

The Contributions of S. Rao Aiyagari to Dynamic Macroeconomics

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S. Rao Aiyagari was 45 years old when he died in 1997, just as his approach to dynamic macroeconomic research was gaining recognition. Rao's vision was motivated by empirical observations and academic debates stemming from the differences between aggregate and individual data. In particular, individual earnings, saving, wealth and labor exhibit much larger fluctuations over time than per-capita averages, and accordingly significant individual mobility is hidden within these cross-sectional distributions. Rao became convinced that this kind of heterogeneity has important implications for the understanding of aggregate economic data and can provide new insights on the role of various economic policies.

The Aiyagari-Bewley economic model, proposed by Bewley (1986) and developed further in Aiyagari (1994) and (1995), has become a leading model for modern dynamic macroeconomics. The economy is populated with heterogeneous infinitely lived agents subject to uninsurable idiosyncratic income risks. Possible long sequence of adverse income shocks naturally lead to borrowing constraints on individuals, and consequently fluctuations in consumption can be mitigated only by precautionary individual savings. Since agents' histories of income shocks are different, the model generates equilibrium cross-section distributions of wealth, saving and consumption, which reflect the fact that borrowing constraints are tighter for wealth-poor agents. These cross sectional distributions are contrasted with or calibrated to fit their empirical counterparts in the data, and their responses to various policy changes can be analyzed. Solving for the equilibrium in dynamic models with heterogeneous agents is complicated, and Rao was among the pioneers in developing and applying numerical solution techniques for that purpose.

In his most influential paper, (Aiyagari (1994)), Rao investigates the implications of precautionary saving due to individual earning risks and borrowing constraints for aggregate savings. He found that the contribution of uninsured idiosyncratic risks to aggregate saving is modest for plausible values of risk aversion, variability and persistence of earnings, (at most 3%), but can be significantly larger with higher variability and persistence parameters of the earning stochastic process. Access to asset markets in that model enables agents to cut consumption volatility by half, and enjoy welfare gain of 14% of per-capita consumption, compared to the equilibrium with no access to assets markets. The model generates a wealth distribution that is positively skewed, more dispersed than income distribution, and inequality is significantly higher for wealth than for income.

Precautionary savings generated by uninsured idiosyncratic shocks and borrowing constraints motivated Rao to examine the recommendation to eliminate tax on capital income (Lucas, 1990). Aiyagari (1995) shows that for the Aiyagari-Bewley economies this dictum may be wrong because the frictions in these models result in agents' behavior that is closer to that in overlapping generations (OLG) models. Precautionary saving can lead to over-accumulation of capital in equilibrium, so that positive taxes on capital are needed to bring the pre-tax return on capital to equality with the rate of time preferences, at any point in time as well as in the long run. In contrast to OLG models, where government debt can also be used to reduce excessive

saving, in Aiyagari-Bewley economies the demand for such assets becomes infinite when the interest rates approaches the rate of time preferences. The suitability of the model for addressing such fundamental issues is evidenced by the fact that a decade later it is still being used to study the same issue, albeit with different conclusions, (Werning, 2005).

Rao has examined many other implications of cross-sectional distributions generated by frictions in capital markets and uninsurable idiosyncratic risks, such as: asset pricing and trading patterns, (Aiyagari and Gertler (1991)), setting taxes in a median voter context, (Aiyagari and Peled (1995)), marriage patterns and investment in children, (Aiyagari et al, (2000), and (2002)). He also studied the equilibrium implications of market frictions and borrowing constraints that emerge endogenously from private information on individual earnings in Aiyagari and Williamson (2000). Many other influential papers have adopted his framework of uninsurable idiosyncratic risks for the study of various phenomena, including, for instance, Kotcherlakota (2005) on optimal taxation, Krueger and Perri (2005) on the joint evolution of income and consumption, and Storesletten et. al. (2004) on age-dependent income and consumption inequality.

Rao's earlier theoretical work focused on the links between dynastic and OLG models, and provided the deep theoretical understanding of dynamic models that he applied in his subsequent work. He examined whether the two models become similar in terms of equilibrium existence, optimality and cyclicalities, with and without money, when the life of each generation and the period of overlap across generations are sufficiently long, or when generations are linked through altruism, (e.g. Aiyagari 1985, 1988 and 1989). Additional work with Wallace and others examined the role for policy in search equilibrium models of money, (e.g. Aiyagari and Wallace 1997, Aiyagari et al 1996).

Aiyagari published over 30 influential papers during his 18 years career as an economist. The force of his work and ideas and the impact they had on his colleagues are evidenced by the continued appearance of his co-authored papers for many years after his unexpected death, exhibiting some of the most innovative dynamic macroeconomic research.

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