the following estimated parameter values: β = 0.95, γ = 0.085, δ = 0.295. The results are summarized in Table 5 below.

Table 5. Calculation Results for Welfare Cost of Inflation

Quarterly Inflation	**Welfare Cost of Inflation as % of GNP**
0.25%	0.00076
0.5%	0.00331
1%	0.00804
1.5%	0.0127

4.5. Discussion

As mentioned in the first chapter, I focus on the inflation-induced welfare costs in terms of reduction liquidity benefits yielded by cash (due to decreased money demand) under Money-in-the-Utility function framework. Although this framework is accompanied with a widely criticized assumption that money yields direct utility, one can still think of functional equivalence between it and Cash-in-Advance models. The paper by Feenstra (1986) provides rationale for this relationship. In particular, he imposes regularity conditions on transaction technology in Cash-in-Advance model and shows that the maximization problem under these conditions is identical to that with real balances entering into the utility function. In addition, as I mentioned in the previous chapter, welfare cost calculations are much simplified in MIUF approach as some variations in money holdings and consumption are not necessarily taken into account. The assumed neutrality property of the model induces the invariance of real consumption associated with different rates of inflation.

In the introduction part, I compared the estimates of welfare costs generated by 4% annual inflation in New Zealand to those obtained by other authors. All these calculations are done through partial equilibrium analysis of economy. The vivid difference between them raises a question regarding its origin. Gillman (1995) argues that the difference is due to different bases chosen by authors at which welfare cost is trivial. The idea is that even if prices are stable, the nominal interest rate can be positive which makes opportunity cost of holding money positive as well. However, the studies mentioned above, all share zero inflation rate (and not zero nominal interest rate) as a cost-zero basis. This makes me think that there must be other factors causing the differences between the estimates of welfare costs. I tend to believe that the specific characteristics of monetary policy can be one of the contributors to the lower welfare losses on the part of the consumers. I summarize two possible views below.

The credibility of the central bank represents one of the main determinants of inflation expectations. If the public believes in the commitment of the bank to keeping inflation at a certain level, then agents form expectations accordingly and those expectations tend to be self-fulfilling (Ferguson, 2005). Thus, in the environment of credibility, inflation expectations are anchored and there are minor distortions after actual inflation is realized. In the context of the model under my consideration, the differences between actual and expected inflation rates may negatively affect optimal behavior of a household as long as expected inflation directly enters the optimality condition (9) from the previous chapter. In turn, the welfare cost might also be larger with such distortions than that without them[12].

Bernanke et al. (1999), Sherwin (1999), Truman (2003) and Horn (2008) characterize *Reserve Bank of New Zealand* as sufficiently credible and committed to the announced policy. Indeed, quarterly reports provided by *Reserve Bank* indicate that inflation expectations and actual inflation were mostly confined to 0-3% target band maintained by the New Zealander policymakers[13]. Consequently, it seems to me plausible to state that the distortions are of a small scale in New Zealand and justify the contribution of *Reserve Bank*'s credibility to minuteness of the welfare cost estimates. Another justification rests on the independent role of *Reserve Bank*. As Truman (2003) points out, the policy-making board of *Reserve Bank* is sufficiently protected from the influence of politicians. Among other things, the actual independence prevents the bank from being forced to carry out inflationary finance (which is usually favored by the government and politicians). As inflation acts as tax under seigniorage policy, individuals' cash holdings experience depreciation. Thus, they lose some part of the liquidity benefit of money

[12] Moreover, if these differences are large, one can question even the validity of the steady-state of the model.
[13] Reports are available at http://www.rbnz.govt.nz/about/Whatwedo/

which translates into welfare loss. Without inflationary finance in the economy, obviously, this loss is to be minimal.

5. Conclusion

The present research estimates the welfare cost of inflation in New Zealand based on the quarterly data from 1992:1 to 2008:4. This time span is distinguished in a way that it captures New Zealand’s experience on inflation targeting regime. The main interest lies in evaluating costs and the role of the monetary policy in reducing them.

I find a partial equilibrium estimate of welfare cost of raising inflation rate from zero to one percent equivalent to 0.00804% of GNP. This is substantially smaller than those reported in other studies with partial equilibrium approach. The research provides two possible justifications for the minuteness of the estimates; however, I acknowledge that other theoretical and empirical factors could also influence the size of the welfare loss.

The first justification rests on the extent of the credibility of the policy-making body. There is a vast amount of literature assessing *Reserve Bank of New Zealand* as highly credible from the point of view of citizens. This has resulted in anchored inflation expectations inducing only minor costs of realized inflation.

The second justification is about actual independence of *Reserve Bank*. The structure of the board is sufficiently insulated from government bodies which often resort to inflationary finance inducing costs on the part of consumers. Because of this characteristic, welfare losses are implied to be smaller.

The research can be extended into several directions. First, the partial equilibrium model employed in the research can be extended to a general one to capture the differences in welfare cost estimates. Second, as inflation targeting regime in New Zealand is known to have started in 1990, it would be a good exercise to include the data which are missing from the present research (due to current unavailability of population quarterly estimates) and carry out estimation of the costs. Finally, in order to further evaluate the role of monetary policy in reduction of welfare losses, one has to estimate the costs in other inflation targeting economies as well.

Although a lot of work has to be done to extend the implications of the present research, I consider this study as a starting point for estimation welfare costs in the economies with inflation targeting.

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APPENDIX

	Definition	Mean	Median	Max	Min	Std. Dev.	Obs.
CONS	Final Consumption Expenditure by Households	42.18552	42.23525	44.14127	38.59619	0.970005	68
CPI	Consumer Price Index	102.1957	99.2	125.9	86.62	10.70897	68
INF	Quarterly Inflation Rate	0.005673	0.005228	0.016306	-0.00795	0.004517	68
M0	Monetary Base	26.45687	29.35487	39.12544	15.87365	7.356984	68
M1	M1 (M0 + Chequeable Deposits)	37.97086	38.6835	50.96962	26.01242	8.793159	68
POPR	Population Growth Rate	0.00296	0.002863	0.004937	0.001215	0.000968	68
RIR	Real Interest Rate	7.65859	7.488743	10.84279	4.561071	1.473293	68

Table 6. Descriptive Statistics

Null Hypothesis: CONS has a unit root		
Exogenous: Constant		
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)		
	t-Statistic	Prob.
Augmented Dickey-Fuller test statistic	-1.432208	0.5614
Test critical values: 1% level	-3.531592	
5% level	-2.905519	
10% level	-2.590262	

Table 7. Unit Root Test for Consumption Variable (before De-trending)

Null Hypothesis: CONS has a unit root		
Exogenous: Constant		
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)		
	t-Statistic	Prob.
Augmented Dickey-Fuller test statistic	-3.003214	0.0398
Test critical values: 1% level	-3.531356	
5% level	-2.905024	
10% level	-2.591596	

Table 8. Unit Root Test for Consumption Variable (after De-trending)

Null Hypothesis: M0 has a unit root		
Exogenous: Constant		
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)		
	t-Statistic	Prob.
Augmented Dickey-Fuller test statistic	-1.245838	0.6496
Test critical values: 1% level	-3.529658	
5% level	-2.912579	
10% level	-2.590365	

Table 9. Unit Root Test for M0 Variable (before De-trending)

Null Hypothesis: M0 has a unit root		
Exogenous: Constant		
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)		
	t-Statistic	Prob.
Augmented Dickey-Fuller test statistic	-5.824524	0.0000
Test critical values: 1% level	-3.531354	
5% level	-2.905265	
10% level	-2.591596	

Table 10. Unit Root Test for M0 Variable (after De-trending)

Null Hypothesis: CONS has a unit root		
Exogenous: Constant		
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)		
	t-Statistic	Prob.
Augmented Dickey-Fuller test statistic	-0.244486	0.9267
Test critical values: 1% level	-3.531592	
5% level	-2.905519	
10% level	-2.590262	

Table 11. Unit Root Test for M1 Variable (before De-trending)

Null Hypothesis: CONS has a unit root		
Exogenous: Constant		
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)		
	t-Statistic	Prob.
Augmented Dickey-Fuller test statistic	-4.000265	0.0000
Test critical values: 1% level	-3.531356	
5% level	-2.905024	
10% level	-2.591596	

Table 12. Unit Root Test for M1 Variable (after De-trending)