
Issue Paper #5

PARTNERSHIP FOR AMERICA'S ECONOMIC SUCCESS

# Dynamic Estimates of the Fiscal Effects of Investing in Early Childhood Programs

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The views expressed in this working paper are those of the authors and should not be attributed to the staff, officers or trustees of the Brookings Institution, the University of Maryland, or The Pew Charitable Trusts. The authors thank William Gale and participants in the Brookings Economics Studies Work-in-Progress seminar for helpful comments. This work was generously funded by The Partnership for America's Economic Success.

**The Partnership for America's Economic Success** was created by a group of business leaders, economists, advocates, and a dozen funders in order to document the economic impacts to the nation of proven investments in children from before birth to age five. The Partnership has been funded by the Buffet Early Childhood Fund; Robert Dugger; George Gund Foundation; Horace Hagedorn Foundation; Paul Tudor Jones; Ohio Children's Foundation; Peppercorn Foundation; The Pew Charitable Trusts; PNC Financial Services Group, Inc.; Scholastic, Inc.; The Schott Foundation for Public Education; and Anonymous. The Partnership is managed by The Pew Charitable Trusts.

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*Release date: February 28, 2008*

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# Introduction

Children living in families with low incomes, a single parent, and/or poorly educated parents are much more likely than other children to grow up to be adults with less education, lower wages and incomes, poorer health, and shorter lives. There have been many attempts to break this cycle of poverty by enriching the environment in which disadvantaged children grow up and to better prepare them to enter school. In order to decide if these programs actually deliver the results they are aiming for, it is necessary to have high-quality evaluations using a random-assignment experimental approach with a long time horizon. Unfortunately, relatively few of these "gold-standard" evaluations have been carried out. However, some programs — notably Perry Preschool, the Abecedarian Project, and the Mother-Child Home Program, have been demonstrated to have positive effects on later life outcomes. Others have shown that the social benefits of such programs can substantially outweigh the social costs suggesting that such programs could be excellent social investments.[1]

Most of the benefits of these programs accrue to the participants while most of the costs, when they are implemented as public programs, fall on taxpayers. Taxpayers, however, also reap some of the benefits. If program participants earn higher incomes as a result of participation, they will pay more taxes and be less likely to rely on government transfers, and; if they are less likely to require special education or to repeat grades, they will cost less to educate. This study attempts to calculate the fraction of the total costs to taxpayers that would likely be recovered by government if large-scale versions of two such early childhood programs were to be instituted. We use a simulation model of the US economy to estimate the net effects of investing in early development programs on government budget surpluses.

Ideally, governments would undertake all projects for which net social benefits are positive.[2] However, if a program which has been shown to have positive net social benefits also pays for a large fraction of its own costs with revenue increases and savings, it then becomes more attractive than other programs that produce the same level of benefits but without the fiscal dividend. More such programs could be undertaken within a limited budget. Thus, we believe that the estimates that we provide here are a useful supplement to the more traditional benefit-cost analysis of these programs.

We examine two programs for which long-term, randomized control experimental evaluations have shown notable, statistically significant, effects on ultimate educational attainment. We find that large-scale versions of both programs that produced the same results for participants as the programs tested could be expected to recover a substantial fraction of their costs within 75 years. These programs are the Abecedarian Project and the Mother-Child Home Program. With our preferred assumptions, both programs more

[1] For example Barnett and Masse, 2002, Schweinhart et al., 1993, Schweinhart et al., 2005.
[2] The deadweight loss from the taxes to obtain the revenue must be counted among the costs of the program.

than pay for themselves over the long run,[3] however, policy makers must be patient to reap this gain, as costs begin accruing immediately, while the fiscal benefits mainly come later. Both programs are quite expensive, and most of their fiscal benefits accrue years later, when the children who took part in the programs enter the labor market with notably improved earning power. Their higher earnings mean more tax revenue for all levels of government. For example, if a targeted early childhood development program could be implemented for the least advantaged 20% of the population and produced the same impacts for each student as the Abecedarian project, we estimate that GDP would be 1.1% higher in 75 years than it would be without the program. When combined with anticipated savings in other areas, that increase in GDP causes an increase in tax revenues that is more than enough to pay for the then current cost of the program.

Available evidence does not allow us to quantify all of the potential positive fiscal effects of these two programs. In particular, the study of the Mother Child Home Program that we rely on allows us only to estimate the impact of the program on high school completion. Although many more outcomes are available from the evaluation of the Abecedarian project, we still don't have the long term data that would allow us to estimate effects on income (beyond those due to increased education), the full effects on educational attainment, or effects on adult crime rates. In a companion paper to this one (Dickens and Baschnagel 2007), we analyzed the fiscal impacts of a universal pre-school program based on the Perry Preschool experimental findings. Much longer-term follow-ups of more outcomes are available for that experiment. If equivalent information were available for the Abecedarian project and the Mother-Child Home Program, simulated economic and fiscal effects would likely be larger.

In this paper, we extend the growth model developed by Dickens, Sawhill and Tebbs (2006), which analyzed the impact of the increased educational attainment due to preschool on economic growth. The new model takes several additional factors into account and allows us to calculate the impact not only on economic growth, but also on federal, state, and local government budgets.

Below, we provide a brief description of the two programs that we analyze and explain how we chose some of the model's crucial parameters (more extensive descriptions can be found in the Appendix). The following section provides a verbal description of the growth model used for the simulations. Next, we present the basic results from the model and analyze its sensitivity to important assumptions. The conclusion reviews the results and describes some important qualifications to our findings.

[3] A program pays for itself in the long run if the present value of the stream of savings and revenue increases to federal, state and local governments exceeds the present value of program costs. Our present value calculations assume a real discount rate of 3% which is equivalent to a nominal interest rate of 5 to 6% assuming expected inflation is 2 to 3%.

# Program Costs and Impacts

States have been showing a growing interest in providing high quality pre-school experiences. In addition, states and the federal government have shown increasing interest in a host of other programs that teach parenting, provide nutrition assistance and health screening, or counsel expectant mothers – programs that provide services that impact children before birth or in their very early childhood. States such as Arizona and Nebraska have passed new initiatives to fund services for infants and toddlers, and their families.

While some evaluations of short-term outcomes are encouraging, most programs do not have long-term follow ups that would allow us to judge their impacts on adult outcomes. Nevertheless, our review of this literature turned up two studies of early childhood development programs that provided satisfactory experimental evaluations of educational attainment at the level of high school graduation or beyond. Those programs are the Abecedarian Project and the Mother-Child Home Program (MCHP, also called the Parent-Child Home Program or PCHP).

### Abecedarian

The Abecedarian project was a randomized treatment-control study of the potential benefits of early childhood education for poor children. Four cohorts of children, born between 1972 and 1977, took part in the project. Participants received full-time, high-quality educational childcare from infancy through age five with considerable individual attention. Educational activities consisted of "games" incorporated into the child's day. Activities focused on social, emotional, and cognitive areas of development but gave particular emphasis to language. Children's progress was monitored over time with follow-up studies conducted at ages 12, 15, and 21. Years of education completed was one of the outcomes assessed at age 21 and the primary input to our simulations. Impacts on special education placement and grade completion were also monitored and are taken into account in our simulations.

At age 21, members of the Abecedarian treatment group were found to have levels of educational attainment 0.6 years greater than members of the control group. Although this result was not statistically significant, when the control and treatment groups were broken down by gender, women in the treatment group did have a statistically significant 1.2 additional years of educational attainment above their counterparts in the control group, while there was virtually no difference between the two male groups (Campbell, et. al, 2002). Due to the small size of the experiment, it is impossible to reject the hypothesis that the impact on male and female educational attainment was equal. Also, while a similar gender difference in education outcomes was found in the Perry Preschool experiment, both men and women in that experiment saw increases in earnings. Since we do not have data on the impact of Abecedarian on income, and since the primary impact of increased education in our simulation is increased earnings, we assume that the impacts on men and women's educational attainment are equal. We assume that, on average, those treated with an Abecedarian-type program will achieve an additional 0.6

years of education. This value is within the 95% confidence interval for effects on educational attainment for both males and females. Since women make up only 47% of the labor force and are more likely to be working part time, if we were to assume that only women's education and earnings were affected we might estimate slightly smaller effects. But, since many of the members of the treatment group were still in school at the time of the 20-year follow-up, we likely underestimate the ultimate effect.[4]

Abecedarian was specifically targeted at children at risk for developmental disadvantage so the program we simulate is targeted on disadvantaged children. Twenty percent of children under the age of six currently live in families with incomes below the poverty line. These are the children we assume a national program would target.

For the model, we must compute the impact of the program on the educational attainment of the average child.[5] Assuming a 70% take up rate for the 20% of the population that is targeted, 14% of the population will receive the full benefits of the program, so on average, each child in the population will receive 14% of the total benefit. For example, we expect an average increase of 0.084 years of educational attainment for the cohort if an additional 0.6 years of educational attainment is achieved by the 14% of the cohort that received the treatment.

Of course, many children are already in some form of childcare already, and for those children, this program would just replace their existing care. Nearly the entire Abecedarian control group attended some pre-kindergarten. Thus gains for Abecedarian participants were all above and beyond any benefits from childcare so we assume that there is no effect attenuation due to the replacement of existing daycare and pre-kindergarten by the new program.

As with educational attainment, the simulation requires that all impacts on children be recorded as the impact on the average child. We multiply all per-child impacts for the Abecedarian program by 0.14 to obtain their impact on the average child. We refer to this as the effect attenuation.

Steven Barnett provided updated per-pupil annual cost estimates for Abecedarian in 1999 dollars to us. We estimate the current costs assuming 92.5% of program costs are for instruction and administrative personnel. For non-instruction, or administrative, costs such as overhead, supplies and interest, we project forward the per-pupil annual costs using a GDP deflator we obtained from the Bureau of Economic Analysis. For instruction and administrative personnel costs, however, we project forward using an index of the change in the average teacher's total compensation over that time. We create this index using information on average teacher salaries from the National Center for Educational Statistics and derive the ratio of wages to total compensation for the state and local government education industry from the National Income and Product

[4] We could be overstating the effect if control group members turn out to be late bloomers who return to school after age 21 to obtain more education.

[5] What evidence there is suggests that returns to education might be slightly higher for less advantaged children so the implicit assumption of equal returns for all children is conservative.

Accounts. The data for average teacher salaries was only available through 2004 at the time this paper was written. When projecting forward the per-pupil costs for instruction and administration after 2004, we use the aforementioned GDP deflator to which we add the average real annual increase in teacher compensation we calculate for the most recent ten-year period for which data are available. Following this procedure, we calculate that the per-pupil annual cost for a participant in an Abecedarian style preschool program would be $17,478 in 2007 dollars. For both of our simulated programs, we assume that the federal government pays the entire cost of the program.

### The Mother-Child Home Program

The Mother-Child Home Program was developed by the Verbal Interaction Project with the intent of preventing educational disadvantage. The program consists of 46 semi-weekly home visits by "Toy Demonstrators" over a two year period. Toy Demonstrators are former mother-participants who visit low-income mothers and children during the child's third and fourth years. The program has both cognitive and affective goals. They are:

- To enhance the conceptual and language development of the child, along with the growth of psychosocial competence
- To enhance the mother's parenting skills and self-esteem and
- To strengthen the family as a whole in its socialization functions.

The curriculum material is comprised of 12 books and 11 toys. The content of the cognitive curriculum includes sensory-motor skills, conceptual development, and language development. All components of the curriculum are designed to promote verbal interaction between mother and child, and family and child. Between 1967 and 1974, more than 300 children and their mothers participated in the program.

Levenstein, Levenstein, Shiminski, and Stolzberg (1998) conducted the evaluation from which we draw the information used for our simulations. Data on high school completion were collected in 1996 for 123 students who had been randomly selected into treatment and control groups for an earlier study of the MCHP. The children in the study were 17 to 22 years old when the follow up data were collected.[6]

As with Abecedarian, we model the effects of MCHP as a targeted (as opposed to a universal) program. The experiment that we use to determine the effects of MCHP restricted participation to a group with several specific disadvantages (Levenstein et al. 1998, p274). Using the Current Population Survey (CPS) March Supplement for 2006,

[6] Only those who stayed in the school district where the study was conducted were included in the follow-up. Analysis of available data showed no statistically significant differences between those who left and those who stayed. Also, the treatment group was assembled over three years while the control group was established only in the third year. However, analysis of the three treatment cohorts showed no differences in their baseline values.

we estimate that about 5.5% of U.S. two-year-olds would be eligible for the program by the criteria used in the experiment.[7]
A direct measure of the increase in educational attainment for those exposed to the MCHP treatment is not currently available since the experimental evaluation was conducted when some participants were as young as 17 and none was older than 22. We use results from Levenstein et al. (1998) to compute intent-to-treat effects for individuals with equivalent cognitive test scores on high school completion rates and from that a lower bound for the increment to education (assuming that those controls who remain in school do not ultimately have higher educational attainment than those who received the treatment). From this data we estimate that participation in the MCHP leads to at least a 0.17 year increase in educational attainment.[8]

In the Levenstein study, there was a 100% take-up rate by parents who were offered the MCHP. Assuming that 5.5% of the U.S population participates in the program (the fraction we computed would be eligible using the CPS) and receives, on average, an additional 0.17 years of education, the effect on the level of educational attainment for the average member of the cohort is 0.0095 years of education. Although these benefits are small, so are the costs. The current cost per child of providing the MCHP is only $2,250 (Zuniga, 2007).

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[7] To be eligible, a child had to qualify on five of eight criteria of which only five could be assessed using the CPS. We assume that a child would qualify if the child's family satisfied four of those five criteria. One of the left out criteria was a below average score on the Peabody Picture Vocabulary Test (PPVT). From analysis of the unrepresentative sample of children of the National Longitudinal Survey of Youth participants where the Peabody Picture Vocabulary Test was administered, we have reason to believe that our method underestimates the fraction that would qualify. The eight criteria used by Levenstein et al. were a PPVT score below the mean, being from a family with a single parent, an unemployed mother, an unemployed father, the family receiving AFDC payments, parents' education less than 12th grade, family income qualifies for poverty status or older sibling in a Capter One remedial program. In the CPS we could identify single parent families, the employment status of parents, parents with less than 12 years of education and families with incomes below the poverty line.

[8] Our method of estimating the effect on completion rate, which uses estimated effects holding PPVT scores constant, yields a slightly smaller value than a simple comparison of the treatments and control groups. This is because the PPVT scores of the treatment group were about a third of a standard deviation higher than those of the controls. PPVT scores are good predictors of later IQ scores which are good predictors of high school completion, so we use the estimate of the effect that controls for PPVT scores. While differences between the treatment and control groups for high school completion are statistically significant, the effects controlling for IQ are not, though point estimates of the effects are still quite large. From table 3 we took the odds ratio for completing high school for all subjects "adjusted for baseline IQ" (PPVT score). Setting the completion rate for those without the program to that of the controls reported in the bottom panel of table 2 we computed the fraction predicted to complete high school with the program for a group with a PPVT score equivalent to the study's control group. We then took the difference between this fraction and the fraction of controls completing the program as the increment to the completion rate the program induces and assumed (conservatively) that those who complete high school get one more year of education than those who drop out. Given the uncertainty about the magnitude of these effects, below we report results of a sensitivity analysis that allows the effects of PCHP on school completion to vary plus or minus one standard error of estimate.

# The Model in Words

The Appendix provides a mathematical description of the model. In this section we present the model's workings in pictures and words. Figure 1 diagrams the flow of cause and effect from the adoption of a program through the economy.

Among the first impacts of a program such as Abecedarian on the economy will be an increase in parental labor supply as their time is freed up by their child's participation in the daytime program (effect 1 in figure 1).[9] We take an estimate of the effect of childcare subsidies (Han and Waldfogel, 2001) on labor supply and treat the part day pre-school program as a 50% subsidy of childcare costs to compute the increase in parental labor supply. The increased parental labor supply increases GDP (effect 2).

Simultaneously, the cost of the program will have to be paid for either by deficit spending or an increase in taxes. Either of these will have a depressing effect on the economy. We assume that the program is paid for by an increase in income taxes (effect 3) and that this reduces labor supply (effect 4) which reduces GDP (effect 5). Our preferred assumption is that a one percentage point increase in the fraction of income taxes reduces labor supply by one-tenth of one percent.

The primary positive impact of a child development program on participants in our model is to increase their educational attainment (effect 6). The initial impact of increased educational attainment on the economy is a reduction in the supply of labor when pre-school program participants remain in school longer than previous cohorts that did not take part in the program (effect 7). This causes a small drop in GDP about 20 years after the start of the early childhood program (effect 8). However, when the alumni of these programs graduate with their greater stock of human capital (effect 9), they are more productive, which increases GDP (effect 10). In addition, more educated individuals are more likely to be employed at all points in their lives and live longer than those who are less well-educated (effect 11). We derive the magnitude of this effect from statistical analysis of employment and mortality data, which also increases the supply of labor and increases GDP (effect 12).

These primary impacts of the child development program have secondary effects from three types of economic feedback. First, savings and investment increase with the increase in output (effect 15). The model makes the common assumption in growth theory that people save a fixed fraction of their income and that these savings become new investment in physical capital or human capital. Increased investment increases the stock of physical capital (effect 16) which further increases output (effect 17). We assume that the stock of physical capital depreciates at a constant rate so that an increasing level of investment is necessary to maintain a growing capital stock.

The model embodies a similar set of assumptions about human capital. In particular, the years of education obtained by each cohort are determined by the total resources

[9] The PCHP program is assumed to have no effect on parental labor supply.

expended in the production of education in each year. In the absence of a policy intervention, these resources are proportional to output in the year.[10] This brings about the second feedback cycle: an increase in output causes an increase in years of education (effect 18), which feed back into output, as described above. The dynamic effects of physical and human capital accumulation go on year after year, with the persistence of the effects on growth depending on the values of the coefficients on physical capital and human capital in the equation that determines output, otherwise known as the production function.

To accomplish the above, the model tracks the number of years of education attained by each cohort. The population projections for each cohort in 2005 are taken from the U.S. Census Bureau's Interim Population Projections, 2000-2050. We assume that each subsequent cohort increases in size by a set amount (the compound average population growth rate projected by the Census Bureau over the period) relative to the prior cohort. Mortality for each cohort is assumed to occur at historical rates that are lowered as cohorts become better educated (reflecting the better health generally experienced by more educated individuals). Years of education for cohorts that have already entered the labor force are estimated from the March 2006 Supplement to the Current Population Survey. The model operates under the assumption that all members of a cohort are identical with regard to the duration of their schooling (their ultimate level of educational attainment). Members of a cohort enter the labor force once they have reached the age at which they complete their schooling. These individuals have an impact on output that rises with their level of educational attainment, because more educated workers are assumed to be both more productive and more likely to be employed.
The third form of economic feedback comes through the tax system. We assume that as the program begins to increase GDP, income tax revenues increase (effect 19). This allows the government to cut income taxes (effect 20) which increases labor supply (effect 21) which increases GDP (effect 22). This effect can more than offset the initial negative impact of program costs on GDP when revenue gains exceed program costs. Additionally, there are numerous other routes by which we allow child development programs to impact government budgets. All of these are assumed to affect the tax rate necessary to pay for the program and thus labor supply and GDP. These are described below and in the Appendix.

The net fiscal impacts of the child development program are calculated as the total of the potential increases in revenue (if tax rates were held constant at initial levels) minus the costs of the program plus cost savings. As GDP increases federal, state, and local tax, revenues are assumed to increase in proportion to their ratio to GDP if tax rates are held constant. This is the primary source of potential net revenue gains, but there are also several costs that are avoided due to having had more children in development programs. With more graduates, fewer children will need special education or be retained in grade. If fewer students are held back, fewer resources are used to produce the same number of

[10] We further assume that these expenditures are proportional to the foregone earnings of students still in school. The ratio of foregone earnings to output in each year is assumed to equal a constant we call the educational savings rate. Foregone earnings are computed assuming that each year of schooling causes a fixed percentage increase in earnings that we refer to as the rate-of-return to schooling.

students with any ultimate level of achievement. We assume that local school systems save the cost of the average number of years of grade retention avoided by graduates in the year those graduates are 19-years-old (the extra year that they would have spent in school to become high school graduates).

Our estimates distinguish between effects on the federal government budget and effects on the total of all levels of government. For each category of cost, savings, or revenue, we have typically assumed that the change in the federal share will equal its share of that total cost or revenue. Figure 2 presents a list of the fiscal effects of our simulated child development interventions. Table 1 shows our assumptions about program effects before and after attenuation.

# Assumptions and Results

In order to estimate the potential impact of an early childhood development program on economic growth, we must first simulate a baseline projection of economic growth in the absence of our intervention. The model can then be used to predict the magnitude of the growth and fiscal effects of each policy initiative relative to the size of the economy assumed in the baseline case. For this purpose, we adopt the Congressional Budgets Offices' (CBO 2006) assumptions about future productivity growth. The CBO assumes that the growth rate of output per worker will be 2.1% per year. In order to calibrate our model we augment the production function scaling constant ($A_t$) in each year by the amount necessary to match the per-capita growth projections of the CBO.

The growth model is highly flexible in that it allows for user-selection of the values ascribed to an extensive set of variables, including: the parameters that represent the rate of return to an additional year of education or of labor market experience; the depreciation rate of physical capital; the investment rate in physical or human capital; and the factor share ascribed to physical capital. To determine our preferred set of parameter values, we mainly used historical averages. In particular, we relied heavily upon data from the National Income and Product Accounts (Bureau of Economic Analysis) and the March Current Population Surveys (Bureau of Labor Statistics). A more detailed account of how we chose each of our parameter values and the values used in the sensitivity analysis described below can be found in appendix table 1. We focus much of our analysis on the 75-year budget window used by the Social Security Administration for long term planning.

Figure 3a shows the impact of a targeted program modeled after Abecedarian on economic growth. Initially, there is a tendency for GDP to increase relative to the baseline due to the entry of some parents into the labor force who would otherwise care for their children themselves at home. This effect more than offsets the negative impact of the program on labor supply that results from the increased taxes necessary to pay for the program's costs so that there is an initial small positive impact on GDP. On the other hand, when the first participants enter the labor force there is a decline in GDP of 0.08% as these program alumni extend their educational careers. This effect is largest in the first year it is present. Despite this decline, output remains slightly above baseline since the direct and indirect effects of increased parental labor supply outweigh the lost labor supply from the participants remaining in school longer. After this initial decline, GDP grows continually reaching a level 1.1% above baseline 75 years after the start of the program.

The inputs to the production process follow a similar profile. All are notably above their baseline levels 75 years after the program's inception. The stock of physical capital is 0.9% larger, the stock of human capital per worker is 1.1% larger, and the labor supply 0.51% larger.

Effects for an MCHP program are much smaller as can be seen in figure 3b. The program we simulate increases GDP only 0.051% over baseline after 75 years. Of course, the program is much less expensive per participant and we have assumed that it serves a much smaller population than the program modeled on Abecedarian. Table 2 shows the effects of both programs at different points in time.

Increased growth means increased government revenues. Going from our baseline simulation to our simulation with a targeted Abecedarian-type program, federal revenues would increase by $134 billion in 2007 dollars 75 years after the programs inception were it not for the tax rate decreases the program allows (all the calculations described here describe budget effects before the tax rate is adjusted to achieve a balanced budget program effect). Costs to the federal government net of savings at that point are $204 billion. Total government revenue is potentially $264 billion larger 75 years after the programs inception at which time total costs minus savings are $172 billion. The increase in total government revenue overtakes net costs 55 years after the start of the program. Figure 4a shows the impact of our simulated Abecedarian style program on government budgets over a 150 year horizon.

The MCHP program produces smaller revenue impacts, but also has much smaller costs (Figure 4b). The revenue increases for MCHP overtake net costs 89 years after the programs inception at the federal level and after 64 years when revenues and net costs at all levels of government are considered. Table 3 presents the budget impacts for both programs at 25, 50, 75 and 150 years.

Since program costs are high in the early years and revenue gains and savings become large only in the later years, it is reasonable to ask if the program is a good investment for government. In conducting this exercise we want to emphasize that it is not normally expected that government programs will pay for themselves. Whether or not early childhood development programs are a good investment depends on whether net benefits to society as a whole are positive, not whether they produce a positive return on net revenues for government.

Both of the programs considered here return a large fraction of their costs over the 75-year budget window. At the federal level, the Abecedarian-type program pays 49% of its costs in increased revenue and savings. For all government, the share is 77%. The corresponding values for MCHP are 16% and 19%.

Both programs might be expected to more than pay for themselves if policy makers were sufficiently patient. If the present value of the streams of increased revenues and net costs to all levels of government are calculated using a 3% real discount rate, the sum of revenues exceed costs for the Abecedarian program after 121 years. It would take 148 years for an MCHP-type program to recover all its costs.[11]

Of course results are only as good as the assumptions behind them. How sensitive are they to our choices? Tables 4a and b show the impact on the fraction of expenses covered in the 75-year budget window of varying all the major parameters in the model over a wide range. Table 1 in the appendix describes how the values for this sensitivity analysis

[11] The federal government would never recover its costs as it is assumed that the federal government is paying all the costs but receives only a fraction of the benefits.

were chosen. Figures 5a and b show the distribution of these percentages across all our simulations. Most of the values cluster around the results produced by our preferred assumptions. There are a few parameters that, when changed, produce results that vary a good deal from those produced by the preferred values. These include the impact of education on productivity and the aggregate importance of education to the economy.[12] This surprising lack of sensitivity to individual assumptions is due in large part to the fact that there are many different paths by which our programs affect outcomes and even very large changes in the assumptions about any one path have limited influence on the overall effect.

[12] The parameter gamma in the production function that determines the importance of human capital relative to raw labor. See the appendix for details.

# Conclusion

The model predicts that interventions that promote child development, starting at the youngest ages, will produce substantial gains in GDP, and the stocks of physical and human capital. This is true across a wide range of assumptions about the growth process of the economy. With our preferred assumptions, we predict that a targeted Abecedarian-type program would increase output by 1.1% after 75 years relative to what it would have been otherwise. The increased growth comes as a result of increases in physical capital, human capital, and labor supply. The MCHP program produces smaller effects at a smaller cost.

A stronger economy means more government tax revenue. We find that a federally-funded Abecedarian-type early childhood development program could begin paying for itself in 55 years after its inception if the savings on other programs and revenue from all levels of government are considered. The MCHP program would pay for itself in 64 years.

Since the revenue gains are in the future and the costs begin immediately, it is reasonable to ask whether the program would pay for itself as an investment. We must emphasize that government savings reflect only a small fraction of the total benefits to society and that we do not normally expect expenditure programs to pay for themselves. Still, it should be much easier to undertake an expenditure such as this in the current budget environment if it is done with the knowledge that the program will eventually have a positive impact on the present value of the budget surplus. For example, this would mean that the program could be debt financed with no long run consequences for the rest of the government budget. We find that both the programs we consider pay for a substantial fraction of their costs within a 75-year budget window and that both more than pay for themselves over the long-run when cost savings and revenue increases at all levels of government are considered. We find this despite the fact that available evidence allows us to examine only a limited range of positive fiscal effects for these two programs.

Our main hesitation in presenting these findings is our concern that it may not be possible to achieve the gains that these demonstration programs did when the programs are operated on a national scale. A safe way to answer these concerns would be to establish a large scale demonstration program. As it would be impractical to wait 20 years to judge the impact of the program on adult outcomes, it would be very important to develop methods to predict adult outcomes on the basis of early program impacts.

# Appendix: The Mathematical Specification of the Model

The model used for the analysis in this paper has three main parts: the equation that describes how the inputs to the production process are combined to get output (the production function), the equations that describe the evolution of the inputs, and the equations that describe federal and total government revenues and expenses. The evolution of the inputs is described in two parts: changes in the population and changes in the stocks of physical and human capital. In this model particular attention is paid to the accumulation of human capital which requires a more elaborate set of equations to describe the evolution of the population and the acquisition of human capital. By modeling the gestation lags in the creation of new human capital, the model is able to track the fiscal effects of investments over time. The model contains a number of features that have not been used in the analysis of the Abecedarian- and MCHP-type programs (such as program effects on crime rates or worker productivity beyond the effects produced by education). They are described here for completeness and for the reader who is interested in knowing the full capabilities of the model.

### The Production Function

The core of the model is the production function. Our production function is a modification of the standard Cobb-Douglas which has the property that a percentage increase in one of the inputs always causes the same percentage increase in output (constant elasticity). That increase is equal to the coefficient of the input. Our production function is specified with three inputs: physical capital, human capital services per worker-hour, and effective hours of labor.

$$(1)\quad Y_t = A_t K_t^{\alpha} (H_t L_t)^{1-\alpha} H_t^{\gamma}$$

*where*

$$H_t = \frac{\sum_{i=18}^{100} f_{i,t}\left[N_{i,t}v_{i,t} + \iota(i=27)\beta\sigma N_{6,t}\right]\ell(1+\beta\rho_{i,t})(1-F_{i,t})}{\sum_{i=18}^{100}\left[N_{i,t}v_{i,t} + \iota(i=27)\beta\sigma N_{6,t}\right]\ell(1+\beta\rho_{i,t})(1-F_{i,t})},$$

$$L_t = \sum_{i=18}^{100}\left[N_{i,t}v_{i,t} + \iota(i=27)\beta\sigma N_{6,t}\right]\ell(1+\beta\rho_{i,t})(1-F_{i,t}),$$

$$v_{i,t} = (1-hT_t)/(1+e^{w_c - w_e E_{i,t} - w_{a1} i - w_{a2} i^2}),$$

$$\textit{and}\quad f_{i,t} = \mu e^{bE_{i,t} + z_1\varepsilon_{t,i} + z_2(\varepsilon_{t,i})^2 + z_3(\varepsilon_{t,i})^3}$$

Here $Y_t$ denotes output, or GDP, in period *t*. The variable $K_t$ is the stock of physical capital in year t, $H_t$ is the average flow of human capital services per worker hour, and $L_t$ is the total effective hours of labor provided. The variable $A_t$ is a normalizing constant. The changes in $A_t$ reflect exogenous technical change and is chosen so that our baseline simulation matches the growth predictions of the CBO (2006). The initial level of *A* is chosen so that GDP in 2006 equals the actual GDP in 2006.

The average flow of human capital services per hour of effective labor provided is computed as the average of the flow value of the services of those at age *i* in time *t* ($f_{i,t}$) weighted by the number of hours of effective labor provided by people of age *i* in year *t*. The effective hours provided by workers of a particular age are determined in the following way. First, we multiply the number of workers (the quantity in square brackets) times the average number of hours worked per worker ( $\ell$ ). Then, this quantity is multiplied by one plus a variable that is equal to the productivity increment due to increased educational attainment received by those who participate in a pre-kindergarten program (the productivity increment is ($\rho_{i,t}$) if those of age *i* participated in the pre-kindergarten program and zero if they did not). The result is then multiplied by the attenuation parameter ($\beta$) times the fraction of the year that they are not in school ($1-F_{i,t}$).

The number of workers of age *i* in time *t* is computed as people age *i* ($N_{i,t}$) times the probability of employment ($v_{i,t}$) plus the number of parents entering the labor force as a result of the pre-kindergarten program (which is equal to the number of six-year-olds) times a constant ($\sigma$) that is set equal to the expected increase in employment for parents of program participants times the attenuation factor ($\beta$). Parents of program participants are assumed to be 27 years of age. ($\iota(i=27)$ is an indicator function equal to 1 if *i* equals 27 and zero otherwise). That factor is only added to the policy simulation. By summing from ages 18 to 100, we are assuming that no one is working beyond age 100.

The probability of employment is derived by estimating a logit model making employment probability a function of  the average years of education (*E*), age, age squared, and the logit parameters ($w_c$, $w_E$, $w_{a1}$, and $w_{a2}$).  We assume that the impact of the pre-school program on the budget is offset by changes in federal and local income taxes. This can increase or reduce income taxes relative to the baseline simulation depending on the net impact of the program on the overall government budget. A one percentage point increase in the overall income tax rate is assumed to reduce labor supply and employment by 100 x *h* percent. The variable $T_t$ is the difference between the baseline tax rates and the tax rates necessary to offset the effects of the program on the total government budget. The derivation of $T_t$ is described in the section on fiscal effects below.

The flow value of human capital services per hour of labor is derived by estimating a regression of the log of hourly wages on a constant, years of education, years of work experience ($\varepsilon$), experience squared, and experienced cubed. Experience is computed as age minus years of education minus six. The values *b,* and $z_1$ to $z_3$ are the coefficients of the variables in that regression. The predicted proportional increase in wages due to education and experience for people of each age in each year is multiplied by the ratio of total compensation to wages ($\mu$) to obtain the flow value.

Equation (1) is a very flexible functional form. With $\gamma$ set equal to $\alpha$-1, the function yields the standard Cobb-Douglas production function without human capital. With $\gamma$ larger than $\alpha$-1 but less than zero the function is the extended Cobb-Douglas with human capital as in Mankiw, Romer and Weil (1992). When $\gamma$ is set equal to zero, the equation yields Uzawa's (1965) production function. Finally, for values of $\gamma$ greater than zero, the production function exhibits increasing returns to scale in the combination of human and physical capital and is equivalent to that used in Lucas (1988).

## Population

We model only the output produced by domestically born workers. Thus, our cohorts do not grow with age. However, they do die at a rate that is affected by their level of education. The youngest cohort represented in our model is 6 years-old, therefore,

$$(2) \quad N_{i,t} = q_{i,t} N_{i-1,t-1} \quad \textit{for all } t, \textit{and } i = 7 \textit{ to } 100$$

$$q_{i,t} = \begin{cases} 1 & \textit{if } i < 18 \\ 1/(1+e^{u_{c,i} - [u_E + u_A(i-1)][E_{i-1,t} - E_{i-1,2005}]}) & \textit{if } i \geq 18 \end{cases}$$

where $q_{i,t}$ is the survival rate of those of age $i$-1 at time $t$ and the $u$ s are the parameters of a logistic survivor function. The survivor logit has a unique intercept for each age, a linear effect for education and an age x education interaction.

The size of each new cohort is given by the equation

$$(3) \quad N_{6,t} = (1 + g_t) N_{6,t-1} .$$

The growth rate $g_t$ is set equal to a constant user-determined parameter. The initial values of $N_{i,t}$ are taken from census projections for 2005.

## Capital Accumulation

We assume that a constant fraction of GDP, $S_K$, is devoted to the production of physical capital. We value the stock of physical capital in terms of the cost of producing it so that

$$(4) \quad K_t = (1 - \delta_K) K_{t-1} + S_K Y_{t-1} ,$$

where $\delta_K$ is the rate of depreciation for physical capital.

Our treatment of human capital is very different from the treatment to physical capital and very different from the standard treatment in abstract growth modeling. Rather than represent human capital as a stock, like physical capital, we instead model the accumulation of human capital by keeping track of the number of years of education attained by people of each age. We do this to properly model the gestation lags in the generation of new human capital due to a change in educational policy. We assume that all members of each cohort get the same amount of education. We model the education of the cohort of age *i* at time *t* as

$$(5) \quad E_{i,t} = E_{i-1,t-1} + F_{i,t} \quad \textit{for } i = 7 \textit{ to } 100 \ ,$$

where $F_{i,t}$ is the fraction of the year that cohort *i* spends in school in year *t*. That fraction is determined by the equation

$$(6) \quad F_{i,t} = Max(Min(1, X_t + P_{i,t} - i), 0) \, .$$

The value $X_t$+$P_{i,t}$ is the age at which people in cohort *i* leave school in year *t*. For those who have had the pre-kindergarten treatment, $P_{i,t}$ is set equal to *p* which is a parameter entered by the user. For older cohorts it is set equal to zero. Thus, the fraction of the year each cohort spends in school is zero for those older than $X_t$+$P_{i,t}$, $X_t$+$P_{i,t}$–*i* for the cohort for which this value is between zero and one, and one for younger cohorts.

The value of $X_t$ in each year is determined by a relationship like the savings equation for physical capital in that we assume that, in the absence of the child development policy, the value of new human capital will be proportional to GDP in that year. We further assume that the total cost of new human capital is proportional to the base year forgone earnings of those in school times a real cost index for educational expenditures. We thus compute $X_t$ as the value that solves the equation

$$(7) \quad S_H Y_{t-1} = \ell \mu c_t \left( [X_t - \text{int}(X_t)] N_{\text{int}(X_t),t} f_{\text{int}(X_t),t} + \sum_{i=\lambda}^{\text{int}(X_t)-1} N_{i,t} f_{i,t} \right)$$

$$\textit{where}$$

$$c_t = \begin{cases} t = 2007 & 1 \\ \textit{otherwise} & c_{t-1}[1 + \dot{A}_t + \alpha \dot{K}_t + (1 - \alpha + \gamma)\dot{H}_t - \gamma \dot{L}_t - \pi] \end{cases},$$

$$\textit{dots denote } \ln(\textit{Variable}_t) - \ln(\textit{Variable}_{t-1}),$$

$S_H$ is the savings rate for human capital, λ is the earliest age at which we consider output to be lost by having children in school (six in the analysis done here), *π* is the rate of productivity growth in education, and the other terms are as previously defined. The term $c_t$ is the real cost index for expenditures on education. Education is virtually unique as an industry that has experienced virtually no productivity growth at all during the post-war period.[13] Thus, the real price of education (its price relative to other goods) has consistently grown over time. The price of education should grow in proportion to the marginal product of labor if there is no increase in labor productivity in education. We model the increase in the cost of education relative to other goods as equal to the percentage increase in the marginal product of labor minus the rate of growth of productivity in education.

### Fiscal Effects

We model the effects of investing in child development on the revenues and expenditures of the federal government and of the federal, and all state and local governments combined. Revenue is assumed to increase in proportion to an average tax rate so

$$(8) \quad R_t^F = \tau_F (Y_t^P - Y_t^B) \quad \textit{and} \quad R_t^G = \tau_G (Y_t^P - Y_t^B),$$

where $R^F_t$ is the increment to federal revenue in year t resulting from the child development program, $R^G_t$ is the increment to all government revenue in year t resulting from the child development program, $\tau_F$ is the average federal tax rate, $\tau_G$ is the average tax rate of all government, $Y^P_t$ is simulated GDP with the child development policy in place, and $Y^B_t$ is the baseline GDP (the simulated GDP without the policy).

The child development program has costs proportional to the number of students in the program in each year, but it is also projected to save costs in other areas. Specifically, we build into our net change in expenditure forecasts savings from less special education, fewer repeated grades and lower criminal justice system costs, and lower incarceration costs. Thus, the impact of the child development program on government expenditures at all levels in year *t* is written as

$$(9) \quad O_t^G = \beta(N_{6,t} c_t C_{ps}^G \theta^G - \sum_{i=6}^{19} N_{i,t} \iota_{i,t} d c_t C_{se}^G - N_{19,t} \iota_{i,t} \eta c_t C_s^G - \sum_{i=12}^{100} N_{i,t} \iota_{i,t} \omega_i^G - \sum_{i=13}^{100} N_{i,t} \iota_{i,t} \kappa_i^G - \sum_{i=18}^{100} N_{i,t} \iota_{i,t} \xi_i C_{Wi,t}^G),$$

where $\beta$ is the attenuation parameter, $C^G_{ps}$ is the total cost per participant of the child development program, $\theta^G$ is the fraction of the cost per pupil of the program that does not replace existing pre-school program costs, $\iota_{i,t}$ is a variable equal to one if people of age *i* in year *t* took part in the child development program, *d* is the reduction in probability that someone will be in special education if they received a child development program, $C^G_{se}$ is the per-pupil cost of special education, $\eta$ is the average number of grade repetitions per student prevented by the pre-school program by the time they reach age 19, $C^G_s$ is the per-pupil cost to of an additional year of school, $\omega^G_i$ is the average criminal justice system savings per person for crimes prevented for those who took part in a child

[13] For example see the calculations on p2-3 of Hoxby 2002.

development program for people of age *i* in year *t*, $\kappa^G{}_i$ is the average savings on incarceration per person for crimes prevented from those who took part in a child development program for people of age *i* in year *t*, $\xi_{i,t}$ is the estimated proportional reduction in the use of welfare services by people at age *i* if they have taken part in the child development program, $C^G{}_{Wi}$ is the governments' costs for providing welfare to people of age i, and $c_t$ is the index of the real cost of educational expenditures as described earlier. Welfare costs per person are assumed to remain constant in real terms with our preferred parameter values and shrink relative to GDP as one might expect if GDP growth ameliorates poverty over time. Alternatively, a relative deprivation measure of poverty might lead to increasing welfare costs over time if a constant fraction of the population receives welfare payments or if a constant fraction of income is devoted to welfare payments. These alternatives are considered in the sensitivity analysis.

A similar equation with all G superscripts replaced with F's (indicating only the federal government's costs and savings) describes the impact on expenditures at the federal level.

The variable $T_t$, the change in the tax rate in year *t* needed to offset the effects of the pre-school program on the total government budget, is set equal to zero for the baseline simulation and equal to

$$(10) \qquad T_{t+1} = \frac{O_t^G - R_t^G}{Y_t}.$$

**Table 1. Assumed Program Impacts**

| Source | Type of Effect | Size of Effect | |
|---|---|---|---|
| | | Before Attenuation | After Attenuation |
| **Abecedarian** | | | |
| Additional Educational Attainment | Increase in years | 0.60 | 0.084 |
| Improved Productivity | Percentage increase | 0.00 | 0.00 |
| Decline in Assignment to Special Education | Percentage decline | 33.33 | 4.67 |
| Decline in Grade Retention | Percentage decline in average years | 43.64 | 6.11 |
| Decline in cost of Crime (Average over age-crime rate categories) | Percentage decline in costs | 0.00 | 0.00 |
| Average Reduction in Welfare Received | Percentage decline | 50.00 | 7.00 |
| **MCHP** | | | |
| Additional Educational Attainment | Increase in years | 0.11 | 0.00605 |
| Improved Productivity | Percentage increase | 0 | 0 |
| Decline in Assignment to Special Education | Percentage decline | 0 | 0 |
| Decline in Grade Retention | Percentage decline in average years | 0 | 0 |
| Decline in cost of Crime (Average over age-crime rate categories) | Percentage decline in costs | 0 | 0 |
| Average Reduction in Welfare Received | Percentage decline | 0 | 0 |

**Table 2. Impact of Preschool Program on Growth**

| Years into Program | % Increase in GDP | % Increase in Physical Capital | % Increase in Human Capital | Increase in Average Years of Education |
|---|---|---|---|---|
| Abecedarian | | | | |
| 25 | 0.09% | -0.06% | 0.14% | 0.021 |
| 50 | 0.56% | 0.23% | 0.68% | 0.072 |
| 75 | 1.09% | 0.86% | 1.05% | 0.100 |
| MCHP | | | | |
| 25 | -0.007% | -0.012% | 0.009% | 0.00116 |
| 50 | 0.019% | -0.001% | 0.043% | 0.00434 |
| 75 | 0.051% | 0.035% | 0.066% | 0.00596 |

**Table 3. Impact of Preschool Program on Federal Budget and Total for All Levels of Government** (Millions of 2007 dollars)

| Years into the program | Change in Revenues | | Program Savings Net of Costs | | Change in Budget Surplus | | Change in Present Value of Cumulative Surplus (3% discount rate) | |
|---|---|---|---|---|---|---|---|---|
| | (Federal) | (All levels) | (Federal) | (All levels) | (Federal) | (All levels) | (Federal) | (All Levels) |
| Abecedarian | | | | | | | | |
| 25 | $2,970 | $5,853 | ($53,771) | ($42,583) | ($50,801) | ($36,830) | ($661,055) | ($497,078) |
| 50 | $35,719 | $70,395 | ($102,674) | ($82,084) | ($66,955) | ($13,218) | ($1,167,029) | ($760,313) |
| 75 | $133,892 | $263,872 | ($204,263) | ($172,399) | ($70,372) | $87,971 | ($1,447,957) | ($650,124) |
| 150 | $1,404,438 | $2,767,845 | ($1,526,237) | ($1,366,785) | ($121,799) | $1,395,303 | ($1,718,201) | $512,479 |
| MCHP | | | | | | | | |
| 25 | ($226) | ($446) | ($2,127) | ($2,509) | ($2,353) | ($2,974) | ($28,191) | ($31,670) |
| 50 | $1,247 | $2,458 | ($4,008) | ($4,724) | ($2,761) | ($2,365) | ($51,083) | ($57,574) |
| 75 | $6,288 | $12,393 | ($7,631) | ($9,076) | ($1,343) | $3,103 | ($60,284) | ($58,703) |
| 150 | $72,722 | $143,320 | ($53,287) | ($63,088) | $19,435 | $79,878 | ($51,170) | $2,232 |

**Table 4a. Sensitivity Analysis Abecedarian Type Policy**

| Abecedarian | %Δ from Baseline GDP | Net Revenue after 75 years: Federal | Net Revenue after 75 years: All Govt. | Fraction of Costs Recovered after 75 years: Federal | Fraction of Costs Recovered after 75 years: All Govt. |
|---|---|---|---|---|---|
| **Preferred Values** | 0.67% | $(1,456.35) | $(1,014.04) | 39% | 57% |
| **% increase in wages from one year of education** | | | | | |
| 0.083 | 0.32% | $(1,734.10) | $(1,409.00) | 29% | 43% |
| 0.053 | 0.05% | $(1,700.81) | $(1,455.21) | 25% | 36% |
| **Capital depreciaiton rate $\delta_K$** | | | | | |
| 6.57% | 0.67% | $(1,681.20) | $(1,253.79) | 35% | 51% |
| 3.57% | 0.63% | $(1,682.18) | $(1,256.34) | 35% | 51% |
| **Savings rate on physical capital $S_K$** | | | | | |
| 16.71% | 0.65% | $(1,681.95) | $(1,256.01) | 35% | 51% |
| 15.28% | 0.65% | $(1,680.52) | $(1,253.77) | 35% | 51% |
| **Coefficient on capital in production function α** | | | | | |
| 0.323 | 0.67% | $(1,661.70) | $(1,222.13) | 36% | 53% |
| 0.389 | 0.59% | $(1,718.65) | $(1,317.65) | 33% | 49% |
| **Population growth rate g** | | | | | |
| 0.28% | 0.65% | $(1,425.18) | $(1,031.94) | 37% | 54% |

| | | | | | |
|---|---|---|---|---|---|
| 0.78% | 0.61% | $(2,000.13) | $(1,555.16) | 32% | 47% |
| **Coefficient of human capital in production funciton Gamma** | | | | | |
| 0 | 0.88% | $(1,570.65) | $(1,068.93) | 39% | 59% |
| -0.33 | 0.40% | $(1,797.78) | $(1,450.88) | 30% | 44% |
| **Coeff of years of ed on employment** | | | | | |
| 0 | 0.35% | $(1,792.24) | $(1,437.68) | 31% | 44% |
| 0.063 | 0.49% | $(1,738.18) | $(1,348.66) | 33% | 48% |
| **% reduction in grade ret.** | | | | | |
| 0 | 0.64% | $(1,682.12) | $(1,264.72) | 35% | 51% |
| 87.27% | 0.65% | $(1,680.38) | $(1,245.12) | 35% | 52% |
| **% reduction in spec. ed.** | | | | | |
| 0 | 0.63% | $(1,721.81) | $(1,409.41) | 33% | 45% |
| 66.67% | 0.66% | $(1,640.67) | $(1,100.39) | 36% | 57% |
| **% reductrion In welfare** | | | | | |
| 0 | 0.61% | $(1,817.58) | $(1,493.29) | 30% | 42% |
| 100.00% | 0.68% | $(1,544.92) | $(1,016.57) | 40% | 61% |
| **Growth in Welfare Baseline** | | | | | |
| **with Pop.** | 0.66% | $(1,642.98) | $(1,187.95) | 36% | 54% |
| with GDP | 0.75% | $(1,358.48) | $ (689.66) | 47% | 73% |
| **Cost of Program** | | | | | |
| $16,582.13 | 0.69% | $(1,319.49) | $ (867.46) | 42% | 62% |
| (+- 12.5 %) | | | | | |
| $21,319.88 | 0.60% | $(2,042.88) | $(1,642.27) | 30% | 43% |

**Table 4b. Sensitivity Analysis for MCHP**

| MCHP | %Δ from Baseline GDP | Net Revenue after 75 years Federal | Net Revenue after 75 years All Govt. | Fraction of Costs Recovered after 75 years Federal | Fraction of Costs Recovered after 75 years All Govt. |
|---|---|---|---|---|---|
| **Preferred Values** | 0.09% | $ (33.29) | $ (27.00) | 45% | 56% |
| **% increase in wages from one year of education $\omega_e$** | | | | | |
| 0.083 | 0.05% | $ (49.12) | $ (53.85) | 15% | 7% |
| 0.053 | 0.02% | $ (59.91) | $ (72.62) | -12% | -36% |
| **Capital depreciaiton rate $\delta_K$** | | | | | |
| 6.57% | 0.09% | $ (33.29) | $ (27.00) | 45% | 56% |
| 3.57% | 0.09% | $ (33.86) | $ (27.98) | 44% | 54% |
| **Savings rate on physical capital $S_K$** | | | | | |
| 16.71% | 0.09% | $ (33.29) | $ (27.01) | 45% | 56% |
| 15.28% | 0.09% | $ (33.28) | $ (27.00) | 45% | 56% |
| **Coefficient on capital in production function $\alpha$** | | | | | |
| 0.323 | 0.09% | $ (31.73) | $ (24.40) | 48% | 60% |
| 0.389 | 0.08% | $ (36.27) | $ (31.97) | 40% | 47% |
| **Population growth rate g** | | | | | |
| 0.28% | 0.09% | $ (29.47) | $ (24.50) | 45% | 54% |

| | | | | | |
|---|---|---|---|---|---|
| 0.78% | 0.09% | $ (40.59) | $ (34.84) | 41% | 50% |
| Coefficient of human capital in production funciton Gamma | | | | | |
| 0 | 0.12% | $ (19.20) | $ (3.48) | 68% | 94% |
| -0.33 | 0.06% | $ (48.14) | $ (51.81) | 21% | 15% |
| **Coeff of years of ed on employment** | | | | | |
| 0 | 0.05% | $ (47.57) | $ (50.53) | 22% | 17% |
| 0.063 | 0.07% | $ (40.64) | $ (39.10) | 33% | 36% |
| **Cost of Program** | | | | | |
| $2,000.00 | 0.09% | $ (25.71) | $ (18.89) | 52% | 65% |
| (+- 12.5 %)(roughly) | | | | | |
| $2,500.00 | 0.09% | $ (40.86) | $ (35.12) | 39% | 48% |

## Appendix Table 1

## Source of Parameter Values and Sensitivity Analysis Bounds

| Symbol | Parameter Meaning | Preferred Value | Other values checked (1) | Other values checked (2) | Notes |
|---|---|---|---|---|---|
| $\omega_e$ | Coefficient of education in productivity | 0.113 | 0.083 | 0.053 | Preferred value derived from regressions done with 2001 March CPS. We expect the result to be upward biased (because of ability bias, education's value as a sorting mechanism, etc). Therefore, the sensitivity analysis only reviews parameter values less than the preferred values. |
| $\delta_K$ | Depreciation rate of physical capital | 4.57% | 6.57% | 3.57% | Preferred value represents average from 1995-2004 ( Calculated from the Bureau of Economic Analysis NIPA Tables) |
| $S^K$ | Savings rate on physical capital | 16.00% | 16.71% | 15.28% | Preferred value calculated from Table 1.5.5 of the Bureau of Economic Analysis's National Income and Product Accounts and represents the average percentage of private domestic fixed investment from 1996-2005. Iterations (1) and (2) represent +/- 1 Standard Deviation of the data from the same time period. |
| $\alpha$ | Physical Capital Coefficient | 0.347 | 0.323 | 0.389 | Preferred value equals the 40 year average share of national income not allocated to labor earnings. Iterations (1) and (2) represent the minimum and maximum physical capital factor shares over the past 40 years. All figures are calculated from the National Income and Product Accounts (Table 1.12). |
| g | Average Population Growth Rate of 18 Year-Olds | 0.53% | 0.28% | 0.78% | Preferred value is the average of Census Projections and reflects domestic population growth (i.e., no immigration). |
| p | Average increase in educational attainment as a result of policy initiative | 0.3650 | 0.2142 | 0.8100 | Preferred value (0.3650 year increase) is taken from "Significant Benefits: The High/Scope Perry Preschool Study Through Age 27" Schweinhart, barnes & Weikart (1993), pp. 55, 57. Lower bound assumes a 50% take-up rate with benefits accruing only to those children who would not have otherwise attended preschool. Upper bound assumes a 90% take-up rate with benefits accruing in full (100% of Perry Preschool effect) to all children. Methodology based on RAND study by Lynn Karoly and James Bigelow (March 2005). |
| b | Coeff of years of education on employment | 0.126 | 0 | 0.063 | Preferred value derived from logistic regression of employment on education with age specific intercept terms using CPS data. Lower values were chosen for sensitivity analysis since worker heterogeneity may explain part or all of correlation between education and employment. |
| | % reduction in grade retention | 28.57% | 0.00% | 57.14% | Preferred value is fractional reduction from Perry preschool experiment after attenuation. The standard error of estimate for the |

| | | | | |
|---|---|---|---|---|
| | | | | effect size in the experiment was greater than the estimated effect so bounds of zero and double the point estimate are used for sensitivity analysis. |
| % reduction in special education | 22.92% | 0.00% | 45.84% | Preferred value is fractional reduction from Perry preschool experiment after attenuation. The standard error of estimate for the effect size in the experiment was greater than the estimated effect so bounds of zero and double the point estimate are used for sensitivity analysis. |
| Average % reduction in welfare expenditures | 6.69% | 0% | 13.39% | Preferred value is fractional reduction from Perry preschool experiment after attenuation. The standard error of estimate for the effect size in the experiment was greater than the estimated effect so bounds of zero and double the point estimate are used for sensitivity analysis. |
| Welfare expenditure growth | None | with Pop | with GDP | Our preferred value holds real welfare expenditures constant at 2006 levels. For sensitivity analysis we allow this value to grow with either the rate of population growth or the rate of GDP growth. |

**Figure 1. Flow Diagram**

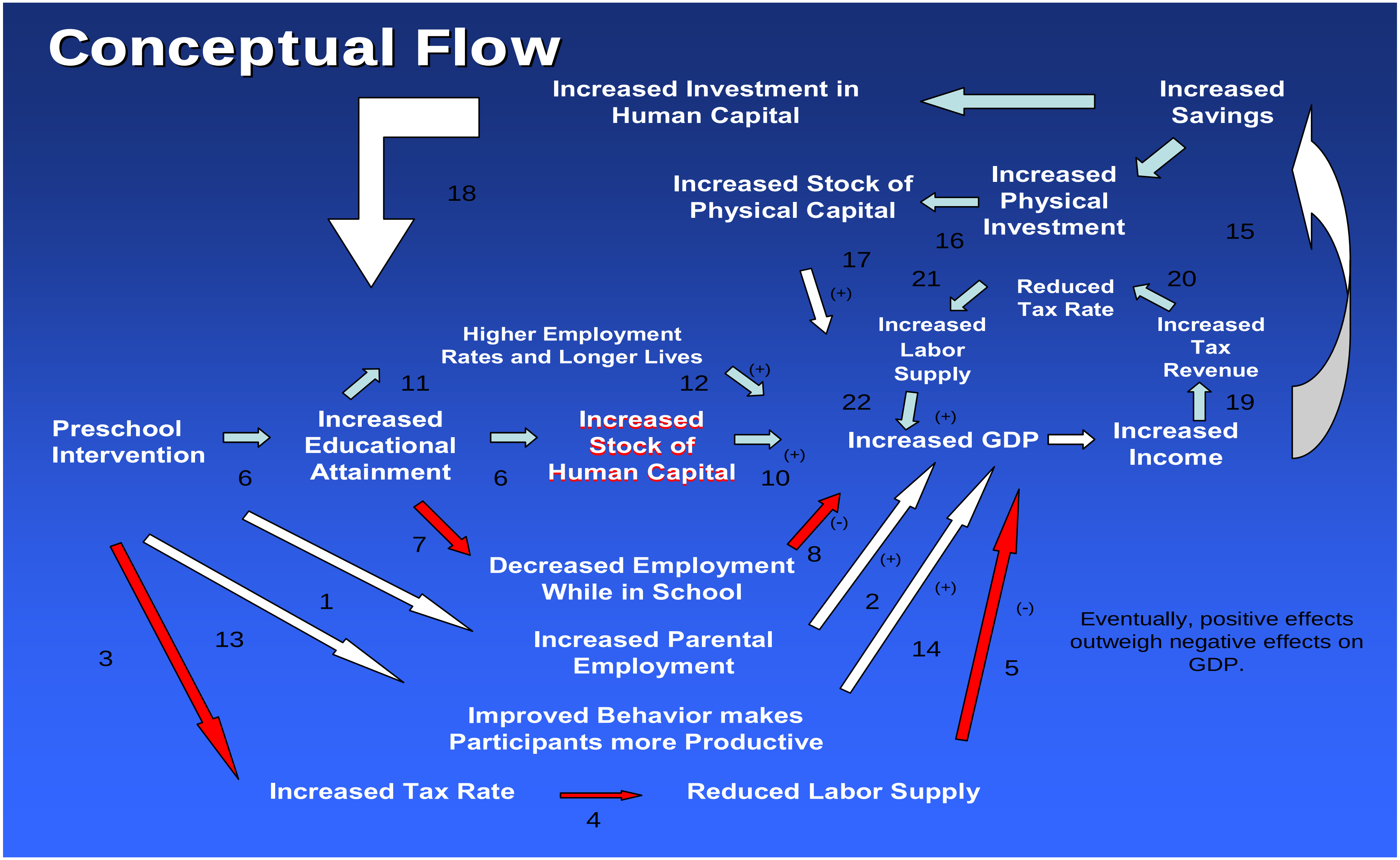


**Figure 2. Potential Budget Impacts of Child Development Programs**

# Potential Effects of Child Development Programs on Government Budgets

- COSTS

  *Abecedarian*
  - High quality full-day program cost $17,478 per child per year or about 48.3 billion a year once the program is fully up and running.
  - 40% of those costs are offset by 100% reduction in current childcare expenditures already targeting "at risk" children.

  *MCHP*
  - Cost of $2,250 per child for home parent training, toys and administration
  - No offsets since no effect on child care

- REVENUE

  *All Programs*
  - Increased productivity and labor supply increases GDP and tax revenue
  - Higher initial taxes reduce labor supply, GDP and further reduce revenue
  - Once revenue gains exceed program costs tax effect is reversed leading to lower tax rates, higher GDP and further enhancement of revenue

- *SAVINGS (Abecedarian Only)*
  - Reduced grade retention lowers costs to local schools of producing graduates
  - Reduced special education costs
  - Reduced welfare costs

**Figure 3a: Impact of Pre-kindergarten Program on Economic Activity**

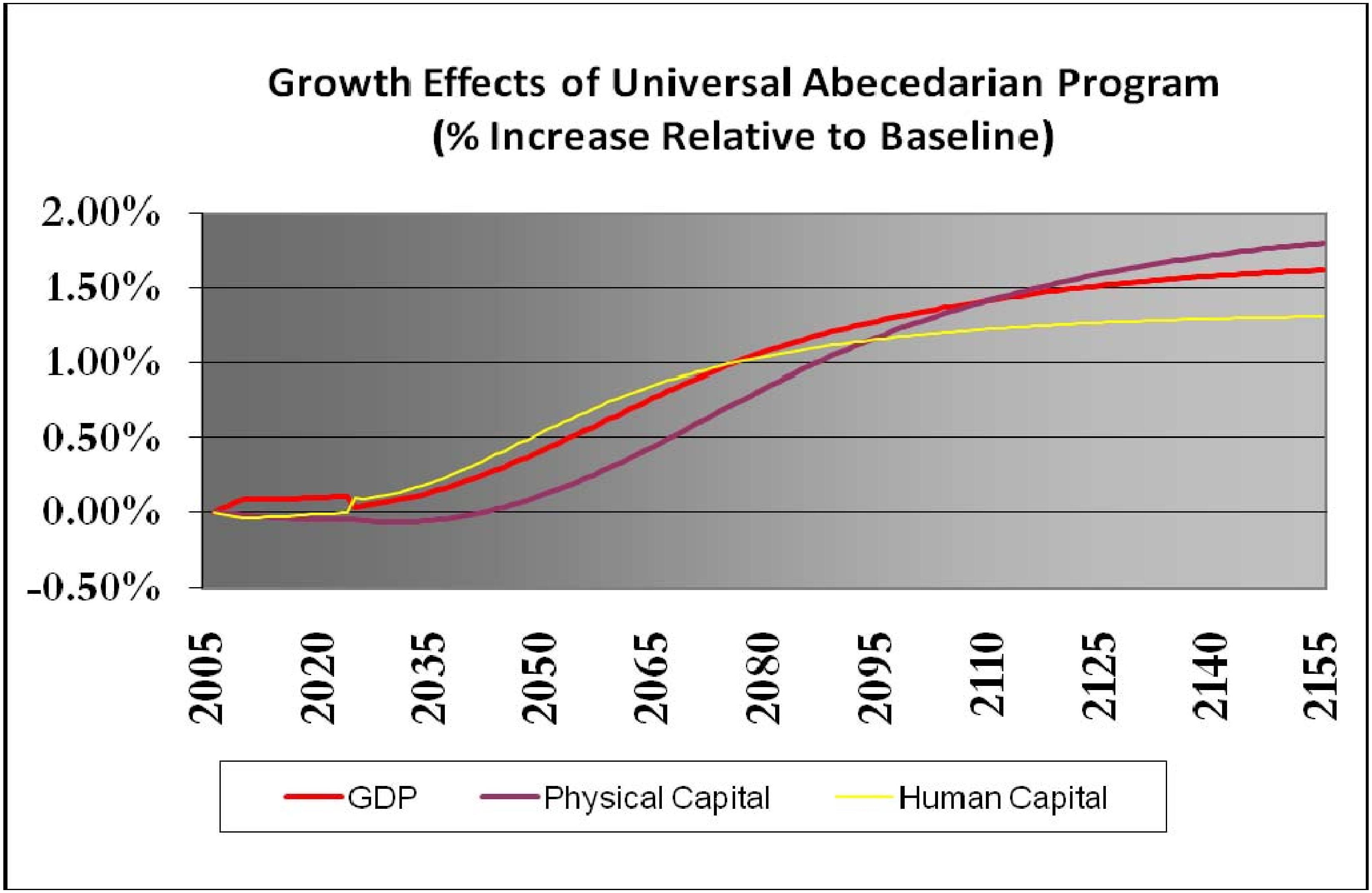


**Figure 3b: Impact of MCHP Program on Economic Activity**

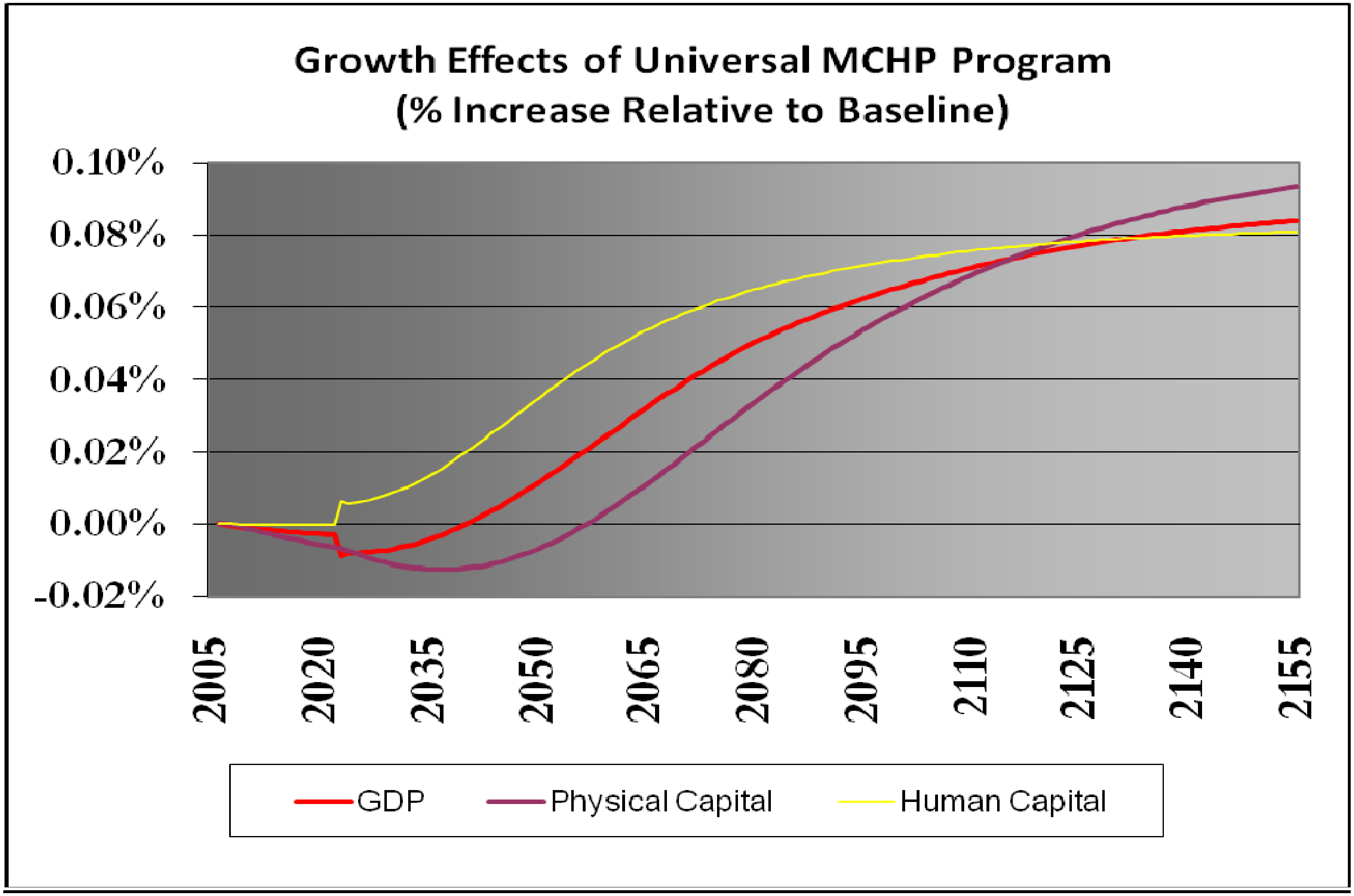


**Figure 4a: Effect of Targeted Abecedarian Preschool Program on Budget Surplus**

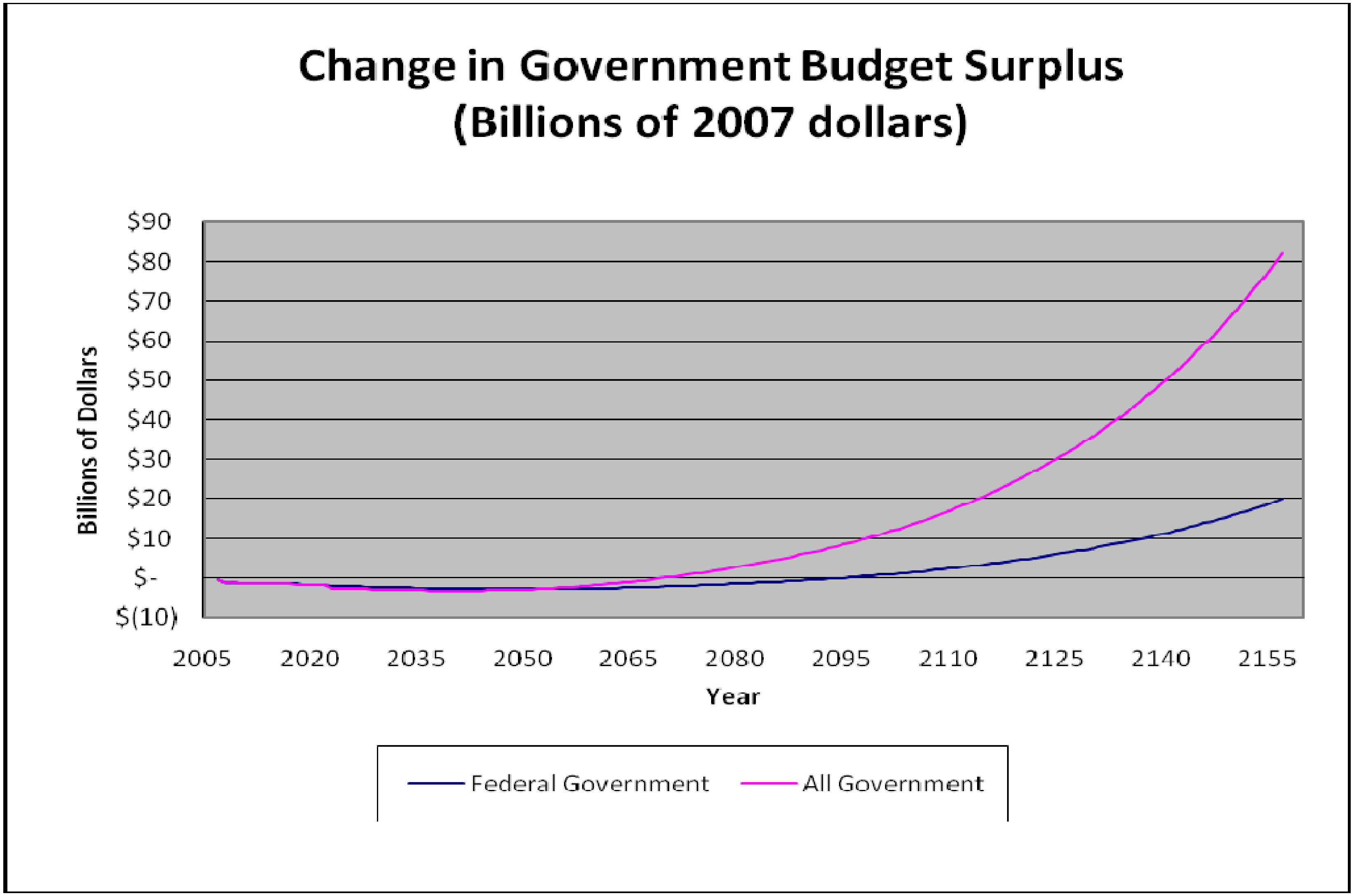


**Figure 4b: Effect of Targeted MCHP Program on Budget Surplus**

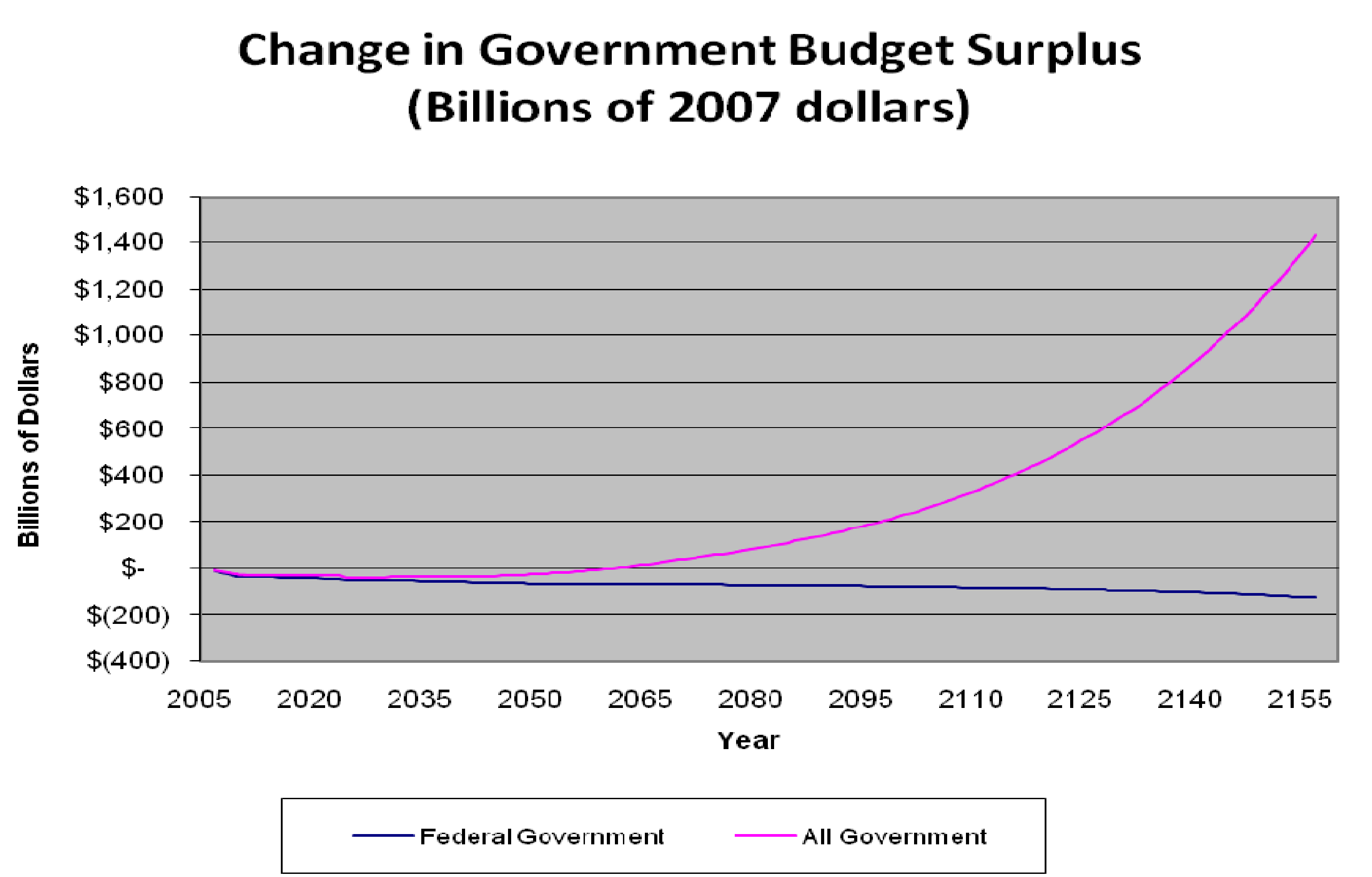
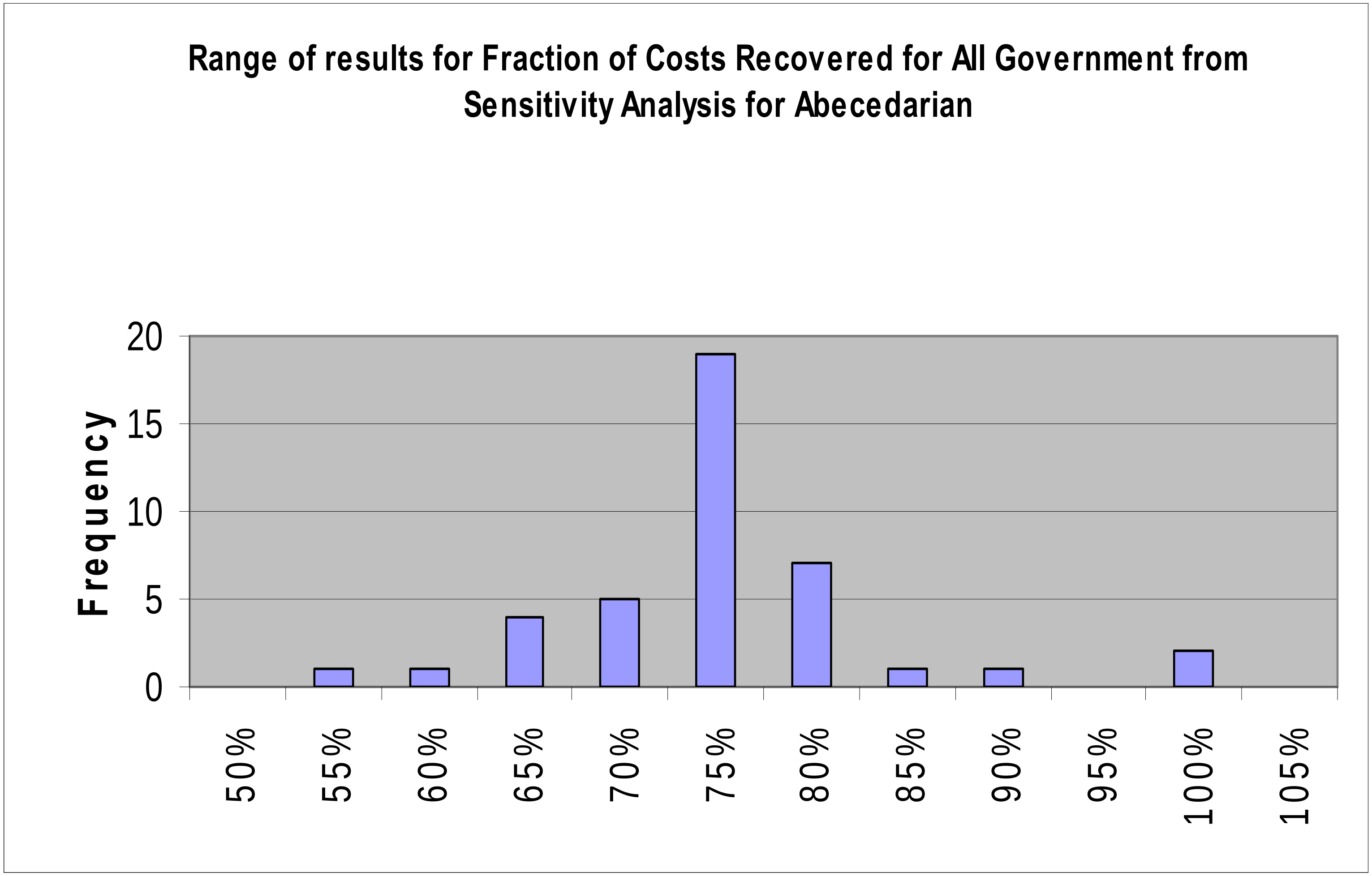
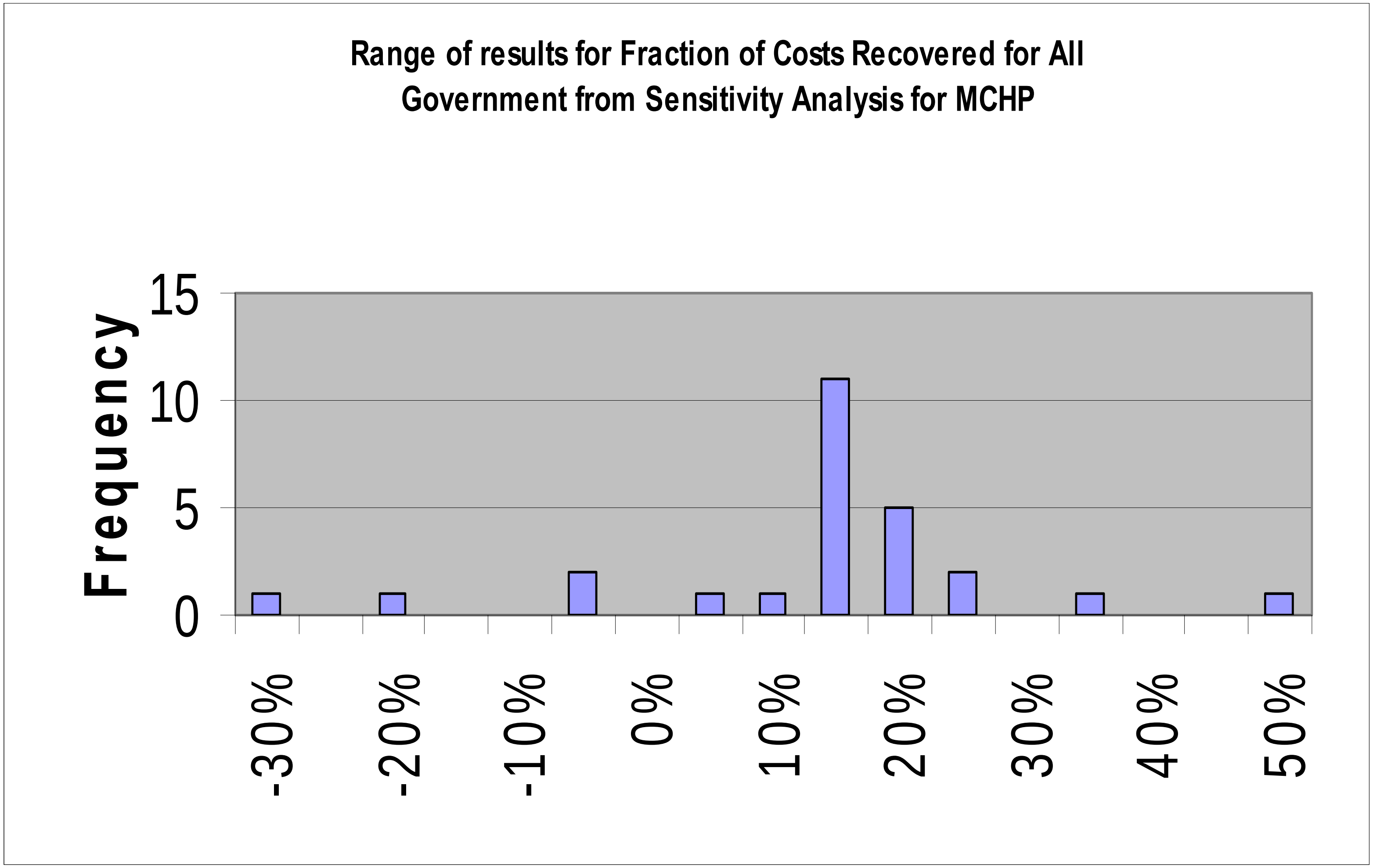


**Figure 5a**



Range of results for Fraction of Costs Recovered for All Government from Sensitivity Analysis for Abecedarian
Frequency
0
5
10
15
20
50%
55%
60%
65%
70%
75%
80%
85%
90%
95%
100%
105%

**Figure 5b**



Range of results for Fraction of Costs Recovered for All Government from Sensitivity Analysis for MCHP
Frequency
15
10
5
0
-30%
-20%
-10%
0%
10%
20%
30%
40%
50%

# References

Barnett, W. Steven, Jason T. Hustedt, Laura E. Hawkinson, and Kenneth B. Robin, 2006. *The State of Preschool 2006.* New Brunswick, N.J.: National Institute for Early Education Research.

Barnett, W. Steven, Jason T. Hustedt, Kenneth B. Robin, and Karen L. Schulman. 2004. *The State of Preschool: 2004 State Preschool Yearbook*. New Brunswick, N.J.: National Institute for Early Education Research.

Barnett, W. Steven, Cynthia Lamy, and Kwanghee Jung. December 2005. "The Effects of State Prekindergarten Programs on Young Children's School Readiness in Five States." New Brunswick, N.J.: National Institute for Early Education Research.

Barnett, W. Steven, and Masse, Leonard N. 2002. "A Benefit Cost Analysis of the Abecedarian Early Childhood Intervention." New Brunswick, N.J.: National Institute for Early Education Research.

Belfield, Clive R., Milagros Nores, and W. Steven Barnett. 2005. *The High/Scope Perry Pre-School Program Cost-Benefit Analysis*, *age 40*. Ypsilanti, Mich.: High/Scope Press.

Bernanke, Ben, and Refet S. Gürkaynak. 2001. "Is Growth Exogenous? Taking Mankiw, Romer and Weil Seriously." *NBER Macroeconomics Annual*, pp. 11–57.

Committee for Economic Development. 2002. "Preschool for All: Investing in a Productive and Just Society." Washington, D.C.: CED.

DeNavas-Walt, Carmen, Bernadette D. Proctor, and Robert J. Mills. 2004. *Income, Poverty, and Health Insurance Coverage in the United States: 2003*. Census Bureau.

Dension, Edward F. 1985. *Trends in American Economic Grown, 1929-1982*. Brookings.

Dickens, William T. and Charles Baschnagel, 2007 *Dynamic Estimates of the Fiscal Effects of Investing in Preschool Education*, The Brookings Institution, mimeo.

Gormley, Jr., William T., Ted Gayer, Deborah Phillips, and Brittany Dawson. 2005. "The Effects of Universal Pre-K on Cognitive Development." *Developmental Psychology* 41: 872–884.

Han, Wenjui and Jane Waldfogel, 2001. "Child Care Costs and Women's Employment: A Comparison of Single and Married Mothers With Pre-School-Aged Children." *Social Science Quarterly* 82: 552-568.

Heckman, James J. and Dmitriy V. Masterov. October 2004. "The Productivity Argument for Investing in Young Children." Working Paper 5, Invest in Kids Working Group, Committee for Economic Development.

Hoxby, Caroline M. April 2002. "School Choice and School Productivity (or Could School Choice be a Tide that Lifts all Boats?)" NBER working paper 8873.

Jorgenson, Dale W., Kevin J. Stiroh, Robert J. Gordon, and Daniel E. Sichel. 2000. "Raising the Speed Limit: U.S. Economic Growth in the Information Age." *Brookings Papers on Economic Activity*, no.1: 125–235.

Karoly, Lynn. A. and James H. Bigelow. 2005. "The Economics of Investing in Universal Preschool Education in California." Arlington, Va.: RAND Corporation.

Levenstein, P., Levenstein, S., Shiminski, J. A. & Stolzberg, J. E. (1998). Long-term impact of a verbal interaction program for at-risk toddlers: An exploratory study of high school outcomes in a replication of the mother-child home program. *Journal of Applied Developmental Psychology,* 267-286(19).

Lucas, Robert E. 1988. "On the Mechanics of Economic Development." *Journal of Monetary Economics* 22: 3–42.

Mankiw, N. Gregory, David Romer, and David N. Weil. 1992. "A Contribution to the Empirics of Economic Growth." *Quarterly Journal of Economics* 107 (May): 407–437.

Rolnick, Arthur, and Rob Grunewald. December 2003. "Early Childhood Development: Economic Development with a High Public Return." *The Region*. Federal Reserve Bank of Minneapolis.

Romer, Paul M. 1986. "Increasing Returns and Long-Run Growth." *Journal of Political Economy* 94 (October): 1002–1037.

——. 1987. "Growth Based on Increasing Returns Due to Specialization." *American Economic Review* 77, no. 2: 56–62.

Schweinhart, Lawrence J., Helen Barnes, and David P. Weikart, with W. Steven Barnett and Ann S. Epstein. 1993. *Significant Benefits: The High/Scope Perry Preschool Study Through Age 27*. Ypsilanti, Mich.: High/Scope Press.

Schweinhart, Lawrence J., Jeanne Montie, Zongping Xiang, W. Steven Barnett, Clive R. Belfield, and Milagros Nores. 2005. *Lifetime Effects: The High/Scope Perry Preschool Study Through Age 40*. Ypsilanti, Mich.: High/Scope Press.

Social Security Board of Trustees. March 2005. "The 2005 Annual Report of the Board of Trustees of the Federal Old-Age and Survivors Insurance and Disability Insurance Trust Funds." (www.ssa.gov/OACT/TR/TR05/I_intro.html#wp1000302).

Solow, Robert M. 1957. "Technical Change and the Aggregate Production Function." *Review of Economics and Statistics* 39 (August): 312–320.

U.S. Census Bureau. "U.S. Interim Projections by Age, Sex, Race, and Hispanic Origin: 2000-2050." (www.census.gov/ipc/www/usinterimproj [December 2005]).

U.S. Department of Commerce, Bureau of Economic Analysis. *National Income and Product Accounts*, various years. (www.bea.doc.gov/bea/dn/nipaweb/index.asp).

U.S. Department of Labor, Bureau of Labor Statistics. *Current Population Survey*, various years.

Uzawa, Hirofumi. 1965. "Optimum Technical Change in an Aggregative Model of Economic Growth." *International Economic Review* 6 (January):18–31.

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