Does Being Different Matter?

Finn E. Kydland
Professor
Carnegie Mellon University
and
Research Associate
Federal Reserve Bank of Dallas

D'Ann M. Petersen
Economist
Federal Reserve Bank of Dallas

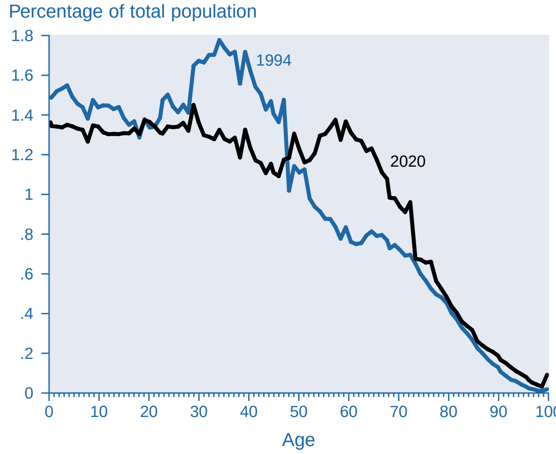
In this article, we outline a general framework appropriate for addressing most quantitative macroeconomic issues.…The research we highlight examines an aging population's impact on savings and/or interest rates and the quantitative impact of immigration policy on savings rates and fiscal policy.

One does not have to look far to notice that, in the real world, people are different. Individuals are of different ages and may have different attributes, such as varying educational achievements or on-the-job skills. There are many real-world examples of why individual differences may matter for economic policy. Some of these examples are related to demographic issues, such as how a population that is getting proportionally older will influence future savings and interest rates or increase the possibility of higher tax burdens for future workers. (See Figure 1 for an illustration of how the population distribution is expected to change.) Another example in which individual differences matter is the question of immigration's impact on society and whether immigrants will reduce the need for higher taxes or increase the burden on the government.

Economists have long conjectured that the best answers to such questions come from models that are inhabited by people—because people make decisions that have implications for the actual economy. Only recently have economists been able to compute the outcomes of models with large numbers of individuals at every stage of the life cycle. Before the 1990s and high-speed computers, solving such models was computationally infeasible. Nevertheless, economists found that they could abstract from life-cycle differences and still get reliable answers to many macroeconomic questions, especially those relating to growth and business cycles.

In this article, we outline a general framework appropriate for addressing most quantitative macroeconomic issues. This approach

Figure 1
Age Distribution of the U.S. Population, 1994 and 2020



SOURCE: U.S. Census Bureau.

requires building artificial economies that replicate (to the degree needed) actual economies, with many mortal individuals making decisions over their lifetimes. Such a framework is ideal for addressing questions in which demographics are at the heart of the issue, and it is presented in the first section of the article.

We next introduce a special case of our general framework that abstracts from life-cycle differences, an assumption that makes solving the model computationally much easier. Economists have found such a framework useful for addressing growth and business-cycle issues for which life-cycle behavior is not essential. The section also discusses how such a framework can be used to incorporate some individual differences—such as skill differences—into the model without adding much computational difficulty.

The final section of this article showcases examples of current work that addresses questions for which life-cycle differences matter. The examples illustrate the type of policy-relevant questions that can be addressed using the mortal consumer framework presented in the first section. In particular, the research we highlight examines an aging population's impact on savings and/or interest rates and the quantitative impact of immigration policy on savings rates and fiscal policy.

The macroeconomist's tool kit

In 1980, Robert Lucas (the 1995 Nobel Prize recipient in economics) described the type of model framework he believes might best serve economists addressing macroeconomic questions. He states, "One of the functions of theoretical economics is to provide fully articulated, artificial economic systems that can serve as laboratories in which policies that would be prohibitively expensive to experiment with in actual economies can be tested out at much lower cost…(Lucas 1980, 696). Our task as I see it…is to write a FORTRAN program that will accept specific economic policy rules as 'input' and will generate as 'output' statistics describing the operating characteristics of time series we care about, which are predicted to result from these policies" (709–10). The desired environments Lucas refers to would make use of information on "*individual* responses [that] can be documented relatively cheaply...by means of …censuses, panels [and] other surveys…" (710). Lucas seems to suggest that economic researchers place people in desired model environments and record how they behave under alternative policy rules.

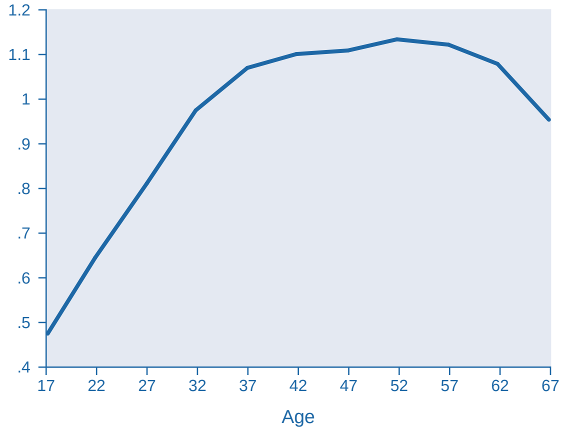
In practice, Lucas' suggestion is easier said than done. All economic models are concerned with the allocation of scarce resources. Accordingly, these models must include a specification of tastes (giving the rate at which people are willing to sacrifice one good in exchange for another) and a specification of technology (giving the rate at which one or more goods can be physically transformed into others).

In our model, the goods are household activity (time) and output. These goods can either be consumed by households (as leisure and consumption) or used (as labor and capital) to produce more output. Tastes are represented by a utility function that depends on the quantities of leisure and output consumed now and in the future. Technology is represented by a production function that gives output as a function of labor and capital. Moreover, it is assumed that goods are allocated across different uses through markets: each good has a market price at which it can be exchanged for other goods. Finally, the economy is assumed to be competitive: households take prices as given as they try to maximize their utility. Details of this model economy (which we call Economy 1) are given in the box entitled "Economy 1: A General Macroeconomic Framework."

An important aspect of Economy 1 is that each individual's decisions about the present are based on expectations about the future. This is especially important when it comes to the consumption–saving decision. For instance, most people receive income from both labor and assets over their lifetime. The individual decides how much to consume now and how much to consume later. The typical hump-shaped lifetime labor earnings profile (a product of the lifetime profile of hourly wages and the lifetime profile of annual hours worked shown in Figures 2 and 3, respectively), combined with a desire for a much less variable consumption path, leads an individual to dissave (or borrow) in the early years, save around the peak of earnings, and finally dissave while approaching and entering retirement.

Computing the aggregate decisions of Economy 1 is complicated for several reasons. First, the economy at each time t includes people at every stage of the life cycle. Second, as indicated above, the market-clearing interest rate depends on the aggregate of capital accumulated up until period t, and the market-clearing wage depends on the aggregate of labor input. The consumption–saving decision depends on each individual's expectations of future asset returns, or real interest rates, influenced by the aggre-

Figure 2
Life-Cycle Wage Profile
(Normalized to 1 on average)



SOURCE: Kjetil Storesletten, Institute for International Economic Studies, Stockholm University.

gate of savings decisions up until that time. With all these considerations, solving such a model is difficult, especially when a lifetime consists of many periods (meaning I is large) and there is uncertainty. Indeed, this task was almost infeasible before the 1990s, given the computational capacity of computers. With today's computers, however, if we define the functional forms for the utility and production functions, and assign values to the parameters and probability distributions to the random shocks, this model economy can be used for computational experiments of the kind Lucas envisioned in 1980.

Calibration. In a sense, model economies, like thermometers, are measuring devices and must be calibrated to provide reliable numerical answers. Some economic questions have known answers (just as we know what the thermometer should read when dipped in boiling water and in ice water), and the model should give an approximately correct answer to them. Thus, economists can use data to calibrate the model economy so that it mimics the world as closely as possible along a limited, but clearly specified, number of dimensions. This way, one will have more confidence in the model's answer to the question for which it was designed. Of course, economic systems are different from models used in the physical sciences, where calibration is commonplace. Economic models are inhabited by people who anticipate and make decisions that are in their ex ante best interest, given that other model people are equally rational. However, in spite of this difference between physical and economic models, the same principle applies: we have more confidence in the answer to the question posed if the model gives correct answers to questions for which we already know the answer.

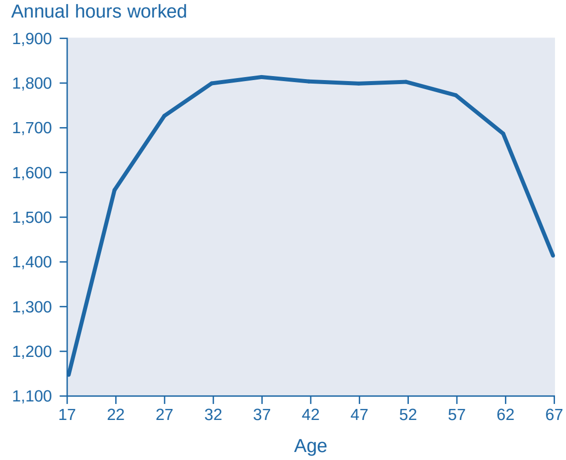
Part of the task of calibration involves merely computing averages of relations among aggregate data series. For example, if the standard Cobb–Douglas production function is used to describe the technology of the business sector in Economy 1—that is, we let $F(N,K) = N^{\theta}K^{1-\theta}$—then the model's average labor share of aggregate national income equals θ. Thus, the parameter θ can be quantified by computing the average labor income as a percentage of GDP over a period of years.

Because model economies are populated by people, another source of calibration is averages across large numbers of the relevant people in the actual economy. For instance, Economy 1 employs a utility function in consumption and leisure, which like the production function mentioned above, is usually specified with a share parameter. The empirical counterpart to this parameter is households' average fraction of time spent in labor market activity. This fraction can be obtained from panel data covering large samples of individuals, such as the Current Population Survey conducted by the Census Bureau. Moreover, the empirical shape of the e_i's, describing the hump-shaped lifetime earnings profile, can be estimated from panel data.

A realistic approach: Immortal consumers

Because computing detailed models inhabited by people at different stages of the life cycle, as in Economy 1, is difficult, researchers aiming for quantitative answers were initially forced to scale down the ambition level of the

Figure 3
Life-Cycle Profile of Hours Worked
Annual hours worked



SOURCE: Kjetil Storesletten, Institute for International Economic Studies, Stockholm University.

questions addressed. In particular, researchers attacked those questions for which certain simplifying assumptions were likely to do little harm to the answers. Especially effective in reducing the computational burden of such detailed models was the assumption that everyone is alike and lives forever—immortal consumers.

When considering long-run growth, life-cycle behavior may not be among the most important contributing factors. Similarly, economists conjectured that heterogeneity and/or life-cycle behavior was not a big deal in answering many business-cycle questions, such as how much of postwar business cycles is accounted for by technology shocks.[1] Thus emerged the neoclassical growth model as a common framework for addressing growth and business-cycle questions.

Consider a basic neoclassical growth model framework with representative agents, which we call Economy 2. This framework is a special case of Economy 1. The difference is that in the representative agent framework, I equals infinity (that is, immortal consumers) and there are no hump-shaped earnings patterns (that is, all e_i's in Economy 1 are set equal to one). In such a framework (with no externalities) it turns out that the equilibrium can be computed by solving the optimization problem of a fictitious social planner, whose objective function corresponds to the utility function of the typical individual:

$$E\sum_{t=0}^{\infty}\beta^t u(C_t, 1-N_t),$$

subject to constraints B.1 and B.2. This property dramatically reduces the dimension of the problem and saves a lot of computational detail, thereby allowing the economist to solve the model with much less difficulty.

This class of models—which obviously abstracts from life-cycle behavior—still has an important role for saving behavior. In a business-cycle model, the impetus is cyclical income volatility rather than life-cycle movements in income. Such saving behavior may occur as individuals attempt to smooth their consumption over time even as income fluctuates, thereby causing individuals to adjust the amounts they save over different business-cycle episodes.

Furthermore, the framework's simplicity makes it relatively easy to introduce additional bells and whistles that are more crucial than heterogeneity.[2] More important for business-cycle questions may be the fact that it takes many quarters to build new productive capital, with newly produced investment goods being allocated to its construction throughout the building period. We can also introduce a role for inventories or allow for increasing worker productivity through on-the-job learning. The interaction of household and market production can be included in the framework.[3]

The introduction of individual differences in a business-cycle framework. Abstracting from life-cycle behavior apparently does not hurt the success of the representative agent model in answering many business-cycle questions, but completely abandoning heterogeneity does prove problematic along at least one dimension. While the early business-cycle models with technology shocks as the main source of fluctuation display considerable similarity between movements of time series such as consumption, investment,

Economy 1: A General Macroeconomic Framework

This model economy attempts to capture the most important economic decisions over individuals' lifetimes. Such an economy would be inhabited by many generations of individuals who live for I periods (where I could correspond to an economic lifetime of about sixty years). People born in period t attempt to maximize the expected value (denoted by E) of a utility function of the form

$$E\sum_{i=1}^{I}\beta^{i-1}u(c_{i,t+i-1}, 1-n_{i,t+i-1}),$$

subject to a budget constraint in every period:

$$R_{t+i-1}a_{i,t+i-1} + W_{t+i-1}e_i n_{i,t+i-1} = c_{i,t+i-1} + a_{i,t+i}, \qquad i = 1,\ldots,I,$$

where c_i is consumption, n_i is market work and $1 - n_i$ is leisure, and a_i is asset holdings, all at age i; R is the gross rate of return on assets; W is price per unit of labor input; and e_i is the person's efficiency in production. Thus, We_i represents the real wage per time unit. Possible additional restrictions are that $a_{1t} = 0$ and $a_{I,t+I} \geq 0$. The maximization is over the lifetime sequences of c_i's and n_i's, and β denotes a discount factor (implied by the utility rate of time preference) for comparing the utility of future outcomes to that of the present.

The individuals in this economy cannot ignore what occurs in the rest of the economy because present and future asset returns (R) and wage rates (W), while taken as given by each individual, are determined by the aggregate of all individuals' decisions. With μ_i people in each generation i, suppose aggregate output is produced according to the production function $z_t F(N_t, K_t)$, where z is the technology level and the arguments represent aggregate labor and capital inputs, which in this case are

$$N_t = \sum_{i=1}^{I}\mu_i e_i n_{it} \text{ and } K_t = \sum_{i=1}^{I}\mu_i a_{it}.$$

Then in equilibrium, asset returns R and labor-input compensation W will be determined by the marginal products of capital and labor, respectively. Also, letting $C_t = \sum_i \mu_i c_{it}$, the following aggregate feasibility constraint must be satisfied:

$$\text{(B.1)} \qquad C_t + K_{t+1} \leq z_t F(N_t, K_t) + (1-\delta)K_t,$$

where δ is the capital's depreciation rate.

A source of uncertainty in this model could be the technology level, whose movement over time could be described by

$$\text{(B.2)} \qquad z_{t+1} = \rho z_t + \epsilon_{t+1}.$$

The random disturbance to the technology, ϵ, has a positive mean and variance σ^2. Another stochastic element in this economy could be the number of newborns, μ_1, in every period.

Table 1
Indicators of Skill Versus Hours Worked

	Wage groups				
	1	2	3	4	5
Hourly real wage	1.48	2.37	3.28	4.46	7.24
Annual hours worked	1,112	1,556	1,795	1,920	2,009
Standard deviation of hours worked	579	529	479	415	341
Years of education	11.18	11.97	12.73	13.00	14.30

NOTE: The table contains averages across individuals and is based on data from the Panel Study of Income Dynamics for the period 1969–82. Each individual is grouped by average real wage over the sample period. The brackets used for each wage group are 0 to 2, 2 to 2.8, 2.8 to 3.8, 3.8 to 5.3, and 5.3 and over, in 1969 U.S. dollars. Ríos-Rull chose these boundaries because they result in similar numbers of people per bracket.

SOURCE: Ríos-Rull (1993, 896).

GDP, inventory holdings, and capital stock and the corresponding ones in the data, the behavior of one key variable—hours of work—appears somewhat anomalous. The hours volatility in the data is substantially greater than the standard business-cycle model would imply. Because the hours of high-skill workers generally fluctuate much less than those of low-skill workers, it is reasonable to think that this may account for a large portion of the difference in the actual and model-produced labor-input series. An obvious way, then, to try to resolve the issue of the labor-input anomaly is to modify the model to include some heterogeneity in the form of multiple skills.

Computational problems in dealing with certain dimensions of heterogeneity relevant to such business-cycle issues have been relatively easy to deal with. For example, Kydland (1984) constructs a business-cycle model with two equal-sized groups of high- and low-skill workers, each calibrated to be as skilled in market production as the respective counterpart in the data when workers are ranked by efficiency and divided into two groups.[4] Moreover, the average hours per period match actual observations—that is, the high-skill workers on the average work more hours to an extent corresponding to actual data. The finding is that the model's volatility of aggregate hours, given volatility of technology, increases substantially when skill differences are taken into account. This simple way of introducing heterogeneity into the model still allows the equilibrium to be solved as a fictitious planner's problem.

Kydland's modeling strategy allows for only a limited number of distinct skills, while one could argue that, in the actual economy, there are as many skill levels as there are workers. Table 1 illustrates differences across workers when they are divided into five groups according to average wage rates. The workers differ both because they are at different stages of the life cycle (as represented by their hump-shaped e_i's in Economy 1) and because each age group consists of workers whose abilities differ due to differences in schooling, training, experience, inherent talent for market work, and a host of other reasons. This means that the entire schedule of e_i's is different across these workers.

An alternative to the complication of allowing for multiple skills within this framework is to maintain the assumption of workforce homogeneity but construct an improved measure of N_t, or the labor input. Rather than using the official figures for N_t (from either the household survey or establishment survey), which weight the hours of a janitor and those of a brain surgeon equally, the better measure would weight the hours of different workers by their relative efficiencies. This approach has been utilized by Kydland and Prescott (1993) and Kydland and Petersen (1996). Using the Panel Study of Income Dynamics from the University of Michigan, these researchers construct quality-adjusted labor-input series consisting of all demographic groups. Their findings suggest that the constructed skill-adjusted labor-input series fluctuates substantially less (by almost one-third) than the corresponding aggregate hours series published by the U.S. Bureau of Labor Statistics and more closely resembles the pattern generated by business-cycle models.

There are other reasons variants of business-cycle models understate the volatility of hours worked. One reason is that, taken literally, all of the labor-input volatility is in the form of variation in hours per worker (because everyone is alike), rather than in the number of workers. In the United States, however, about two-thirds of the volatility in hours worked comes in the form of the latter. With recent advances in business-cycle theory, through which movements in and out of the labor force can be incorporated in the model (following the lead of Hansen 1985), we now understand that such movements of the workforce add to the total volatility of hours of work.

In sum, by abstracting from life-cycle differences, the representative agent framework with immortal consumers proves to be useful for answering a certain class of questions—namely, those related to sources of impulse for the business cycle. Even allowing for some heterogeneity, such as skill differences, these models ease the computational difficulties because the equilibrium can be computed by solving the optimization problem of a stand-in social planner.

Nonetheless, the business-cycle model is quite different from our Economy 1, especially with its omission of the life-cycle earnings profile, so the question remains: Would the introduction of the life-cycle dimension of heterogeneity change the conclusions drawn from business-cycle models? Until recently, computational difficulties made answering this question infeasible. However, advances in computing capabilities have allowed researchers to compute artificial economies both with and without heterogeneous/mortal consumers and compare the results. Ríos-Rull (1996), using an overlapping generations (OLG) framework, with the hump-shaped earnings pattern described above, finds that the implications for most business-cycle issues, such as the role of technological shocks, do not change if one switches from an infinitely lived, representative-agent model with no life-cycle behavior to a sophisticated demographic structure with mortal consumers. His finding confirms the early guess by other economists that one can safely abstract from life-cycle considerations when dealing with many questions related to the business cycle.[5]

Accounting for individual differences across generations

While the immortal consumer framework works well for some questions, such model economies are not of much use when asking questions for which life-cycle behavior is likely to be important for the answer. Many interesting policy issues revolve around life-cycle behavior. These include questions for which demographic factors are important, such as the future impact of immigration on the economy, Social Security reform in light of the aging population, and the impact of the baby boomers' retirement on savings and interest rates. For such questions, economists have known that another type of model is required (one that is computationally very intensive), where consumers are considered mortal and make their decisions based on where they are in the life cycle.

Miller and Upton (1974), in their macroeconomics textbook, had already formulated a special case of a life-cycle economy in which each individual lives for four periods ($I = 4$). Mimicking a lifetime divided into four parts, the individuals in their model earn income only in periods two and three but desire a smooth stream of consumption. With this simple textbook framework Miller and Upton shed quantitative light on several issues, such as the time path from a less developed to a fully developed economy, the role of government debt, and money's role in the behavior of output and other real aggregates when debt is denominated in nominal terms.

Given the technology of the time, computing the full equilibrium of such a model was a major task—even for the small number of generations. Instead, Miller and Upton constrained consumers to calculate their wealth on the assumption that interest rates in all future periods will be the same as in the current period. In contrast, in the examples we discuss in the remainder of this article, the models' people understand how future interest rates will adjust to clear markets. The resulting computational burden is heavy but, given the vastly improved capabilities of today's computers, eminently feasible, even with a value of I much greater than four (perhaps 55 or 60 if the model uses a period length of one year).

In the remainder of this article, we focus on examples of questions that can be addressed using the mortal consumer framework envisioned by Miller and Upton and others. Although many researchers have addressed life-cycle issues, we focus on the work of two researchers in this article because of space constraints. This is obviously not meant to be an exhaustive survey of the literature. Rather, these researchers' work provides representative examples of the type of questions that can be addressed using such a framework and of what has been done to answer them. We chose the work of Ríos-Rull because he has been instrumental in expanding this type of model to relevant life-cycle questions. We chose Storesletten because of his work on immigration and the current national interest in this topic.

Demographics and savings. The change in the age distribution of the population associated with the aging of the baby boom generation has sparked economists' interest in the potential impact on the national savings rate. Because typical consumers tend to borrow when young, save during middle age, and dissave during retirement, people's savings are affected by demographic factors, especially age. In addition, because a nation's savings is the sum of all individuals' savings, changes in the composition of the population could drastically affect the national savings rate. A policy issue associated with this question is the effect the retirement of the baby boom population will have on the Social Security system—a question that has recently become a hot topic in both the popular press and among economists.[6] Several researchers have addressed the savings issue. But, as mentioned earlier, we focus on the work of Ríos-Rull and Storesletten as examples of what can be done using a mortal consumer, OLG framework.

Ríos-Rull has made great strides in the ability to deal with OLG models. His pioneering models allow for uncertainty about individuals' lifetimes as well as labor force productivity, which affects individuals' earnings differently, depending on which stage of the life cycle they are in. Ríos-Rull (1994) attempts to provide a quantitative answer to the issue of how the aging of baby boomers will affect savings rates and interest rates in the future. He permits laws of motion for population movement rather than simply assuming constant population growth. For example, in our notation from Economy 1, the number of newborns in the following period is given by $\mu_{1,t+1}$. If the age-specific fertility rates are ϕ_i (which are readily quantifiable from panel data), then this number can be written as

$$\mu_{1,t+1} = \sum_{i=1}^{I} \phi_i \mu_{it} + \zeta_t,$$

where ζ_t is a stochastic term whose statistical properties can be estimated from past population data. In studies that include population dynamics such as these, researchers have typically opted for a period length of five years, so that a lifetime of ninety years corresponds to a value of the parameter I of 18. Moreover, if the probability of surviving between age i and age $i + 1$ is s_i, then $\mu_{i+1,t+1} = s_i \mu_{it}$ for all $i = 1, ..., I - 1$. In the lifetime decision problem, the utility associated with age i would presumably be weighted by the unconditional probability of reaching age i, $\Pi_{j=1}^{i-1} s_j$, as well as by the usual term involving the discount factor. Finally, a rule needs to be specified for how the assets of the deceased are divided among the survivors.

With these features added to Economy 1, Ríos-Rull calibrates the model with age-dependent birth and mortality rates and simulates the population distribution, with an associated asset distribution, until a combination similar to the current distribution is obtained. This is used as the initial condition. Accounting for population dynamics is especially difficult to do for the United States because immigration is such an important factor in the country's population growth. For that reason, Ríos-Rull considers Spain, which like many Western countries is experiencing an aging of its population due to a baby boom in the 1950s and 1960s. As he notes, "The aging of the population brings forward a variety of very important issues as so many features of individual behavior are age-dependent. The allocation of time between work in the market and leisure, and the allocation of income between consumption and savings, are among the key variables for which the age of the individuals is a very important determinant" (1994, 1). Such a statement applies to the United States as well as Spain; thus his findings have implications for the U.S. economy.

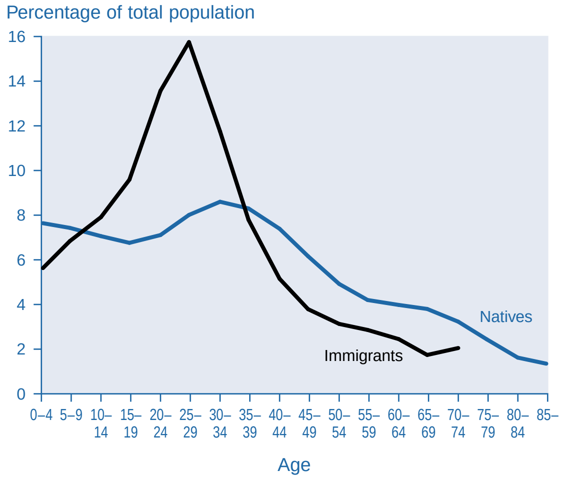
Ríos-Rull reviews the economic implications of the baby boom based on two fertility schemes (one using historic fertility and one that assumes the current drop in fertility is permanent). In addition, for each of the two fertility scenarios, he considers alternative paths for productivity growth, an open versus closed economy, and alternative asset distributions. His main findings suggest that the aggregate savings rate will be reduced, but the amount of reduction depends on the fertility scheme used. Under the historic fertility scenario, the reduction in savings is relatively small—at most, a reduction of 2 percentage points at the lowest value. But, under this scenario, the aggregate savings rate rises again as the baby boom exits the economy (after the year 2010). In contrast, based on the permanent fertility scheme, aggregate savings rates decline sharply over the entire period—about 12 percentage points from 1980 to 2040.

Immigration's impact on savings and fiscal policy. A policy issue that has spurred debate both in the press and among economists is the effect of immigration on the U.S. economy. Opponents of immigration suggest that immigrants are "stealing" U.S. jobs and that immigrants do not contribute to the country's welfare because they are less educated, have lower wages, and are more likely to require social assistance. On the other hand, proponents for immigration suggest immigrants are hard workers who already have an education and give back to the country by saving and investing.

Economists have joined in the debate on the impact of immigration. In a survey article based on his own and others' work, Borjas (1994) suggests that on balance, current immigration policy may be detrimental to the U.S. economy. He finds that the newer waves of immigrants to the United States have lower wages relative to Americans and are unlikely to reach parity with U.S. native wages over their work life. He concludes that the increase in the flow of less skilled immigrants may have been partly responsible for the decline in the earnings of unskilled U.S. workers during the 1980s. Borjas also indicates that immigration may have an adverse fiscal impact on the United States because the new waves of immigrants participate in welfare programs to a greater extent than the previous waves of immigrants.

Storesletten (1997) positions the impact of immigration in a more positive light, suggesting immigration can be beneficial to the U.S. economy—helping to offset a decline in savings as the baby boom generation begins to retire and possibly even sustaining current fiscal policy in the face of rising public expenditures associated with an older population. Building on the work of Ríos-Rull, Storesletten takes the finitely lived consumer, OLG framework one step further by modifying the population dynamics of the model to include both natives and immigrants. He calibrates a general equilibrium model to U.S. data and creates a role for immigration where immigrants are separate distinct agents. The individuals in his model differ in national origin and age at the time of immigration. The key difference between immigrants and natives in the model is in labor productivity, which is strongly influenced by the age at the time of arrival. Children of immigrants are assumed to be identical to natives.

Figure 4
Age Distribution of U.S. Natives And New Immigrants



NOTE: The figure shows the age distribution of natives in 1991 and the average distribution of new immigrants over 1982 – 88.

SOURCE: Kjetil Storesletten, Institute for International Economic Studies, Stockholm University.

Impact on savings. Storesletten's (1995) findings indicate that changes in immigration policy can significantly affect projected savings rates and interest rates in the United States. First, he solves his model under current immigration policy, and then he explores three alternative immigration policies, which range from shutting down all future immigration to doubling the current level of immigration. Under the current policy, he finds that the aging of the U.S. population is likely to cause the savings rate to decline as the baby boom population moves into retirement—the decline being 3.6 percentage points from peak to trough (2036). This finding is consistent with the work of other researchers that suggests the aging of the baby boom population will negatively affect aggregate savings, with Storesletten's work providing a quantification of this effect.

Findings from the alternative scenarios suggest savings rates are quite sensitive to changes in immigration policy. In fact, the projected savings rates from different scenarios differ by as many as 3 percentage points at the trough. Storesletten's results indicate that by boosting immigration quotas, savings rates would be higher than under current immigration policy. Under one scenario—increasing future immigration to twice the current level—there is an instant increase in the U.S. savings rate of 0.4 percentage point relative to the base case, and the difference between the two rises to about 1.4 percentage points by the year 2041. In contrast, by shutting down all future immigration, the projected savings rate falls 0.5 percentage point below the base scenario, and the difference between the two projected savings rates rises by 1.5 percentage points over the next fifty years. These results arise because the population ages faster without immigration (immigrants on average tend to be younger than natives, as shown in Figure 4).

Impact on fiscal policy. It is a widely held view that maintaining government expenditures at current levels without a significant increase in taxes will not be a practical policy for the U.S. government as the population ages. For example, Social Security and Medicare—major players in fiscal policy—transfer wealth from the young working population to the old. With the aging trend of the U.S. population, such payments will become a larger liability for the government in future years, at the same time that there will be fewer workers to pay for it. This, combined with the current budget deficit, makes future tax increases seem inevitable. Storesletten (1997), on the other hand, argues that changes in immigration policy could reduce the need to raise taxes on future generations—and that by changing immigration policy alone, current fiscal policy could be sustained. Because on average new immigrants are younger than the native population but still old enough to have acquired some education, an increase in immigration has an impact on the age structure of the population, which in turn increases government receipts by more than it raises government expenditures.

To illustrate the quantitative impact of immigration policy on fiscal policy, Storesletten examines whether there exists a class of immigration policies that could sustain fiscal policy at the current level, in the sense that the current debt will eventually be paid off without a tax increase. Using his OLG model with immigration, his findings suggest that such policies do exist if immigrants are added, most of whose ages range from the mid-twenties to the late forties. A particular implementation of the policy is to increase annual immigration to roughly four times the current level, assuming all the new immigrants are in their thirties. Such a policy turns out to be an alternative, in his model, to raising the income tax rate by about 5 percentage points. While this is a dramatic change in immigration policy, the example illustrates that, even for less extreme scenarios, significant fiscal relief could be achieved and that immigration policy can be viewed as an important tool in the determination of fiscal policy.

Concluding remarks

In concluding, we return to our initial question: Does being different matter? And the answer is: It depends. Many quantitative macroeconomic issues can be addressed using models that abstract from life-cycle behavior. For example, many business-cycle and long-run growth questions can be answered in an immortal consumer framework in which everyone is alike and lives forever. Such questions might include: What percentage of business cycles are accounted for by technology shocks? By monetary shocks? By changes in fiscal policy? For this class of questions, differences across generations have been found not to matter to any degree of quantitative importance. Still, although dissimilarities *across* generations may not be relevant to this class of questions, individual contrasts *within* generations, such as skill variation, may be. Researchers have found that it is relatively easy to introduce some such differences into the immortal consumer framework and still be able to compute the models with relative ease.

There is another class of questions for which individual differences—both across generations and within generations—matter a great deal. These are questions in which demographics are at the heart of the issue. Such questions can be addressed using an overlapping generations framework in which consumers are mortal and make decisions based on where they are in the life cycle. Issues that dictate this type of life-cycle framework include the quantitative impact of an aging population on savings rates and interest rates and the quantitative effect of alternative immigration policies. While it is still computationally difficult to solve such models, as computers become ever more powerful and theoretical advances are made, the scope of questions that can be addressed with the help of such models is broadening steadily.[7]

Notes

We would like to thank Carlos Zarazaga, Evan Koenig, and Lori Taylor for helpful comments and suggestions. We would also like to thank Kjetil Storesletten for providing us with his data.

1 This question is addressed in Kydland and Prescott (1982).

2 For an overview of the use of such model features, especially as they relate to the labor market, see Kydland (1995).

3 See Benhabib, Rogerson, and Wright (1991).

4 For a recent extension see Prasad (1996).

5 An exception is the Altig–Carlstrom (1991) study of the cyclical implications of the interaction of inflation with personal tax rates when taxes are not fully indexed. The issue addressed by them dictates an OLG framework with life-cycle earnings profiles. For example, a progressive income tax schedule implies cyclical bracket creep to an extent that depends on where the worker is in the life cycle.

6 See Imrohoroglu, Imrohoroglu, and Joines (1995).

7 Recently, researchers have even begun to explore questions about institutional arrangements that may arise when people vote. For example, Krusell and Ríos-Rull (1994) study the quantitative implications for capital accumulation arising from different systems of collective choice of taxes as reflected in the frequency of elections and the lag between policy decision and policy implementation. Cooley and Soares (1995) investigate how a pay-as-you-go Social Security system is maintained by subsequent voters even though it is not actuarially fair. A methodological challenge of such models is that they require both an economic and a political equilibrium.

References

Altig, David, and Charles T. Carlstrom (1991), "Inflation, Personal Taxes, and Real Output: A Dynamic Analysis," *Journal of Money, Credit, and Banking* 23 (August): 547–71.

Benhabib, Jess, Richard Rogerson, and Randall Wright (1991), "Homework in Macroeconomics: Household Production and Aggregate Fluctuations," *Journal of Political Economy* 99 (December): 1166–87.

Borjas, George J. (1994), “The Economics of Immigration,” *Journal of Economic Literature* 32 (December): 1667–717.

Cooley, Thomas F., and Jorge Soares (1995), “A Positive Theory of Social Security Based on Reputation,” University of Rochester working paper.

Hansen, Gary D. (1985), “Indivisible Labor and the Business Cycle,” *Journal of Monetary Economics* 16 (November): 309–27.

Imrohoroglu, Ayse, Selahattin Imrohoroglu, and Douglas H. Joines (1995), “A Life Cycle Analysis of Social Security,” *Economic Theory* 6 (June): 83–114.

Krusell, Per, and José-Víctor Ríos-Rull (1994), “What Constitutions Promote Capital Accumulation: A Political-Economy Approach,” University of Pennsylvania working paper.

Kydland, Finn E. (1995), “Business Cycles and Aggregate Labor Market Fluctuations,” in *Frontiers of Business Cycle Research,* ed. Thomas F. Cooley (Princeton, N.J.: Princeton University Press), 126–56.

——— (1984), “Labor Force Heterogeneity and the Business Cycle,” *Carnegie–Rochester Conference Series on Public Policy* 21: 173–208.

———, and D’Ann M. Petersen (1996), “Skill Difference and the Measurement of Cyclical Labor Input” (Working paper presented at the Western Economic Association meetings, July).

———, and Edward C. Prescott (1993), “Cyclical Movements of the Labor Input and Its Implicit Real Wage,” Federal Reserve Bank of Cleveland *Economic Review*, Quarter 2, 12–23.

———, and ——— (1982), “Time to Build and Aggregate Fluctuations,” *Econometrica* 50 (November): 1345–70.

Lucas, Robert E., Jr. (1980), “Methods and Problems in Business Cycle Theory,” *Journal of Money, Credit, and Banking* 12 (November): 696–715.

Miller, Merton H., and Charles W. Upton (1974), *Macroeconomics: A Neoclassical Introduction* (Homewood, Ill.: Richard D. Irwin).

Prasad, Eswar (1996), “Skill Heterogeneity and the Business Cycle,” *Canadian Journal of Economics* 4 (November): 910–29.

Ríos-Rull, José-Víctor (1996), “Life-Cycle Economies and Aggregate Fluctuations,” *Review of Economic Studies* 63 (July): 465–90.

——— (1994), “Population Changes and Capital Accumulation: The Aging of the Baby Boom,” University of Pennsylvania working paper.

——— (1993), “Working in the Market, Working at Home, and the Acquisition of Skills: A General-Equilibrium Approach,” *American Economic Review* 83 (September): 893–907.

Storesletten, Kjetil (1997), “Sustaining Fiscal Policy Through Immigration,” Stockholm University working paper.

——— (1995), “The Economics of Immigration” (Dissertation, Graduate School of Industrial Administration, Carnegie Mellon University).