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How many children? – Fixing total annual births as a population control policy

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Abstract. Traditional family planning's emphasis on manipulating the total fertility rate often results in erratic number of births which disrupts school enrollment and labor supply. Fixing total annual births to a permanently lower level will avoid such repeated disruptions and can eventually lead to a lower stationary population with annual deaths equal to the fixed annual births. If allocation of the fixed birth quotas is conditional upon deaths, each death can be converted to a variable number of inheritable and tradable birth quotas. Tradable birth coupons allow families to have the number of children they want and can afford within the overall fixed birth quotas. Inheritable birth quotas provide incentive for higher old-age mortality and consequently less aging in a declining population.

Keywords: Death-linked birth quotas, One-child policy, Population control, Stationary population, Total fertility rate

Ad hoc vs long-term goals in family planning

Most family planning programs have no specific goals regarding the number of children a child-bearing woman should have or the desired size of the stationary total population. This lack of specific goals may not seem to be important when the total fertility rate (i.e., lifetime births per fertile woman) is very high and the total population keeps increasing even when fertility is falling. The most pressing immediate concern is to reduce fertility as much as possible and worry about any possible adverse consequences later. But demographic cohorts stay with the population for a life time. Any poor planning now will lead to certain unwelcome consequences in the future.

Even where a specific goal regarding the ideal number of children a child-bearing woman exists, the number chosen is often limited by the family planners' imagination. For example, the chosen number is often a round number, such as one or two children. In addition, birth control is seldom linked to death control. In other words, family planning is solely concerned with how to reduce birth rates and seldom concerned with how birth rates interact with death rates to determine the population size. Very often, both birth rates and

old-age death rates are reduced. The results are excessive population aging and continual decline in school enrollment and labor supply.

May be the proper question is not how many children a child-bearing woman should have but how many total annual births are required to maintain a lower stationary population. Fixing total births at such a lower level will eventually lead to a lower stationary population with births equal to deaths if age specific mortality rates stay constant. And because total births are fixed over time, school enrollment and labor supply will not suffer repeated disruptions.

But how are the fixed annual births to be allocated among families and how can fixed births reduce population aging? China's 1990 population census data will be used to illustrate how linking deaths to the allocation of fixed births can reduce population aging and stabilize school enrollment and labor supply while achieving a lower stationary population.

Projecting one-child policy

China's one-child policy has reduced the total fertility rate (TFR) from 4 in 1970s to 2.2 in 1990. Suppose the goal of one-child policy is achieved overnight, what will happen to total births and the age structure of the population? Total births will fall sharply from 24 million in 1990 to 12 million in 1991 and continue to fall more gradually after that (Figure 1a). With lower entry into the working age from lower recent births, and higher entry into the old age from higher past births, the population will rapidly age as indicated by the old-age dependency ratio. In 1990, there were only 8 persons aged 65 and over for every 100 working age (15-64) persons. In 2020, there will be 19 persons aged 65 and over for every 100 persons in the working age. If the one-child policy is continued beyond that, the ratio will peak and stabilize at 46 per 100 (Figure 1b). And if the mortality rates of those aged 65 and over drop by 20% from the 1990 level, the old-age dependency ratio will peak and stabilize at 52 per 100 (not shown).

The horror story of an old-age dependency ratio of 52 per 100 is unlikely to happen, of course. To reach such extreme aging implies that the one-child policy is continued well into the latter part of the 21st century with the total population reduced to less than 400 million from the 1990 level of 1.1 billion.

Fixing total annual births

If, on the other hand, the total population is to be reduced to and stabilized at around only 845 million in the year 2110, the one-child policy need only

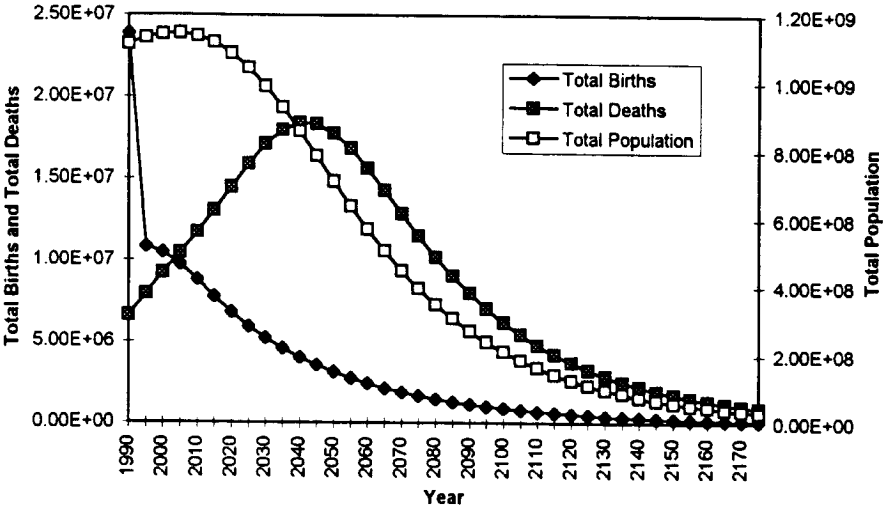

Figure 1a. Total population, births, and deaths under one-child policy. *Notes*: Total fertility rate = 1, 1990 mortality rates. *Source*: Tabulation on the 1990 population census of the People's Republic of China.

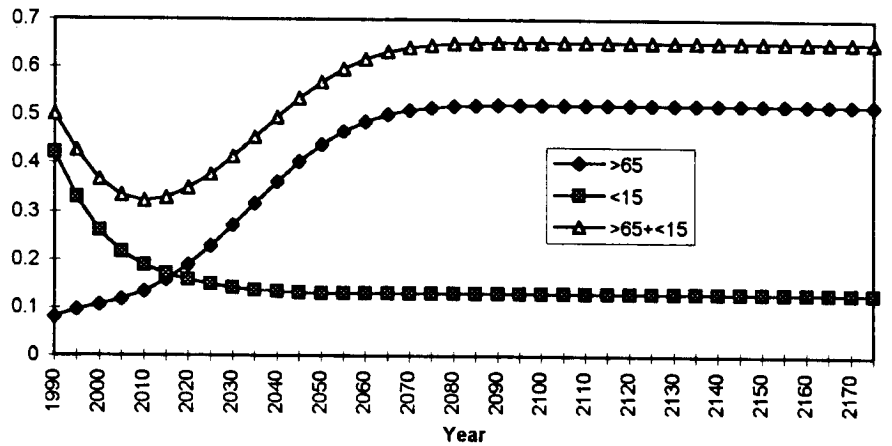

Figure 1b. Age dependency ratios under one-child policy. *Notes*: The denominators of age dependency ratios consist of people in the working age group (i.e., 15–64). *Source*: Tabulation on the 1990 population census of the People's Republic of China.

be continued to about 2015 (when total population falls back to the 1990 level). After that, a 2.17 children (i.e., replacement level of TFR) policy can be adopted. The old-age dependency ratio will reach a maximum of about 34 per 100 if old-age mortality stays at the 1990 level. But the large fluctuations of total births in the 60-year period between 1990 and 2050 will create un-

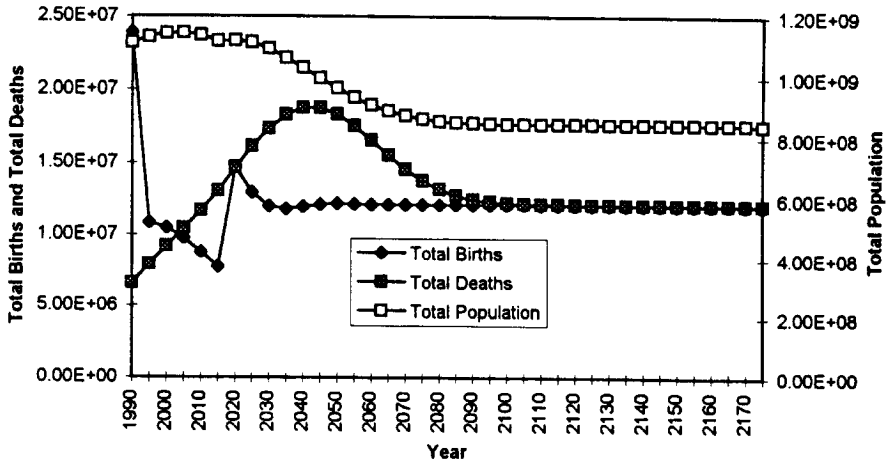

Figure 2a. Total population, births, and deaths under variable TFR's. *Notes*: Total fertility rate (TFR) = 1, until total population = 1990 level, then TFR = 2.17. 1990 mortality rates. *Source*: Tabulation on the 1990 population census of the People's Republic of China.

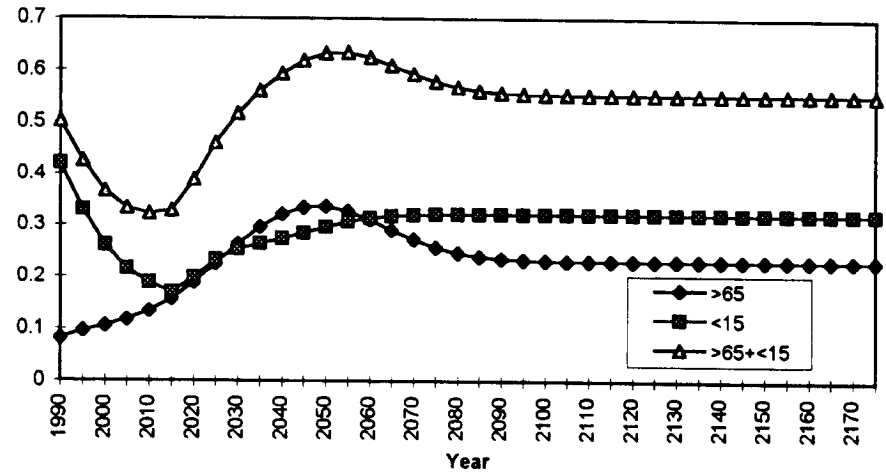

Figure 2b. Age dependency ratios under variable TFR's. *Notes*: Total fertility rate (TFR) = 1 until total population = 1990 level, then TFR = 2.17. 1990 mortality rates. The denominators of age dependency ratios consist of people in the working age group (i.e., 15–64). *Source*: Tabulation on the 1990 population census of the People's Republic of China.

necessary disruptions to school enrollment and labor supply (Figures 2a and 2b).

Such disruptions are entirely avoidable if total annual births are fixed. Suppose the one-child policy is 100 percent implemented from the 1990 population base, then annual births will be reduced from 24 million to about 12 million a year. If this birth number is maintained every year afterwards,

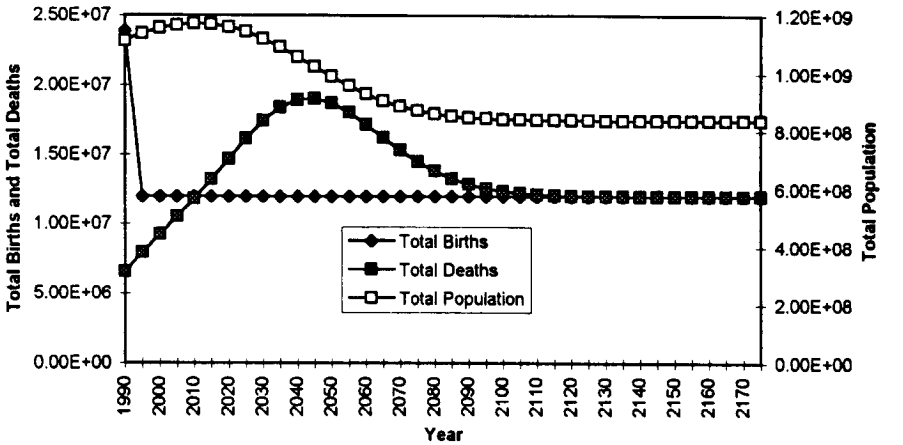

Figure 3a. Total population, births, and deaths under fixed births. *Notes*: 12 million annual births. 1990 mortality rates. *Source*: Tabulation on the 1990 population census of the People's Republic of China.

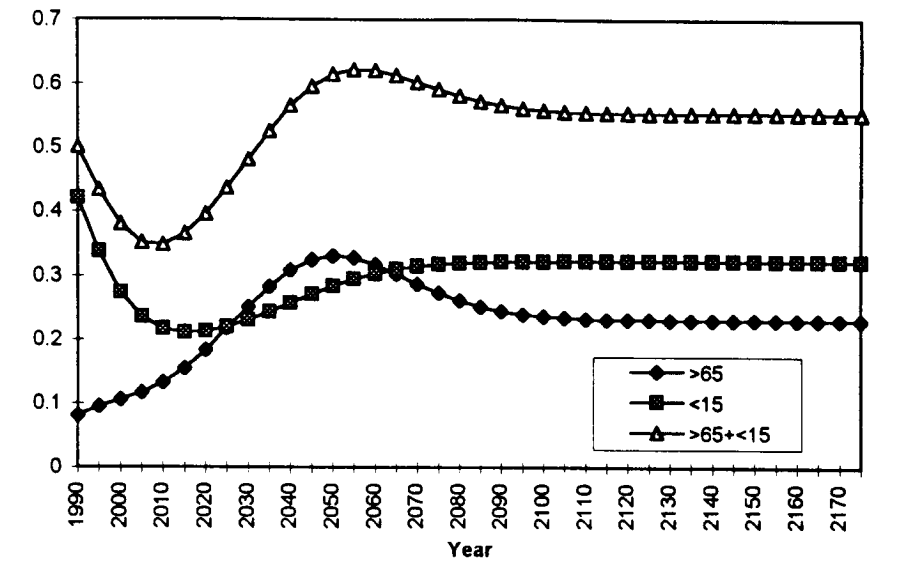

Figure 3b. Age dependency ratios under fixed births. *Notes*: 12 million annual births. 1990 mortality rates. *Source*: Tabulation on the 1990 population census of the People's Republic of China.

total population will eventually decline and stabilize at 837 million in 2120. At that level, the population will generate just enough annual deaths to offset the fixed annual births (Figure 3a). In addition, the old-age dependency ratio ($\geqslant$65/15–64) will never be more than 33 per 100 and will stabilize to 23 per 100 (Figure 3b). In other words, no higher than the old-age dependency ratios resulting from a combination of one-child and 2.17 children policy. And since annual births are constant, there will be no repeated disruptions in student enrollment and labor supply.

If a lower stationary total population is desired, the constant annual births can simply be set lower. For example, if annual births are pegged at 8 million, the total population will stabilize at 558 million. But the old-age dependency ratio will peak at a higher 42 per 100 and stabilize at 23 per 100 (not shown).

In general, to achieve a stationary population of a certain size, the annual birth quotas can be set equal to the projected annual deaths of the desired population (Cohen 1995: 156–157). Specifically, projected annual deaths = desired stationary population/average life expectancy. The fixed annual birth quotas thus set will at first be higher than the actual annual deaths. That means total population will continue to increase (though at a slower rate) for a while. As the current population ages, actual annual deaths will exceed the fixed annual birth quotas. Total population will decline to the stationary level when the actual annual deaths equal the fixed annual births (Figure 3a).

Linking deaths to fixed births

Fixing total births is a simple idea that must have occurred to many demographers. But allocating fixed birth quotas is not so simple. Assigning fixed annual birth quotas on a lifetime per woman basis is almost impossible. It would require continuous adjustment of the lifetime per woman birth quota and difficult behavioral adjustments on multiple parties as the total fertility rate (lifetime births per woman) first falls to 1 and gradually rises to 2.17 when total population stabilizes. But if the right to birth quotas is linked to deaths, both the allocation problem of quotas and the problem of excessive population aging can be managed.

Linking deaths to fixed birth quotas means that each death will trigger the issue of a certain amount of birth quotas. The number of deaths required for securing one birth quota is determined by the expected number of deaths in one year relative to the fixed annual birth quotas. For example, in 1991, each death would have been converted to 2 births because the annual deaths were only about half of the fixed births of 12 million (Figure 3a). On the other hand, when the total population finally stabilizes at 837 million in 2120, one

death will generate only one birth because expected annual deaths will be the same as the fixed births.

Linking deaths and births also serves to focus society's attention to the integral relationship between births and deaths in population control. Such a changed focus may induce higher mortality among the hopelessly ill (see *Dying for children?* below). More deaths in the population will, of course, reduce aging since most of the deaths come from the old-age groups. There is, however, no need to increase deaths to create the fixed number of annual births. Under a fixed-births regime, the number of birth quotas will stay the same regardless of the number of deaths. The number of deaths relative to the fixed birth quotas will affect only the conversion ratio of deaths into births.

Dying for children?

Linking births to deaths sets up an incentive for the hopelessly ill to seek earlier exits. The traditional neglect of mortality as a policy instrument has inadvertently encouraged the hopelessly ill to live as long as possible at any cost to themselves and to the rest of society. Indeed, early exits may be seen by the hopelessly ill as abandonment of their next of kin. If use-it-or-lose-it taxpayer-funded entitlements are available, early exits will also mean a loss of potential benefits.

When deaths and births are linked, a mutually beneficial exchange between the hopelessly ill and society can be set up. Specifically, in exchange for earlier exits, the hopelessly ill can now be given a painless physician-assisted death, a death benefit converted from any projected entitlements (Fung 1993: 275–288), and death-linked birth quotas. Since death benefit and death-linked birth quotas only benefit the beneficiaries of the deceased, earlier exits will be seen as an altruistic act. Any hopelessly ill person who refuses an earlier death would then be faced with these added tangible opportunity costs of staying painfully alive.

It is reasonable to expect that some hopelessly ill people may be willing to exit earlier in order to avail themselves of a painless physician-assisted death. There is evidence that some hopelessly ill Chinese do not want to hang on for dear life. For example, a study at an unidentified Chinese hospital found that 28% of 563 hopelessly-ill patients asked to have their lives ended (*Agence France Presse*, 28 October 1994).

There is also evidence some hopelessly ill may be attracted by the death benefit and death-linked birth quotas that they can pass on to their next of kin. The example of job inheritance (*dingti*) may be relevant here (Goldstein & Goldstein 1986: 188–189). Immediately after the Cultural Revolution (1966–1976) in China, fathers with secure jobs in state enterprises were allowed

to pass on their jobs to their children if they chose to retire early. Many fathers chose to do so since jobs were scarce. Giving up one's job may be quite different from giving up one's life. But some sociobiologists believe that humans are genetically capable of giving up their lives to ensure the survival of close relatives who share their genes (Wilson 1978). Even those who don't believe in the existence of an altruistic gene think that altruism can be induced by social conditioning or peer pressure. Death benefits and death-linked birth quotas will simply reinforce such inducements.

To arrange these tradeoffs between the hopelessly ill and society, it is necessary to legalize physician-assisted deaths. Linking deaths to births can strengthen society's support for legalized physician-assisted deaths. Already, a survey of 500 people in Beijing found 79.8% favored mercy killing (*Agence France Presse*, 28 October 1994).

A market for birth quotas

If birth quotas can be obtained only by deaths of members in the same family, covert or overt pressure on the hopelessly ill or even the healthy old might become oppressive. But if birth quotas can be traded in the free market, there is no need for births to coincide with deaths in the same family. Most births can be licensed with bought rather than inherited birth quotas.

Since one death does not usually convert into one birth except when the stationary population level is reached, birth coupons can be more conveniently traded in denominations representing fractions of a birth. For example, one coupon may represent one-tenth of a child (cf., Boulding 1964: 135–136). In addition, to prevent hoarding of coupons over an extended period of time, each coupon will carry an expiration date. A redemption period of about 12 months should give enough time for holders to plan their pregnancy and smooth out any seasonal fluctuations in the issue of coupons in response to deaths (see *Redemption of birth quota coupons* below).

At first sight, one might think that there will be few sellers of birth coupons since the fixed birth quotas allow less than two children per fertile woman initially. But the following people can be reasonably expected to sell their inherited birth quotas instead of using them: (a) couples who already have enough children; (b) singles who can't use the quota; (c) couples who can use the quota but have inherited more than enough within the same or overlapping redemption period; (d) couples who are not yet ready to have children; (e) couples who have less than a full birth quota but cannot yet afford to buy enough coupons to make up for a full quota; (f) couples who don't want to have any children; (g) people who are not biologically ready to have children.

In addition to the benefits of time shifting, a market for transferable and salable birth quotas allows families who love and can afford more children to have more than one child. This flexibility can potentially avoid some serious adverse social and reproductive consequences that are already evident from a uniform one-child policy. For example, single children are likely to be spoiled by excessive love and protection (*Agence France Presse*, 6 July 1994). And parental preference for boys often has led to selective abortion of female fetuses (*New York Times*, 16 August 1994).

A market for birth quotas is also needed to ensure that all birth coupons are redeemed. If birth quotas are not tradable, many birth coupons may simply be left unredeemed at the expiration date. The goal of constant annual births will be under-fulfilled. With a market value, coupons left unredeemed will mean a loss of potential income. Indeed, in a well organized market, this potential loss of value will be reflected in the declining price of birth coupons as their expiration dates are neared. Thus, a pregnant woman holding coupons with different expiration dates could be expected to exchange for a profit those coupons with expiration dates beyond the expected birthday of the fetus for those coupons that coincide with the birthday.

Since hoarding is limited by the short redemption period and one woman cannot redeem more than one full-child coupon over a nine to twelve month period, the free market price for coupons is not expected to be high. If it becomes unaffordable to the average family, interest-free loans can be arranged by birth-quota banks for at least one child per woman. These loans can be repaid in the form of inherited birth quotas. These banks can also accept donations of birth quotas from deceased with no relatives or other beneficiaries and give the donated birth quotas to hardship cases for free.

To prevent large families from perpetuating their numerical advantage using inherited birth quotas from their more numerous relatives, a progressive tax on inherited birth quotas above two children can be imposed. The tax revenues can then be used to fund the birth-quota banks.

Redemption of birth quota coupons

Limiting the annual issue of birth coupons to 12 million births is not difficult if the actual number of deaths is close to the expected number of deaths. A births/deaths conversion ratio can be established at the beginning of the year based on the fixed birth quotas and the expected number of deaths in that year. The number of one-child birth coupons issued for one death will be given by the births/deaths conversion ratio. These coupons carry different expiration dates depending on when they are issued. Holders of these coupons can redeem them on or before their expiration dates. Since births happen

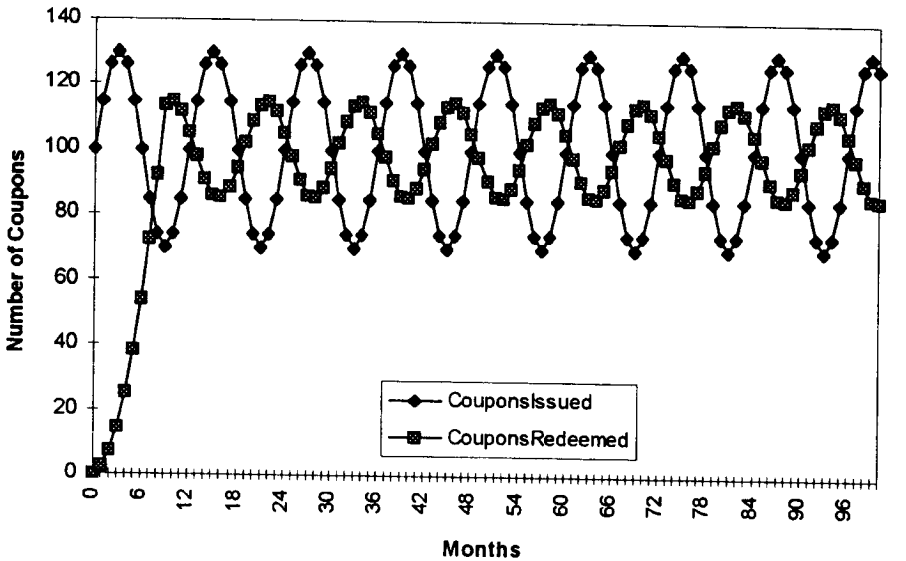

Figure 4. Birth coupons issue and redemption patterns. *Notes*: Coupons issued is simulated by sinwave (30, 12) with initial value of 100. Nine months expiration period. Linearly increasing redemption rates from date of issue.

about nine months after conception, the conception date can be considered to be the redemption date. If holders of coupons tend to redeem them just before they expire, how can we be sure that the number of coupons redeemed in a year is in fact equal to 12 million births and that redemption will not be bunched up at certain time of the year?

Let us assume that deaths are uniformly distributed throughout the year and holders of coupons have a tendency to redeem most of their coupons close to their expiration dates. Computer simulations show that after an initial period of adjustment, the monthly redemption will equal the monthly issue of coupons regardless of how long the redemption period. If deaths are not uniformly distributed but have a consistent seasonal pattern and redemption is backend-loaded, the redemption pattern will simply echo the issue pattern with a delay. The length of delay varies with the length of the redemption period. The shorter the redemption period, the shorter the delay of the redemption echo. Regardless of the redemption period, the amplitude of the seasonal fluctuations in redemption will be smaller than that in issue (Figure 4). But annual total redemption will still be equal to total issue. There is no collective bunching of redemption in any of these scenarios other than an echoing of the seasonal distribution of issue some months earlier.

These seemingly surprising results are quite understandable. In any one month, most of the coupons redeemed tend to be those issued 11 or 12 months

ago, assuming procrastination and a redemption period of 12 months. But the rest would come from those issued less than 11 months ago. If a large number of coupons were issued 12 months ago, a lot of coupons would be redeemed 12 months later. If a small number of coupons were issued 12 months ago, a small number of coupons would be redeemed 12 months later. But because of the moderating effects from redeemed coupons issued less than 11 months ago, peaks and troughs of redemption are less pronounced than those of issue. Thus, individual procrastination explains why fluctuations in redemption simply reflect those in issue, and does not introduce additional collective bunching. If individuals do not procrastinate and redeem coupons uniformly throughout the redemption period, any fluctuations in issue would be completely smoothed out in redemption (not shown).

A fertility revolution

Fixing births vs fixing TFRs. Traditional methods to control population try to reduce births by reducing the total fertility rate (TFR). For example, if the average number of births per fertile woman is limited to 2.17 from a currently higher level, total population will eventually reach a stationary level with annual births equal to annual deaths. But before the stationary population is reached, annual births will continuously decline and the stationary population will still be higher than the current population. In other words, fixing the TFR to stabilize total population turns annual births and total population into residual variables that cannot be directly controlled. On the other hand, fixing annual births can directly target a lower level of stationary population. The TFR then becomes a residual variable that need not concern policy makers. For example, if the annual births are fixed at 12 million, the TFR will fall from 2.2 in 1990 to 1, and gradually rise to 2.17 as the total population stabilizes at a lower level that generates deaths equal to the fixed births. It would be an endless nightmare if family planners had to constantly adjust their birth-limit advice to fertile women.

Even if the ultimate lower stationary population is to be achieved through a number of successively lower fixed annual births instead of a one-step downward adjustment of annual births, there is still no need to get bogged down with changing birth-limit advice. Instead, only the births/deaths conversion ratio needs to be adjusted. And this adjustment will be conveyed to fertile women through a change in the market price for birth coupons.

In addition to administrative simplicity, fixing annual births also has much needed social benefits compared to one-child policy. Because life-time one-child birth quotas under the one-child policy are not transferable, the right to birth quotas is based on the use-it-or-lose-it principle. If a child-bearing

woman does not use it, that quota cannot benefit anybody else. This arrangement leads to uniform one-child families with adverse social and reproductive consequences. For example, single children are likely to be spoiled by excessive love and protection (*Agence France Presse*, 6 July 1994). And parental preference for boys often has led to selective abortion of female fetuses (*New York Times*, 16 August 1994). Such adverse impact can be largely avoided if the annual birth quotas are freely transferable by sale or gift. People who don't want children can sell or give their birth quotas away. Couples who want more children are not limited to a single child as long as they can round up enough quotas.

Enforcing birth quotas. If voluntary birth control methods are used to enforce fixed birth quotas, the enforcement costs are likely to be very high. Too many abortions may have to be done to eliminate unlicensed pregnancies. And unlicensed pregnancies must be detected before they progress too far for safe abortion. Teenage pregnancies can be a particularly serious problem because teenagers are not experienced in preventing pregnancies. Even before the one-child policy was fully implemented, up to 46% of married women in surveys conducted in Shanghai in 1987 and 1990 had had at least one abortion. More than one-third of those who had abortions had at least two (*US News & World Report*, 19 September 1994). If the fixed birth quotas amounted strictly to one child per couple initially, abortions would have to be more frequent.

To reduce enforcement costs, some means of birth control must be found that can deactivate the reproductive ability of all fertile females. Their reproductive ability will be activated only if a proper birth quota is produced, and will be deactivated once the baby is born. Current birth control methods are not suitable for such universal application. First, they must be applied on a regular basis to maintain effectiveness. Second, they require regular cooperation from recipients. Third, they sometimes produce undesirable side effects. Ideally, a universally applicable birth control method would behave like a reversible anti-sperm vaccine with long-lasting effect (*Business Week*, 31 July 1995: 87). Using vaccines to induce immune responses is a tried and true method and should be generally acceptable to the population.

Such a vaccine and anti-vaccine could of course be applied to fertile males only. But the enforcement costs would be much higher. Men with activated reproductive ability can impregnate more than the intended women and they have to be specially called in for deactivation as soon as they have successfully performed their reproductive duties. Such uncertainty can result in unnecessary pregnancies and abortions.

Transition costs to a stationary population

Anybody who has tried to negotiate their way through a crowded Chinese city almost at any time of the day knows that China has an over-population problem. Workers have to take different days off just to avoid absolute congestion. Queues are everywhere. So the question is not whether total population should be reduced but how and how fast.

The matter of how and how fast to reduce total population is, of course, significantly affected by the cost of demographic transition.

- First, the cost of foregone output. Since China has a serious underemployment and unemployment problem, there is no general under-supply of labor (see *Equity issues* below). Thus, the opportunity cost (in terms of foregone national output) of foregone births is very low or may even be negative.
- Second, the cost of capital under-utilization. The generally crowded and under-equipped schools, housing units, medical clinics, and hospitals can certainly use the relief that will be provided by a lower level of annual births.
- Third, the cost of old-age dependency. Reducing births will inevitably increase the old-age dependency ratio. The lower the births, the higher the old-age dependency ratio. If the desired stationary population is much lower than the current population, the acute cost impact of old-age dependency can be moderated by phasing in lower births through a number of successively lower annual birth quotas. If linking births to deaths can indirectly shorten the process of dying, the cost of old-age dependency can also be reduced. And because there is little tax-payer funded retirement and health-care entitlements in China, the burden of population aging on the national budget is minimal.
- Fourth, the cost of kinship truncation. Because one-child policy prunes off too many kinship branches, only very desperately crowded countries would pursue such a demographic transition. On the other hand, two-child policy might take too long to achieve the desired lower population size. If a faster decline of total population is desired, fractional birth-limit per family will be necessary. Unfortunately, any birth-limit per family below 2.17 will not lead to a stationary population but a continuously declining population. So, the simplest way to achieve a lower stationary population without serious kinship truncation and without constantly tempering with birth-limit per family is to fix the annual births and convert deaths into tradable birth quotas. Tradable birth quotas at least allow some families to have full kinship branches. The cost of kinship truncation in China due to the one-child policy has been so high that any

flexibility to the use-it-or-lose-it per family birth-limit policy will result in an unqualified cost reduction.

In view of these uniquely low costs of demographic transition, China has a rare golden opportunity to remedy its rampant population growth in the last 7 decades.

Equity issues

Will the rich have all the babies? Unlike the one-child policy which gives the right to one child to each fertile woman, death-linked birth quotas are allocated upon each death. That means each person, whether married or not, has equal right to pass on births. So death-linked birth quotas are more egalitarian than lifetime birth quotas per woman. However, if inherited birth quotas were all used up by their holders, the absolute numerical advantage of large families would be perpetuated. But because inherited birth quotas are subject to progressive taxation above 2 children, the growth rate of large families will be lower than those with fewer inherited birth quotas. So the relative numerical advantage of large families will not increase.

Since bought birth quotas may be expensive to some families, only those who value children most and can afford them will have more children than their inherited birth quotas allow. So an element of efficiency is injected into the allocation of births. This market discipline will prevent structural shift of population towards the less well off but more fertile. In China, as elsewhere, fertility rates are not uniform across the country, or across income and ethnic groups. For example, the one-child policy is more thoroughly implemented in urban than rural areas. Minority nationals are more or less exempt from the one-child policy (*US News & World Report*, 19 September 1994). Because rural population and minority nationals are less well off and less educated, higher fertility among them can, over time, lead to unacceptable deterioration in the quality of human capital. Faster growth among ethnic minorities may also be politically explosive.

With fixed annual birth quotas, such unwelcome structural shifts in population compositions can be largely avoided. Rural population can expand only if they buy birth quotas from urban areas. And minority nationals can expand only by buying birth quotas from the majority population. Since rural population and minority nationals are less well off, it is unlikely they will gain much, if any, population.

But, if the less well off are not going to grow in their relative share, will their share shrink because they cannot afford to keep their birth quotas from the urban rich? Because children are highly valued in China across all income

groups, it is not likely that the less well off will give up much, if any, of their birth quotas. This is especially true because the birth quotas of 12 million are only half of the 1990 births. Any buying or selling of birth quotas is likely to be for the purpose of time shifting.

Will the poor get richer? In many countries, poverty interacts with high fertility in some sort of a downward spiral. In other words, high fertility perpetuates poverty because of insufficient human capital investment. Poverty in turn leads to high fertility because of cultural and economic reasons. Whatever the reasons for high fertility may be, the collective result of every poor family having more children is a tragedy of the commons. The collective lot of the poor will be improved only if they all reduce fertility to a manageable level. Birth quotas may initially lead to hardship because labor for subsistence production will be scarcer. But greater human capital investment on fewer children will eventually lift the poor out of poverty.

Personal liberty

Universal vaccination of fertile women may appear to unduly infringe on women's personal liberty. But it is much less intrusive than the current system of birth control in China. Currently, women of child-bearing age who have not been sterilized are under constant surveillance of the family planning police. They are regularly reminded by the neighborhood family-planning grannies of the importance of having only one child. Their menstrual cycles are carefully observed for signs of unapproved pregnancy. If pregnancies are not detected in time, the pregnant women have to be coerced into having late-term abortions.

Under universal vaccination, there is no need for an army of family-planning police because vaccinated women cannot become pregnant until their vaccination is neutralized. Without the fear of accidental pregnancy, married women can probably have a more fulfilling sex life.

Without the fear of accidental pregnancy, unmarried people also have more freedom to explore their sexuality. Unmarried people would refrain from sex only out of personal responsibility. Sexually transmitted diseases must, of course, still be controlled through other preventive measures.

Summary and conclusion

Fixing births rather than tinkering with the total fertility rate offers a direct way to achieve a desirable level of stationary population. Once a permanently

lower number of births is set, total population will eventually decline to a stationary level that generates an equal number of deaths. Although the total fertility rate will first fall below the replacement level of 2.17 children per fertile woman and then gradually rise to 2.17, family planners need not be concerned with constantly changing birth-limit advice any more.

Instead, family planners can simply set a births/deaths conversion ratio to allocate the constant annual birth quotas to families with deaths. This ratio will change depending on the actual number of annual deaths relative to the fixed annual birth quotas. If these birth quotas are tradable, the resulting scarcity due to the changing births/deaths conversion ratio will be reflected in the market price for birth quotas. Families can then choose the number of children they want to have by buying or selling birth coupons.

Because birth quotas are inheritable, they may also provide incentive for higher old-age mortality and consequently less population aging as total population declines to the stationary level.

Constant births also mean predictable school enrollment and labor supply, and moderating cycles of capital shortage and surplus.

Appendix: Technical notes on population simulations

Simulations are based on the 1990 Population Census of the People's Republic of China. Population is divided into 5-year age cohorts except for the 90 and above age group. At the end of every year, one-fifth of the survivors from a lower age cohort will advance to the next higher age cohorts. The number of survivors is simply the product of (1 – cohort mortality rates) and the cohort population at the beginning of the year. The 0–4 cohort is augmented by annual births. The 90 and above cohort does not age but simply die. The total fertility rate (TFR) is computed by summing the age-specific fertility rates and then multiplying the total by 5/1000. When the TFR is assumed to be different than the 1990 level, each of the 1990 age-specific fertility rates are simply multiplied by a factor that would produce the desired TFR using the above-mentioned formula.

Simulation was first performed with the help of a computer simulation software called Powersim. Powersim, and other similar competitive products, simplifies modeling via a diagram interface. The links among included variables are first sketched out in a diagram and then their functional relationships mathematically defined. Once the model is set up, computer simulation simply takes away the drudgery of numerous repeated calculations based on the same basic assumptions and functional relationships.

The fact that a constant inflow of water to a reservoir with an outflow which is a constant fraction of the water stock will result in an equilibrium

level of stored water is well known to system dynamics model builders. Its application to population control is perhaps new. The author discovered it by chance since it is the easiest way to model population inflow for someone who just started learning system dynamics modeling. In population control, the constant inflow is of course the fixed annual birth quotas. The reservoir is the total population. And the constant fraction of outflow is the cohort mortality rates reported in 1990 Chinese population census.

Although Powersim generates spreadsheets, it has limited charting capability compared to Microsoft Excel. An expert Excel user, Simon Edkins, whom I "met" in the internet Excel newsgroup, kindly offered to model the simulation in Excel. Figures 1–3 are based on his Excel simulation model.

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