Aggregate and Welfare Effects of Redistribution of Wealth Under Inflation and Price-Level Targeting *

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August, 2008

Abstract

Since the work of Doepke and Schneider (2006a) and Meh and Terajima (2008), we know that inflation causes major redistribution of wealth —between households and the government, between nationals and foreigners, and between households within the same country. Two types of monetary policy, inflation targeting (IT) and price level targeting (PT), have very different implications for the price level path subsequent to a price-level shock, and consequently, have different redistributional properties which is what we explore in this paper. For Canada, we show that the magnitude of redistributions of an unexpected 1% price-level increase under IT is about three times larger than under PT. Households' and foreigners' wealth losses from a price level increase is matched by the gains of the government. Even though this redistribution is zero-sum, we observe positive effects on GDP due to the wealth loss, the lower value of the debt and its associated fiscal adjustment, and the non-linear effects on work effort of the redistribution of wealth across households. Although the effects on GDP are positive, the direction of the change in the weighted welfare of households depends on the details of the associated fiscal policy.

Keywords: Inflation, redistribution of wealth, nominal assets and liabilities, monetary policy regimes. *JEL Classification:* E31, E42, H23

*We thank participants in Demography Workshop at the Bank of Canada, Conference on Defining Price Stability at the European Central Bank, 2008 Midwest Macro Meetings, 2008 Canadian Economic Association Meetings, 2008 North American Econometric Society Summer Meetings, 2008 Far Eastern and South Asian Econometric Society Summer Meetings, 2008 Computing in Economics and Finance Conference, 2008 Society of Economic Dynamics, and the Bank of Japan. We also thank Matthieu Darracq-Paries for discussing the paper at the ECB conference, and Ian Christensen, Allan Crawford, Martin Eichenbaum, Walter Engert, Martin Schneider and Nancy Stokey for comments. We thank David Xiao Chen and Thomas Carter for excellent research assistance. Ríos-Rull thanks the National Science Foundation (Grant SES-0079504). The views expressed in this paper are those of the authors. No responsibility or imputation of the views should be attributed to the Bank of Canada, the Federal Reserve Bank of Minneapolis or the Federal Reserve System.

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1 Introduction

Doepke and Schneider (2006a) and Meh and Terajima (2008) have shown that inflation causes major redistribution of wealth as it erodes the real value of nominal assets and liabilities while leaving real assets unaffected. This is due to differences in portfolio composition between households, as well as the existence of nominally denominated government debt and the fact that the domestic economy's net position with respect to the rest of the world in nominal instruments is non-zero. Some households, mostly young, have real assets and nominal liabilities (mostly mortgages), while others, mostly old and high income, have a large share of their wealth in nominal assets such as long-term bonds and pension benefits. Portfolio composition differs not only with regard to whether instruments are real or nominal, but also with regard to the maturity structure of nominal holdings.

While a sizeable number of central banks have embraced inflation targeting (IT) as their official *modus operandi*, price-level targeting (PT) is considered a serious contender. The differences between these regimes are non trivial. The main difference is that under IT past "mistakes" are ignored, while under PT they are corrected. This results in different price level paths; under IT, there is a permanent deviation from the pre-shock path, while under PT the price level eventually returns to its initial path. Short-term nominal assets (e.g., cash), which are depreciated at the instantaneous rate of inflation, and real assets (e.g., houses, business capital), which are not affected by inflation, fare equally under IT and PT. However, long-term nominal assets, which are depreciated by the ratio of the current price to the price level at the time of maturity, fare differently under these frameworks. More specifically, under PT, gains and losses on long-term nominal claims are attenuated relative to those under the IT regime since the initial price shock is off-set over time as the monetary authority seeks to return the price level to its pre-shock path.

In this paper, using Canadian data, we consider the effects that arise under IT and PT through the redistributional channel as nominal holdings are revalued following an unexpected surge in the price level.[1] More specifically, we address two questions. First, through the detailed documentation of nominal portfolios of different agents in the economy, we assess the potential redistributions of unexpected inflation under IT and PT regimes. Second, we quantify the aggregate and welfare implications of these redistributions under both regimes.

With respect to the first question, we find that the size of redistributions is large and consistently higher under IT than PT. Redistributions occur due to the fact that the portfolios of agents are different. Moreover, the difference between the two monetary policy regimes arises because the use of long-term assets and liabilities is prevalent in the economy.[2] The young middle-class and the poor are net nominal borrowers due mostly to mortgage liability holdings, a long-term liability, while the rich and the old are net savers due to pension and long-term bond holdings, long-term assets.

[1] The Canadian data are used at least for two reasons. First, Canada already implements inflation targeting. Second, a review of the monetary policy framework is currently underway and a price-level targeting policy is considered as one option. However, insights of the paper are applicable to other countries.

[2] As mentioned, a price-level shock does not affect long-term nominal claims as dramatically under PT while short-term nominal claims fare similarly under both regimes.

The middle-aged are also savers due to pensions. Among different sectors, the government is a net nominal borrower due mostly to long-term bonds while the household sector as a whole and the foreign sector are net nominal lenders. Based on these portfolios, a one-time positive 1% price-level shock lasting one period leads to a gross redistribution among households of 5.5% of GDP or $76 billion.[3] In net value, under IT, the household sector loses wealth equivalent to 0.4% of GDP or $5.5 billion which is 2.7 times larger than under PT. In addition, on average under both regimes, the young poor, the young middle-class, and the government are winners, while the middle-aged workers, the old and the rich are the losers.

Concerning the second question, we utilize an overlapping-generations model with additional heterogeneity within households in each cohort due to differences in labour productivity profile as well as in propensities to work and save. In analyzing the effect of redistributions on aggregate output and welfare we incorporate in our analysis the role fiscal policy plays in transferring the government's windfall gain or loss to households. With a positive price-level shock, the government's nominal debt decreases in its real value, an improvement in the government's portfolio. We consider several fiscal policies that re-balance the government budget after the initial change in the real value of government debts. The government transfers the windfall gain through a reduction in labour taxes over several periods, a lump sum transfer, and a transfer to retirees.

Our main findings on aggregate output are that there are non-zero effects and that these effects are larger under IT than PT. We show that despite the fact that the redistribution shock is zero sum across agents in the economy, the aggregate effects on output are non-zero under either monetary policy regime. Because winners (net borrowers) during a surprise inflation episode are younger and relatively poorer than losers (net lenders), the incentives to work and save are affected in ways that are not offset during aggregation. That is, redistributions generate wealth effects on household labour supply decisions. When a household receives a negative (positive) redistribution, the household increases (decreases) its labour supply to make up for the wealth loss (gain). Since households are heterogeneous in the age, the productivity and the preferences, their labour supply responses will also be heterogenous. More redistributions under IT lead to larger responses by households to generate larger aggregate effects.

Specifically, we find that the aggregate output effects from an unexpected price level surge are greater under IT than PT. For example, when the government cuts the labour tax rate to reallocate its windfall gains to households, a one-time 1% price-level shock leads to an increase in output of 0.1% of GDP or $1.4 billion under IT, while under PT, the increase is less than one-third of that under IT. Using the standard measure of utilitarian aggregate welfare of households alive at the time of the shock, we find that weighted aggregate welfare of households depends on how fiscal policy transfers the government's windfall gain to households. If the fiscal policy favors workers (i.e., a tax cut on labour income), weighted average welfare worsens with the price-level shock by -0.06% of consumption under IT and by -0.03% under PT. On the other hand, if fiscal policy favors retirees

[3]Even though our discussion throughout the paper focuses mainly on a positive 1% shock, our framework is not limited to it. Shocks can be of different magnitudes and signs. The analyses of different shocks are conducted as a part of sensitivity analysis.

(i.e., an increase in transfer), welfare increases by 0.20% and 0.09% under IT and PT, respectively.

The documentation of nominal portfolios of agents in the United States is done by Doepke and Schneider (2006a), and a framework for quantitatively studying the redistributional effects of inflation is developed by Doepke and Schneider (2006b). In this sense, our work is closely related to theirs, but they do not consider monetary policy regimes and the differential effects under IT and PT. Their focus is on the effects of inflation in general. Comparing our work and theirs empirically, one of the main differences between the portfolios in Canada and the United States concerns that of middle-aged, middle-class households. In Canada, middle-aged, middle-class households are net lenders while in the United States they are borrowers. Even though Doepke and Schneider (2006b) does not study monetary policy regimes, some of their results can be compared to ours qualitatively. In our quantitative work based on a positive price-level shock, the difference in the portfolio of middle-aged, middle-class households is shown to generate a positive aggregate output effect as well as a negative average welfare effect. These results contrast sharply with those of Doepke and Schneider, which connect positive price-level shocks with negative output effects and positive welfare effects.

There exists a literature studying the benefits and costs of IT and PT (see for example, Gaspar, Smets, and Vestin (2007), Ambler (2007), Cote (2007), Vestin (2006), Svensson (1999), Duguay (1994)). However, this literature does not account for the redistributional effects of price level changes and its macroeconomic consequences under PT and IT. There are other related studies on redistributions. For Canada in the 1970s, Maslove and Rowley (1975) assess the redistributional consequences of inflation but focus on the expenditure effects that arise from the consumption pattern of households while we focus on the wealth effects that come from the valuation of nominal assets. The paper is also related to earlier literature, such as Bach and Stephenson (1974) and Cukierman, Lennan, and Papadia (1985), who document redistribution of wealth in the 1970s in other countries. However, they do not conduct their analysis within a unified framework where direct and indirect positions are considered together. Our focus on both sectoral and household data also distinguishes our approach from theirs. There is also a literature that considers the welfare costs of inflation in monetary models where inflation affects the distribution of wealth (see Albanesi (2007), Erosa and Ventura (2002) and Cukierman, Lennan, and Papadia (1985)). Burnside, Eichenbaum, and Rebelo (2006) investigate the fiscal consequences of currency crises in emerging market economies. Their findings suggest that the devaluation of nominal government debt is a more important source of government revenue than seigniorage. Persson, Persson, and Svensson (1998) show that because of incomplete indexation of the tax system and the transfer program, moderate inflation has large effects.

The remainder of the paper is organized as follows. Section 2 describes in detail how IT and PT have different redistributional impacts. Section 3 calculates the extent of redistribution based on nominal and real portfolios held by Canadian households and by the government and the foreign sectors. Section 4 describes the overlapping generations model and defines equilibrium under both regimes. Section 5 discusses the calibration of the model and describes how agents are affected when the price level experiences a 1% shock. Section 6 discusses the aggregate and welfare results of the price-level shock under various fiscal and monetary regimes as well as some sensitivity analyses.

Section 7 concludes.

2 Methodology to compute the redistribution of wealth under IT and PT

In this section, we describe the method we use to compute the extent of redistribution of wealth from a permanent price-level shock or equivalently a transitory inflation shock. The extent of the inflation-induced redistribution of wealth depends on the monetary policy in place. Put differently, the size of the redistribution of wealth depends on inflation expectations which are affected by the policy. Hence, we explicitly incorporate a monetary policy, *inflation targeting* (IT) or *price-level targeting* (PT), in our framework by capturing the difference in the post-shock price-level path.

An unanticipated rise in the price level redistributes wealth from lenders to borrowers, and this is because such an increase in the price level lowers the real value of nominal assets and liabilities. Using the framework in this section and the nominal portfolio documentation in Section 3.2, we will assess the magnitude of the redistribution of wealth by computing the present value gain or loss of such a price-level shock for each sector as well as different groups of households under IT and PT. Under IT, bygones are bygones, and the price level remains at its new path after a price level shock. On the other hand, under PT, a credible central bank brings the price level back to its original path. Given that the unanticipated price level shock will be brought back to the initial path under PT, the redistribution of wealth would be on average smaller under PT than IT.

2.1 Inflation targeting

Suppose there is a one-time transitory unanticipated inflation increase of Δ that leads to a surprise jump in the price level. Under IT, the central bank does not bring the price level back and therefore the price level will remain at its new path after the shock. This surprise jump in the price level leaves nominal interest rates unchanged. Redistribution of wealth emerges since a jump in the price level reduces proportionally the real value of nominal claims.

Let us now discuss formally the present value gain or loss of a one-time transitory surprise inflation. Define i_t^{t+n} to be the nominal return on an $n-$year nominal zero-coupon bond at date t. Let $V_t(n) = \exp(-i_{t+n}^n)$ be the present value of one dollar at date $t+n$ before the price level shock of Δ. Because the nominal term structure does not change under IT after the surprise price-level shock at time t, the new time t present value of one dollar due at time $t+n$ is given by $V_t^{IT}(n)$ defined as follows

$$\begin{aligned} V_t^{IT}(n) &= \exp(-i_t^{t+n})\exp(-\Delta) \\ &= V_t(n)\exp(-\Delta). \end{aligned} \tag{1}$$

Equation (1) shows that the present value of a one dollar claim at time t is lowered by $\exp(-\Delta)$ and

that such a present value is independent of the maturity of that claim. Therefore, the present value gain or loss G^{IT} is given by the following expression

$$G_t^{IT} = V_t(n) - V_t^{IT}(n) \quad = \quad V_t(n)\left[\exp(-\Delta) - 1\right]. \tag{2}$$

As equation (2) shows, the net present value gain or loss is independent of of the maturity of a position and depends on the size of the shock and the size of the overall position. The gain is, indeed, proportional to the net position with a coefficient of $\exp(-\Delta) - 1$. If $G^{IT} > 0$ then there is a gain from the price level shock and otherwise there is a loss. In the next section, equation (2) will be used to compute the size of the redistribution under IT. More specifically, the gain/loss of a sector or an individual household at a given point in time, will be computed by multiplying the overall net nominal position documented in the previous section by the factor of $\exp(-\Delta) - 1$.

2.2 Price level targeting

An important difference between IT and PT is that the central bank commits to bringing the price level back to its initial path after the shock. Under a PT regime, assuming that the central bank is credible, agents in the economy expect that the central bank will bring the price level back to its targeted path after H periods, where the target horizon is given by H. Assume for simplicity that the central bank follows a linear rule (which is publicly known) with a constant slope Δ' to bring the price level back to its targeted path,

$$\Delta' = -\frac{\Delta}{H}. \tag{3}$$

To bring the price level back after an unanticipated rise in inflation, the central bank must generate inflation that is lower than the slope of the targeted price-level path. For example, if central bank targets full price stability (that is, a constant targeted price level), the central bank must create deflation in order to bring the price level back.

Since PT does not currently exist in Canada, we can think of our experiment of redistribution of wealth under PT as follows. In period t, there is a surprise one-time credible announcement of a PT regime starting from t and at the same time there is a surprise one-time transitory increase in the price level. After the surprise price level shock and the surprise announcement of the new regime, bond prices will instantly change to account for the new inflation path or price level path. Assume that the Fisher equation holds ex ante: $i_t^{t+n} = r_t^{t+n} + \pi_t^n$, where r_t^{t+n} is the real interest rate and π_t^n is the cumulative expected inflation. Supposing that the real interest rate does not change after the shock, the nominal $n-$year return is $\widehat{i}_t^{t+n} = i_t^{t+n} + \Delta' \min\{n, H\}$. In this case, the time t present

value of a dollar at $t+n$ becomes

$$\begin{aligned} V^{PT}(n,H) &= \exp(-\Delta)\exp(-\widehat{i}_t^{t+n}) \\ &= \exp(-\Delta)\exp(-i_t^{t+n} - \Delta' \min(n,H)) \\ &= \exp(-\Delta)\exp(-i_t^{t+n})\exp(-\Delta' \min(n,H)) \\ &= V_t(n)\exp(-\Delta)\exp\left(\frac{\Delta}{H}\min(n,H)\right). \end{aligned} \tag{4}$$

Using equation (4), we derive the present value gain or loss $G^{PT}(n,H)$ of a given position of maturity n under PT with a target horizon H:

$$G^{PT}(n,H) = V^{PT}(n,H) - V_t(n) = V_t(n)\left[\exp(-\Delta)\exp\left(\frac{\Delta}{H}\min(n,H)\right) - 1\right]. \tag{5}$$

The total present value gain or loss $G^{PT}(H)$ under a PT regime with a target horizon equal to H periods is given by the summation of $G^{PT}(n,H)$ over the maturity n:

$$G^{PT}(H) = \sum_n G^{PT}(n,H) = \sum_n \left\{V_t(n)\left[\exp(-\Delta)\exp\left(\frac{\Delta}{H}\min(n,H)\right) - 1\right]\right\}. \tag{6}$$

Equations (4)-(6) show that the size of the present value gain or loss from a price level shock depends not only on the size of the position but also on the interaction between the target horizon H and the maturity structure n of assets and liabilities. More specifically, equation (6) illustrates that the contribution of a particular instrument to the total gain or loss from a price level shock depends on three elements in addition to the size of the shock: (i) the size of the position, (ii) the maturity of that position, and (iii) the target horizon used by the central bank. Note that the dependence of the present value gain under PT on the maturity structure contrasts with IT.

We assume that once a position comes to maturity at time $t+n$, the funds are reinvested at the real interest rate.[4] For example, if the target horizon is high ($n < H$) then

$$V^{PT}(n,H) = V_t(n)\exp(-\Delta)\exp\left(\frac{\Delta}{H}n\right) \tag{7}$$

$$G^{PT}(n,H) = V_t(n)\left[\exp(-\Delta)\exp\left(\frac{\Delta}{H}n\right) - 1\right]. \tag{8}$$

In this case, only nominal assets and liabilities with maturity $n = 1, ..., H-1$ will be affected by the shock. For a given target horizon, H, gains or losses will be smaller for longer maturity positions. This comes from the fact that $G^{PT}(n,H)$ is decreasing in n in absolute values. Moreover, $\lim_{H\to+\infty} G^{PT}(n,H) = G^{IT}$. This means that, as the target horizon under PT goes to infinity, the

[4] Actually, for the wealth effects we are investigating, the precise manner in which short-term instruments are protected from inflation after coming to maturity is irrelevant. In the real world, it is possible to see funds generated by the short instrument be consumed, or be reinvested at a higher nominal interest rate or at the real interest rate. Moreover, because the central bank is credible and agents in the economy have perfect foresight, the wealth effects are exactly the same whether long-term bonds are held to maturity or sold early at loss.

resulting price-level path converges towards that under IT. Put differently, for a given maturity n, gains or losses are larger for longer target horizons (G^{PT} is an increasing function of H in absolute values).

Let's now discuss the case where the target horizon is small ($n \geq H$). The time t present value of a dollar at time $t+n$ and the gain or the loss are given by

$$V^{PT}(n,H) = V_t(n)\exp(-\Delta)\exp\left(\frac{\Delta}{H}H\right) = V_t(n) \quad (9)$$

$$G^{PT}(n,H) = 0. \quad (10)$$

The present value of nominal assets and liabilities of maturity $n \geq H$ remains unchanged. This is because the price level will be brought back by the central bank by the time the instruments come to maturity. Therefore, if the target horizon is short, longer term-to-maturity assets and liabilities are more likely to be unaffected by the price level shock.[5]

3 Redistribution based on nominal assets and liabilities

Given that we have a methodology to calculate the size of redistributions for a given nominal instrument, we now turn to the documentation of portfolios of agents in the economy in Canada and the calculation of the redistribution based on the existing portfolio.

3.1 Construction of net nominal positions

Our methods and specific variables used for constructing net nominal positions are detailed in Meh and Terajima (2008). Hence, we briefly discuss them in this section while the resulting portfolios will be discussed in Section 3.2. We define nominal assets and liabilities to be all nominal securities denominated in Canadian dollars. We observe four sectors of the economy: household, government, foreign and business. Since the business sector is entirely owned by other sectors through equity, we define household, government and foreign sector to be the three *end-user* sectors. The redistribution effects on the business sector are indirectly carried over to these end-user sectors through the equity claim they hold against businesses. The computation of the net nominal position involves the use of indirect positions (through equity holdings) of a sector or a group of households. Therefore the net nominal position (NNP) of a sector or a household group is the difference between the market value of its nominal assets and liabilities, both direct and indirect.

Data Our main data source for computing the positions of the government, foreign, household and corporate sectors is the National Balance Sheet Accounts (NBSA) in 2005, as provided by Statis-

[5] This section suggests that the target horizon under price level has important implications for the choice of maturity structure of assets and liabilities.

tics Canada.[6] The NBSA documents the ownership of financial and non-financial assets by sector. Specifically, it details assets and liabilities for persons and unincorporated businesses, corporations (including investment intermediaries), governments (at the federal, provincial and municipal levels), and non-residents (including foreign-owned banks and corporations). Within our study, we title these the household, business, government and foreign sectors, respectively. Our three end-users are the household, government and foreign sectors since the assets and liabilities of the business sector are distributed to these end-users in proportion to their equity holdings.

For detailed household nominal positions, we use the 2005 Survey of Financial Security (SFS), which provides microdata on income and wealth collected by Statistics Canada.[7] Based on the equity holdings, we assign the assets and liabilities of the business sector to the government, foreign and household sectors and to household groups. Values of assets and liabilities are given at market value in the NBSA by Statistics Canada. For financial positions, the total values of liability-side bonds and equity have been estimated directly in the NBSA; asset-side figures are then linked to these estimates. The market value for shares of all listed companies is based on information taken from the exchanges and reconciled to survey data. Assets of the major domestic institutional investors (e.g., pension funds, segregated funds of life insurance companies, mutual funds) are converted to market values based on data in Statistics Canada surveys. The market value of the non-resident sector's assets is estimated by Statistics Canada using microdata in a debt inventory system, as are domestic bond liabilities. Therefore, unlike Doepke and Schneider (2006a), we do not impute market values from payment streams within our dataset.

Categories of nominal instruments and term structures For our purposes, any financial instruments denominated in Canadian dollars are considered nominal unless their returns are indexed to inflation. Non-financial instruments and those denominated in foreign currencies are real.[8] We define four broad categories of nominal financial instruments: Short-term Instruments, Bonds, Mortgages, Employer Pension Plans. For the purpose of our study, all nominal assets and liabilities of sectors and household types are assigned to one of these categories.[9]

The short-term instrument category includes assets and liabilities with a term-to-maturity of one year or less, i.e., domestic currency and bank deposits, other deposits, consumer credit, Canada short-term paper, other short-term paper, trade receivables and payables, and reserve positions and drawing rights at the IMF. For mortgages, we assume that they mature according to the distribution over the *term* of mortgages estimated for fixed-rate mortgages from the 2005 Canadian Financial Monitor, an annual household survey conducted by Ipsos Reid.[10] The bond category comprises non-

[6]Brief descriptions of the data sets used in the paper are attached in Appendix A. For more details, see Meh and Terajima (2008).

[7]The 2005 SFS is the latest one available.

[8]Some positions reported in the NBSA and SFS are defined to include both domestic and foreign currency-denominated instruments without further detail. We have estimated currency-specific components using a procedure explained in Meh and Terajima (2008).

[9]Assets held within Registered Retirement Savings Plans (RRSPs) are assigned to one of these categories. In the 2005 SFS data, the values of assets within RRSPs are documented and therefore we assign RRSP assets to short-term instruments, bonds and equities.

[10]The *term* of mortgages is the period after which the mortgage rate is re-adjusted to the prevailing market rate.

mortgage and non-pension financial instruments with maturity greater than one year and includes the following items: bank loans, loans from other institutions, Canada bonds, provincial bonds, municipal bonds, corporate and other bonds, government claims, and other financial instruments that have not been assigned to the mortgage, pension or short categories. As for the term structure of bonds, we employ a distribution over terms-to-maturity for bonds. We derive this distribution from annual data on the maturity and face value of federal government debt outstanding in 2005 as detailed in Meh and Terajima (2008).

Finally, we distinguish among three types of Employer Pension Plans: non-indexed defined benefit, indexed defined benefit, and defined contribution. Defined benefit plans pay the beneficiary based on a formula (usually involving years of service and average earnings) while payments from defined contribution plans depend on the performance of the portfolio in which contributions have been invested. Partially indexed defined benefit plans are taken as non-indexed in our analysis. Fully indexed plans are treated as real assets. For the term structure of non-indexed defined benefit plans, we assumed that they pay nominally fixed benefits on an annual basis, beginning at retirement and ending at death, again, as detailed in Meh and Terajima (2008).

3.2 Composition of net nominal positions across economic agents

3.2.1 Household types

For household types, we consider six age groups: $\leq$35 years, 36-45, 46-55, 56-65, 66-75, and $\geq$76. Within each age group, we consider three economic classes: *rich*, *middle-class* and *poor*. The classes are defined as follows. The top 10% of households in net worth are characterized as rich. The rest of the households (90% of all households) are sorted by income ignoring their net worth. Then among these households, those (70% of all households) with higher income are characterized as middle class and the remaining households (20% of all households) as poor.

Table 1 describes the net nominal positions and nominal portfolios for different income classes and age groups from the 2005 SFS.[11] It shows that, overall, young households are net borrowers and old households are net lenders. There is, however, heterogeneity within age groups in terms of borrowing and lending. For example, in the 36-45 age group, the middle class and poor borrow while the rich save. In fact, all rich age groups are net savers except for the youngest. The positive net nominal positions of the elderly middle class are large, and the oldest middle class's ratio of net nominal savings to net worth (33.88%) is the highest, followed by the oldest rich (29.82%). In contrast, middle-class households under 36 have the highest ratio of net nominal debt to net worth (-89.44%), followed by the youngest poor (-52.11%). The poor on average remain nominal net-debtors later in life than other income classes. For example, poor households are borrowers until age 56

Hence, for our exercises, the term is taken to be the maturity of mortgages.

[11] Real asset positions are also shown in the table. Note that the net nominal position and the real position add up to 100%.

while middle-class households have stopped being net debtors by age 46 and only the youngest rich households are net debtors.

Poor households save mainly through short-term nominal instruments. The youngest poor cohort holds debts in mortgages (-37.77% of net worth) and bonds (-37.66%).[12] In older age groups, the poor save in bonds and, to a lesser extent, pensions. Rich households save in bonds, particularly the two middle-age cohorts, with about 12% of net worth in these instruments. They hold savings in mortgages reflecting the business sector's mortgage lending through their large equity holdings. Pension holdings relative to net worth are not large for this group, similar to poor households, and these holdings are negative before retirement age, reflecting indirect positions in the business sector's pension liabilities.[13]

The middle-aged and old middle class use more pensions in the form of non-indexed defined benefit assets for their savings, compared to their poor and rich counterparts who rely more on short-term instruments and bonds respectively. For example, pensions are the largest savings category for households in the 56-65 and 66-75 age brackets, where they account for 19.36% and 14.11% of net worth respectively. Young middle-class households are the most indebted in nominal positions, and most of their direct borrowing occurs through mortgages. The ratio of their overall net nominal debt to net worth is 89.44% while the ratio of mortgage debt to net worth is 81.62%.[14] The young middle class are similar to the poor young in holding negative bond positions largely due to student loans.

Comparing the observations in Canada and the United States (Table 1 in Doepke and Schneider (2006a)), one major difference emerges. Middle-class middle-aged households, specifically in the 46-55 age bracket, are net nominal lenders in Canada while they are net nominal borrowers in the United States. These households are important in affecting aggregate outcomes through their labour supply decisions since they account for the largest fraction (i.e., 70%) of the population in that age cohort. Since a price-level shock affects the labour supply through wealth effects and the labour supply is the main channel through which aggregate output is affected in our analysis, this difference can potentially lead to significant aggregate and welfare differences between Canada and the United States.

3.2.2 The government and foreign sector

For the positions of the government and foreign sectors, national balance sheet account (NBSA) data from Statistics Canada are used. All the numbers are for the year 2005. Table 2 shows the results for these two sectors as well as the aggregated household sector positions as percentage of GDP. As expected, the government sector is a net negative holder of nominal instruments (-42.99% of GDP).

[12] The negative bond holdings of the poor young households reflect their student loans.

[13] These households own the largest proportion of the sector's equity holdings and so have the largest indirect positions. Please see Meh and Terajima (2008) for details.

[14] Note that households could conceivably hold a positive net nominal position in mortgages. This is because their indirect mortgage position through shares held in financial institutions could be positive.

It holds large bond debts (-29.67%) as well as short-term debts (-7.60%) and a small mortgage asset (3.19%). The government is also a net borrower in the pension category (-8.91%).

The foreign sector in Canada has a small positive net nominal position (2.85%) in nominal instruments in 2005. It is composed of pension debts (-8.79%), bond assets (7.53%), short-term debts (-4.65%) and mortgage assets (8.75%). Given the small size of its position, the size of the redistribution with respect to this sector is also expected to be small. The nominal positions of the government and foreign sectors are balanced by those of the household sector so that nominal positions throughout the economy sum to zero.

3.3 Redistribution impact of an unexpected price increase

Based on the net nominal positions of agents in Section 3.2, we measure the extent of the direct redistribution among these agents for a one-time unexpected price increase of 1% under two monetary policy regimes, IT and PT with a six-year horizon to correct the price level. As discussed in this section, under the PT regime, the term to maturity of a nominal instrument is an important factor in determining the change in its real value following a price-level shock, while the maturity difference does not affect the real value under IT.

The maturity structure of these instruments are assumed as follows. For the nominal short-term instruments, we set the time to maturity to be one year. For the nominal long-term instruments, bonds, mortgages and pensions, we determine the maturity structure by directly applying the distributions of time to maturity in 2005. Given the maturity structures for these instruments, we calculate the direct impact of a one-time 1% price-level increase on the agents' net worth under the two monetary policy regimes.

Table 3 shows the extent of the direct impact from the unexpected 1% price-level increase on different age and class household groups under two monetary policy regimes. It is generally the case that the sign of the direct redistribution is the opposite of that of the net nominal position, which is defined to be the sum of the nominal short-term and the nominal long-term positions as in Table 1. As the exposition in Section 2 shows, the magnitude of the redistribution is smaller under PT than IT. Under IT, the redistribution ranges from a gain of 0.89% of net worth for the youngest middle-class to a loss of -0.34% of net worth for the oldest middle-class. Under PT with the six-year horizon, the numbers for the same groups are 0.19% and -0.19%, respectively. Under both regimes, young middle class and young poor households receive positive redistributions, whereas old or rich households receive negative redistributions. These are direct results of the young middle class and young poor households having a negative nominal position in nominal instruments. The table also shows the results under PT with the fifteen-year horizon. As observed, the numbers are between those under IT and those under PT with the six-year horizon. This result is expected as the price-level path after the shock under PT with the fifteen-year horizon falls between those under IT and under PT with the six-year horizon.

Table 4 shows the redistributions between sectors. Government receives a positive redistribution from the reduction of its nominal debts by 0.43% of GDP under IT while the foreign sector receives a negative redistribution of -0.03%. Under PT with the six-year horizon, the numbers are again smaller with redistributions of 0.14% and 0.01% for government and foreigners, respectively. The positive redistributions to these two sectors are from the household sector, which loses wealth in these scenarios. Under PT with the fifteen-year horizon, all the numbers are between those under IT and under PT with the six-year horizon. Specifically, the net loss in the household sector is 0.19% of GDP, about a half of that under IT. There are two reasons why a gap exists between IT and PT despite a long horizon of fifteen years in PT. First, there are nominal instruments which have longer-than fifteen-year term to maturity such as pensions and long-term bonds. As a result, those instruments are not affected by a price-level shock under PT. Second, shorter-term instruments (i.e., terms to maturity of less than fifteen years) are still affected since there is still a gap between the pre-shock expected price level and the post-shock realized price level.

Discussion The extent of the redistribution is higher under IT than PT. This is due to the fact that long-term positions are less sensitive to price-level shocks under PT, given that the central bank credibly brings the price-level back to its original path. Quantitative differences between IT and PT are also large. For example, the total household sector loss from the 1% positive price-level shock is almost three times as large under IT relative to PT with the six-year horizon. The result speaks to the potential importance of taking into account the portfolio of assets and liabilities with different term-to-maturities into the monetary policy analysis.

4 Model

Given the redistributions that we calculated in the previous sections, we now turn to the aggregate and welfare effects of those redistributions. We consider a small open economy populated by overlapping generations with a positive world rate of return, $\overline{r}$.

Demography and preferences Agents can live up to I periods and can be one of $j \in \{1, \cdots, J\}$ skill types with an endowment of efficient units of labour, e_{ij}. The measure of each type ij is given by $\Omega(i,j)$ where $\sum_{i,j}[\Omega(i,j)] = 1$. Agents retire at the mandatory age i^*. Each agent faces a probability s_i of surviving from age i to age $i+1$. For simplicity, we assume that before retirement age agents do not die (i.e., $s_i = 1$ for $i < i^*$). In period t, each individual of age i and type j maximizes his expected discounted lifetime utility,

$$E\left\{\sum_{i=1}^{I} \beta_j^{i-1}\, u_j(c_{i,j,t}, 1-n_{i,j,t}) + \beta_j^I\, \Psi_j(a_{I,j,t})\right\}, \tag{11}$$

where E is the expectations operator. Expectations are taken over age-specific mortality shocks and stochastic price level shocks z. In equation (11), u_j is the temporal utility function of type j agents, $c_{i,j,t}$ and $n_{i,j,t}$ are respectively consumption and labour supply of age i and type j agents at time

t, β_j is the discount factor of type j agents. Agents have a bequest motive and it is modeled as a "warm glow" preference for transfer to the next generation: $\Psi_j(a)$ where only agents of age I give intended bequests to their children.[15] The warm glow preference implies that agents derive utility from giving bequests to their children. Bequests left by age I agents of type j at time t is equally allocated to age 1 agents (i.e., newborns) of the same type j at time $t+1$. The preference for a bequest is also type-specific so that we can capture the observed heterogeneity in bequest by type.

We assume that each household chooses savings, labour, and bequests optimally. We assume, however, that the composition of assets is exogenously determined and depends on age and skill. Let us denote α^s_{ij}, α^ℓ_{ij} and α^r_{ij} to be these exogenous shares of assets as follows.

- α^s_{ij} : the share of assets held in short-term nominal form for age i and type j households with a nominal interest rate equal to zero,
- α^ℓ_{ij} : the share held in long-term nominal form for age i and type j households with a nominal rate of return equal to $(1+\overline{\pi})(1+\overline{r})$ where $\overline{\pi}$ is the targeted inflation rate,
- α^r_{ij} : the share held in real assets for age i and type j households with a real rate of return equal to $(1+\overline{r})$.

Production Output in this economy is given by a Cobb-Douglas aggregate production function, F

$$F(N_t, K_t) = K_t^\alpha N_t^{1-\alpha}, \tag{12}$$

where N_t and K_t are respectively aggregate labour and capital inputs at time t. Given prices, firms maximize profits and as a result we have the following:

$$\overline{r} + \delta = \alpha \left(\frac{K_t}{N_t}\right)^{\alpha-1} \text{ and } w = (1-\alpha)\left(\frac{K_t}{N_t}\right)^{\alpha}, \tag{13}$$

where δ is the depreciation rate of capital and w is the wage rate. Given that the world interest rate $\overline{r}$ is constant the capital labour ratio is constant.

Stochastic shock and the central bank The stochastic nature of the model is given by *iid* aggregate proportional shocks z to the price level targeted by the central bank. In this context, under IT, the central bank sets its actions such that

$$\frac{P'}{P} = (1+\overline{\pi})(1+z') \qquad \text{or} \quad E\{P'\} = P\,(1+\overline{\pi}),$$

[15] The bequest is modeled to analyze the importance of the intergenerational effects of an inflation shock.

where z' and P' are respectively the next period shock and price level. Under PT, the central bank sets

$$P' = (1+\overline{\pi})^t(1+z') \qquad \text{or} \quad E\{P'\} = (1+\overline{\pi})^t.$$

Problem of households It is convenient to recursively represent the problem of a household under two different regimes: $\pi = IT$ and $\pi = PT$. Let $v_{i,j,t}(a)$ be the beginning of period value function where a is the current wealth holdings of age i and type j household at time t. The dynamic program of the household can be described as follows.

$$v_{ijt}(a) = \max_{c,n,y} u(c,n) + s_i\beta_j \, E\Big\{v_{i+1,j,t+1}[a'(z')]\Big\} + 1(i=I)\cdot\beta_j E\Big\{\Psi_j(a'(z'))\Big\} \tag{14}$$

$$s.t. \qquad c + y = a + n\cdot w\cdot e_{ij}(1-\tau_t) + T_{it}, \tag{15}$$

$$a'(z') = y\left(R^{s,\pi}(z')\alpha^s_{i+1,j} + R^{l,\pi}(z')\alpha^l_{i+1,j} + (1+\bar{r})\alpha^r_{i+1,j}\right), \tag{16}$$

where the respective real returns on short-term and long-term nominal assets under different monetary policy regimes $R^{s,\pi}(z')$ and $R^{l,\pi}(z')$ depend on z' and are given by

$$R^{s,PT}(z') = R^{s,IT}(z') = \tfrac{1}{(1+\bar{\pi})(1+z')}\,,$$

$$R^{\ell,PT}(z') = 1+\bar{r} \quad \text{and} \qquad R^{\ell,IT}(z') = \tfrac{1+\bar{r}}{1+z'}.$$

Equation (15) is the budget constraint of the household. The left hand side of equation (15) is consumption c and savings y for next period. The right hand side of the budget constraint consists of resources at hand a, after-tax labour income with a current labour income tax rate τ_t, and government period t transfer $T_{i,t}$ which is age dependent. The transfer consists of two parts and is given by $T_{it} = T^d_t + T^r_{it}$. The first part T^d_t is the accidental bequest which is distributed equally as a lump sum transfer to all households.[16] The second part $T^r_{i,t}$ is the government retirement income transfer to the retired households in the form of social security or the government's retirement income transfer program. Equation (16) gives the law of motion of next period assets $a'(z')$ where z' is the next period inflation shock. The indicator function $1(i=I)$ is one when households reach the last age and thus can give bequest $a'(z')$ to their children. It is assumed that households can not die with negative assets or negative bequests.

[16]The accidental bequest is the reallocation of those assets left behind by households who died before reaching age I.

Government The government finances government consumption (G_t), transfer to retirees, and interest payments on government debt B_t by raising revenue from taxing labour income and issuing government debt. We define two types of government budget constraints, the period-by-period budget constraint and the present value budget constraint. The period-by-period budget constraint of the government is described as follows.

$$G_t + (1+\overline{r})B_t + \sum_j \sum_{i \geq i^*} \Omega(i,j)\, T^r_{i,t} \;=\; \sum_j \sum_{i=1}^{i^*-1} \Omega(i,j)\, \tau_t\, w\, e_{ij}\, n_{i,j,t} + B_{t+1} \tag{17}$$

Similarly, the present value budget constraint is given by

$$\sum_{t=0}^{\infty} \left(\frac{1}{1+\overline{r}}\right)^t G_t + \overline{r} \sum_{t=0}^{\infty} \left(\frac{1}{1+\overline{r}}\right)^t B_t + B_0 + \sum_{t=0}^{\infty} \left(\frac{1}{1+\overline{r}}\right)^t \sum_j \sum_{i \geq i^*} \Omega(i,j)\, T^r_{i,t}$$
$$= \sum_{t=0}^{\infty} \left(\frac{1}{1+\overline{r}}\right)^t \sum_{i=1,j}^{i^*-1} \Omega(i,j)\, \tau_t\, w\, e_{ij}\, n_{i,j,t}, \tag{18}$$

where the left-hand-side shows the present value of all current and future expenditures and the right-hand-side the tax revenues. Both types of the budget equation are used in the simulations.

The transfer to retirees depends on the age of households. The government also collects all accidental bequests and distributes them equally to all households in a lump sum fashion.

$$\sum_{i>1,j} \Omega(i-1,j)(1-s_{i-1})a_{i,j,t} \;=\; T^d_t. \tag{19}$$

The behaviour of the government is taken as exogenous and is calibrated to the steady state of the actual economy. We will consider various fiscal policy reactions after an inflation-induced redistribution shock.

Foreigners The behaviour of the foreign sector is taken as exogenous. The foreign sector period t asset or debt in the domestic asset market is given by a^F_t.

4.1 Equilibrium

Definition 1. *An equilibrium for a given regime $\pi \in \{IT, PT\}$ is a world interest rate $\overline{r}$, a sequence of wage rates $\{w_t\}$, a sequence of individual decisions $\{c_{i,j,t}, n_{i,j,t}, a_{i,j,t}\}$, firm decisions $\{K_t, N_t\}$, government decisions $\{G_t, \tau_t, B_t, T_t\}$, foreigners' debt $\{a^F_t\}$ such that:*

1. *Given $\overline{r}$ and government policies, each household solves the household problem (14)-(16).*

2. *Given prices, firms maximize profits.*

3. *The equal lump sum transfer constraint (19) of accidental bequest holds every period.*

4. *The government budget constraint (17) or (18) is satisfied.*

5. *The labour market clears in every period:*

$$N_t = \sum_j \sum_{i=1}^{i^*-1} \Omega(i,j) e_{i,j} n_{i,j,t}. \tag{20}$$

6. *The good market clears in every period:*

$$\sum_{i,j} \Omega(i,j) c_{i,j,t} + I_t + G_t + NX_t = Y_t, \tag{21}$$

where $NX_t = (1+\overline{r})a_t^F - a_{t+1}^F$ *is net export,* $I_t = K_{t+1} - (1-\delta)K_t$ *is aggregate investment.*

4.2 Shocks

To have shocks to the environment that directly translate into unexpected price changes, consider a transaction technology such that

$$Y\ v = \frac{M}{P},$$

where Y is output, v is velocity and M is money, or more precisely, short term nominal assets. A shock to the price level z can be thought of literally as a permanent shock to velocity. Money creation then implements either IT and PT. This is the simplest, but not only, possible theory of the shock consistent with this model.

5 Calibration

5.1 Model parameters

We calibrate the parameters of the model to the steady state of our model economy by matching the selected moments from the model to counter-parts from the data. We use the six age cohorts, i, and the three economic classes, j, of as defined previously in Section 3.2.1. Our basic calibration strategy for choosing the household parameters is to jointly match the distributions of effective wage rates and asset holdings across household groups. For production technology and government parameters, we calibrate them to match their relevant moments. Table 5 summarizes the calibrated parameter values for preferences, demography, technology and the government as discussed in this section.

Preferences We assume the following functional form of the utility function.

$$u_j(c_t, n_t) = \frac{c_t^{(1-\eta_j)(1-\sigma)}(1-n_t)^{\eta_j(1-\sigma)}}{1-\sigma} \tag{22}$$

In addition, the preferences for leaving bequests are given by

$$\Psi_j(a_{I,t}) = \xi_j \frac{a_{I,t}^{1-\epsilon_j}}{1-\epsilon_j} \tag{23}$$

The parameters to be determined consist of the intertemporal elasticity of substitution, σ, the economic class specific weight on leisure, η_j, the class specific bequest parameters, ξ_j and ϵ_j, and the class specific time discount factor, β_j. We set σ to 2, a standard value. The value of η_j is set to achieve the average work hour fractions of 0.331, 0.409 and 0.427 for the poor, the middle-class and the rich, respectively.[17] ξ_j is the weight the household puts on leaving bequests to the next generation. The 2005 SFS data set contains the bequest information. According to the data set, the average amounts of life-time bequests received are $\$146,103$, $\$26,766$ and $\$11,584$ for our classifications of rich, middle class and poor, respectively. Since the values for middle class and poor are relatively small, we set $\xi_j = 0$ for these groups. In determining ξ_3, we target the ratio of the average bequest over the average net worth of the rich. This ratio is 0.088 from the 2005 SFS. The values of ϵ_j are set so that $\epsilon_j = 1 - (1-\eta_j)(1-\sigma)$.

The discount factor, β_j, directly influences household asset accumulations. We set the economic class specific value of β_j to match the relative net worth of three classes and the ratio of output to household assets. Specifically, we pin down the three values of β_j to match the following ratios: (1) the average net worth of rich households to that of the middle class, (2) the average net worth of the middle class to the poor, and (3) the average net worth of the middle-class to GDP per household. These ratios are 6.5, 3.8 and 2.4, respectively. The net worth numbers are from the 2005 SFS. In 2005, the GDP per household was $\$112,159$. The annualized values of β_j obtained are 0.99, 1.01 and 1.10 for the poor, middle class and rich, respectively. In order to match the between-group ratios of the net worth, the β_j for the rich had to be much higher than the other two classes.

Portfolio For each household group defined by i and j, there are three parameters for the exogenous share of short-term, long-term and real assets, α_{ij}^s, α_{ij}^ℓ and α_{ij}^r, respectively. In order to map the portfolio findings from the data to the model, we assume that the long-term assets in the model represent the categories bond, mortgage and pensions all together. With this assumption, the numbers in Table 1 for bonds, mortgages and pensions are added to make up the value for α_{ij}^ℓ.[18] For α_{ij}^s and α_{ij}^r, they are directly taken from Table 1.

[17] These fractions are from Dorolet and Morissette (1997) who document average work hours by income based on the 1995 Survey of Work Arrangements from Statistics Canada.

[18] The average term to maturity of all long-term categories in the data is about 11 years.

Demography Households face a conditional probability of survival, s_i. The main margin that we want to capture is the relative size of the young and the old. We assume that the households do not die before retirement and start facing a positive probability of death when they retire. In 2005, the ratio of those who were 65 or older to those who were 20 or older was 17% in Canada.[19] We adjust the probability of death of retirees, s_4 and s_5 to achieve this ratio. We assume that half of the model population of cohort 66-75 survives to the next age category, $\geq$76. The parameter values obtained as a result are $s_4 = 0.547$ and $s_5 = 0.500$. Since all the $\geq$76 households will die in the following period, $s_6 = 0$.

Labour Productivity The age-class specific labour endowments, e_{ij}, are directly estimated using panel data from Statistics Canada. The Survey of Labour and Income Dynamics (SLID) contains information on Canadian households and persons regarding labour supply and income over time. We have used the 1999-2004 wave. We estimate the age-class specific hourly wage rate by the following fixed-effects regression.

$$\begin{aligned} \ln(\text{wage rate})_{ht} &= \theta_1(\text{age})_{ht} + \theta_2(\text{age}^2)_{ht} + \theta_3(\text{work experience})_{ht} \\ &+ \theta_4(\text{years of school})_{ht} + \nu_h + \varepsilon_{ht}, \end{aligned}$$

where the index h specifies the person and t the time. The wage rate is defined by the total wage and salary income divided by the total hours worked. We use this variable to approximate the labour endowments. The work experience is the number of years worked. The years of school are the number of school years completed. The regression results are presented in Table 6. In order to derive the results for our economic classes, we approximate them using the years of schooling. For each appropriate age group, we sort them into the poor, middle class and rich by the school years so that the size of the sample for each class is as defined previously, 20%, 70% and 10%, respectively for the poor, middle class and rich. With this definition of the groups and the parameters from the regression estimation, we apply the average age, the average school years and the average work experience to derive the average wage rate for each age-class group. Table 7 shows the resulting relative endowment of each household group.

Technology The production technology in our model economy is standard and assumed to be Cobb-Douglas. The capital share parameter α is set to 0.33. The annual depreciation rate is assumed to be 0.07 and appropriately adjusted for the model period of 10 years by setting $\delta = 1.0 - (1.0 - 0.07)^{10}$.

Government Debts and Transfers There are four parameters that concern the government, the labour tax rate (τ), the retirement income transfer, government spending and government debts. The tax rate is set to match the ratio of tax revenue to output of 32% as in the Canadian data in 2005. We obtained $\tau = 0.301$. The average retirement income transfer was 13% of GDP per household in 2005. Hence, government transfer by age, T_i^r, with $i \geq i^*$ is calibrated to achieve this ratio, where i^* is the retirement age. Government debts, B, are calibrated to match the government nominal debts to the GDP ratio of 42.99% in 2005. Finally, since there is no guarantee that the government

[19]The number is from Statistics Canada at "http://www40.statcan.ca/".

budget constraint holds under our calibration strategy, we chose to set the value of G to balance the government budget. The resulting government spending to GDP ratio is 16%. The number in the data is 35% in 2005. This gap in the government spending to GDP ratio exists because the only roles of the government (in the steady state) are to tax workers and to transfer the tax revenue to retirees. The model does not take into account all other government activities.

Foreigners The foreigners' asset position, a^F, is set to match their assets to GDP ratio of 2.85% in 2005. Even though the foreign sector in our economy does not interact directly with other sectors due to the assumption of the small open economy, it is important to capture the asset position of this sector to entirely account for the redistribution. The redistribution through the foreign sector is a leak from the economy. We will conduct a sensitivity analysis to check how important this leak is by closing down this leak with the assumption that the household sector absorbs the foreign sector's nominal position. The analysis will show the difference in the aggregate response to the price-level shock.

Feeding the Direct Redistributional Impacts into the Model as Wealth Shocks In order to analyze the aggregate effects on output and welfare from the initial price-level shock, we model the price-level shock directly as the shock to wealth. We feed the household direct impact numbers in Table 3 and those of the government and the foreign sectors in Table 4 into the model presented above for both IT and PT. We set the PT policy horizon to a baseline of six years. The assets of the households in the steady-state equilibrium are redistributed as a shock according to the results in Table 3 for each age-class group. Specifically, the positive or the negative redistributions of the age group $\leq$35 are applied to their beginning-of-period asset position before they make decisions for the period. All other age groups' beginning-of-period assets are shocked similarly. Also, the steady-state position of the government and foreign sectors are redistributed according to the numbers in Table 4. Given these one-time shocks, we solve the model for its transition path by assuming that agents' decisions are approximated linearly at the zero price-level shock from the second period on.

6 Findings

The mechanism by which aggregate effects on output and welfare can result from zero-sum redistributions has to do with the asymmetric responses in labour supply through wealth effects of different agents. With the assumption of preferences, households who gain (lose) wealth from the price-level shock reduce (increase) their labour supply. If redistributions are zero-sum and labour supply responses to wealth changes are linear for all agents, the aggregate labour supply change would be zero. However, because of asymmetric labour supply responses by different households, these effects do not cancel out even with zero-sum redistributions.

There are two dimensions where asymmetry exists among households. First, between workers and retirees, while workers can respond to the change in wealth level by adjusting their labour supply, retirees cannot. Second, among workers, there are two types of worker heterogeneities leading to

asymmetric labour supply responses. The preference weight on leisure, η_j, is economic-class specific and labour productivity, e_{ij}, is age and class specific. These heterogeneities lead to asymmetric labour responses even among workers. Finally, these asymmetric responses between workers and retirees as well as among workers are amplified by the fact that each household group is hit by a different magnitude of wealth change based on their portfolio. Hence, the aggregate output effect is caused by the aggregate labour supply change due to these asymmetric responses by different households.

We present the results for the transition dynamics and the welfare from the initial direct impact of the price-level shock described in Section 3.3. We simulate the transition back to the steady state under several different assumptions about the government's fiscal policy regarding the windfall gains it receives and the foreign sector's redistribution.[20] In doing so, we make an assumption about how government debts change over the transition period. With the positive price-level shock, the real value of government debts is reduced creating a windfall gain. We assume that the level of debts goes back to the steady state after one period or 10 years.

In Section 6.1, we show the results of the baseline case where the government transfers its windfall gain to households by lowing the labour income tax rates. Next, in Section 6.2, we show the results of simulations where the government's fiscal policy regarding the windfall gain changes. The welfare analysis of the households who are alive at the time of the shock is conducted in Section 6.3. Section 6.4 conducts sensitivity analyses.

6.1 The response to the redistributional effects across households

We assume in the baseline simulation that the government's fiscal policy lowers the labour income tax to transfer its windfall gain to households. The tax rate is lowered for the first 50-year period where the rate goes back to the steady state level in a linear fashion at the end of the period while maintaining the present value government budget balance. In Section 6.2, we vary the assumptions on fiscal policy as well as on the government budget constraint.

Households First, under IT, Figures 1 and 2 show the percentage deviations from the steady state in life cycle asset and labour, respectively, for agents who are alive at the time of the shock. In the figures, the age in the title is that of the time of the shock. The values are normalized by the economic class average. The cohort 56-65 has, for example, zero values for the first 3 periods (i.e., $\leq$35, 36-45 and 46-55) as the shock arrives at the fourth period of its life. From the asset figures, under IT, the middle-class tends to lose the most, especially the three cohorts aged 56 and above which decrease their assets by up to 0.5% of the class average.

Figures 3 and 4 show the results under PT. All rich cohorts aged 46 and above show declines

[20]The government budget balance is assumed throughout the analysis according to one of the constraints, (17) or (18).

in assets over the life cycle but the magnitudes are much smaller than under IT. The poor cohort that loses the most is aged 56-65 with a decline of 0.25%. Middle-class and rich households show a similar pattern in that changes are smaller under PT. Under both IT and PT, we also observe that the intended bequest left by the rich decreases for all cohorts aged 46 and above. This will create a persistent effect through the following generations' initial asset level.

As discussed in the beginning of this section, the aggregate effects do not cancel out due to several dimensions of heterogeneity. The households differ in terms of portfolio, age- and type-specific productivity (both among workers and between workers and retirees) and propensities to work and save. With the specified household preferences, wealth effects dictate that whoever gains (loses) in assets will reduce (increase) labour supply over the life cycle on average. In the baseline case, these wealth effects are coupled with substitution effects of the labour income tax change. Figures 2 and 4 show the net effect of the two under IT and PT, respectively. For example in, Figures 2, the middle-class $\leq$35 cohort gains assets and, the wealth effect should dictate that the labour supply decreases. However, the substitution effect from the reduction in the labour income tax overpowers, and we observe a net increase in the labour supply. Qualitatively similar patterns can be observed under both IT and PT graphs, however, quantitatively they are different. For example, the rich 46-55 cohort increases labour supply by 0.25% under IT while the number is about 0.06% under PT.

One qualitative difference that displays the importance of maturity structure is observed for the cohort aged 56-65. Under IT, the initial decrease in assets for the poor is smaller than that of the middle-class. However, under PT, the decrease is much larger than that of the middle-class. This is consistent with the numbers in Table 3 and is a result of the middle-class 56-65 age cohort having a larger position in long-term assets as shown in Table 1 as opposed to the poor having a larger position in short assets. Under PT, the values of long-term nominal instruments are less affected by a price-level shock, while under IT the values of all nominal instruments are equally affected.

Aggregates Aggregate effects are generated due to household heterogeneities together with the fiscal policy to transfer the government's windfall gain. The aggregate responses over time in output and household sector assets under IT and PT are shown in Figure 5 for the baseline fiscal policy of labour income tax cuts. The figures show percentage deviations from the steady state. At $t = 0$, we observe the magnitude of the contemporaneous responses of output to the direct redistribution. The first result to note is that the initial impact on output is positive at $t = 0$ both under IT and PT. This is not an obvious result. As seen in Figures 2 and 4, some households increase their labour supply while others decrease at the time of the impact. Specifically the decreases in work hours by the young poor and middle-class are more than offset by the increases in hours from the middle-aged middle-class and all the rich workers. Hence, the net effects on output are positive. In terms of aggregate assets, the initial direct impact is -0.158% from the steady state value under IT and -0.057% under PT. The increase in the output is caused by the wealth effects among workers. In aggregate, the increase in labour supply of workers who lost wealth overpowers the decrease of those who gain wealth so that the aggregate labour supply increases as a result.

With the 1% price-level shock, output under IT initially increases by 0.104% above the steady state level compared to 0.031% under PT. Thus, the output response under IT is 3.3 times higher than under PT. This is caused by smaller redistributions under PT leading to smaller changes in household behaviors. In terms of aggregate assets, the initial direct impact is -0.158% from the steady state value under IT and -0.057% under PT. Correlating with these initial impacts, the transition back to the steady state seems to take a longer time under IT than under PT, which is especially apparent in the asset figure. As time passes, aggregate labour supply continues to decrease as the tax rate returns to its initial value before the shock. This decrease in labour supply continues until the tax rate goes back to the steady state level at which point labour supply is below that of the steady state. This is due to the potential for intertemporal substitution associated with the labour supply decision. That is, workers work longer hours before the tax rate increases back to its steady state level and reduce their work hours thereafter.

As previously mentioned in Section 3.2.1, there is a difference between Canada and the United States: the middle-class, middle-aged households are net lenders in Canada but net borrowers in the United States. Thus, with a positive price-level shock, these groups will lose their wealth and increase their labour supplies in Canada, whereas, in the United States they decrease their labour supplies. This margin turns out to be the decisive force in the positive initial aggregate output reaction in Canada compared to the negative one in the United States as shown in Doepke and Schneider (2006b).

6.2 Redistributional effects with other fiscal policies

In this section, we discuss the results from other fiscal policies regarding windfall gains and the budget constraint. In Section 6.2.1, the tax rate is adjusted as in the baseline case but the government budget balance is met every period. We conduct two other simulations where the government no longer cuts taxes to transfer its windfall gain to households but instead pursues other fiscal policies. In Section 6.2.2, the government distributes the windfall gain in a lump sum fashion to all households while maintaining the government budget balance period by period. Finally in Section 6.2.3, the government gives the lump-sum transfers only to retired households, again holding the government budget balance every period.

6.2.1 Labour tax changes that balance the budget period by period

We show what can happen if the government pursues a balanced budget period by period under the tax rate adjustment policy. Figure 6 shows the results. As can be seen, the volatility of output and assets are higher. The contemporary reactions of output are 0.21% and 0.035% for IT and PT, respectively. The high volatility is due to the fact that, under the small economy assumption with a fixed interest rate, the volatility of output depends primarily on the volatility of labour supply. The tax rate has a direct effect on labour supply. Thus, the government, in trying to balance the budget period-by-period by adjusting the tax rate, creates the extra volatility that we observe in Figure 6

as compared to the case in Figure 5. If we compare the relative initial response of output under IT and PT, the output response under IT is six times larger than under PT. These results suggest that fiscal policy regarding the government's windfall gains is an important determinant of the price-level shock's effects on the aggregate economy. Relative differences between PT and IT also depend on the fiscal policy choice. The behaviour of fiscal policy does not lead to large fluctuations under PT because the size of the direct redistribution impact is small, and hence there are smaller windfall gains for the government to transfer back to households.

6.2.2 Lump sum transfer

With lump-sum transfer, the initial impact on output is much smaller. As shown in Figure 7, the initial output effects are small: 0.003% above the steady state under IT and 0.0005% under PT. Both series almost converge back to the steady state after 40 years. Comparing the initial responses of output under IT and PT, the output response under IT is six times higher than under PT. This is caused by smaller redistributions under PT, leading to smaller changes in household behaviours. Smaller overall responses in output are caused by smaller labour supply responses.

6.2.3 Transfer to retirees

The fiscal policy of a lump-sum transfer to retirees contrasts with the baseline case in that the recipients of the government's windfall gain are retirees instead of workers. Figure 8 shows the results from the case where the government gives lump-sum transfers only to retired households in the form of increased retirement transfer income. The reactions of output are positive and 0.049% above the steady state level under IT and 0.014% under PT. Since workers do not directly benefit under this fiscal policy, the increase in aggregate labour supply is smaller here than in the baseline case. The output response under IT is about 3.5 times that under PT.

6.3 Welfare analysis

In this section, we study the welfare of households who are alive at the time of the shock. The direct redistributional impacts in Table 3 give us an idea about the welfare of these households. However, the ultimate measure of welfare depends also on the government's fiscal policy in redistributing its windfall gains and households' reactions to these redistributions. To observe the ultimate impact of the price-level shock under the two monetary policy regimes, Tables 8 and 9 show for each group of households alive at the time of the shock a welfare measure under IT and PT, respectively. Each table contains welfare measures for the three fiscal policies discussed above, excluding the case with labour taxes adjusted to balance the budget period by period. To be more precise, the numbers in the table are percentage changes in consumption (i.e., equivalent variations) that make the pre-shock steady state household just as well off over the transition period as for each combination of monetary and fiscal policy regimes.

For example, in Table 8, under IT with the tax cuts policy, "0.101" for middle-class ≤35 households indicates a welfare improvement over the pre-shock steady state of 0.101% of steady state consumption. Negative numbers indicate welfare losses. The weighted average of the welfare measure for all household groups is provided in the table. In calculating these numbers, we hold constant the other dimensions of decisions – that is, the labour supply and savings decisions – at the steady state values. Hence, this welfare measure includes effects arising through the labour supply and the savings margins, all expressed in consumption terms.

Under both IT and PT, the tables show that, in the baseline simulation with tax cuts, the group that loses the most is middle-class households older than 75. The loss is higher under IT, at -1.099%, than under PT, at -0.609%. On the other hand, the two youngest groups in the middle class show welfare gains both under IT and PT. Comparing the two tables, the welfare losses and gains of each group of households are much smaller under PT than under IT. There are average welfare losses across all households of -0.055% and -0.034% under IT and PT, respectively. Thus, despite the positive output effects, there are welfare losses both under IT and PT with the tax cuts policy. The main trade-off underlying the *average* welfare effect is that, on one hand, with a positive shock, rich and retired households are worse off due to the reduction in the value of assets. On the other hand, workers are mostly better off with lower tax rates. This second effect is non-linear since the labour supply decision is non-linear with respect to tax rates. The first effect prevails over the second effect and hence the average welfare loss under both monetary policy regimes.

With the lump sum transfer policy, there is no longer any substitution effect among worker households as the effective wage rate is unchanged in the absence of the tax cuts. Instead, the only effects will be the wealth effects from the initial redistribution and the lump-sum transfer. The combined wealth effects under the lump sum transfer policy lead to smaller welfare effects among workers than in the baseline case. For example, the middle-class ≤35 cohort now gains only 0.78% under IT relative to the baseline case of 0.101%. On the other hand, welfare losses of older households decrease and even turn positive for the poor. In particular, the loss of the poor ≥76 cohort changed from -0.286% in the baseline case to 0.223% in the lump sum transfer policy. This is because the relative change in household wealth from the lump sum transfer is higher for the poor, whose initial wealth is lowest. The average welfare loss under IT is -0.015%. Under PT, relative to IT, the lump sum transfer fiscal policy leads to welfare effects that are smaller in absolute values. This is due to the fact that initial direct gains and losses from a price-level shock are smaller and also on account of the smaller role that fiscal policy plays under PT. The average welfare loss under PT is -0.009%.

With respect to the increase in the retirement income transfer, more retired household groups gain compared to all retirees having a negative sign under the tax cuts fiscal policy in both IT and PT. Despite the wealth loss from the initial price-level shock, the poor and middle-class retirees have positive welfare effects due to the retirement income transfer. The average welfare measures under this fiscal policy are positive compared to the other two fiscal policies, with 0.195% and 0.094% for IT and PT, respectively. Since the major losers from a positive price-level shock are the retired households, who are not able to adjust their labour supplies, this welfare result suggests that compensating these groups can improve average welfare better than other fiscal policies for positive

price-level shocks.

The interaction of monetary and fiscal policy can have important welfare effects. Under IT, different fiscal policies can lead to a wide range of welfare gains and losses. For example, the middle-class ≥76 cohort displays a welfare loss of -1.099% of consumption under the tax cuts policy as opposed to a gain of 2.130% of consumption under the retirement income transfer policy. In comparison, under PT, these numbers are -0.609% and 0.542%, respectively. Thus, under IT, different fiscal policies lead to wider variation in welfare losses and gains than under PT. Or in other words, under PT, households are better shielded against the actions taken by the government. This is because, under IT, the government's windfall gain from a price-level shock is larger than under PT. Hence there is less room for the different fiscal policies to distort the economy under PT. The smaller gains accruing to government under PT are due to the fact that the government's long-term debts are less sensitive to price-level increases.

Discussion Clearly the fiscal policy strategy of how the government dispenses its windfall gains is very important in determining the aggregate and welfare effects of price-level shocks. A tax cut further enhances gains among the young while a transfer in the form of retirement income benefits compensates the old for their losses. The transfer to the old is mostly financed by the rich. With each fiscal policy, the aggregate output effects are higher under IT than PT, and the largest effects come from the tax cut policy. This is because the fiscal policy scenario matters less under PT than IT. For example, under IT, when a tax cut policy is adopted so as to balance the government's budget every period, output increases substantially and becomes highly volatile. However, under PT, output increases only slightly and is not volatile. The intuition behind this result comes from the fact that under PT, the windfall gains of the government are relatively small and therefore the policy used by the government will not affect the incentives facing private agents in labour and capital markets as dramatically. We interpret our findings as a strong reminder that the effects of monetary policy depend on fiscal policy.

Moreover, the welfare effects depends on fiscal policies. For example, weighted average welfare is similar between IT and PT with the tax cut policy but higher under IT than PT with the fiscal policy that gives a higher transfer to retirees. This is because different fiscal policies compensate different groups of households. With a higher transfer to retirees, windfall gains by the government overly compensate the poor and the middle-class retirees who lose from the price-level shock to raise average welfare. This effect is larger under IT due to larger windfall gains.

6.4 Sensitivity analysis

Several sensitivity analyses are conducted. Specifically, in Section 6.4.1, we observe the effects of changing the horizon of the PT policy, and in Section 6.4.2, we study the results from a wider range of the price-level shocks. In Section 6.4.3, we analyze a case where the foreign sector's nominal position is reallocated to the household sector. Finally, in Section 6.4.4, we address the sensitivity

of the fixed-portfolio assumption by conducting price-shock experiments for a hypothetical portfolio of agents.

6.4.1 Different price-level target horizons

Figure 9 shows the output and asset responses during transition for IT, PT with a 15-year horizon and PT with a 6-year horizon, all with the tax cuts fiscal policy. It is expected that, as the horizon under PT becomes longer, the magnitude of the redistribution converges to that under IT. As a result, we would expect the reactions in output and assets under PT also to converge to those under IT as the PT horizon increases. This is what the figures show. The line for PT with the 15-year horizon stays in between IT and PT with the 6-year horizon. The initial responses in output are 0.104%, 0.049% and 0.031% for IT, PT with the 15-year horizon and PT with the 6-year horizon, respectively. Table 10 summarizes the welfare effects to each household group under each monetary policy. As was the case for the direct redistributional impacts, the individual welfare numbers are mostly monotonically changing from IT to PT with the 15-year horizon, and to PT with the 6-year horizon.

6.4.2 Different shocks

We conduct a sensitivity analysis that considers shocks of varying sign and magnitude: 5%, 2%, 1%, −1%, −2% and −5%. For the baseline case with the baseline tax cuts fiscal policy, under IT, the initial reactions in output, respectively, are 0.511%, 0.209%, 0.104%, −0.079%, −0.192% and −0.547%. The respective numbers under PT are 0.163%, 0.064%, 0.031%, −0.017%, −0.039% and −0.151%. Under both IT and PT, initial output reactions monotonically change with shocks. Given the shock, the effect is larger in absolute value under IT than PT. Asymmetric output responses (in absolute values) between positive and negative shocks are observed due to non-linear and asymmetric labour supply responses by different households. Household preferences over labour supply are non-linear with respect to the after-tax wage rate. In addition, as a result of this non-linearity, changes in labour supply responses among different household groups are also different.

Table 11 presents the average welfare measures for IT and PT with different fiscal policies. The welfare numbers are in general monotonic with respect to the sign and the magnitude of the shock. Also, it is observed that the magnitude of the average welfare effect in absolute value for each price-level shock is larger under IT than PT. When government adjusts the retirement income transfer to distribute its windfall gains, we observe the change in the sign of the effects. With positive shocks under IT, the welfare effects are positive and vice versa for negative shocks. This is in contrast to the previous two fiscal policies. As explained in Section 6.3 for the 1% positive shock, this contrast is because the transfer to retired households helps those demographics who lose the most from the price-level shock.

6.4.3 Redistributional effects, with the changed debt, and without the changed foreign net asset position

All the direct redistributional impacts sum to zero. However, from the standpoint of the domestic economy, the redistribution with respect to the foreign sector is a leak. In order to analyze the zero-sum redistribution within the economy, we analyze a case where the foreign sector's nominal position is reallocated to the household sector. We adjust the household sector's real assets to balance out this shift. Hence with this assumption, there will not be any redistribution to the foreign sector from a price-level shock. The additional redistribution to the household sector, as a result of this adjustment, is allocated lump-sum to all households. Figure 10 shows the dynamics under the baseline simulation and the case where the foreign sector has nominal position under IT with a 1% price-level shock. As can be seen from the figures, there is not much difference between the two lines. This is due to the fact that the foreign sector net nominal position is small in absolute value in 2005.[21]

6.4.4 Portfolio Change

Throughout the paper, we have assumed that the portfolios of agents are fixed. In this section, we attempt to address this concern.

Following the successful implementation of a PT regime, one would expect risk-averse agents to shift into long-term instruments. Given this tendency, we conduct an experiment with a hypothetical portfolio, where all short-term instruments are swapped for bonds, one of the long-term instrument categories.[22] We do this for each household type and each sector of the economy. Note that these hypothetical portfolios do not affect any previous results under IT since the portfolio's maturity structure does not matter in measuring the extent of redistribution in this case. However, under PT, since long-term instruments are less vulnerable to price-level shocks, the results change. More specifically, under PT, with more long-term positions, a price-level shock causes less redistribution.

Figure 11 shows the output response comparisons for the baseline portfolio and the hypothetical portfolio for different fiscal policies under PT. As expected, the initial output responses are lower relative to the baseline case under all three fiscal policies and even negative under the lump-sum transfer policy. On welfare, Table 12 shows the welfare effects under PT for the hypothetical portfolios. Comparing these results against the baseline welfare effects under PT in Table 9, most welfare numbers became smaller in absolute value along with the average welfare measure, reflecting smaller redistributions. This is a result of the smaller redistribution due to more long-term instruments

[21] However, Meh and Terajima (2008) shows a negative trend for the foreign sector's NNP. In 2007, the foreign sector becomes a net borrower. Hence, the effects with foreign sector could be larger in near future assuming the continuation of this trend.

[22] We chose bonds over other long-term instruments like mortgages and pensions. We do this because the weighted average time to maturity of bonds is longer at 9.9 years than that of mortgages at 5.1 years. In addition, bonds address the potential transition to more long-term instruments better than pensions as pensions can be short-term instruments, particularly for retirees.

which are less sensitive to price-level shocks under PT. As mentioned, the results under IT are not affected by the portfolio changes.

7 Conclusion

We have documented that there are substantial differences in portfolio holding between different household groups as well as between different sectors of the economy. As a result of these differences, a price-level shock can create redistributions among agents. The extent of these redistributions depend on the monetary policy in place. We studied the redistributional implications under inflation targeting and price-level targeting and found that the extent of redistributions is much larger under IT than PT.

Based on these redistributions, we have demonstrated that there are substantial differences in the real effects of inflation targeting and price-level targeting monetary policies. These differences arise from the redistributive effect of inflation and the fact that the different policies imply different levels of correction following a surprise inflation. The channels through which this happens are the changes in the real value of the public debt together with fiscal policy to confront them and the changes in the wealth distribution due to the different portfolios of various households groups. The wealth redistribution among different households leads them to respond in labour supply differently to affect aggregate output. Overall, we find that inflation targeting tends to have much larger effects than price level targeting on both aggregate output and welfare.

For future research, there is a need to address one shortcoming in our analysis, the assumption of fixed portfolios of households. Analyzing how household portfolios change following the implementation of a PT regime is important in deriving more precise measures of redistributions, aggregate and welfare effects. Furthermore, it is also important to consider the process of price-level shocks, rather than a one-time shock. Although the welfare analysis with one-time shocks in this paper gives us insights on how bad these shocks are under different monetary polices, it does not directly imply, before the implementation of the policy, that one policy is preferred over the other. This is because welfare over different monetary policies should be with respect to all possible realizations of shocks (i.e., the distribution of shocks) in order to take into account how higher-ordered moments affects household welfare.

Appendix

A Data Sets

Survey of Financial Security The Survey of Financial Security (SFS) provides a comprehensive picture of the balance sheet of Canadian households. Information was collected on the value of all major financial and non-financial assets and on the money owing on mortgages, vehicles, credit cards, student loans and other debts. We have used the 2005 wave of the SFS and the sample consists of about 5,300 households.

National Balance Sheet Account The National Balance Sheet Accounts (NBSA) in Canada are statements of the non-financial assets owned/used in the sectors of the economy and of the financial claims outstanding among the economic units in the sectors in the economy. They consist of the National Balance Sheet for the nation as a whole, as well as the underlying sector balance sheets. The four broad sectors in NBSA consist of "Persons and Unincorporated business", "Corporations and Government Business Enterprises", "Government", and "Non-residents." The data set reports the market values of the assets and liabilities for 1990 and onwards.

Survey of Labour and Income Dynamics The Survey of Labour and Income Dynamics (SLID) are panel data based on a household survey from Statistics Canada, on Canadian persons and households with information on employment, hours of work, education, family and personal income and work transitions over life stages. There are several waves of the data set. The latest one covers the period of 1999-2004. The sample for this wave consists of roughly 15,000 households.

Canadian Financial Monitor The Canadian Financial Monitor is a private database provided by Ipsos Reid. It is based on a household survey in Canada. The sample consists of about 12,000 households every year starting in 1999. It provides detailed information across a wide range of issues related to Canadian household finances. The scope of information includes chequing & saving account detail, investment values and asset allocation, debt obligations, financial service delivery channels utilized and insurance coverage.

B Estimation of labour productivity

Table 6 shows the regression results from Section 5 using the SLID data set from Statistics Canada. All the parameter estimates are significant at the 1% level. The numbers in Table 7 were calculated by applying the average school years and the average work experience for each group to obtain the average wage rate for the group. The numbers are normalized by the wage rate of the poor and $\leq$35 household group.

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Table 1: Nominal and real positions as % of net worth by age and income class

	Age Cohort					
Type of instrument	≤ 35	36-45	46-55	56-65	66-75	> 75
	All households					
Short	4.83	-1.01	1.48	2.40	9.00	12.27
Mortgage	-37.95	-13.57	0.07	4.48	3.55	3.29
Bond	-2.63	4.70	6.50	7.90	6.70	7.68
Pension	-0.05	-1.31	5.01	7.36	8.68	8.65
Total NNP	**-35.80**	**-11.19**	**13.06**	**22.14**	**27.93**	**31.89**
Real	**135.80**	**111.19**	**86.94**	**77.86**	**72.07**	**68.11**
	Rich households					
Short	3.86	-3.73	-1.97	-2.36	8.48	8.57
Mortgage	-11.31	4.71	12.92	13.66	7.15	5.71
Bond	7.71	9.72	11.73	13.00	10.50	12.37
Pension	-2.92	-8.53	-6.25	-6.77	1.38	3.18
Total NNP	**-2.66**	**2.16**	**16.43**	**17.53**	**27.51**	**29.82**
Real	**102.66**	**97.84**	**83.57**	**82.47**	**72.49**	**70.18**
	Middle-class households					
Short	5.83	2.24	4.40	5.49	9.06	14.91
Mortgage	-81.62	-35.43	-11.11	-2.91	1.62	1.70
Bond	-18.11	-0.90	2.16	4.10	4.56	4.56
Pension	4.46	7.63	15.96	19.36	14.11	12.71
Total NNP	**-89.44**	**-26.47**	**11.40**	**26.04**	**29.36**	**33.88**
Real	**189.44**	**126.47**	**88.60**	**73.96**	**70.64**	**66.12**
	Poor households					
Short	18.90	-0.06	5.04	13.84	12.58	10.95
Mortgage	-37.77	-19.44	-9.39	2.35	-2.56	2.10
Bond	-37.66	-3.53	0.17	2.59	1.40	6.06
Pension	4.42	-4.09	0.92	1.95	2.73	4.63
Total NNP	**-52.11**	**-27.13**	**-3.26**	**20.73**	**14.15**	**23.75**
Real	**152.11**	**127.13**	**103.26**	**79.27**	**85.85**	**76.25**

Table 2: Nominal positions as % of GDP by sector

Sectors	*Households*	*Government*	*Foreigners*
Short	12.25	-7.60	-4.65
Mortgage	-11.94	3.19	8.75
Bond	22.14	-29.67	7.53
Pension	17.69	-8.91	-8.79
NNP	**40.14**	**-42.99**	**2.85**
Real	**327.42**	**31.92**	**12.72**

Table 3: Gains and Losses as % of Net Worth with 1% Shock

Age cohort	≤ 35	36-45	46-55	56-65	66-75	> 75
	Inflation targeting					
All	0.35	0.11	-0.13	-0.22	-0.28	-0.32
Rich	0.03	-0.02	-0.16	-0.17	-0.27	-0.30
Middle class	0.89	0.26	-0.11	-0.26	-0.29	-0.34
Poor	0.52	0.27	0.03	-0.21	-0.14	-0.24
	Price level targeting (6-year horizon)					
All	0.06	0.04	-0.02	-0.06	-0.12	-0.17
Rich	-0.02	0.01	-0.03	-0.04	-0.12	-0.14
Middle class	0.19	0.07	-0.01	-0.07	-0.12	-0.19
Poor	0.03	0.06	-0.01	-0.13	-0.11	-0.13
	Price level targeting (15-year horizon)					
All	0.23	0.10	-0.03	-0.13	-0.20	-0.25
Rich	0.02	-0.01	-0.09	-0.12	-0.20	-0.22
Middle class	0.58	0.22	0.02	-0.13	-0.20	-0.27
Poor	0.27	0.16	0.03	-0.17	-0.13	-0.19

Table 4: Redistribution of Wealth across Sectors as % of GDP with 1% Shock

Sectors	Government	Foreigners	Households		
			Net	Gains	Losses
Inflation targeting	0.43	-0.03	-0.40	2.56	-2.95
Price level targeting (6-year horizon)	0.14	0.01	-0.15	1.15	-1.29
Price level targeting (15-year horizon)	0.22	-0.03	-0.19	1.70	-1.89

Table 5: Calibrated Parameters

Parameter	Value	Target
Preferences		
σ	2	RBC literature
η_3	0.64	33.1% of time at work
η_2	0.55	40.9% of time at work
η_1	0.61	42.7% of time at work
β_3	1.10^{10}	$\frac{\text{Wealth of rich}}{\text{Wealth of middle class}} = 6.54$
β_2	1.01^{10}	$\frac{\text{Wealth of middle class}}{\text{Annual GDP per HH}} = 2.4$
β_1	0.99^{10}	$\frac{\text{Wealth of middle class}}{\text{Wealth of poor}} = 3.8$
ξ_3	0.012	$\frac{\text{Bequest}}{\text{Average wealth}} = 0.088$
Demography		
s_4	0.547	Fraction of Retirees = 0.17
s_5	0.500	$\frac{\text{Size of } >76}{\text{Size of 66-75}} = 0.5$
Technology		
α	0.33	RBC literature
δ	0.52	7% annual depreciation
Government		
τ	0.301	$\frac{\text{Tax revenue}}{\text{GDP}} = 0.32$
$T_{retired}$	0.039	$\frac{\text{Retirement Income Transfer}}{\text{GDP per HH}} = 0.13$

Table 6: Fixed Effects Estimates of the Average Wage Rate of Workers

	Model Result
Age	0.076012*
	(0.002876)
Age Squared	-0.000847*
	(0.000029)
School Years	0.029377*
	(0.002994)
Work Experience[1]	0.016393*
	(0.001752)
Constant	0.536536*
	(0.053876)
R^2	0.2695
Number of observations	57360

Note: $(*)$ indicates significance at the 1% level. (1) Number of years working as full-time.

Table 7: Relative Labour Productivity

	$\leq$35	36-45	46-55	56-65
Poor	1.00	1.52	1.67	1.49
Middle Class	1.12	1.70	1.87	1.67
Rich	1.30	2.03	2.25	2.11

Table 8: Welfare Effects Based on Redistribution in 2005 for Different Fiscal Policies under IT with 1% Shock

	Tax Cuts			Higher Lump-sum Transfer			Higher Retirement Income Transfer		
Age	Poor	Middle	Rich	Poor	Middle	Rich	Poor	Middle	Rich
≤35	0.054	0.101	0.084	0.051	0.078	0.040	0.018	0.048	0.008
36-45	0.070	0.107	0.030	0.062	0.084	0.007	0.037	0.065	-0.011
46-55	0.032	0.002	-0.141	0.051	0.002	-0.136	0.043	0.007	-0.145
56-65	-0.051	-0.116	-0.171	0.005	-0.081	-0.150	0.019	-0.058	-0.154
66-75	-0.200	-0.175	-0.180	0.150	-0.109	-0.161	2.045	0.300	-0.057
≥76	-0.286	-1.099	-0.200	0.223	-0.589	-0.175	2.943	2.130	-0.039
Total		-0.055			-0.015			0.195	

Table 9: Welfare Effects Based on Redistribution in 2005 for Different Fiscal Policies under PT with 1% Shock and six-year Horizon

	Tax Cuts			Higher Lump-sum Transfer			Higher Retirement Income Transfer		
Age	Poor	Middle	Rich	Poor	Middle	Rich	Poor	Middle	Rich
≤35	0.011	0.022	0.013	0.025	0.026	0.010	0.028	0.032	0.003
36-45	0.016	0.026	0.023	0.027	0.029	0.020	0.043	0.045	0.016
46-55	0.003	0.003	-0.018	0.024	0.014	-0.011	0.056	0.045	-0.007
56-65	-0.029	-0.036	-0.034	0.006	-0.013	-0.026	0.072	0.042	-0.019
66-75	-0.122	-0.073	-0.078	0.009	-0.036	-0.070	0.727	0.172	-0.029
≥76	-0.151	-0.609	-0.089	0.027	-0.430	-0.080	0.999	0.542	-0.031
Total		-0.034			-0.009			0.094	

Table 10: Welfare Effects Based on Redistribution in 2005 for Tax Cut Policy under Different Target Horizons with 1% Shock

	IT			PT15			PT06		
Age	Poor	Middle	Rich	Poor	Middle	Rich	Poor	Middle	Rich
≤35	0.054	0.101	0.084	0.021	0.051	0.040	0.011	0.022	0.013
36-45	0.070	0.107	0.030	0.031	0.065	0.015	0.016	0.026	0.023
46-55	0.032	0.002	-0.141	0.012	0.018	-0.074	0.003	0.003	-0.018
56-65	-0.051	-0.116	-0.171	-0.044	-0.064	-0.117	-0.029	-0.036	-0.034
66-75	-0.200	-0.175	-0.180	-0.163	-0.120	-0.132	-0.122	-0.073	-0.078
≥76	-0.286	-1.099	-0.200	-0.224	-0.887	-0.150	-0.151	-0.609	-0.089
Total		-0.055			-0.045			-0.034	

Table 11: Welfare Effects Based on Redistribution in 2005 for Different Fiscal Policies under IT and PT with a Range of Shocks

Shocks	Tax Change	Lump-sum Transfer	Retirement Income Transfer
	Inflation targeting		
-5%	0.295	0.154	-0.698
-2%	0.132	0.070	-0.233
-1%	0.080	0.045	-0.063
1%	-0.055	-0.015	0.195
2%	-0.104	-0.037	0.334
5%	-0.247	-0.109	0.725
	Price level targeting (six-year horizon)		
-5%	0.190	0.139	-0.103
-2%	0.091	0.070	0.015
-1%	0.048	0.043	0.041
1%	-0.034	-0.009	0.094
2%	-0.065	-0.033	0.119
5%	-0.151	-0.099	0.186

Table 12: Welfare Effects Based on Redistribution in 2005 for Different Fiscal Policies under PT with 1% Shock and six-year Horizon, Short Instruments in Bonds

	Tax Cuts			Higher Lump-sum Transfer			Higher Retirement Income Transfer		
Age	Poor	Middle	Rich	Poor	Middle	Rich	Poor	Middle	Rich
≤35	0.005	0.015	0.011	0.023	0.025	0.012	0.030	0.035	0.009
36-45	0.008	0.020	-0.004	0.025	0.028	-0.001	0.044	0.048	-0.001
46-55	0.002	0.004	-0.032	0.023	0.019	-0.023	0.062	0.052	-0.021
56-65	-0.016	-0.024	-0.049	0.021	-0.001	-0.040	0.089	0.057	-0.034
66-75	-0.053	-0.046	-0.045	0.058	-0.010	-0.039	0.600	0.165	-0.007
≥76	-0.083	-0.332	-0.053	0.064	-0.186	-0.046	0.778	0.528	-0.010
Total		-0.019			0.006			0.093	

Figure 1: Lifecycle Asset, 1% shock, Labour Tax Reduction Policy under IT

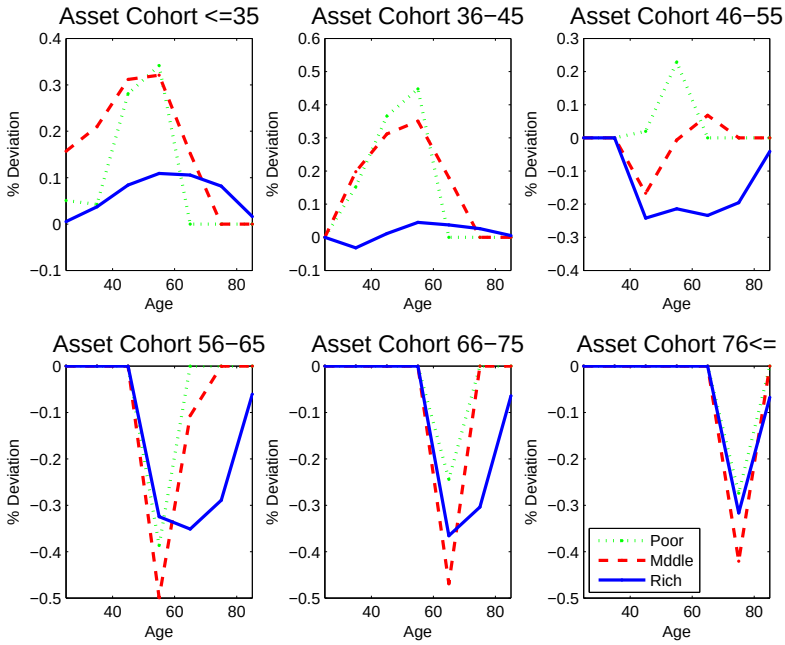

Figure 2: Lifecycle Labour, 1% shock, Labour Tax Reduction Policy under IT

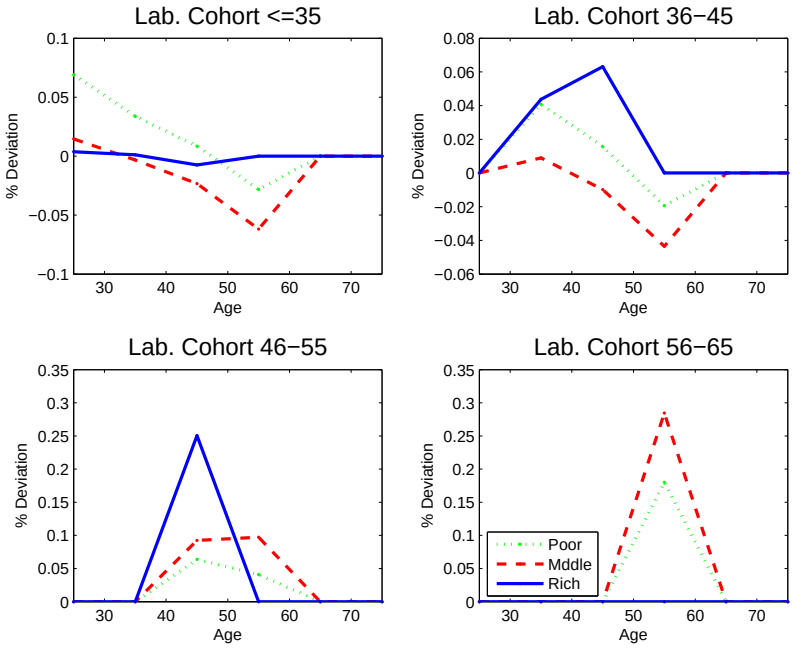

Figure 3: Lifecycle Asset, 1% shock, Labour Tax Reduction Policy under PT

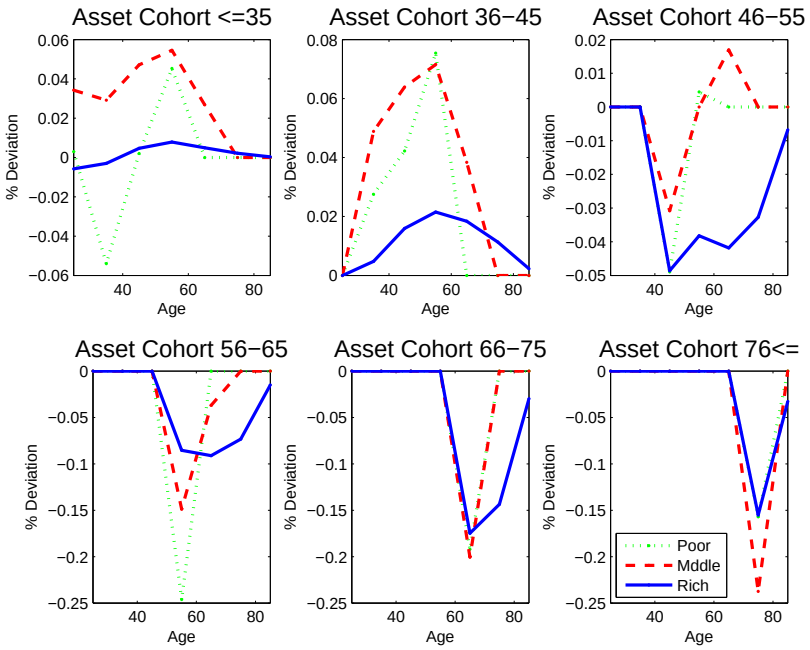

Figure 4: Lifecycle Labour, 1% shock, Labour Tax Reduction Policy under PT

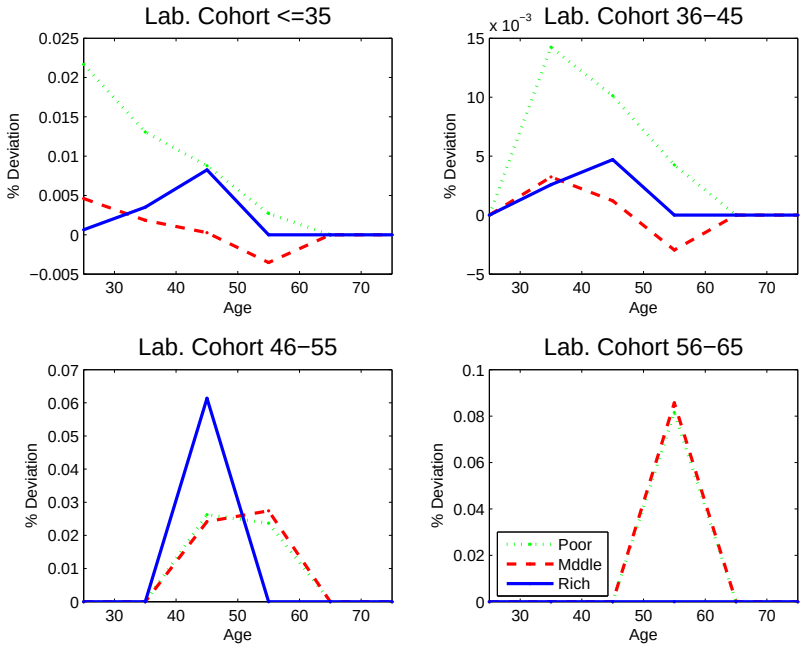

Figure 5: Output and Asset, 1% shock, Labour Tax Reduction Policy under IT and PT

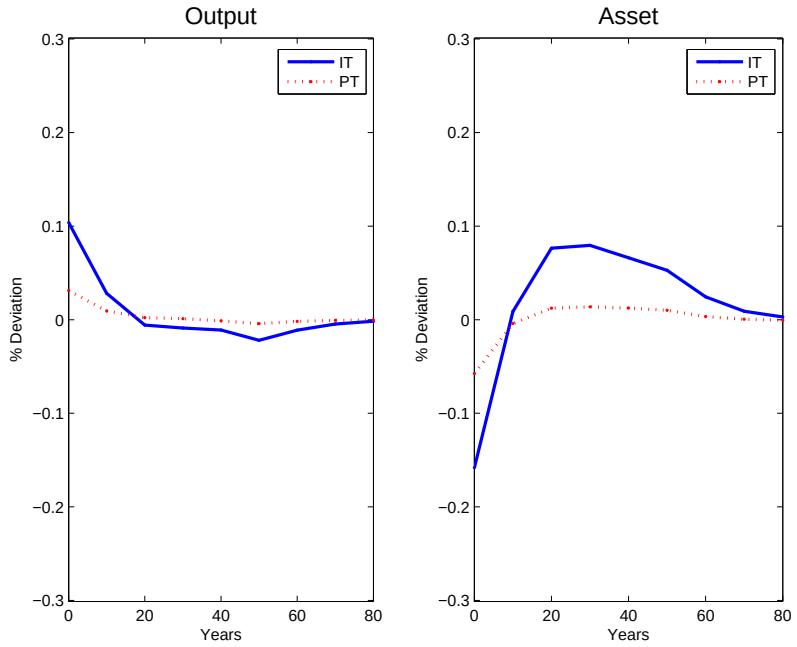

Figure 6: Output and Asset, 1% shock, Labour Tax Rate Adjustment Period by Period under IT and PT

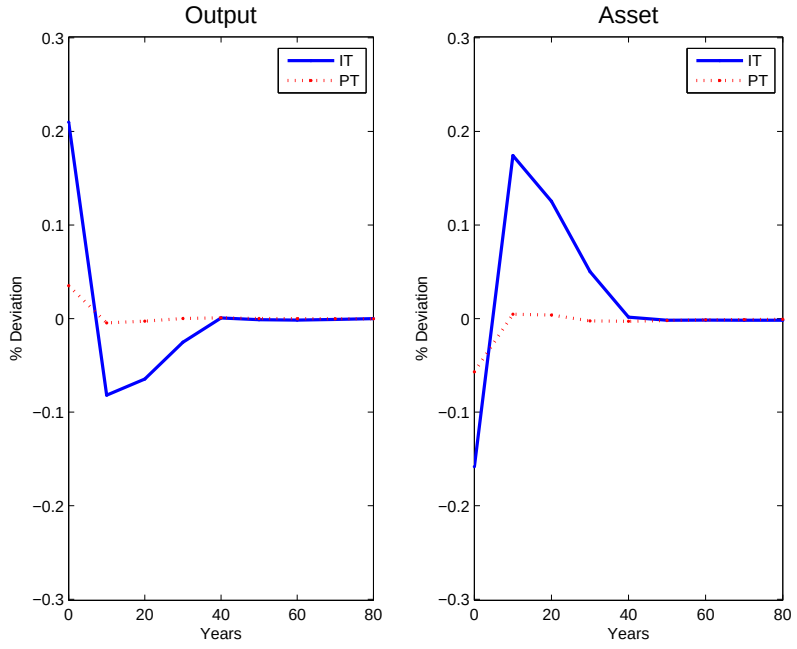

Figure 7: Output and Asset, 1% shock, Lump-sum Transfer Policy under IT and PT

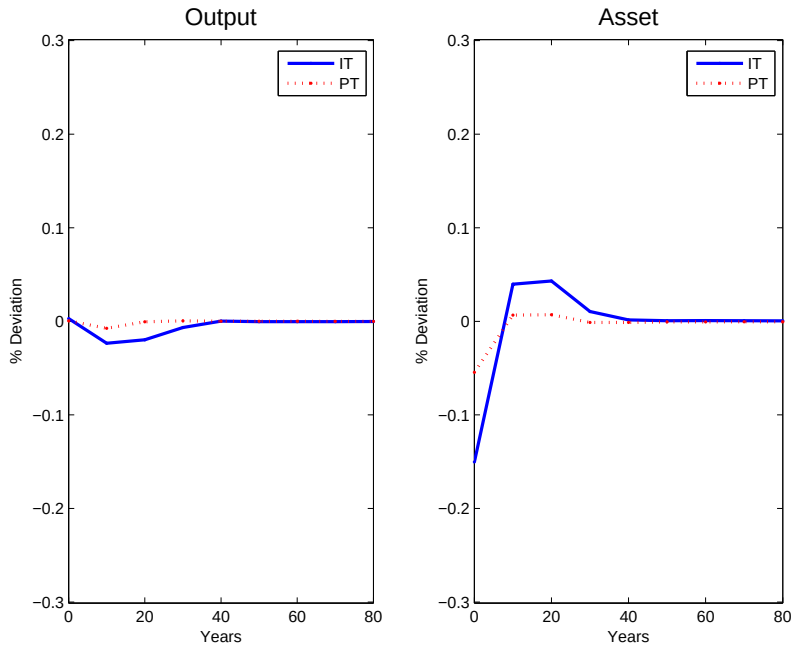

Figure 8: Output and Asset, 1% shock, Transfer to Retirees Policy under IT and PT

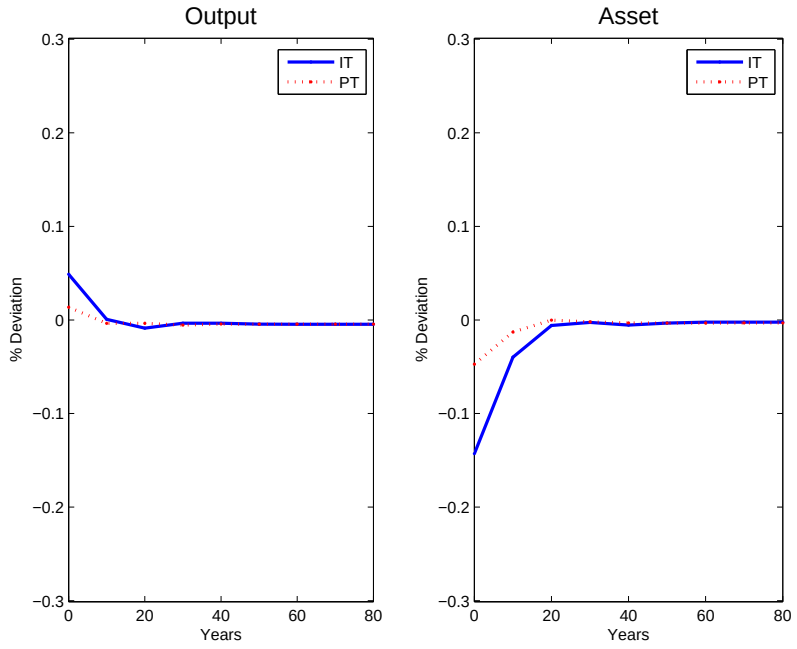

Figure 9: Output and Asset, 1% shock, Labour Tax Reduction Policy under IT, PT6 and PT15

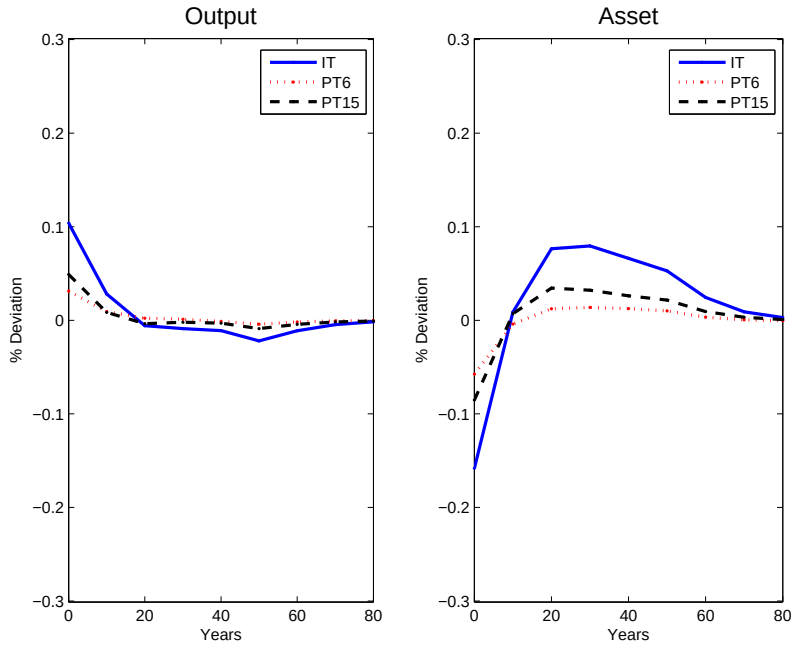

Figure 10: Output and Asset, 1% Shock, Labour Tax Reduction Policy under IT, with and without Foreign Sector

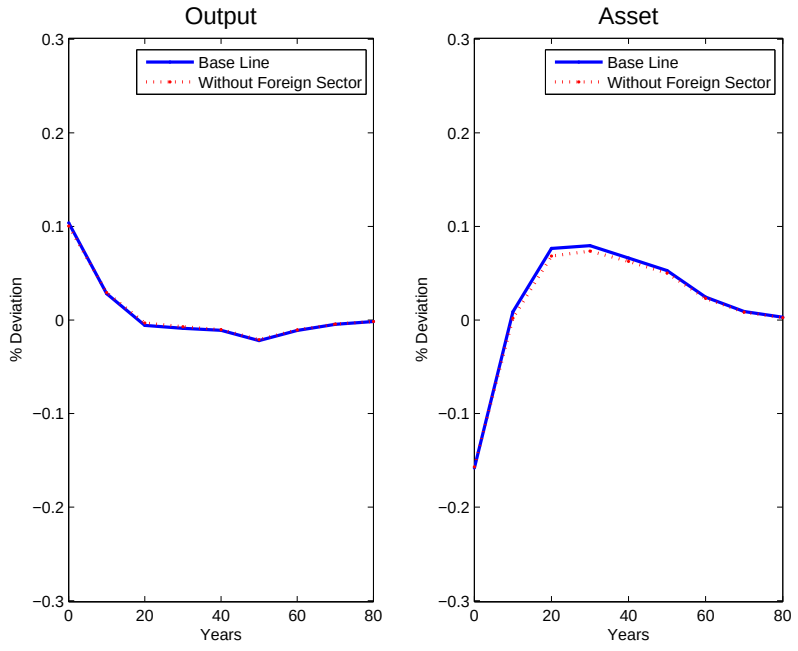

Figure 11: Output, 1% shock, for Different Policies and Different Scenarios under PT, Different Portfolios