Life Cycle Implications of Recent Developments in the Age Structure of the US with Emphasis on the Determinants of Economic Growth

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Ever since Nathaniel Leff published his original work on dependency and saving rates in 1969, there has been a large sphere of economic interest into the effect of demographic variables on an economy's overall performance. Most of the focus to date on age structure has been concentrated on how it is related to the country's saving rate. Documentation of the transitive effects of changes in the age structure of the US through a saving rate mechanism will help to provide more insight into the macroeconomic implications of population growth, fertility swings, and other demographic issues. At the same time there are other more direct impacts of age structure to be explored, which affect the economy as a whole.

Demographers such as Demeny and Coale noticed long ago that age structure is largely determined by a nation's fertility. Furthermore, they argued that factors such as immigration and changes in mortality were only minor influences on the age structure of most developed countries (Clark, Kreps, Spengler, 1978). The level of fertility in most countries, even developed nations, is at best known as "quasi-stable." Fertility boom and busts occur and have a large impact on an economy. Just as fertility has varied over time, the role of demographic analysis, and the importance applied to it by the field of economics has fluctuated as well.

Today, the issues of changing fertility and age structure receive even more interest, for a range of reasons. In the developing world, many nations undergoing the demographic transition have yet to experience a decline in fertility following their decline in mortality. Countries such as India have been forced to cope with high young-age dependency and its consequences (Chesnais, 1990). On the other hand, many developed nations are now following a starkly different path. In many of these countries, the natural growth rate is approaching replacement levels, and in a few places, such as Italy, Russia, and the former Soviet satellite countries, population has begun to decline.

Rather than focus on dependency as Leff did, this paper primarily focuses on the labor force proportion of the entire working age population. While this age range varies over time and with economic factors such as the business cycle, for the purposes of simplicity we will assume that the working age runs from 15 to 64. Those persons aged 0-14 will be considered young-age dependents and those aged 64 and beyond will be termed old-age dependents.

The current age structure of the US is heavily weighted towards an older and aging work force. This is largely due to the relative size of the baby-boom generation. The movement of the baby-boom generation through the age structure of the US can be easily seen by looking at Table 3 (in the appendix), "The Growth Rates of Different Age Groups n the Overall Age Structure of the United States Over Time." The average population age and relative availability of workers has been trending upward in recent history (Table 2). Some estimates, made with the current census, have suggested that the proportion of workers age 45 and above will rise from 28.3% in 2000 to 37.4% in 2005 (Owyang, 2001).

I. Relationship between Age-Structure and Saving

The first empirical study of the effect of the life cycle on saving rates was the aforementioned study by Nathaniel Leff. He concluded that indeed, high dependency should imply a lower saving rate. Assuming this to be true, we should see several trends taking place in the US. First, as the population ages and mortality declines, we are seeing longer periods of old-age dependency. We should expect to see falling saving rates as a result. Leff's study also argued that the negative correlation between saving and dependency was stronger for old age rather than for young age dependency (Leff, 1969). If we couple this with the fact that many economists such as Clark and Spengler would argue that the expenditures on children constitute investment rather than consumption, net savings in the United States should be declining (Becker, 1975).

Saving represents nothing more than deferring present consumption towards future uses. It is often easiest to look at the motivation for saving by looking at the motivation for spending our income. The simplest consumption function, known as the Keynesian Consumption Function, takes the following form:

(Equation 1 – Keynesian Consumption Function)

$$C^D = a + bY_t^*$$

In the above equation, the level of consumption is dependent upon two factors. The term a is a constant which represents some fixed level of spending, while b is also a constant and it is the proportion spent out of current income in time t, Y_t^*, commonly

referred to as the marginal propensity to consume. Recent economists (Modigliani, 1963, Friedman, 1957) have advanced the study of consumer behavior.

Albert Ando and Franco Modigliani's consumption function for an individual takes the following form:

(Equation 2 – Ando and Modigliani's Life Cycle Consumption Function)

$$C_t^T = \Omega_t^T Y_t^T + (N-T)\Omega t^T Y^e{}_t^T + \Omega t^T A_{t-1}^T$$

Here, consumption depends on a range of factors. First, t is again the time period during which we are looking at consumption. The big modification they make comes from the fact that we now look at T, the age of the individual. The symbol Ω represents a sort of weighted average that consumers in this age group will spend. This allows for the study of different levels of consumer consumption (and consequently saving) depending upon the age of the individual. Also factored in are the following: Y_t is current non-property income, $Y^e{}_t$ is expected annual income, and A_{t-1} is net worth from the previous period.

A further avenue for study which lies outside the scope of this paper might consist of looking at these components of the consumption function, specifically non-property income, expected annual income, and net worth, to see if the MPS amongst these three variables have similar values for the different age groups. Varying possibilities could stem from different reactions to inflation, inequality in income, or even wealth effects. There can be variations in the saving rate among these groups as well. For example, in Friedman's Permanent Income Hypothesis, the propensity to save out of transitory income is much higher than that out of permanent, expected income (Friedman, 1957).

Modigliani's life cycle hypothesis allows us to argue that at two different stages of their life, individuals will be dependents. In their younger years, children constitute a large amount of consumption burden without contributing to output, which places them in the category of dependency. Most current models factor expenditures on children as consumption rather than investment. The argument that has been frequently made, and rightly so, is that expenditures on children are actually a form of investment (in human capital) for the future. And although this makes intuitive sense it is often disregarded. The second category is old age dependency. These people hold claims on consumption, but once in retirement, contribute nothing to the current level of economic output.

The argument can be further made that if the age structure changes, as it is in the United States, the level of personal aggregate savings will change. The aging of the US population will change the proportion of individuals to higher age groupings with higher Ω's and lower saving rates. More recent studies into the savings motive for individuals have found that the life cycle model needs to incorporate a broader reason for saving in the later years of life. There are two explanations for this, as given by Dynan, Skinner, and Zeldes. The first is something that Keynes called the precautionary motive. Perhaps older workers will save a higher proportion of their income in order to cover unexpected losses. For workers, this could be a buffer for job loss and the associated search unemployment. It could even take the form of contingency planning for health problems. The second is known as the bequest motive. Here, individuals save a portion of their income in the hopes that this will be passed on to a beneficiary. This would seem irrational in economics unless we factor in a certain amount of psychic income that is derived from the bequest. The lack of such an inclusion into the preliminary model of the

life-cycle hypothesis has been one of the major criticisms of Ando and Modigliani's work.

II. The Transition from Savings to Investment

It is commonly argued that savings drive investment. In effect, the level of savings can affect the national growth rate through the "golden rule of capital accumulation" (Gramlich, 1999). If this is true, then through transitivity we should see an effect of age structure on aggregate personal investment through a country's dependency and consequently through its saving rate.

There are several pitfalls associated with any study of the saving rate. The most commonly cited measure of US savings is derived from the National Income and Product Accounts (NIPA). This measure has shown significant declines over the past few decades, and has dipped into negative territory in recent months. However, there are several problems in this statistical measure (Rippe, 1999). First, capital gains are not included in income. Taxes on earned income from capital gains are taken as deductions from income. Rippe further notes that some forms of business sponsored savings like pensions are counted as income, when they effectively should be considered as deferred consumption or savings. When we take these factors into account, there is a higher level of saving than reported by NIPA.

While the NIPA may be useful in assessing trends in the level of US savings, it fails to tell us adequately about the current level of personal savings. In order to better assess the current level of US savings in the economy, it becomes necessary to find a

different measure. The Federal Reserve keeps track of the "Flow of Funds." This can be used as a measure of the saving rate as well (Rippe, 1999). When this data is analyzed, the level of saving is found to be much higher than that of the NIPA accounts. At the same time however, the data is trending towards lower savings rates in much the same manner as the NIPA. Further research suggests that while the trend for personal saving in the US has been downward, national saving has been relatively constant and strong with respect to other OECD nations.

The classical economists such as Marshall and Pigou argued that the interest rate would serve as a mechanism to bring the level of savings in line with the level of investment. This argument implied that savings would drive investment and thus drive economic growth. More sophisticated statistical studies have been done to try to quantify a relationship between savings and investment today (Baxter, Crucini, 1993). To do this, economists such as Martin Feldstein and Robert Murphy have regressed the investment output ratio on the saving to output ratio. Most analysis found the ratio to be very close to 1, with some of the smaller US Saving-Investment correlations coming in at close to .9. Using a basic savings model, Baxter and Crucini can find the equilibrium of savings and investment in a large home country:

$$S_t = I_t + (1 - \pi)I^*t$$

The United States is an equivalently large country, so we could argue that π approaches 1. Thus it will be treated as if the economy is closed. The equation can then be written more simply as the classical identity:

(Equation 3 – Saving – Investment Identity)

$$S_t = I_t$$

where saving and investment in time t are equal. We can take Modigliani's consumption function and put this into the equation to find an age-specific amount of investment. A basic savings model in a closed economy might look like this:

$$S_t = Y_t - C_t - G$$

$$\text{Equivalently: } I_t = Y_t - C_t - G$$

Here it is evident that we can substitute our consumption function into the model of savings for the economy. Our model of the consumption looked at an age specific group and their consumption preferences. In order to look at the aggregate savings of the economy we will need to look at the total spending of these different individual age groups. Taking equation two we get:

(Equation 2 – Ando and Modigliani's Life Cycle Consumption Function for one specific age group)

$$C_t^T = \Omega_t^T Y_t^T + (N-T)\Omega t^T Y^e{}_t^T + \Omega t^T A_{t-1}^T$$

(Equation 4 – Ando and Modigliani's Life Cycle Consumption Function for Total Consumption)

$$C_t = \sum_{j=0}^{j} (\Omega_t^T Y_t^T + (N-T)\Omega t^T Y^e{}_t^T + \Omega t^T A_{t-1}^T)$$

The modification above involves the summing of each of the consumption amounts for the age specific groups. The variable j simply represents the age structure divisions, which can vary based on the data used. Typical age structure data runs in five-year period blocks. We can take total consumption and substitute it into our national income equations. Substituting our consumption function (equation 4), we get:

(Equation 4 – Investment Model with Life Cycle Consumption)

$$I_t = Y_t - \Omega_t^T Y_t^T + (N-T)\Omega t^T Y^e{}_t^T + \Omega t^T A_{t-1}^T - G$$

This is simply a restatement of national accounting with some minor modifications. It does however help to show that an aging population can constitute a drain on the current level of investment should their level of saving decline. We can see the implications of this on long-run growth models (Solow, 1956):

(Equation 5 – A Simple Production Function with Constant Returns to Scale)

$$Y = F(K, N)$$

Here, output is simply a function of capital and labor, both of which are positively correlated to growth. We can complicate the matter by looking at a specific time period. Solow argues that potential output, P_t, is a function of the capital stock K_t and the labor supply N_t.[1]

(Equation 6 – Time specific production function)

$$P_t = F(K_t, N_t)$$

For this equation to be of use, we must define the equivalent capital stock K_t in year *t*, and a previous year, *v*, based on investment I and productivity λ.

(Equation 7 – Equivalent Capital Stock in year t)

$$K_t = \sum_{v=-\infty}^{t} (1 + \lambda)^v \boldsymbol{B}(t - v)\, I(v)$$

$\boldsymbol{B}$ is a constant, so $\boldsymbol{B}(t - v)$ is simply the capital surviving from the previous period. This is done because when we are looking at economic growth and the influence

[1] The symbols in some of Solow's models have been changed to different letters to avoid confusion with previously used equations.

of investment, we want to distinguish between replacement of and addition to the capital stock. By separating these, we can look at the effects of net investment and still use our model for gross investment. Equation 4 can be plugged back into Equation 7 to get:

(Equation 8 – Capital Stock Model Accounting for Age Differences in Saving-Investment)

$$K_t = \sum_{v=-\infty}^{t} (1 + \lambda)^v \boldsymbol{B}(t - v) \left(Y_t - \sum_{j=0}^{j} (\Omega_t{}^T Y_t{}^T + (N-T)\Omega t^T Y^e{}_t{}^T + \Omega t^T A_{t-1}{}^T) - G\right)$$

An economy is typically not producing at its potential output. It is constrained by aggregate demand and a range of other factors. For this reason, Solow argues that we should not be looking at potential output, but at actual output. To do this we will make the potential output a function of the unemployment rate:

(Equation 9 – Simple Actual Output of an Economy at Less that Full Employment)

$$A_t = f(u)F(K,N)$$

into which we can substitute our capital stock / investment savings model (equation 8):

(Equation 10 – Actual Economic Output Equation with Age Specific Saving Rates)

$$A_t = f(u)F\left(K_t = \sum_{v=-\infty}^{t} (1 + \lambda)^v \boldsymbol{B}(t - v)\{Y_t - \sum_{j=0}^{j} (\Omega_t{}^T Y_t{}^T + (N-T)\Omega t^T Y^e{}_t{}^T + \Omega t^T A_{t-1}{}^T - G)\},N\right)$$

From this equation, we can see some of the effects of a change in the age structure of a country on its actual economic output. We can see that if the age structure influences the saving rate, it will influence economic growth. At the same time, if age structure

influences productivity, the size of the labor force, or the level of unemployment, it can affect the level of economic output. These possibilities will be explored later in this paper.

III. A Relationship between Age-Structure and Productivity?

The question as to whether age and productivity are in and of themselves related dates back to the work of a psychiatrist named Alan Welford. In talking about individual's problems in the work environment, Welford noted that aging "holds a magnifying glass to human performance so that many facets present but scarcely noticeable in the twenties have become important by the time we reach the sixties" (Welford qtd. in Clark, Kreps & Spengler, 1978). Thus he argued that individuals reach some peak performance, after that point their productivity declines.

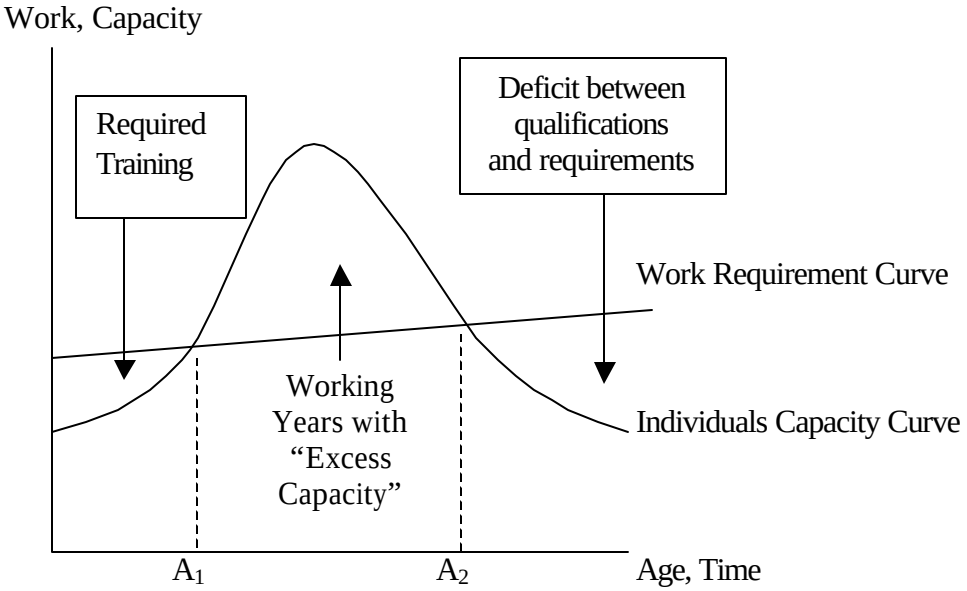
Another issue commonly cited has come to be known as the vintage effect. This argues that over time with the introduction of new technologies, the experience and skills that workers possess will become more and more obsolete. This could be more and more of an up and coming issue with the increased implementation and rapid adaptation of computers in the workplace. With computers, the need to adapt rapidly to changing capital (software) becomes a portion of the job. Alternatively, some advances of technology such as computers can be used to combat the vintage effect. Developments in the power and scope of computers can make many task previously requiring large amounts of education, experience, or intelligence easier or more readily completed with

even fewer possibilities for error. Putting these together, the most common answer is that the relationship is ambiguous, varying by industry.

There are other forces counteracting these drains on productivity. It really comes down to the relative effectiveness of older workers. Typical arguments that support a positive correlation between productivity and age include: (1) higher levels of experience (2) steady job patterns (3) higher levels of company loyalty (4) and a shift of the economy from more physical manufacturing industries into less manual service industries (Clark, Kreps & Spengler, 1978). Spengler makes one final distinction that is pertinent to the study of any direct relationship between age and productivity.

He argues that for the greater portion of a person's working life, his or her ability greatly exceeds the demands levied by work's tasks. This means that there would be a buffer between what he calls an individuals capacity curve and the work's requirement curve. While Spengler doesn't do this, we can model this graphically. The result very closely resembles graphical representations of the life cycle hypothesis of consumption. I've drawn work requirements as an upward sloping curve to represent the possibilities of increased demand for skills that might result from either capital deepening or capital widening in a given industry.

(Graph on following page due to page margin restraints)



We can see that there is a period of time where the worker is not qualified and either needs education or training. This continues until age A_1, at which time the worker would shift from this inadequacy and become productive. This productivity would later extend beyond the requirements of the workplace. After point A_2, decreases in the workers productivity will lead to a gap between wages and productivity. Evidence of this is supported in many cases in the American workplace (Kotlikoff and Gokhale, 1992). There are other important implications for businesses as well.

The graphical representation is misleading because it suggests that the only time there is equilibrium in business needs and worker skills is from age A_1 to A_2. The problem is that this is only looking at productive capacity. Perhaps there is an incentive to hire workers before age A_1 because they will train faster or build loyalty. There likewise may be incentives to retain workers past age A_2. Perhaps older, more experienced workers will be able to help younger workers and raise their capacity curves

through an instructive mechanism. Technological advances could change both the work requirement curve and the individual capacity curve. Therefore, it is possible that even with an age distribution moving towards an older working population, we may be able to avoid the case of divergence between capacity and demand.

IV. Age Structure's Effect on the Labor Force and its Implications

As a population ages we can expect to see changes in the average age of the labor force as well. One of the major issues with respect to the labor market is that of wage tilt, or a steepness of the curve, which relates earnings and experience (Hirsch, Macpherson, and Hardy, 2000). This wage tilt, as some recent economists argue, may induce workers to work beyond point A_2 from the previous graph. This leads us to a dangerous conclusion. Suppose as the working population, and in particular the large baby-boom population, in the US ages, we do see a decline in worker productivity relative to worker wages. This leaves the economy vulnerable to several economic problems, including inflation. The root of the danger can be seen using spot market theory.

Spot market theory argues that workers should be paid a wage equal to their marginal product. Thus, should workers become less productive as they age beyond some point, they will constitute drains to companies. In effect, what the companies should do is pay their laborers less money when they become less productive but this is not always socially feasible. This difficulty is expounded in two classic texts. First, Keynes, in his general theory made a relative wage argument. Here, he notes that:

> A fall in real wages due to a rise in prices, with the money-wages unaltered, does not as a rule, cause the supply of available labour on offer at the current wage to fall below the amount actually employed prior to the rise in prices.

Keynes is arguing that workers will not resist a fall in real wages, as through inflation. At the same time he says:

> Since there is imperfect mobility of labour, and wages do not tend to an exact equality of net advantage in different occupations, any individual or group of individuals, who consent to a reduction of money-wages relative to others, will suffer a relative reduction in real wages, which is sufficient justification for them to resist it. (Keynes, 1932)

Keynes argues that workers will resist a decline in their relative income. He is saying that because money-wage income changes will take place in an inequitable piecemeal fashion. As a result, workers will fight them. Thus, in his mind, the only possible outcome would be one where declining productivity would lead to inflation.

James Duesenberry made a second and more contemporary argument. In a relative sense, he argued that perhaps an individual's marginal propensity to consume would be influenced by his community. This could lead to two different conclusions. First, if we see individuals trying to maintain their previous peak levels of income, then those few older individuals who do lose their job and are unable to find a new one will be forced to experience large levels of dissavings to keep up with their peers (Duesenberry, 1949). Next, it supports Keynes claim of resistance by workers to wage cuts.

However, there are alternative solutions. One suggestion includes the implementation of incentives to be offered for early retirement. Another idea included

using defined benefit pension plans to help encourage retirement before this inefficiency is reached (Hirsch, Macpherson, Hardy, 2000). It might also be possible to influence other factors going into the decision for retirement. Take a far-fetched example; if the government offered a large amount of free recreational activities, in particular those of interest to the target age group, the opportunity cost of working will rise and this may help alleviate the problem.

Perhaps of more importance, changes in the age structure should have a strong impact on the amount of structural unemployment in an economy. This is because older workers are less likely to become unemployed and less likely to be able to find another job if they do become unemployed. The explanations of these conclusions are explored in further detail in section VI, and the results will be explored in section VIII.

Nonetheless, the size of the problem is dependent on the rigidity of the labor market. For example, this may be a smaller problem for countries such as the United States with a flexible labor market, lower levels of unionization, and less stringent governmental regulations. In other countries, such as the EU and Japan, this decline in worker productivity could lead to inflation or higher unemployment through labor market rigidities.

V. Age Structures Impact on Education and its Consequences

A collinear argument could be made that education tends to rise with age, and therefore may offset any decline in productivity resulting from natural causes. Education's role in the economy has been increasing over time. Economist Gary Becker

noticed that there was a trend in the return to education. He found that from the time period 1939 to 1959, the average rate of return on education rose for both high school graduates (from 16% to 28%) and for college graduates (from 14.5% to 14.8%) (Becker,1975 p 206). There are two possible explanations for this. The first is a rise in the quality of education, which these people are receiving. The second, and more plausible, argument is that the capital, which these skilled workers employ, has been improving as well. The argument that can be made from this then is that over time, with productivity advances, education will be a key factor in garnering higher output and maintaining the capital to labor ratio. We can then draw a picture where the labor force ages, but at the same time, the workers become more productive with higher levels of experience and education.

The problem this is that education is like most other things in economics, subject to the law of diminishing returns (Becker, 1975 p 219). At the same time, there is a limit to the overall level of education that can be obtained. Even more, it is unrealistic socially to believe that the level of education will continue to rise indefinitely. I would argue that this is true, but there are other factors besides the years of schooling. There is therefore still the possibility for further gains. While the nominal level of education may at some point level out, the quality of that education can be improved, both as teaching methods improve and as the general knowledge of society expands. Furthermore, the capital employed may be able to take better advantage of that level of education.

Some economists make another contradictory argument. Because younger workers require training and lack experience, older workers are shown to fare better (Hirsch, Macpherson, and Hardy, 2000). They conclude that there are returns to skill

acquisition. This they contend shows up in higher wages, and lower unemployment rates for older workers. At the same time they note that while older workers have fewer cases of unemployment, the duration of the unemployment is longer. This implies several things for an aging age structure.

First, if the labor force is aging, it will become less flexible. Some of this may be due to increased difficulty and resistance to retraining at older ages (with shorter time horizons for discounting the value of this training.) Second, there should be an observable trend in the labor market from the continued change in the age-structure of the economy. This is explored further in section VI.

VI. Other Implications of Changing Age Structure on the Economy

We can immediately observe several significant trends in the labor market over the past fifty years. Some of the more recent interest has centered around the relationship between the working age of the population and the NAIRU (Owyang, 2001). The argument is as follows. As the work force ages, in particular the large baby boomer work force, transitional unemployment is reduced. This is because companies can better evaluate a worker who has had previous work experience. At the same time, we have the aforementioned fact that the likelihood of being cast into the ranks of the unemployed falls with age. From equation 10 we can see that perhaps the burgeoning of the employed labor force in the US is helping to fuel our nations current decade long expansion. Chart 1 depicts the growth in the older age labor force, which should continue in the near future.

There has also been an increase in the labor force participation rate. Data collected by the Bureau of Labor Statistics (see chart 3) indicates that the labor force participation rate has increased nearly 10% over the past 30 to 40 years. The rise in the labor force participation rate may have several different effects on the economy. First, it may create a higher level of national income. The employment of more persons in the economy is a good social goal if we are trying to maximize income per capita and overall utility. Second, if we believe that all firms are acting rationally in their employment decisions, the there is a distinct possibility that the added workers will be of a lower quality. The argument that can be made is that the firms will hire the most qualified person first, so when they decide to hire another worker, he will contribute a smaller amount to output and consequently be less productive. This would tend to be inflationary. At the same time, the increase in labor supply should have the opposite effect. It should serve as a dampener on inflation, as firms are given more flexibility in hiring and workers have less bargaining power.

VII. What can the Current Age Structure of the US tell us about the Future Economic Growth in the US?

One implication of using the life cycle model with a bequest motive is that we can no longer allow for models of debt neutrality (Buiter, 1988). Debt neutrality is further violated by a changing age structure if we assume that this implies changing levels of productivity growth. Debt neutrality would imply increased effectiveness of fiscal

policy, particularly with respect to the near future in which the status of the current US surplus is in flux.

The current fiscal surplus and projections for a continuation of this surplus by the CBO and the OMB present our current government with a quandary. Some argue that a fiscal stimulus, particularly a tax cut will boost the economy. The danger that is implied by the above model of a tax cut is that even while the government isn't accumulating debt, it isn't saving or paying down the national debt. Some of the recent declining trend of savings has been covered by increased saving by the government. At the risk of sounding like a supporter of Ricardian Equivalence, should fiscal saving be cut off, there is a possibility that some of the net effect of macro stimulus may be lost to a reduction in consumer demand. This could happen if people paired back current consumption to accommodate for the loss of government savings.

The aging of the baby boomer generation has created a lot of talk concerning the need to save in the sense of the precautionary motive for the retirement of a large portion of the labor force. Some economists argue that in fact, the correct response of the government with respect to savings is ambiguous (Elmendorf and Sheiner, 2000). Others have argued that the correct fiscal response would be a reduction in savings. For example, Schieber and Shoven argue that the large-scale sale of the accumulated wealth of the baby boom generation in the future could have destructive effects on the prices of these assets, and continued fiscal saving would only aggravate the issue.

One of the largest research areas with respect to the aging of the population deals with issues such as welfare and social security with growing levels of older age dependents. With social security's future in peril, one solution might be to increase the

future retirement age. This would decrease the old-age dependency burden and provide more revenues to pay current benefactors. The problem with this is that forcing people to work to an older age may not be a socially optimal goal. At the same time, these older workers are subject to all the previously mentioned disturbances on productivity, wages, and labor force effects.

VIII. Conclusions

Using Ando and Modigliani's life cycle hypothesis of consumption, this paper makes the argument that there is a savings-investment mechanism, which allows changes in an economy's age structure to impact the overall economy. The resulting equation (equation 10), using one of Solow's growth models, can be used to argue that there is in fact a relationship between age structure and the overall level of economic output when we consider saving's effects (Solow, 1962).

The implications of these conclusions on the labor market are direct. Looking at equation 10, we can see several possible routes for age structure to affect output. First, it could lead to lower levels of unemployment. This would move the economy closer to the potential output from its actual output with the net effect being an economic increase in output. Second, it could lead to higher labor force participation, doing much the same thing but this time increasing N rather than decreasing u. Finally, it could lead to a more experienced, educated, and productive labor force.

The possibility of a direct relationship between age-structure and productivity was explored in Section III. While age taken alone was seen as a drag on overall worker

productivity, the most likely case is that workers will still become more productive as they age. This is the result of a number of explanatory variables that happen to be correlated with age and which also have strong effects on productivity. This argument is supported by empirical evidence of increased output and wages (Hirsch, Macpherson, and Hardy, 2000). Mechanisms for this included increased education, higher levels of experience, and the natural processes of the "life cycle" of the worker.

In several cases, the possibility of older workers' wages outstripping their marginal product came into play (Hirsch, Macpherson, and Hardy, 2000). Possible solutions included opportunities for and advocating of early retirement. Other possible outcomes, as supported by Keynes and Duesenberry would be a general price level inflation to wipe out these gaps (Keynes, 1932).

The current baby-boomer generation in the US is aging in such a way that the overall working labor force of the US is aging. This has structural implications, which were explored including an impact on the rate of structural unemployment. The general consensus was that structural unemployment would fall as a result of better worker evaluation and in general a tendency for older age workers to have higher job stability (Owyang, 2001).

Overall, prospects for the short-term future are bright as a larger, more experienced work force continues to drive unprecedented levels of economic growth in the US. Likewise, a trend of continued population aging after the baby-boomer generation has run its course could have potential gains for the US from a labor market standpoint as well. In the longer-term, prospects are less optimistic. Here, from a savings-investment standpoint, higher levels of old-age dependency as these workers

enter retirement may strain the economy. This may come in the form of further declines in saving and investment. One thing is certain, if the aggregate saving rate is to remain constant, the sources of saving will have to shift further from individuals and more onto businesses and the government.

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Appendix

Table 1 : United State of America Age Structure Data

Age	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005*
Total	157813	171074	186158	199796	210111	220165	230406	241855	254106	267115	277825	287863
0-4	17237	19263	20849	20444	17814	16853	16777	18358	19570	20197	18763	18664
.5-9	13785	17207	19263	20958	20574	18015	16852	17092	18720	19869	20456	19020
.10-14	11574	14003	17268	19398	21171	20826	18276	17148	17394	19075	20176	20756
.15-19	11217	11399	13791	17336	19504	21360	21089	18573	17460	17770	19402	20495
.20-24	12250	10923	11509	13978	17025	19743	21747	21441	19130	17863	18132	19756
.25-29	12872	12267	11365	11736	14163	17764	20206	22419	22139	19647	18336	18601
.30-34	12143	12907	12398	11490	11964	14518	18011	20500	22617	22577	20064	18761
.35-39	11563	12126	12895	12376	11495	11935	14401	17995	20404	22806	22762	20277
.40-44	10682	11416	11990	12788	12369	11514	12038	14342	17969	20433	22828	22803
.45-49	8491	9929	11260	11777	12630	12176	11350	11898	14139	17877	20327	22716
.50-54	8636	9120	10162	10857	11450	12228	11895	11065	11617	13959	17636	20067
.55-59	7635	8082	8717	9816	10371	10902	11748	11413	10694	11318	13604	17196
.60-64	6685	7358	7573	7897	8916	9566	10225	11031	10776	10186	10809	13014
.65-69	5485	6005	6466	6693	7124	8135	8696	9291	10096	9934	9431	10044
.70-74	3541	4190	4791	5402	5581	5832	6814	7523	8075	8870	8786	8384
.75-79	2216	2655	3201	3695	4124	4378	4823	5485	6095	6648	7351	7313
80+	1801	2223	2643	3154	3837	4690	5460	6279	7211	8070	8961	9995

* = projected

Table 2: Average Age of Available Population Within Labor Force Age Groups

Workers	102174	105527	111660	120051	129887	141706	152710	160677	166945	174436	183900	193686
Experience	3821685	4016993	4251800	4509023	4814073	5160340	5529225	5866323	6178583	6579980	7076805	7588620
Average Age	37.40369	38.06602	38.07809	37.55922	37.06354	36.41582	36.20735	36.51003	37.00969	37.72146	38.48181	39.18001

Table 3: Rates of Growth in Each Age Category for US Age Structure Data

Age	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005*
Total	NA	2%	2%	1%	1%	1%	1%	1%	1%	1%	1%	1%
0-4	NA	2%	2%	0%	-3%	-1%	0%	2%	1%	1%	-1%	0%
.5-9	NA	5%	2%	2%	0%	-2%	-1%	0%	2%	1%	1%	-1%
.10-14	NA	4%	5%	2%	2%	0%	-2%	-1%	0%	2%	1%	1%
.15-19	NA	0%	4%	5%	3%	2%	0%	-2%	-1%	0%	2%	1%
.20-24	NA	-2%	1%	4%	4%	3%	2%	0%	-2%	-1%	0%	2%
.25-29	NA	-1%	-1%	1%	4%	5%	3%	2%	0%	-2%	-1%	0%
.30-34	NA	1%	-1%	-1%	1%	4%	5%	3%	2%	0%	-2%	-1%
.35-39	NA	1%	1%	-1%	-1%	1%	4%	5%	3%	2%	0%	-2%
.40-44	NA	1%	1%	1%	-1%	-1%	1%	4%	5%	3%	2%	0%
.45-49	NA	3%	3%	1%	1%	-1%	-1%	1%	4%	5%	3%	2%
.50-54	NA	1%	2%	1%	1%	1%	-1%	-1%	1%	4%	5%	3%
.55-59	NA	1%	2%	3%	1%	1%	2%	-1%	-1%	1%	4%	5%
.60-64	NA	2%	1%	1%	3%	1%	1%	2%	0%	-1%	1%	4%
.65-69	NA	2%	2%	1%	1%	3%	1%	1%	2%	0%	-1%	1%
.70-74	NA	4%	3%	3%	1%	1%	3%	2%	1%	2%	0%	-1%
.75-79	NA	4%	4%	3%	2%	1%	2%	3%	2%	2%	2%	0%
80+	NA	5%	4%	4%	4%	4%	3%	3%	3%	2%	2%	2%

* Estimates

Growth rates shown are the average 1yr growth rate during the period.

The band of high growth rates represents the movement
of the baby-boomer generation through the age structure data

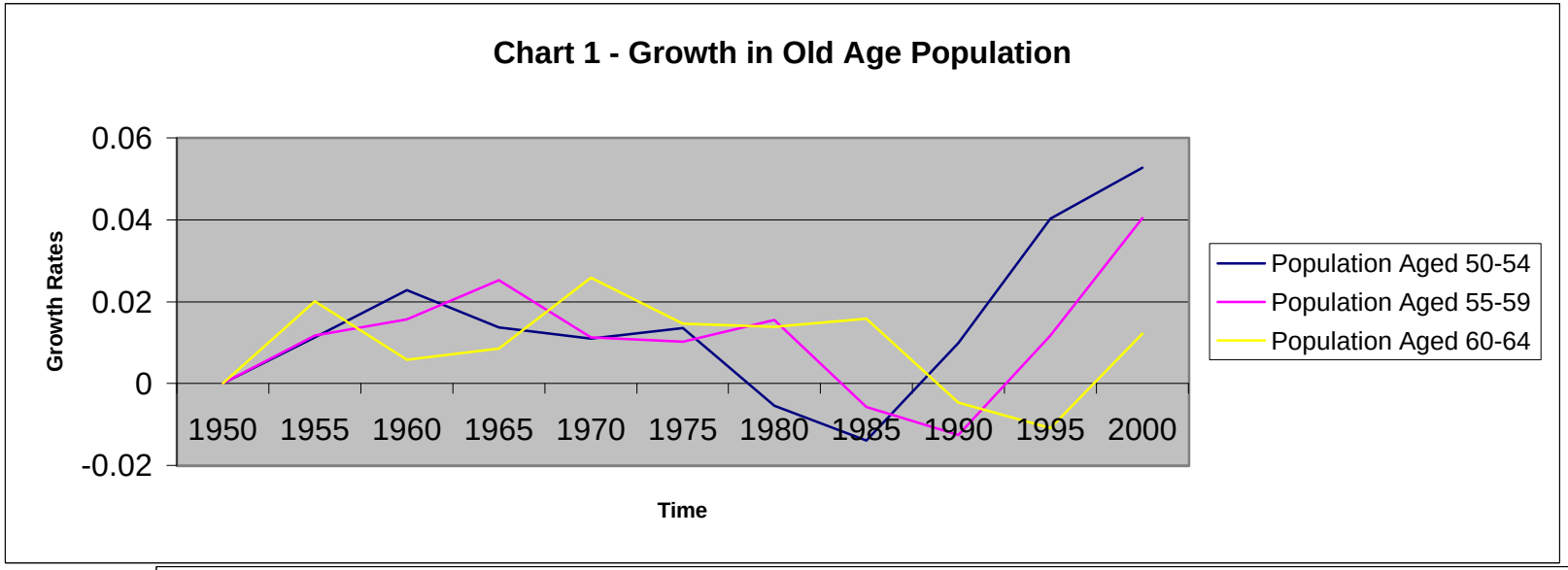
Chart 1 - Growth in Old Age Population
0.06
0.04
0.02
0
-0.02
Growth Rates
1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000
Time
Population Aged 50-54
Population Aged 55-59
Population Aged 60-64

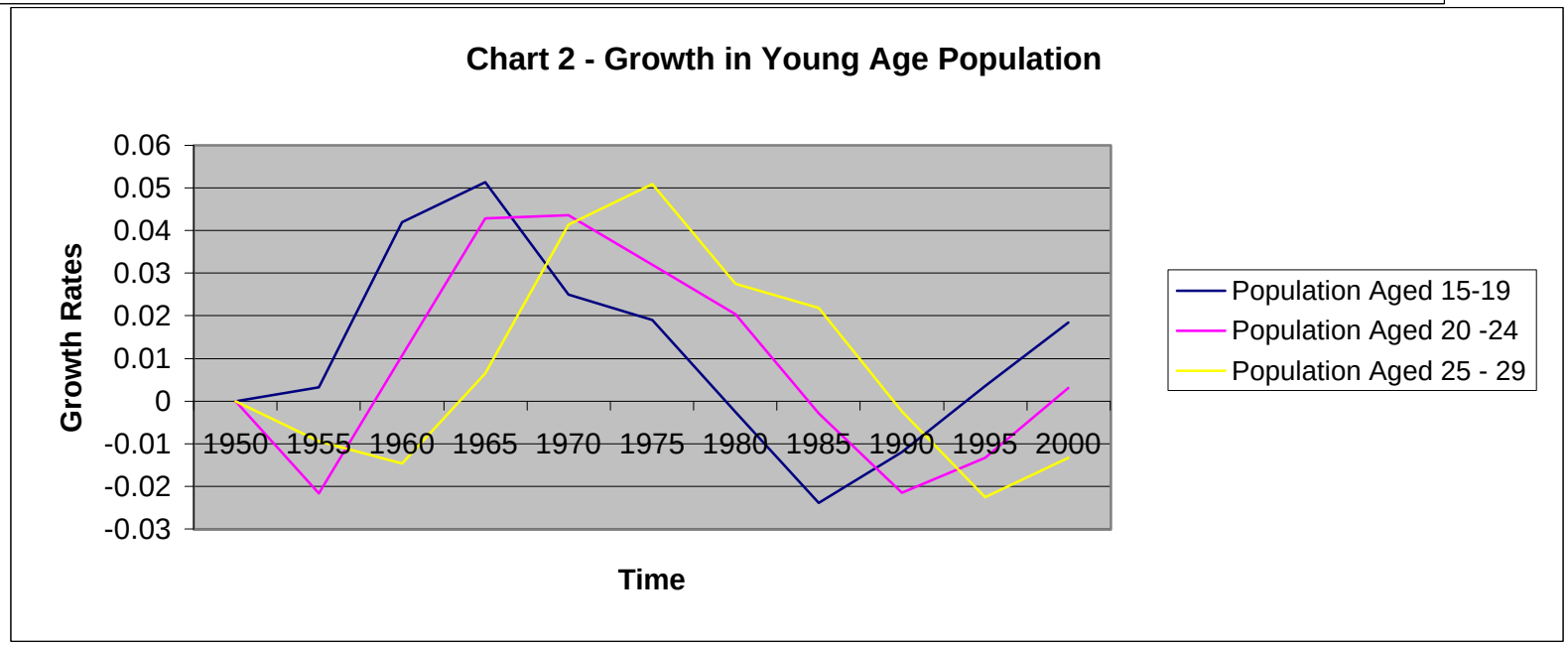
Chart 2 - Growth in Young Age Population
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
Growth Rates
1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000
Time
Population Aged 15-19
Population Aged 20 -24
Population Aged 25 - 29

Chart 3: Labor Force Participation in the US