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Shock from Graying: Is the Demographic Shift Weakening Monetary Policy Effectiveness

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Monetary and Capital Markets

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Abstract Empirical evidence is mounting that, in advanced economies, changes in monetary policy have a more benign impact on the economy—given better anchored inflation expectations and inflation being less responsive to variation in unemployment—compared to the past. We examine another aspect that could explain this empirical finding, namely the demographic shift to an older society. The paper first clarifies potential transmission channels that could explain why monetary policy effectiveness may moderate in graying societies. It then uses Bayesian estimation techniques for the U.S., Canada, Japan, U.K., and Germany to confirm a weakening of monetary policy effectiveness over time with regards to unemployment and inflation. After proving the existence of a panel co-integration relationship between ageing and a weakening of monetary policy, the study uses dynamic panel OLS techniques to attribute this weakening of monetary policy effectiveness to demographic changes. The paper concludes with policy implications.

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I. Introduction

Prior to the global financial crisis, a consensus view emerged that monetary policy in the form of inflation targeting (IT) was the most appropriate framework to stabilize an economy. The trend since the mid-1990s among many central banks around the world was to formally adopt inflation targeting, with some success (Roger, 2009). Since the global financial crisis, however, an emerging view has arisen that argues that by ignoring the emergence of asset bubbles prior to 2008, it was partly to blame for the crisis (Frankel, 2012). New proposal such as targeting nominal GDP have arisen, while some central banks appear already in practice quietly distanced themselves from IT.

However, even though central banks around the world are broadening their mandate by shifting their focus to include financial stability, IT is not being abandoned. Some prominent central banks, such as the U.S. Fed, have formalized their inflation objective of 2 percent in early 2012, or like the Bank of Japan in early 2013 have only recently introduced it. In other words, despite some of the flaws evoked by critics, the trend towards IT is not dead, and may even continue its assent. This reflects the ingrained belief in the effectiveness of IT arising from its successful track record in controlling inflation. This is a reflection of the dominance of economic models used by the economic profession that assume that the effectiveness of monetary policy is dependent on the credibility of the central bank, and its ability to impact expectations (e.g. Mishkin, 1998).

This belief in IT is surprising, as empirically, recent studies (see the survey conducted by Boivin and others, 2010) have found mounting evidence that monetary policy have a more benign effect on variables such as unemployment and inflation since the mid-1980s. The decrease in the effectiveness of monetary policy, measured by the impact of interest rate changes on unemployment and inflation, are attributed to better anchored inflation and output expectations. Inflation is generally less responsive to changes in cyclical unemployment, while inflation expectations remain well anchored on the central bank's inflation target, including during deep recessions such as the global financial crisis (see IMF, 2013). Paradoxically therefore, as the ability of monetary policy to influence expectations via movements in the interest rate has decreased, interest rate changes have less of an impact on the economy.

A much cited IMF (2013) study has illustrated that inflation remains stuck around 2 percent throughout the business cycles in the U.S., and does not respond much to changes in the output gap. Prices have increased at similar rates as before the global crisis, despite huge drops in output. This explains why extraordinary monetary policy expansion of an unprecedented scale has not had a larger impact on inflation or output. The literature has identified two main channels to attempt to explain this phenomenon: (i) structural transformation of the economy, particularly institutional change in the credit market; and (ii) changes in the way monetary policy impacts the expectations of economic agents (see Boivin and others, 2010).

Some have argued that institutional changes in the credit market explain the weakening of monetary effectiveness. The argument is that over the last two decades, regulatory restrictions have in general been loosened and credit markets have been liberalized. New forms of lending—securitization in particular—have, as a result of better information technologies and improved information, allowed a wider set of institutions to engage in the supply of credit. The resulting shadow banking has led to easier access to credit and an expansion of credit to a part of the population that had previously been credit constrained, namely lower income segments. These changes were expected, in principle, to increase the effectiveness of monetary policy. However, they may also have been accompanied by a growing role for household balance sheet channels, increasing for instance the effects of house price movements on their consumption decisions. This, in turn, also meant that transitory shocks could be financed through the refinancing of housing, thus reducing the importance of the credit channel, and hence the sensitivity of economic activity to monetary policy changes (see Boivin and Giannoni, 2006).[2]

Another argument often used is that central banks—given their strong credibility—have increasingly operated through 'open mouth operations,' allowing them to manage expectations without having to act using actual interest rate changes as much as in the past.

[2] Even if these explanations can account for the weakening of the transmission mechanism over time, the global financial crisis may have dented the effects, since many of the institutional changes in the credit market have been reversed and central bank credibility in many countries is being increasingly challenged. Thus, these explanations may not hold going forward.

Therefore, the expectation that monetary policy would respond strongly to deviations of output from potential or to deviations from the inflation target has led to more stability in expectations for income and inflation and, therefore, greater stability in actual spending and inflation (Boivin et al., 2010). This, in turn, means that interest rate changes per se will have paradoxically a weaker effect.

While not denying the importance of these factors, we will in this paper offer an additional explanation, which the literature has so far largely ignored. We will argue that monetary policy also has a weakened effect on the economy due to changing demographics. Demographic profiles vary significantly by country: while some countries are ageing more rapidly than others (e.g. Germany, Japan); no part of the world remains untouched by this phenomenon (see Appendix 1). With fertility rates plummeting around the world—often below replacement rate—including in low-income countries, the world is going through an unprecedented demographic shift that is leading to a rapidly graying world. The elderly used to account for a small share of the population, but technological breakthroughs and social changes over the last two centuries have transformed this demographic structure (e.g. Towers Watson, 2011). Based on the life-cycle hypothesis, we would expect older societies to typically have a large share of households that are creditors, and to be less sensitive to interest rate changes, while younger societies would typically have a larger share of debtors with higher sensitivities to monetary policy. This, it will be argued, is another factor explaining the moderating effect of monetary policy.

To our knowledge, this is the first paper that attempts to empirically assess the impact of graying on monetary policy effectiveness. We use Bayesian methods to first estimate the impact of monetary policy on unemployment and inflation, and illustrate a general weakening of monetary policy effectiveness over time, with unemployment and inflation less responsive to interest rate changes as society grays. Note that we are only interested in testing the *net* effect on the economy; estimating the importance of each channel on its own goes beyond the scope of this paper. After illustrating that a co-integrating relationship exists, we then use dynamic panel OLS techniques to explain this finding, and confirm the negative and statistically significant effect of demographic changes on monetary policy effectiveness. That monetary policy effectiveness weakens with an older population has significant policy implications. For instance, to obtain the same impact on output and inflation, ceteris paribus, interest rate changes will have to become larger in older societies than in younger ones (see also conclusion for some of the policy implications).

The paper is structured as follows. In Section II, we provide a literature review, followed by an explanation of the various channels through which demographic shifts may lead to changes in the effectiveness of monetary policy. In Section III, using a time-varying vector autoregressive model, we estimate the impact of monetary policy effectiveness on the five biggest advanced economies that have independent monetary policies—U.S., Canada, Japan, U.K., and Germany. Using impulse response functions, we find that there is a general weakening of the impact of monetary policy effectiveness on unemployment and inflation, suggesting declining effectiveness over time. In Section IV, we subject the results to a series of robustness checks, and find that the relationship between demographic shifts and weakening monetary policy is not spurious, as a robust co-integrated relationship is found. We conclude in Section V, and discuss policy implications.

II. Literature Review

There is little empirical evidence to date on whether, and to what extent, monetary policy changes have different effects on various cohorts and, therefore, on whether monetary policy effectiveness changes in an ageing society. The limited work on this topic has been mainly theoretical in nature. Miles (2002), using an overlapping generation model, points out that changes in the effectiveness of monetary policy in graying societies is ambiguous. On the one hand, as wealth tends to be concentrated among elderly households in ageing societies, the effectiveness of monetary policy could rise as a result of the increased wealth. On the other hand, Miles concedes that other channels may reduce its effectiveness, and the impact may be more ambiguous if it is assumed that an ageing population is less credit-constrained, and the pension system is well funded, as this would reduce the effectiveness of the credit channel. Depending on the relative importance of these channels, monetary policy could, in principle, become more or less effective with ageing.

Following this line of work, researchers have recently explored the impact of demographic shifts on monetary policy effectiveness, but no consensus has been reached. Using a small-scale DSGE model with an embedded demographic structure, Kara and von Thadden (2010) calibrate a model over a 20-year horizon for the euro area. They find that demographic changes, while slowly contributing to a decline in the equilibrium interest rates, are not important enough within the short-time horizon of monetary policy-making to impact monetary policy effectiveness. While they do concede that monetary policy may lead to distributional consequences when agents are heterogeneous, they conclude that for policy makers, monetary policy effectiveness remains essentially unchanged. Bean (2004) also hypothesizes that “the glacial nature of demographic change appears to suggest that the implications for monetary policy should be modest”.

In contrast, Fujiwara and Teranishi (2007), using a dynamic new Keynesian model that incorporates households with life-cycle behavior, simulate the impact of the demographic structure on monetary policy, and come to different conclusions: they find that monetary policy effectiveness does in fact depend on the demographic structure, as retirees, with a higher reliance on financial assets, are differently impacted—via the wealth effect for instance—than the currently active population. However, their theoretical work does not permit to make any conclusions about the net effect of ageing on the monetary transmission mechanism, reflecting the multitude of factors that change in the way monetary policy works as populating ages.

Given the ambiguity of the theoretical literature, it is surprising that limited empirical work has yet been undertaken to bring us closer to the true impact of monetary policy changes in an ageing society.

Conceptually, in an ageing society, we would expect *a priori* that the various channels through which the monetary transmission mechanism works would vary, some becoming strong, others weaker, and some having an ambiguous effect. Younger and older cohorts are affected differently, thereby impacting monetary policy effectiveness (see Table 1). Let us look at them in turn.

Table 1: Channels through which Monetary Transmission Mechanism differs across Demographics

	Young Society	Old Society	Rationale
Interest Rate Channel	More Important	Less Important	Credit Demand: Young adults need more credit than older ones
Credit Channel	More Important	Less Important	External Risk Premium: Young adults have higher external risk premium
Wealth Effect	Less Important	More Important	Income distribution: Young possess little wealth while old own much of it, making the latter more sensitive to monetary policy changes
Risk Taking Channel	More Important	Less Important	Risk-Aversion: Older adults are more risk averse, reacting less to changes in monetary policy
Expectation Channel	Less Important	More Important	Inflation Expectations: Older adults more sensitive to inflation than the younger ones
Exchange Rate	Not Clear	Not Clear	Not Clear

- **Interest Rate Channel**: According to the life-cycle hypothesis (Modigliani, 1970), individuals acquire assets, first housing, and then financial assets, throughout their working lives, and sell them once they retire. Both the savings and consumption patterns of households follow, therefore, a well-established path that changes as they age, with debt levels rising and then falling during the life-cycle. In these circumstances, we expect young households, which are typically debtors, to be more sensitive to interest rate changes—particularly if interest rates on housing are mostly variable—while older households, who typically do not need to borrow and are creditors, are less sensitive to this channel.[3] Hence, societies dominated by young households would tend to be more sensitive to interest rate changes, ceteris paribus (i.e. we assume no other effect such as the wealth effect), and monetary policy changes would be more effective, given the importance of smoothing consumption over the life-cycle.

[3] Note that theoretically, the impact of any given (unexpected) temporary change in interest rate is going to be spread out over fewer periods for older people, implying that the impact of an interest rate change is going to be larger, assuming some desire to smooth consumption. In practice, older households that are poor are likely to be credit constraint by banks, given that their risk profile will discourage banks to lend to them (see Seidman and Lewis, 1999, for evidence that elasticity of savings and consumption has been found to be positive, close to zero and even negative in various studies).

- **Credit Channel**: This channel amplifies the interest rate channel by impacting the external finance premium, which is the difference in the cost of capital available to households/firms versus the cost of borrowing externally (Bernanke and Gertler, 1989). The credit channel assumes that the size of the external finance premium is inversely related to the borrower's net worth. In an ageing society with older households having greater net worth, they are more likely to rely on self-financing as a means to fund investment/consumption. For these older individuals, given their large level of collateral, the risk-premium of borrowing is lower, and the cost of raising external funds should therefore be lower. This implies a lower sensitivity of monetary policy on the credit channel in graying societies. (Old age poverty is also afflicting many individuals, but credit rationing may prevent them from borrowing, as banks may be reluctant to lend them given that they may not easily repay the loan).

- **Wealth Effect Channel**: Based on the life-cycle hypothesis, demographic shifts can be expected to affect asset prices. Young individuals typically possess few assets, while older ones own many. When a household has acquired substantial assets, the impact of interest rate changes on its wealth are larger than when a household has few assets (see Iacoviello, 2005). In graying societies, wealth effects would gain increasing importance, since wealth tends to be concentrated among the elderly (at least in OECD countries). For example, older households have portfolios that are typically more heavily made up of interest-sensitive fixed-income products rather than equities, thus accentuating the sensitivity to interest rate changes arising from the wealth effect channel. The demographic shift would, therefore, tend to raise the relative importance of the wealth effect channel, increasing the effectiveness of monetary policy.[4]

While less studied and more difficult to discern, other potential channels that may alter the monetary transmission mechanism and thereby the effectiveness include:

[4] Not all asset prices are equally impacted though. For example, riskier assets may be more sensitive to the demographic shift, as individuals purchase riskier assets during their prime working age, and the effect on housing prices will depend on the extent to which housing demand remains strong among the elderly.

- **Risk-Taking Channel**: Monetary policy impacts economic agents' perception of risk, what has been termed the "risk-taking channel" of monetary policy (see Borio and Zhu, 2008). Monetary policy influences risk-taking by encouraging the "search for yield." Both for psychological (e.g. due to money illusion) and institutional reasons (e.g. desire to have a guaranteed minimum return), financial entities have been found to take on more risk when interest rates fall (and less when interest rates rise). In an ageing society, the time to recoup losses is lower (or less) than in a younger society, which may lead to more risk-averse households and, hence, less overall risk-taking. As a result, the risk-taking channel is likely to be less potent in a graying society than in a younger one, thus reducing monetary policy effectiveness.

- **Expectation Channel**: The expectation channel should not be impacted as much by the demographic shift, as it is conditional on the credibility of the central bank, which should not change with the demographic shift. Recent preliminary work, using survey data, does suggest that, ceteris paribus, inflation expectations rise with age, suggesting higher concern and, hence, risk aversion to inflation in a graying society (Blanchflower and MacCoille, 2009). The behavioral finance literature explains the differences in expectations with older households putting more weight on worse inflation outcome than younger households, due to larger impact it would have on them given their creditor status. In practice, therefore, it is possible that central banks will place a greater emphasis on price stability, making them even more averse to inflation spikes. This would imply that the expectation channel is gaining in importance in ageing societies, as the central bank would employ monetary policy more aggressively to combat inflation.

- **Exchange Rate Channel:** The net impact of ageing on the external current account, and by implication on the exchange rate, depends on the relative declines in savings and investments. From the life-cycle hypothesis, an ageing population is expected to exert a negative impact on private savings. With population ageing, the rise in older cohorts relative to the younger ones leads in principle to more dis-saving than saving, with the total dis-saving of the old being superior to the total saving of the young. The net effect is a decline in the savings of the population. Similarly, the fiscal position—

and hence public savings—of countries should worsen with ageing, both because of declining revenues and higher expenditures.[5] But both public and private investments are expected to decline as the population ages. As there is no theoretical *a priori* on which effect outweighs the other, with both savings and investment also being driven by inter-temporal choices, the effect on the current account and the exchange rate is therefore ambiguous and country specific.

Caveats. In the estimation below, the focus will be on estimating the aggregate effect, rather than the individual channels. Testing the importance of each channel on its own goes beyond the scope of this paper. However, it should be noted that, in addition to the effectiveness of monetary policy, a graying population is expected to reduce real interest rates, diminish *long-term* growth potential, and impact international capital flows (e.g. Bean, 2004, Bloom et al., 2011, Poterba, 2004, Shirakawa, 2012). In addition, ageing itself may have a direct impact on price developments. The demographic shift, especially if it is accompanied by a population decline, is likely to impact aggregate demand negatively, putting downward pressure on prices if aggregate supply does not fall commensurately, and explaining deflationary tendencies that exist in graying societies (see Shirakawa, 2011). At the same time, increased demand for services by an ageing population—where price changes tend to be stickier in nature than for tradable goods—implies that prices are less flexible, but potentially also less inflationary, in general. Some of these biases are addressed by the estimation methodology. By using a time-varying constant term, this should in principle correctly control for changes in real interest rates and implied inflation targets.

III. The Time-varying Impact of Monetary Policy: Has Monetary Effectiveness Weakened Over Time?

This section estimates the time-varying impact of monetary policy across our sample of five large advanced countries that conduct their own independent monetary policy. As population

[5] While a well-planned transition to an older society with fewer active and more inactive individuals could, in principle, be managed without impacting public finances, in practice most AEs, but also EMs, are not well prepared for this transition. Major funding gaps projected in defined benefit pension and health care systems are the norm, while defined contribution pension systems are often underfunded, creating potential contingent liabilities to the government (see IMF, 2011).

ageing is a smooth, long-term phenomenon that occurs over time, the response of an economy to monetary policy changes is not easy to estimate. This has to be taken into account in the evolution of the estimation procedure. To address this problem, the literature has typically focused on two main modeling approaches: the first avenue consists of splitting the sample and estimate the model over the subsample—which is problematic as it is not clear where to break the sample as the economy changes gradually, not abruptly. The alternative approach, which has less restrictive assumptions about the behavior of the economy, it to use time-varying coefficients for the full sample using Bayesian VARs. We illustrate that, across all countries, the impact of monetary policy has declined steadily from the 1980s onwards.

A. Model

The changing impact of monetary policy is estimated using a time-varying coefficient vector autoregressive model (TVC-VAR) with stochastic volatility (SV) on $\mathbf{y}_t = [\pi_t, u_t, i_t]'$, where π_t denotes inflation, u_t the unemployment rate and i_t the policy rate. The estimation approach used is analogous to Primiceri (2005). We consider the model:

$$\boldsymbol{y_t} = \boldsymbol{\mu_t} + \boldsymbol{\Phi_{1,t} y_{t-1}} + \boldsymbol{\Phi_{2,t} y_{t-2}} + \cdots + \boldsymbol{\Phi_{p,t} y_{t-p}} + \boldsymbol{\epsilon_t}, \quad \mathbb{V}[\boldsymbol{\epsilon_t}] = \boldsymbol{\Omega_t} \quad \textbf{(1)}$$

where μ_t denotes a time varying $k \times 1$ vector of coefficients multiplying the constant term[6], $\Phi_{p,t}$, $i = 1, \dots, p$ an $k \times k$ matrix of time-varying coefficients, and ϵ_t, an $k \times 1$ vector of heteroskedastic shocks with covariance matrix Ω_t. Similar to Cogley and Sargent (2001) for instance, the covariance matrix is modeled as:

$$\boldsymbol{\Omega_t} = \boldsymbol{\Phi_{0,t}^{-1} \Sigma_t \Sigma_t' \Phi_{0,t}^{-1\prime}}, \quad \textbf{(2)}$$

where

[6] Note that the time varying constant accommodates, to a certain extent, misspecifications in the measure of spare capacity and/or changes in the inflation target.

$$\boldsymbol{\Phi}_{\mathbf{0},t} = \begin{bmatrix} 1 & 0 & 0 \\ \phi_{1t} & 1 & 0 \\ \phi_{2t} & \phi_{3t} & 1 \end{bmatrix}, \qquad \boldsymbol{\Sigma}_t = \begin{bmatrix} \sigma_{1t} & 0 & 0 \\ 0 & \sigma_{2t} & 0 \\ 0 & 0 & \sigma_{3t} \end{bmatrix}. \qquad \textbf{(3)}$$

The covariance matrix decomposition used is standard in the VAR literature allowing both for time-varying instantaneous coefficients and stochastic volatility (see Koop and Korobilis, 2009 for an overview). The vectorized version of (2) is:

$$\boldsymbol{y}_t = \boldsymbol{X}_t' \boldsymbol{\Phi}_t + \boldsymbol{\Phi}_{\mathbf{0},t}^{-1} \boldsymbol{\Sigma}_t \, \boldsymbol{e}_t \,, \quad \mathbb{V}[\boldsymbol{e}_t] = \mathbf{I}_k \qquad \textbf{(4)}$$

$$\boldsymbol{X}_t' = [\mathbf{I}_n \otimes (1, \boldsymbol{y}_{t-1}', \boldsymbol{y}_{t-2}', \ldots, \boldsymbol{y}_{t-p}')]. \qquad \textbf{(5)}$$

To ease the computational burden, we model the parameters of (4) and (5) instead of (2) and (3). The dynamics of the model parameters: $\boldsymbol{\phi}_t = [\boldsymbol{\phi}_{1t}, \boldsymbol{\phi}_{2t}, \boldsymbol{\phi}_{3t}]'$, $\boldsymbol{\Phi}_t$ and $\log(\boldsymbol{\sigma}_t) = \log\,[\boldsymbol{\sigma}_{1t}, \boldsymbol{\sigma}_{2t}, \boldsymbol{\sigma}_{3t}]'$ are assumed to follow random walks, i.e.:

$$\boldsymbol{\phi}_t = \boldsymbol{\phi}_{t-1} + \boldsymbol{e}_t^{\boldsymbol{\phi}} \qquad \textbf{(6)}$$

$$\boldsymbol{\Phi}_t = \boldsymbol{\Phi}_{t-1} + \boldsymbol{e}_t^{\boldsymbol{\Phi}} \qquad \textbf{(7)}$$

$$\log(\boldsymbol{\sigma}_t) = \log(\boldsymbol{\sigma}_{t-1}) + \boldsymbol{e}_t^{\boldsymbol{\sigma}}. \qquad \textbf{(8)}$$

Assuming that the diagonal components of $\boldsymbol{\Sigma}_t$ follow a geometric random walks implies that the model belongs to the class of VARs using stochastic volatility to capture heteroskedasticity in the errors. Other approaches are considered in Koop and Korobilis (2009) but are found to be either inferior in their fit or computationally more burdensome. The random walk assumptions in (6) to (8) are convenient as they simultaneously reduce the number of parameters in the estimation procedure while still allowing the parameters to exhibit numerous permanent shifts. As shown in Primiceri (2005), both features appear important when modeling changes in the impact of monetary policy.

Last, all innovations in the model are assumed to be jointly normally distributed, with covariance matrix:

$$\boldsymbol{V} = \mathbb{V}\left(\begin{bmatrix} \boldsymbol{e_t} \\ \boldsymbol{e_t^{\phi}} \\ \boldsymbol{e_t^{\Phi}} \\ \boldsymbol{e_t^{\sigma}} \end{bmatrix}\right) = \begin{bmatrix} \boldsymbol{I}_k & 0 & 0 & 0 \\ 0 & \boldsymbol{V^{\phi}} & 0 & 0 \\ 0 & 0 & \boldsymbol{V^{\Phi}} & 0 \\ 0 & 0 & 0 & \boldsymbol{V^{\sigma}} \end{bmatrix}. \qquad \textbf{(9)}$$

In addition, we assume that $\boldsymbol{V^{\phi}}$ is block-diagonal with blocks corresponding to parameters from different equations (see Koop et al (2009) for alternatives to this).

B. Estimation Technique

The estimation of (4) and (5) subject to (6-9) is done using Bayesian MCMC methods. The Gibbs Sampler is used to exploit the block structure of the unknowns and draw a sample from the joint posterior, $p(\boldsymbol{A^T}, \boldsymbol{a^T}, \log(\boldsymbol{h^T}), \boldsymbol{V})$, given the data. Gibbs Sampling is carried out in four steps described in Primiceri (2005). The main advantage of this approach over classical estimation techniques is in dealing with the high dimensionality and non-linearity of the problem. In addition, Bayesian MCMC methods can efficiently deal with the so-called 'Pile-up Problem', implying that the Maximum Likelihood (ML) estimator of the covariance matrix has a point mass at zero if the changes in the covariance terms are small (see Stock and Watson (1998)).

Priors. Following the literature—in particular Cogley and Sargent (2005) and Primiceri (2005)—we use data driven normal-inverse-Wishart conjugate priors.[7] Succinctly, the priors can be summarized as:

$$\boldsymbol{\Phi^0} \sim N\left(\widehat{\boldsymbol{\Phi}}^{\boldsymbol{LS}}, 4\mathbb{V}(\widehat{\boldsymbol{A}}^{\boldsymbol{LS}})\right),\ \boldsymbol{\phi^0} \sim N\left(\widehat{\boldsymbol{\phi}}^{\boldsymbol{LS}}, 4\mathbb{V}(\widehat{\boldsymbol{\phi}}^{\boldsymbol{LS}})\right) \qquad \textbf{(10)}$$

$$\log(\boldsymbol{\sigma^0}) \sim N\left(\log(\widehat{\boldsymbol{\sigma}}^{\boldsymbol{LS}}), \boldsymbol{I}_n\right). \qquad \textbf{(11)}$$

[7] ***Priors for the hyper-parameters*:** $\boldsymbol{V^A}$, $\boldsymbol{V^h}$ and the blocks of $\boldsymbol{V^a}$ are assumed to be distributed as independent inverse-Wishart. In order to make the priors as diffuse as possible, the degrees of freedom are set to the smallest number possible to obtain a proper distribution (for instance, for $\boldsymbol{V^h}$, the degrees of freedom, $\underline{\boldsymbol{v}}_h$, are set such that: $\underline{\boldsymbol{v}}_h$ = dim($\boldsymbol{V^h}$) + 1) . That said, for $\boldsymbol{V^A}$, a slightly tighter prior was deemed necessary to avoid implausible behavior of the time-varying coefficients. The scale matrices, $\underline{\boldsymbol{Q}}_A$, $\underline{\boldsymbol{Q}}_h$ and $\underline{\boldsymbol{Q}}_{a,i}$, $i = 1, \dots, S$, where S is the number of blocks in $\boldsymbol{V^A}$, are chosen to be constant fractions of the variances of the corresponding LS estimates on the initial subsample multiplied by the degrees of freedom (the reason being that for an inverse-Wishart distribution, the scale matrix can be interpreted as a residual sum of squared errors).

$$V^{\sigma} \sim IW\left(4\, k_{\sigma}\ \boldsymbol{I}_k\, , 4\right),\ \boldsymbol{V}^{\boldsymbol{\Phi}} \sim IW\left(40\, k_{\boldsymbol{\Phi}}\, \mathbb{V}\left(\widehat{\boldsymbol{\Phi}}^{\boldsymbol{LS}}\right), 40\right), \tag{12}$$
$$\boldsymbol{V}_{\boldsymbol{1}}^{\boldsymbol{\phi}} \sim IW\left(2\, k_{\boldsymbol{\phi}}\, \mathbb{V}\left(\widehat{\boldsymbol{\phi}}_{\boldsymbol{1}}^{\boldsymbol{LS}}\right), 2\right),\ \boldsymbol{V}_{\boldsymbol{2}}^{\boldsymbol{\phi}} \sim IW\left(\boldsymbol{3}\, k_{\boldsymbol{\phi}}\, \mathbb{V}\left(\widehat{\boldsymbol{\phi}}_{\boldsymbol{2}}^{\boldsymbol{LS}}\right), 3\right). \tag{13}$$

where $k_{\Phi} = k_{\phi} = k_{\sigma} = 0.01^2$ are set according to the literature while $\boldsymbol{V}_{\boldsymbol{1}}^{\boldsymbol{\phi}}$ and $\boldsymbol{V}_{\boldsymbol{2}}^{\boldsymbol{\phi}}$ specify the two blocks of $\boldsymbol{V}^{\boldsymbol{\phi}}$. The priors used are therefore not flat, but diffuse and uninformative, so that the data can be free to speak about the relevant features.[8]

Identification. To identify the monetary policy shock, we begin by ordering the dependent variable, $\boldsymbol{y}_{\boldsymbol{t}}$, as $\boldsymbol{y}_{\boldsymbol{t}} = \left[\pi_t\ , u_t\ , i_t\ \right]'$. The structural model has the form:

$$\boldsymbol{y}_{\boldsymbol{t}} = \boldsymbol{X}_{\boldsymbol{t}}'\boldsymbol{A}_{\boldsymbol{t}} + \boldsymbol{B}_{\boldsymbol{t}}\ \boldsymbol{u}_{\boldsymbol{t}}\ , \tag{14}$$

where $\boldsymbol{B}_{\boldsymbol{t}}$ imposes the identifying assumptions and $\boldsymbol{u}_{\boldsymbol{t}}$ denotes the structural innovations (see Lutkepohl (2005)). The identifying assumption for the monetary policy shock is that changes in the policy rate do not immediately impact inflation or unemployment. This identification assumption is common in the literature (e.g. Bernanke and Mihov, 1998 and Christiano et al. 1999). For, $\pi_{\boldsymbol{t}}$ and $u_{\boldsymbol{t}}$ (often denoted the non-policy block), we assume that unemployment has no contemporaneous impact on inflation. Taken together, these assumptions imply that $\boldsymbol{B}_{\boldsymbol{t}}$ is given by the Cholesky decomposition:

$$\boldsymbol{B}_{\boldsymbol{t}} = \boldsymbol{\Omega}_{\boldsymbol{t}}^{\boldsymbol{1/2}} = \mathbf{A}_{\mathbf{0},\boldsymbol{t}}^{-\mathbf{1}}\mathbf{H}_{\boldsymbol{t}}\ , \tag{15}$$

The MCMC draws of $\mathrm{A}_{0,\mathrm{t}}$ and H_{t} can in this way be transformed into draws of B_{t} .

[8] The model is estimated by simulating the distribution of the unknown parameters using MCMC methods. The Gibbs Sampler is used to exploit the block structure of the unknowns and draw a sample from the joint posterior, $p\left(\boldsymbol{A}^{\boldsymbol{T}}, \boldsymbol{a}^{\boldsymbol{T}}, \log(\boldsymbol{h}^{\boldsymbol{T}}), \boldsymbol{V}\right)$, given the data. Gibbs Sampling is carried out in four steps. First, we draw the time varying coefficients, $\boldsymbol{A}^{\boldsymbol{T}}$, using the Carter and Kohn [1994] simulation smoother.[8] Second, conditional on $\boldsymbol{A}^{\boldsymbol{T}}$, $\boldsymbol{a}^{\boldsymbol{T}}$ is part of a normal linear state space and can therefore be sampled using the same method. Third, conditional on the first two parameters, drawing $\log(\boldsymbol{h}^{\boldsymbol{T}})$ can be done using the method presented in Kim et al. (1998). And finally, simulating the conditional distribution of V is done in a standard way as it is a product of independent inverse-Wishart distributions.

C. Empirical Results

To estimate the impact of monetary policy on unemployment and inflation, we apply a TVC-BVAR with SV described in Section B to each country in our sample. The data set is restricted to the five largest economies (U.S., U.K., Canada, Germany, Japan) that have an independent monetary policy and for which the availability of data goes back the furthest in time. Two lags are used in the estimation, to help conserve degrees of freedom. We initialize the priors using full-sample non-time-varying VAR estimates. The estimation is based on 10,000 runs of the Gibbs Sampler, discarding the first 2,000 to allow for convergence to the ergodic distribution. To mitigate the serial correlation in the draws, only every other draw is saved.

For our five countries data were mainly obtained on a quarterly frequency from the national statistical offices, ministries, and central banks of the given countries (see Appendix 2). Inflation is measured as the annual growth rate in the CPI, while the unemployment rate used is the civilian unemployment rate. Both series are seasonally adjusted. For the U.S., the U.K., and Canada, the nominal interest rate is measured by the yield on three-month treasury bills, and preferred to the actual policy rate as it is available for a longer period of time (we use the policy rate for the robustness tests, without a significant change in the results). These set of variables are typically considered the minimum set allowing analysis of larger economies. Due to data limitations, for Germany and Japan, three-month money market rates are used instead of treasury bills. The estimation sample stretches from 1963Q1 to 2007Q1, to avoid any bias of the estimation driven by the global financial crisis. To not contaminate our estimates for Germany and Japan with the introduction of the euro and the zero-lower bound, respectively, the corresponding estimation sample ends for these countries in 1999 and 1995.[9]

[9] While in the case of Japan, a Tobit-type regression methodology to adjust for the lower bound was attempted, but failed to provide results that were satisfactory.

As proxies for the dependent variable, we use two measures for the effectiveness of monetary policy: (i) the cumulative response of inflation and unemployment over the subsequent five years following a one percentage point shock to the interest rate; and (ii) the corresponding maximum response over the same horizon (both measures are depicted in Figures 2 and 3). We introduce both measures to help illustrate the impact of aging on the effectiveness of monetary policy.[10]

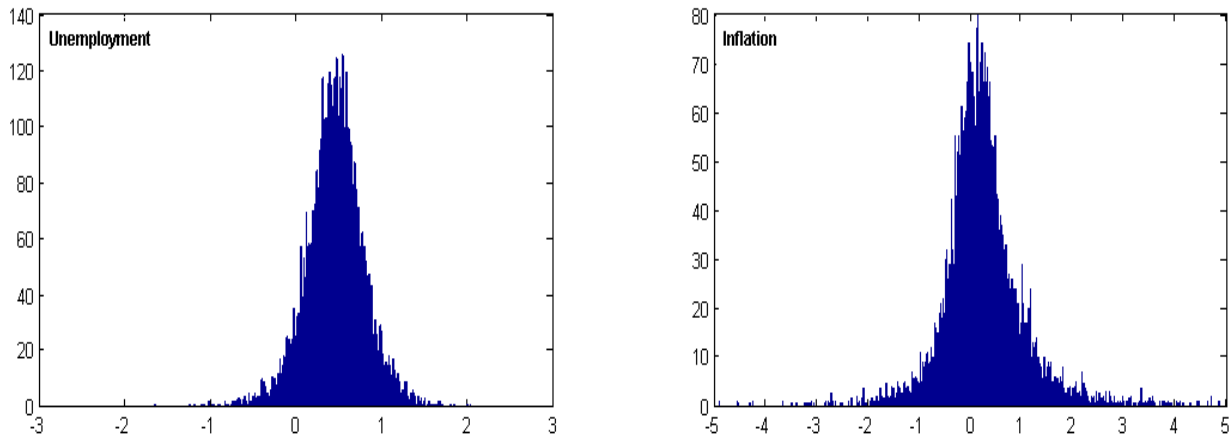
Figures 2 and 3 present the point estimates of the impact of a one percentage point unanticipated increase in the interest rate on unemployment and inflation across our sample of countries. Judging by the point estimates in Figure 2, unemployment generally increases for all countries during the first 10 quarters after the monetary policy shock. That said, noticeable cross-country differences exist: the U.K. and Canada, for instance, appear, on average to have unemployment rates that are up to four times more sensitive to changes in interest rates than Japan. In addition, the unemployment response appears somewhat more protracted in Canada, the U.K. and Japan—with on average more than 40 percent of the peak responses still remaining after 20 quarters—than in the U.S. and Germany.

Interestingly, there is also a significant time-series variation in the estimates. For all countries, although less visible in the case of Canada, there is a noticeable decrease in the impact of monetary policy on the unemployment rate. For the U.S. and the U.K., peak responses decline by around 0.2 percentage points, with an even larger maximum decrease observable for Germany. Japan and, in particular, Canada exhibit somewhat smaller decreases in peak responses (circa 0.05-0.01). While a decrease in the effectiveness of monetary policy is visible for all countries, the timing of the decrease varies substantially from country to country. The conspicuous decrease starts around 1980 for the U.S. and Germany, while for the U.K., Canada and Japan, the decrease is a more recent phenomenon, starting a good decade later. In addition, as illustrated in Figure 2, comparing estimates along the same sample path, the probability that the maximum impulse response has decreased

[10]For all countries considered, we also include a dummy variable measuring changes in the central banks' formal policy framework. Exact dates were taken from central bank websites. All data are available from the author upon request.

from its peak to its trough is 92 percent for the U.S., 72 percent for the U.K., 81 percent for Germany, 70 percent for Canada, and lastly 95 percent for Japan (see also Figure 1).[11]

Figure 1: The Distribution of the Difference in Maximum Responses (peak to trough)



Note: p-value listed in text is the proportion of the corresponding distribution that is greater than zero.

Figure 3 indicates that monetary policy shocks have also had a decreasing impact across time on inflation. In absolute terms, peak responses decrease by about 0.2 percentage points for Canada and Germany, while decreasing somewhat less for the remaining countries. Note in particular that the years associated with large changes in the impact of monetary policy on inflation correspond roughly to the dates indentified for unemployment in the above, indicating that some common factor may be driving the time-variation in both responses. Again comparing estimates along the same sample path, the probability that the minimum impulse response has increased is 63 percent for the U.S., 77 percent for the U.K., 68 percent for Germany, 67 percent for Canada, and lastly 83 percent for Japan. There is, therefore, also some statistical evidence illustrating a decrease in the effectiveness of monetary policy on

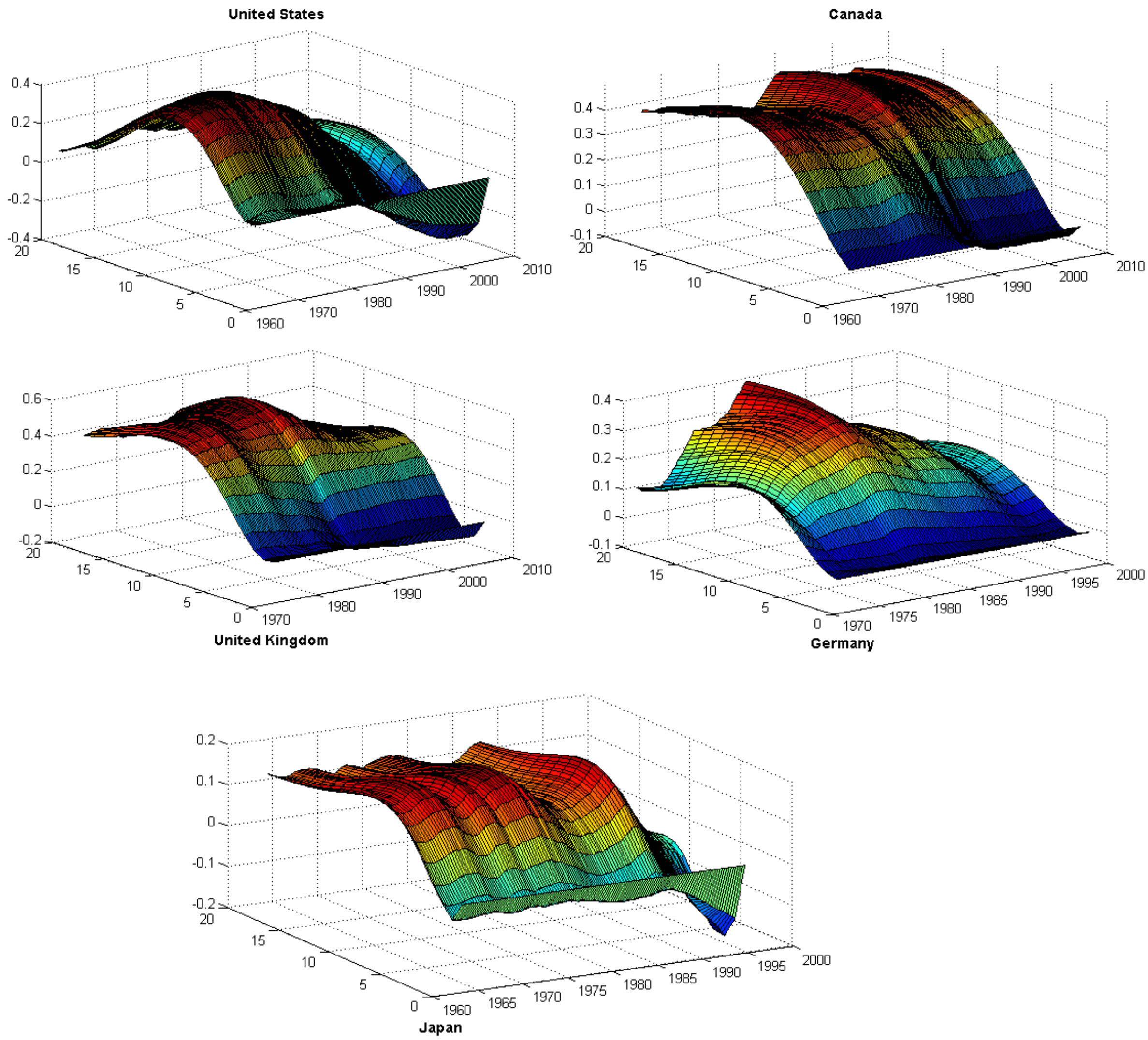
[11] Admittedly, the sharp decrease in the estimates of the impact of monetary policy on unemployment for Japan in the late 1980s/early 1990s indicate that the crisis in Japan, which resulted in the policy rate reaching the zero lower bound (ZLB) in 1995, had perhaps already begun to impact the monetary transmission mechanism during this period.

inflation, albeit slightly less strong than was the case with the corresponding unemployment estimates (see also Figure 1).[12]

In sum, our point estimates indicate fairly large changes in the effectiveness of monetary policy across time, confirming the evidence in Boivin and others (2011). In particular, our estimates imply that changes in interest rates across our sample of five countries has less of an impact on inflation and unemployment today than it used too. This could potentially explain in some part the significant output losses that occurred in the recent recession, despite the large decreases in policy rates.

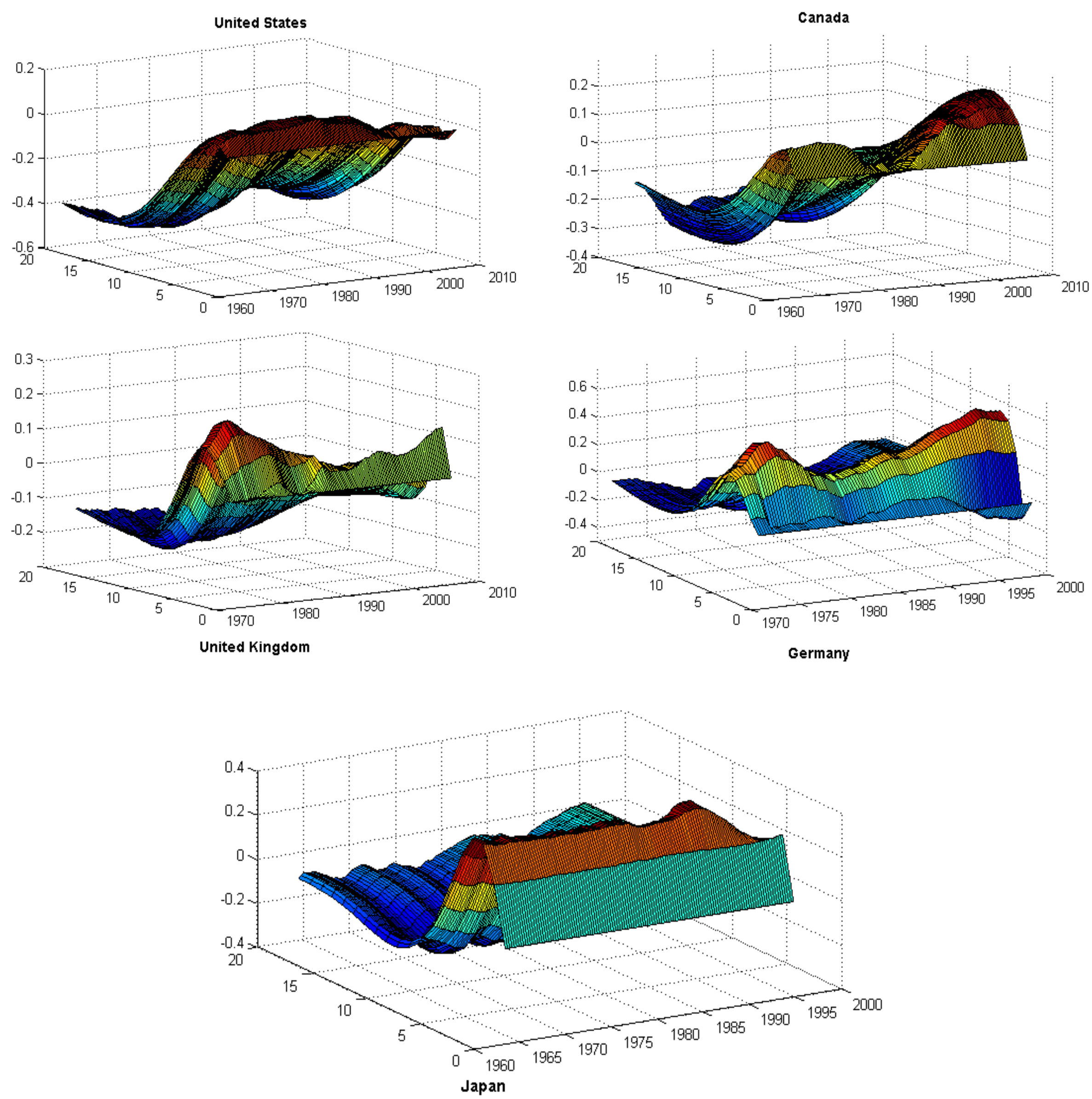
[12] For both inflation and unemployment estimates, we note that for most countries there are quite sizable "prize-puzzles" (Sims 1980) in the estimated IRFs.

Figure 2: The Impact of Monetary Policy on Unemployment



Note: Median impulse response of unemployment to a 1 percentage point unanticipated shock to the monetary policy instrument, using the TVC-BVAR with SV described above. The right axis indicates time, the left axis horizon, while the vertical axis indicates the impact, measured in percentage points

Figure 3: The Impact of Monetary Policy on Inflation



Note: Median impulse response of inflation to a 1pp unanticipated shock to the monetary policy instrument, using the TVC-BVAR with SV described above. The right axis indicates time, the left axis horizon, while the vertical axis indicates the impact, measured in percentage points

IV. DOES THE DEMOGRAPHIC SHIFT EXPLAIN THE WEAKENING OF THE EFFECTIVENESS OF MONETARY POLICY?

In the previous section, we observed a quite noticeable decline in the effectiveness of monetary policy across our sample of five countries. As we have argued, there is a multitude of channels through which monetary policy changes, and we restrict ourselves to estimate the net effect, rather than testing for the alternative hypothesis. This section attempts to explain which factor contributed to this decline. In particular, we focus on the potential impact of ageing—as measured by the old-age dependency ratio—as an explanation for the decreasing effectiveness of monetary policy. To address this issue, we exploit the differential unemployment and inflation responses estimated for each country, and ask whether the time-series and cross-sectional variations in the size of the responses are systematically related to the hypothesized explanatory variables described below. The advantage of exploiting both cross-sectional and time-series variations is that it increases the effective observations available. In this context, this is especially important as the ageing of society is a very slow-moving process.

A. Estimates and Findings

To estimate the impact of the graying of society on the effect of monetary policy, we employ the following panel regression for our sample of countries:

$$imp_{it}^{j} = \beta_{i1} + \beta_2 oldage_{it} + \beta_3 manu_{it} + \beta_5 open_{it} + \beta_6 sfirm_{it} + \beta_7 credit_{it} + e_{it},$$
$$j = u, \pi, \qquad (16)$$

where imp_{it}^{j} denotes the impact of monetary policy on variable *j* at time *t* in country *i*; $oldage_{it}$ the ageing of society *i*; $manu_{it}$ the intensity of manufacturing output in total production; $open_{it}$ the degree of economic openness; $sfirm_{it}$ the share of small firms; and lastly, $credit_{it}$ the level of private sector credit in the economy. These independent variables are commonly used in studies attempting to explain changes in monetary policy effectiveness over time.

The degree of openness of an economy is calculated in a standard way as the ratio of total trade (exports plus imports) to GDP, while the manufacturing share is measured by the real Gross Value Added (GVA) produced by the manufacturing sector as a share of total real

GVA.[13] The share of small firms in the economy is defined by the share of total employment made up by firms with less than 50 employees. Lastly, private credit data are taken from the IFS database. The demographic shift is proxied by the old-age dependency ratio, defined as the ratio of the number of people above the age of 65 relative to those between 15 and 64.

Before we proceed to estimate equation (16), we check the stationarity of the variables. Table 2 presents standard panel data unit root tests for the variables in equation (16). All variables except imp_{it}^{j} and $oldage_{it}$ are in logs. As documented in Table 2, the unit root hypothesis cannot consistently be rejected for any of the data series (the null hypothesis is that there is a unit root). That said, stationarity is achieved once we consider first-differences. Standard asymptotics thus do not hold for fixed effects or pooled least squares estimates of equation (16). However, under the assumption that our variables co-integrate, standard least squares estimates of equation (16) will nonetheless be consistent. We therefore proceed, testing equation (16) for a potential co-integrating relationship. Note that the resulting co-integration framework has an advantage: other factors—such as the stage of the business cycle (Garcia and Schaller, 1995) and the level of interest rates (Ravn and Sola, 2004), which have been shown to be potential short-run factors contributing to the variation in the effectiveness of monetary policy—are on most statistical tests' stationary series, implying that they, unlike $oldage_{it}$, can have only a temporary effect on the impact of monetary policy. The cointegrating framework allows us to focus on the factors that have a permanent impact on the effectiveness of monetary policy, without the need to consider those variables with only temporary influence.

Results from unit root tests show that all the series under study are unit root non-stationary. In particular, all specifications of ADF and PP tests cannot reject the null hypothesis of a unit root process at a 10 percent significance level.

[13] For the U.K., only output indices, rather than output per se, are available at the sectoral level. In addition, only data for the total production sector are available for our sample.

Table 2: Panel Unit-Root Tests

	Levin, Lin & Chu t-stat	Im, Pesaran & Shin W-stat	ADF - Fisher Chi-square	PP - Fisher Chi-square
Cum_U	0.20	0.64	0.68	1.00
Max_U	0.11	0.20	0.20	0.99
Cum_Pi	0.21	0.40	0.48	0.98
Max_Pi	0.12	0.36	0.40	0.95
Old-Age	0.33	0.86	0.13	0.33
Openness	0.32	0.76	0.89	0.90
Manufacturing	0.39	0.23	0.04	0.29
Credit	0.38	0.23	0.33	0.80

*Asymptotic p-values reported for all unit root test. The first five variables include an intercept term, while the remaining three include both an intercept and a time trend.

As the panel unit-root test show that the series under study are I(1), the Dynamic OLD (D-OLS) procedure is employed to estimate the single cointegrating vector that characterizes the long-run relationship, adding leads and lags of first differences to equation (13). Lag and lead terms included in D-OLS regression have the purpose of making its stochastic error term independent of all past innovations in stochastic regressors. As shown in Wagner and Hlouskova (2007), in the case of one-dimensional panel co-integrating spaces, the D-OLS Panel Estimator is substantially more efficient and robust than alternative panel estimators. To test for whether there is indeed co-integration between our set of variables, we employ Kao’s (1999) Panel Co-integration test. As highlighted by Gutierrez (2003), Kao’s (1999) test has better power properties than the alternative panel co-integration tests for small numbers of effective observations, similar to what we have in our dataset.

Four estimated regressions are presented in Table 3. Equation (1) and (2) use as dependent variable the impact of monetary policy on inflation, while equations (3) and (4) pertain to unemployment; “cum” refers to a dependent variable of type (i) above, whereas “max” refers to one of type (ii).

Table 3: Estimated D-OLS Regression[1,2]

Variable	Equation (1) Cum π	Equation (2) Cum u	Equation (3) Max π	Equation (4) Max u
Constant	-25.271***	-25.431***	-0.423*	-1.688***
	(3.175)	(3.176)	(0.176)	(0.210)
Old-age Ratio	0.073*	-0.350***	0.013***	-0.019***
	(0.044)	(0.045)	(0.002)	(0.003)
Share of Manu.	3.634***	10.129***	-0.037	0.659***
	(0.695)	(0.697)	(0.039)	(0.046)
Openness	3.414***	0.381	0.001	0.021
	(0.520)	(0.521)	(0.029)	(0.034)
Credit-to-GDP	-0.114	0.958***	0.010	0.071***
	(0.195)	(0.195)	(0.010)	(0.013)
Target Change	0.290	0.444**	0.029**	0.026**
	(0.205)	(0.205)	(0.011)	(0.014)
Number of Obs.	173	173	173	173
Kao (1999) CI-test[b]	-2.122**	-2.820***	-3.217**	-2.388**
	[0.02]	[0.00]	[0.00]	[0.00]

[1] Standard errors in parentheses. *,**,*** indicates that a null hypothesis of zero is rejected at the 10%, 5% and 1% level, respectively. [b]P -value given in squared brackets. Test conducted without trend.
[2] one lead and one lag used in the D-OLS estimates.

The cointegration test shows that each regression cointegrates at the 5 percent level, with all but one also cointegrating at the 1 percent level. Because the impulse responses are measured with sampling errors, Sieve bootstrapped standard errors are used throughout. There is, thus, quite strong statistical evidence in favor of a long-run relationship between our measures of the impact of monetary policy and our set of explanatory variables.

The results reveal that a graying society, as measured by the old-age dependency ratio, exerts a negative (in absolute terms) statistically significant long-run impact on the effectiveness of monetary policy. All else being equal, an increase in the old-age dependency ratio of one point lowers (in absolute terms) the cumulative impact of a monetary policy shock on inflation and unemployment by 0.10 percentage points and 0.35 percentage points, respectively. The corresponding maximum impact of monetary policy is lowered by 0.01 percentage points and 0.02 percentage points. These estimates thus imply, when taken at face value, quite a strong negative long-run effect of the ageing of the population on the effectiveness of monetary policy. This is particularly significant when linked to, for instance, the projected 10 point rise in the old-age dependency ratio in Germany over the next decade.

Our findings contrast the theoretical results in Miles (2002)—indicating that monetary policy, due to an increased wealth effect, might become more potent—but confirm the conjecture in Bean (2004) and Fujiware and Terakashi (2008). Specifically, the results indicate that the negative impact expected from ageing (e.g. the credit channel) outweigh the positive impact (e.g. wealth channel) of monetary policy. That said, our estimates are naturally confined to the net effect of ageing on monetary policy and, thus, do not allow us to discuss the relative merits of the individual channels listed in Section II.

The estimates in Table 3 also reveal that countries with a larger concentration of manufacturing output tend to have a real sector that is more responsive to shifts in monetary policy than countries containing a smaller concentration of manufacturing. In fact, across our set of countries and dependent variables, the share of manufacturing output appears to be the most important variable (measured by t-statistics) in explaining differences in the responsiveness of unemployment to monetary policy shocks. Thus, our findings corroborate the results of Carlino and Defina (1998), indicating that the manufacturing sector is, all else being equal, more interest rate sensitive than other sectors.

Nonetheless, the impact of the share of manufacturing on the responsiveness of inflation is, however, less clear. The estimate in equation (3) is negative, while the estimate in equation (1) is positive and statistically significant. This suggests that countries with a larger concentration of manufacturing have inflation rates that are less impacted by changes in the monetary stance. This negative effect appears, when using the Phillip's Curve framework, to contradict the positive effect on the responsiveness of unemployment. However, as discussed in Peneva (2008), the manufacturing sector is considered to exhibit less nominal price rigidity than the service sector, potentially explaining part of this discrepancy.

Like the share of manufacturing, the degree of economic openness appears to be associated with a weaker effect of monetary policy on inflation. The effect of economic openness on the responsiveness of unemployment is found to be positive. The positive sign of the estimates in equation (2) and (4) is puzzling, as we would expect a tightening of monetary policy to be associated with a nominal exchange rate appreciation, leading a more open economy to experience, all else equal, a larger decline in inflation. However, given that the result is statistically insignificant in these two equations, we should not put much weight on it.

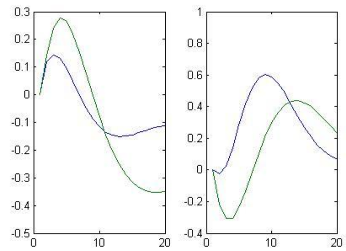
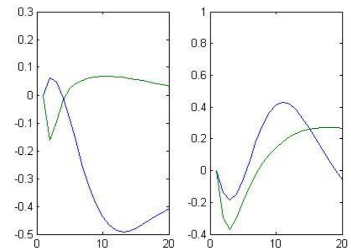
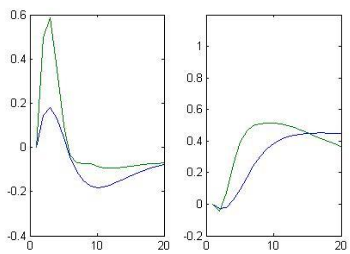
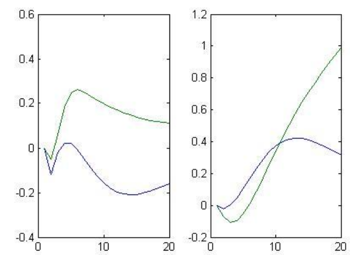
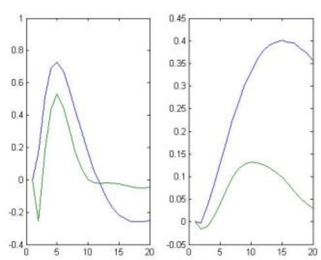
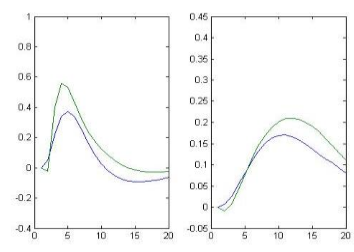
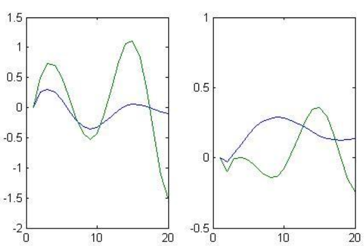
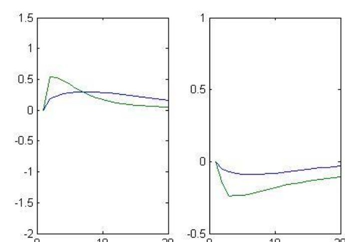
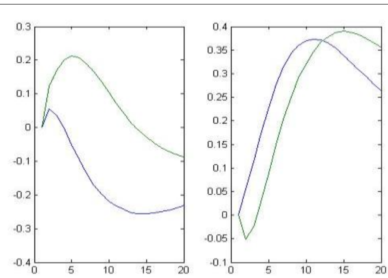
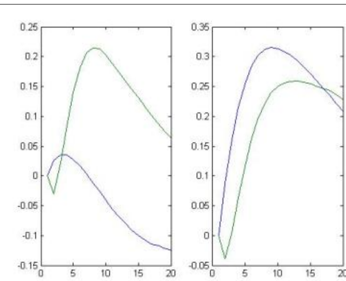
Lastly, the effect of credit-to-GDP on the effectiveness of monetary policy is largely as expected. Countries with more credit tend to have a real sector that is more responsive to changes in monetary policy. While the decreased responsiveness of unemployment is matched by a decreased responsiveness of the cumulative effect of interest rate changes on inflation, the latter effect is statistically insignificant. Nonetheless, the large impact of credit-to-GDP on the effectiveness of monetary policy on unemployment is consistent with the findings of Carlino and Defina (1998).

B. Robustness Tests

We conduct a robustness check to ensure that the results stand up to alternative data specification. To check the robustness of our results, we test our results using different variables for inflation, unemployment and 3 month interest rates for the 5 countries. In particular, we use the deflator rather than inflation, spare capacity rather than unemployment, and the policy rater rather than the 3 month interest rates. The results (Figure 4) to a 100 basis point increase in interest rates are robust, with the impact on inflation and unemployment found to be weakening for most of the countries.

The U.K.—which can perhaps be explained by its tumultuous monetary history over the last four decades, with numerous changes in policy regime impacting the credibility of monetary policy—is an exception. This does imply that the significant time-variation we have found in unemployment and inflation’s response to changes in interest rates in an ageing society are largely robust.

Figure 4: Baseline and Robustness test [1]

U.S. – Baseline	U.S. – Robustness
	
U.K. – Baseline	**U.K. – Robustness**
	
Germany – Baseline	**Germany – Robustness**
	
Japan – Baseline	**Japan – Robustness**
	
Canada – Baseline	**Canada – Robustness**
	

[1] The blue and green lines correspond to IRF in 1975Q1 and 2005Q1 or latest available respectively, on inflation (left picture) and unemployment (right picture)

V. CONCLUSION AND POLICY IMPLICATIONS

In this paper, we illustrate that demographic changes in five large advanced economies with independent monetary policy have been a contributing factor explaining the observed decrease in monetary policy effectiveness. Societies dominated by young households would tend to be more sensitive to interest rate changes than graying societies. Monetary policy may therefore become less potent in a society going through a demographic transition to an older population; this implies that monetary policy will have to operate differently to achieve the same impact as in a younger society[14]. Future research should attempt to assess the impact of ageing on optimal policy in more depth, but some possible policy conjectures are as follows:

- *Changes in the optimal conduct of monetary policy*: In a society going through the demographic shift, new trade-offs might arise. First of all, the relative preference of inflation versus output stabilization is likely to change, as older households have on average larger asset holdings and, therefore, have more to lose from unexpected inflation. In addition, the increasing aversion to inflation may, *ceteris paribus,* lead to a lower optimal inflation target, while a declining real interest rate, which is viewed as an important consequence of ageing (e.g. Bean, 2004), is likely to work in the opposite direction. Central banks around the world will, therefore, have to think through these trade-offs, and may want to adjust their policies accordingly.

- *More aggressive monetary policy needed*: If monetary policy is less effective in a graying society, *ceteris paribus*, a larger change in the policy rate will be needed to bring about a change in the economy than in a younger society. This implies that traditional changes of 25bps, which have been the norm in previous decades, may

[14]One way to stem the populating ageing effect is through persuading families to have more children (via favorable tax policies/subsidies, or through providing more nurseries for instance), or encouraging the arrival of migrants, one way monetary policy effectiveness can be enhanced would be by reversing the population ageing trend (and the decline in the population in the oldest societies). However, this choice also carries risks, and is often easier said than done. The entry of a large number of foreigners may create other problems, from lack of integration to mass large unemployment levels among the new arrivals, if not well planned for, and is therefore not always seen as a panacea, and only a partial solution.

have to be amplified. Monetary policy will have to become more "activist" in ageing societies, with higher variation in interest rates possible going forward.

- *Increasing importance of other policy tools to stabilize the economy*: Monetary policy is a key tool of policymakers to stabilize the economy, and has proven to be a powerful weapon during the global crisis. If graying societies are a reason for monetary effectiveness becoming less potent, the burden to stabilize the economy and the financial system may increasingly be borne by other policy policy tools. With monetary policy effectiveness marginally reduced, the relative role of fiscal and macroprudential policy as a means to stabilize the economy may become more important.

- *Monetary Policy in the Low-Income Context*: The paper has focused on Advanced Economies (AEs), which will be the first ones to go through the demographic shift. While Emerging Markets (EMs) and Low-Income Countries (LICs) will also gradually age, the impact is likely to be different than in AEs, as wealth is not as skewed towards the older generations. EMs and LICs are in a peculiar situation, as they will go through a demographic transition without having grown rich. As older people are often poor in EMs/LICs, and supported by active family members, some of the factors discussed—such as the increasing dominance of the wealth effect over the credit channel effect—are likely to be less important, implying that monetary policy effectiveness may not weaken as much as it does in AEs, or manifest itself through other channels.

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Appendix 1: Demographic Shift: Past, Present, and Future

Longevity has been made possible by a combination of changes in lifestyle, better nutrition, medical advances, and improved education, among others. In the first half of the 20th century, the improvements in mortality seen in Advanced Economies (AEs) mainly benefited those under 35, thanks to public health initiatives that introduced wide-scale immunization, penicillin, and other drugs. In the second half of the 20th century, life expectancy gains accrued to the elderly (see Towers Watson, 2011), in part due to lifestyle changes that have been key in advancing the ageing process in AEs (e.g., less smoking and drinking, though this has recently been counterbalanced by less exercise, worse dieting and fewer marriages, which tend to reduce life expectancy). Better education, which has increased the awareness of the importance of a well-balanced diet, has also helped, as have medical advances (e.g. new diagnostics and treatments) that have eliminated diseases or made it possible to live longer with chronic diseases (e.g. AIDS).[15]

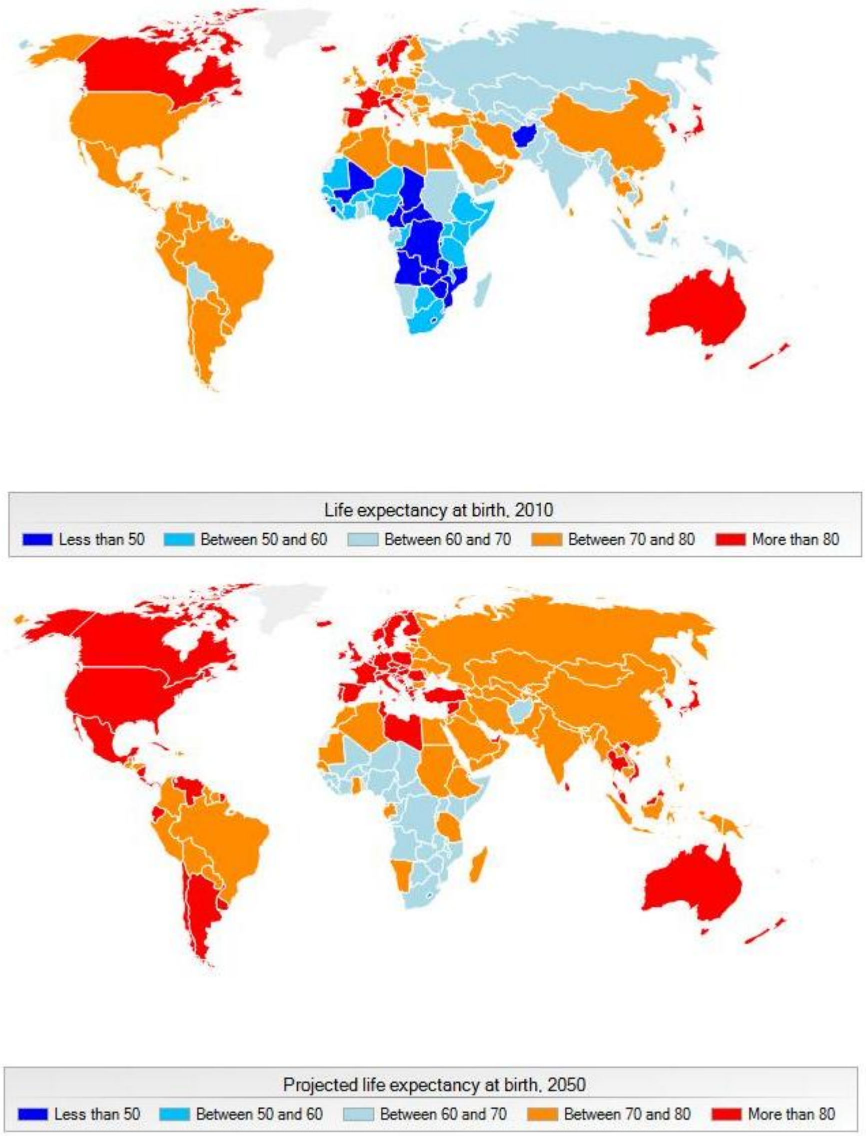
An ageing society is therefore a worldwide phenomenon caused by a combination of declining fertility and increasing longevity (see Figure 1). These developments have led to an increasing share of old people and a decreasing share of children. The cohort of old (65+) and very old (80+) people in AEs is growing much stronger than the young, with the population of old people also ageing. Because these are long-term trends and demographic changes take a long time to work themselves through the age structure, significant graying going forward is unavoidable. Since fertility is unlikely to rise for the foreseeable future, and immigration policy remains restrictive in most AEs, the current trend of ageing populations appears irreversible.

While the developing world is still younger, this demographic transition is starting to increasingly encompass Emerging Markets (EMs) in particular, but also Low Income

[15] Sharp divisions among academics have appeared in recent years on whether ageing can continue with its current trajectory or whether we are close to reaching a natural limit, though it seems almost certain that if there is a maximum, it has not yet been reached. One school, led by Vaupel (see Oeppen and Vaupel, 2002), believes that ageing can continue, while another, led by Olshansky (see Olshansky et al., 1990) thinks that recent advances will not stop, and that degenerative diseases cannot be held back by medical advances. The appearance of new diseases (e.g. SARS) or lifestyle changes leading to obesity will also hold back further advances in ageing.

Countries (LICs). Developments in individual countries are expected to differ (see Figure 1); however, as a general observation, significant ageing has already occurred in AEs, but rapid catching-up in developing countries is already taking place, or is expected to happen in the course of this century (because fertility has declined only recently).

Figure 1. Life Expectancy at Birth, by Country, 2010 and 2050

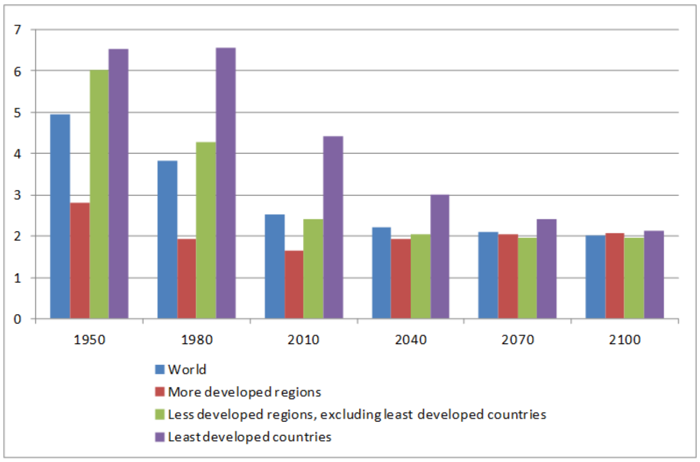


Source: United Nations (2011)

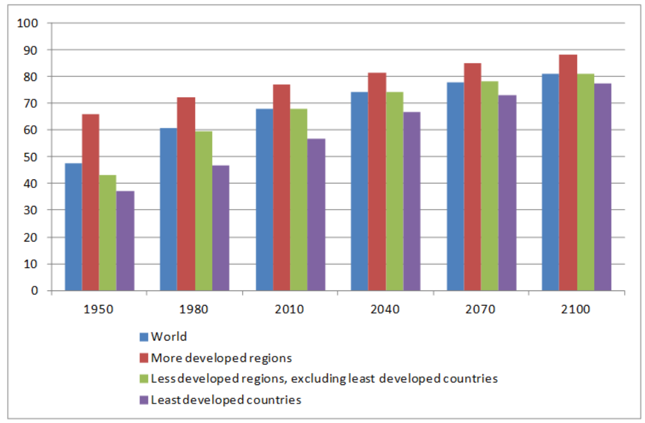
This demographic shift matters, as it leads to an increasing old-age dependency ratio, i.e. an increasing number of old people that have to be supported by younger cohorts. Increases in longevity are easier to deal with by society if there is less ageing, i.e. if fertility keeps pace with the increase in longevity, or migration augments the share of the young. In that case, the rising number of old people can be supported by more working age persons.[16]

Figure 2. Demographic Shift Around the World

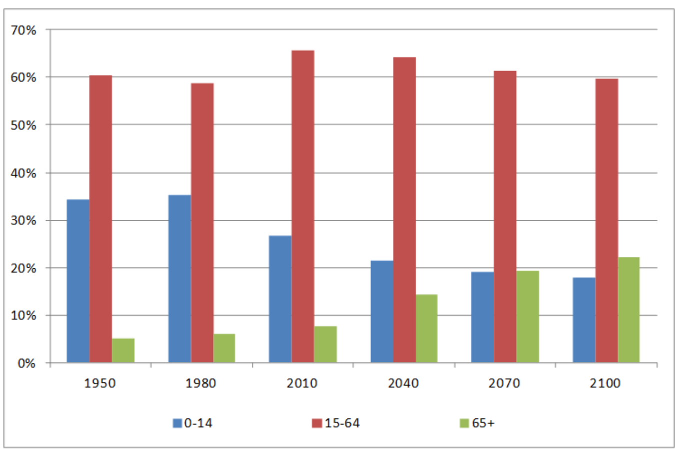
Total Fertility by Region, 1950-2100



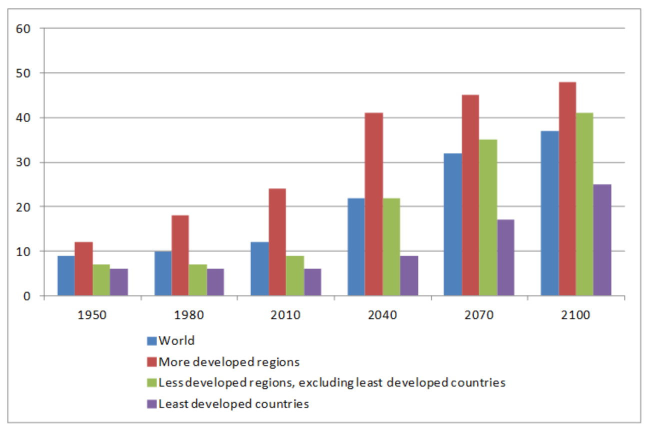
Life Expectancy at Birth by Region, 1950-2100.



Proportion of Age Groups, 1950-2100



Old-Age Dependency Ratio, 1950-2100



Source: United Nations (2011)

[16] Errors in forecasting longevity has typically been large, reflecting unanticipated influences on demographic behavior, such as the AIDS epidemic, periods of economic depressions (these impact psychological well being), social changes (euthanasia increasingly being legalized in certain countries), climate change (heat waves have led to a rise in the death of the elderly) and other disturbances. Collapses of countries, such as that of the Soviet Union, which have lead to declines in longevity, were not forecastable (see GFSR, 2012).

Appendix 2: Data-Sources

Table 1: Data Sources

	VAR data				
	U.S.	**U.K.**	**Germany**	**Japan**	**Canada**
Inflation	BLS	ONS	Stat. Bundesamt	Min. of Internal Affairs and Com.	Statistics Canada
Unemployment	BLS	ONS	Stat. Bundesamt	Min. of Internal Affairs and Com.	Statistics Canada
Interest Rate	Fed. Reserve Board	BoE	Haver Analytics	Nikkei	Bank of Canada
	Regression data				
	U.S.	**U.K.**	**Germany**	**Japan**	**Canada**
Manufacturing Share	BEA	ONS	Stat. Bundesamt	Cabinet Office of Japan	Statistics Canada
Openess	BEA	ONS	Stat. Bundesamt	Cabinet Office of Japan	Statistics Canada
Credit	IFS	IFS	IFS	IFS	IFS
Share of Small Firms	Census Bureau		Stat. Bundesamt	Min. of Internal Affairs and Com.	Statistics Canada
Old-Age Dependency Ratio	Census Bureau	ONS	Stat. Bundesamt	Min. of Internal Affairs and Com.	Statistics Canada