Forward Thinking and Family Support: Explaining Retirement and Old Age Labor Supply in Indonesia

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Abstract

This article develops a structural dynamic model of retirement for developing countries and estimates this model using Indonesian data. The model incorporates forms of old age support that are common in developed countries, such as government pensions, as well as mechanisms that are more important in developing countries including coresidence with family members, transfer payments, and health-related changes in labor productivity. By simulating the model, I show that implementation of a unified defined-contribution pension program for government and private sector workers would provide modest welfare gains, but would not offset welfare losses brought by potential future declines in family support.

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1 Introduction

In recent decades much of the developing world has experienced pronounced improvements in health and mortality, which have led to dramatic gains in life expectancy and growing numbers of the elderly. Even though more than 80 percent of the world's population lives in a developing country, we know very little about the labor supply and retirement decisions of older people in these settings. Few developing countries offer broad-based formal retirement support. Instead, older people rely on their own labor income and households and extended families for support in the form of transfer payments, coresidence, and participation in family businesses. But sustained declines in fertility and mortality have increased dependency ratios and call into question the sustainability of traditional forms of old age support (World Bank 1994). These trends highlight two important areas for research. First, what are the determinants of old age labor supply in developing settings? Second, how might changes such as shrinking families or the expansion of formal pensions affect old age labor supply and welfare in these contexts?

Answering these questions requires modeling several component processes simultaneously. The first question involves computing causal estimates of the factors that determine whether someone chooses to work at a given age. The second question requires an analytic strategy that accounts for individuals' forward looking behavior because assessing the effects of expansions in formal pension systems involves accounting for individuals' propensity to consider future income and utility when making current choices about working. These questions are difficult to answer with reduced form models that require finding separate sources of exogenous variation that affect each component process. Instead they are well suited to a structural dynamic model of labor supply, which offers causal estimates, a way to capture forward looking behavior, and a way to simulate the effects of pension reform or changing families on behavior and wellbeing of older people.

In this paper I begin to fill this important gap in the economic literature by examining the mechanisms that underlie the retirement decisions of older men in Indonesia.[2] Using recent innovations from the U.S. retirement literature as my starting point, I build and estimate the first structural dynamic model of old age labor supply for a developing country. I use this approach to assess the effects of demographic changes on labor supply and to conduct policy experiments that examine the labor supply and welfare effects of a broad public pension reform, which many believe could address the growing needs of an aging population. This allows me to evaluate different aspects of potential policy changes including program intensity by comparing observed behavior to simulated behaviors under relevant policy counterfactuals.

Indonesia is a particularly useful case study for several reasons. The world's fourth most populous country, Indonesia is similar in size to the United States but at a middle level of socioeconomic development. Like most developing countries, Indonesia has experienced enormous demographic and socioeconomic changes in recent decades. Fertility and mortality have declined substantially while life expectancy has increased from 48 years in 1970 to 65 years in 1998 (United Nations Children's Fund (UNICEF) 2000). At the same time, educational attainment has increased, participation in traditional agriculture has declined, and the modern industrial and service sectors have grown. People are living longer, families are smaller than ever before, and family members are more likely to migrate away from the familial home for work. In this context, there has been significant public debate about the needs of an aging population and how best to reform Indonesia's pension system to provide the necessary support for future generations of retiring workers (Leechor 1996; Holzmann et al. 2000; Brodjonegoro and Simanjuntak 2002). This paper offers some answers to these important policy questions.

[2]Because I view retirement as a process, rather than an irreversible exit from the labor market, I use the terms old age labor supply and retirement interchangeably. During this process, they may leave and later return to the labor force, change employment sectors, or slowly decrease hours.

2 Previous Research

In general, old age labor supply is shaped by three key mechanisms: formal old age support and private savings, family support, and health. Although these mechanisms vary greatly across countries at different levels of economic development, these are the basic building blocks of models that describe decisions to work at older ages. Most of what we know about the determinants of old age labor supply comes from research on developed countries. Although this research provides important insights into individuals' behavior, it does not transfer entirely to the developing world because few developing societies have significant formal programs for old age support.

In the United States and other developed nations, labor supply of older people is framed significantly by formal institutions such as the Social Security system and private company pensions. Most American workers become eligible for Social Security benefits at age 62 and can receive full benefits if they retire at age 65.[3] In addition, about half of all American workers are eligible for private pension benefits when they retire (Stock and Wise 1990). In these settings, the incentives of formal old age support shape individuals' labor market choices. The evidence shows that participation rates respond to program features across the developed world and that dynamic models of labor supply fit observed participation patterns quite well (see survey in Gruber and Wise 1999). Moreover, the total wealth of older workers in the United States is dominated by the expected stream of Social Security and pension earnings. Estimates from the 1992 Health and Retirement Study suggest that this stream accounts for over 60% of the wealth of the median income older worker (Gustman et al. 1999).

In contrast, most developing countries outside Latin America have little in the way of public institutions for old age support. In the Middle East and North Africa, public pension systems cover approximately one third of the labor force but only five to ten percent of the elderly (age 60 or older) receive a pension (Robalino et al. 2005). With the exception of South Africa, Mauritius, and

[3] The age of eligibility for full benefits for individuals born in 1960 or later gradually increases to 67.

Botswana, the vast majority of workers in Sub-Saharan Africa do not participate in any pension program (Barbone and Sanchez B. 1999). And while all East Asian countries provide pensions for government workers, only a few (Japan, Singapore, Malaysia, and Taiwan) provide significant support to non-governmental workers (Holzmann et al. 2000; Chan et al. 2003).

Wealth displays an ambiguous relationship with retirement in developing countries. The patterns are complicated by the fact that assets are generally measured at the household level and older parents often coreside with adult children. While older family members may be dissaving, younger members may be accumulating wealth, leading to an ambiguous net effect on household saving. Coresiding older family members may also dissave much faster than expected because they may invest their wealth in the schooling or businesses of younger family members in an effort to increase the household's future wealth. Furthermore, some researchers believe that the bulk of wealth held by households in low-income countries is precautionary savings used to smooth relatively short-term shocks and not used for long-term purposes such as funding retirement (Rosenzweig 2001). The evidence on whether wealth levels are correlated with labor force exit in developing countries is mixed. While research on China and Taiwan finds that higher levels of wealth are associated with reduced work in old age, research on Indonesia finds no strong relationship (Benjamin et al. 2003; Mete and Schultz 2002; Cameron and Cobb-Clark 2001).

With a few exceptions, most analyses of retirement behavior in developed countries assume that families play little or no role in older adults' decision to leave the labor force.[4] However, throughout the developing world, the family plays a critical role in supporting the elderly. This support comes from family members who live with the older person as well as family members outside the household who make transfer payments (Knodel and Debavalya 1997; World Bank 1994). In Indonesia, for example, more than half of all couples with adult children receive monetary transfers from at least one child (Frankenberg et al. 2002). In this context, the labor income of other household members

[4] One exception is that family members can sometimes influence individual behavior through a bequest motive.

and transfer payments from outside family members may be more relevant determinants of labor supply in old age than measures of individual or household assets.

Finally, the effect of health on labor supply of older men in developing countries is unclear. Not only are jobs more likely to be physically demanding in developing countries, but health care systems are less widespread and less advanced technologically. This suggests that poor health may be a greater impediment to labor force participation in these settings. But the lack of formal retirement support and health insurance suggests that individuals with poor health may need to stay in the labor force longer than they might otherwise, in order to support themselves and their families and afford medical treatment when necessary. The existing evidence on the net effect is mixed. For example, poor health has a strong significant negative effect on labor force participation of older people in Taiwan (Mete and Schultz 2002). Research on China, however, suggests that health has little effect on labor supply decisions, although there is no evidence about the different mechanisms through which health could affect labor supply and whether these might be offsetting in this context (Benjamin et al. 2003). Previous work on Indonesia finds significant positive effects of good health on labor supply (Thomas et al. 2004; Cameron and Cobb-Clark 2001, 2002).

3 The Indonesian Context

Indonesia has developed rapidly in recent decades. Health and mortality have improved dramatically as modern infrastructure, such as running water, sewage treatment, and basic health care have taken root. These improvements in health technology have lowered infant and adult mortality, increased productive working lives, and lengthened average life expectancies. Overall, people are living and working much longer than ever before. Indonesia has also experienced phenomenal economic growth. This growth has come from both increases in productivity in the traditional rural sector and from rapid industrialization. Indonesia grew from being one of the poorest countries in the world during the 1960s to one of the wealthiest in the developing world before the economic crisis in the late 1990s. Other measures of human capital such as literacy and schooling have increased as well, especially among women. These changes, along with large-scale family planning programs, have led to smaller family sizes as completed fertility has dropped from more than 6 to about 2.2 children per woman.

If development and modernization lead to a decline of the traditional system of family support for the elderly, Indonesia has little in the way of public institutions to take over this function. In 1975 most government employees became eligible for some benefits that allowed retirement at age 55, and in 1992 limited retirement benefits were extended to some private sector employees. But by 1996 only 16% of the labor force was participating in a pension program (Holzmann et al. 2000). Even relative to other Asian countries such as Taiwan or Malaysia, Indonesia's pension system is quite underdeveloped (Brodjonegoro and Simanjuntak 2002; Leechor 1996). And while Indonesia is getting wealthier in the aggregate, these economic gains have not been equally distributed and many older workers lack the personal savings they would need to support themselves.

Indonesians working in the public sector are eligible for substantial benefits through the civilian TASPEN retirement program (4% of labor force) and the much smaller military ASABRI retirement program (less than 1% of labor force). Participants in both programs contribute 4.75% of their salaries and receive a monthly pension of between 1.875% and 2.5% of their last month's salary times their number of years of service (up to a maximum of 35) when they retire. Benefits are adjusted on an ad hoc basis for inflation based on nominal wage growth in the economy. The retirement age is 55 for civilians and 50 for the military. In contrast, retirement benefits and participation are both much lower for JAMSOSTEK, the government-sponsored retirement program for private sector workers. Employees participating in JAMSOSTEK contribute 2.0% of their salary and employers contribute an additional 3.7% to the fund. At age 55, retiring workers collect the amount contributed plus 14% nominal interest. This return is comparable to that of a standard savings account, partly explaining the lack of participation in this program. In 1995 only a quarter of paid workers participated and only a quarter of these complied with the contribution requirements.

Panels (a) and (b) of Figure 1 show the relationship between age and labor supply by urban/rural status in Indonesia. The first panel shows the mean level of labor force participation, while the second panel shows mean hours worked (among those who chose to work) for men ages 40 to 75 estimated from the Indonesia Family Life Survey (IFLS), described below. In both urban and rural areas, men's labor force participation rates decline steadily starting at age 50, albeit much more rapidly for urban versus rural men. Nonetheless, at every age participation levels are substantially higher than those observed in developed countries. At age 75, for example, about 60% of men in rural areas and 30% of men in urban areas are still in the labor force.[5] Among those who work, mean hours worked does not differ substantially by urban/rural status. As expected in a country with a large informal sector, individuals have some flexibility in choosing hours, and mean hours worked decline smoothly with age.

Patterns of labor supply differ substantially by type of work and by urban/rural status. Figure 2 shows labor force participation rates and hours worked for self-employment (i.e., informal sector), the private sector, and the government sector. Although rural men are much more likely to report self-employment than men in urban areas, age patterns of participation are similar. The fraction of individuals reporting self-employment is generally constant from age 45 to 65 and declines thereafter. Urban men are more likely to be in the private or government sectors. In the private sector, urban men's labor force participation is fairly constant from age 40 to the mid fifties, then drops dramatically after the pension eligibility age of 55. Rural men's participation also declines with age in both the private and government sectors although they have much lower levels of participation in these sectors. Of course, leaving a particular sector does not necessarily mean that men leave the labor force entirely. For example, individuals' employment histories in the IFLS show

[5] In contrast, in 1990, 68% of U.S. men age 55 to 64 and 16% of U.S. men age 65 and older were working (U.S. Census Bureau 2005).

that half of those leaving government work move into either the private sector or self-employment. Similarly, 61% of those leaving the private sector move into self-employment.

Panels (b), (d), and (f) of Figure 2 show that hours worked decline steadily with age in both the informal and private sectors but very little in the government sector. This pattern suggests individuals may have less flexibility in choosing hours in the government sector. These patterns are generally the same by urban/rural status except that urban men ages 65 and older work slightly more hours than their rural counterparts when they are self-employed.

Finally, while health in Indonesia has improved substantially over recent decades, it remains a significant predictor of labor supply. As discussed above, health can affect labor supply through several possible mechanisms and in Indonesia there is a strong correlation of good health and labor force participation. The bottom four panels of Figure 1 show that both labor force participation and hours worked for those individuals who work decline faster with age for individuals in poor health than in good health. Declines in labor force participation given poor health are especially precipitous in urban areas where fewer than 20 percent of men in poor health choose to work after age 70 compared to more than half of rural men at those ages.

Based on previous research and descriptive statistics presented above, the dimensions that stand out as the most important correlates of old age labor supply in Indonesia are age, urban/rural status, available family support, health, and pensions. Furthermore, we observe significant movement between three very different sectors of the labor market. I incorporate these elements in the model presented next, and use structural assumptions to estimate several causal parameters including the effect of health on productivity in each sector and its direct effect on utility.

4 The Model

The model presented here relies on a number of assumptions about human behavior and the environment in which older men in Indonesia make decisions about work. These assumptions aim to balance the often conflicting goals of realism, parsimony, identification, computational tractability, and data availability. Although inevitably stylized in some ways, the model nonetheless emphasizes the key mechanisms that drive labor supply decisions and the effects that changes in family support and pension systems might have on these decisions.

At its core, the model takes the form of a standard discrete choice dynamic programming problem where individuals make a choice in each time period to maximize the expected present value of their future utility stream:

$$V_t(s_t) = \max_{h_t^1, h_t^2, h_t^3, \ldots, h_T^1, h_T^2, h_T^3} E\left[\sum_{\tau=t}^{T} \beta^{\tau-1} \pi_\tau^S(s_\tau) U(c_t, h_\tau, s_\tau) | s_t\right] \tag{1}$$

In each period, individuals choose to work or not work, and if they choose to work, they also choose the number of hours and the sector of work. h_t^j corresponds to the number of hours worked in sector j in time period t. To simplify computation, individuals have three possible choices of hours.[6] They can work part-time ($h_t^j = 20$), full-time ($h_t^j = 40$), or over-time ($h_t^j = 60$) in exactly one of three possible job sectors indexed by the superscript j: self-employed ($j = 1$), private-sector ($j = 2$), and government ($j = 3$).

Per-period utility, $U(\cdot)$, depends on consumption (c_t), total hours worked (h_t), and the state of the world (s_t). β is the discount factor, time periods are years, and $\pi_\tau^S(s_\tau)$ is probability of survival to period $\tau + 1$ conditional on the state in period τ. To simplify the notation, subscripts for individuals are suppressed throughout this section. The model is designed to describe the behavior of individuals age 40 to 75. To allow for solution using backwards induction, the model assumes that individuals who survive to age 84 die with certainty at age 85.[7]

[6] Discretizing hours worked is a common modeling choice that allows agents to choose along the intensive margin, but still lets the model be estimated using standard discrete-choice dynamic programming methods. See Keane and Wolpin (2001) and French (2005) for examples.

[7] In these data, healthy 60 year-old Indonesian males have only a 16% chance of survival to age 85.

Job Offers

Individual choices are limited by the fact that jobs are not always available for every combination of sector and hours. The model allows per-period job offers for each hours sector combination to vary with education and whether the individual held a job in the same sector in the previous period. Limited job availability can explain why individuals do not always choose government jobs, which generally pay higher wages and include pensions. This formulation allows some sectors to have more institutional rigidity in terms of hours than others. For example, it can capture the fact that part-time and over-time formal sector jobs are often more difficult to find than full-time formal sector positions.

Because the model allows offer rates to depend on education, it can explain why highly educated individuals may have an easier time finding government jobs. Similarly, the probability that a job is available will be higher if the individual worked in that sector in the previous period. That is, once an individual establishes himself in a sector, it is easier to continue to work in that sector than to enter it after having worked either in another sector or not worked at all in the previous period.

Using the sector where the individual worked in the previous period to summarize the previous employment history greatly simplifies computation of the model by reducing the dimension of the state space to a manageable level. But it is important to understand the costs of this assumption. In particular, individuals who build up sizeable experience in a sector and leave for one year will have just as difficult a time re-entering that sector as an individual who never worked in the sector. This assumption is not unreasonable in the Indonesian context where very few individuals leave either the private sector or the government sector and return more than a year later.[8]

These ideas are formalized in (2) below where $\Psi_t^{jh} = 1$ if a job with hours h in sector j is available to be chosen in year t. $I(\cdot)$ is the indicator function denoting that the expression in

[8]Because sector is such a large, but well-defined category, there seem to be few cases of people misreporting sector. A more detailed discussion of this issue is included in the appendix.

parentheses is true.

$$\begin{aligned}
\mu_t^{JA,jh} &= \psi_{0,j} I(h = 20 \text{ and lastsector}_t \neq j) + \psi_{1,j} I(h = 40 \text{ and lastsector}_t \neq j) \\
&\quad + \psi_{2,j} I(h = 60 \text{ and lastsector}_t \neq j) + \psi_{3,j} I(h = 20 \text{ and lastsector}_t = j) \\
&\quad + \psi_{4,j} I(h = 40 \text{ and lastsector}_t = j) + \psi_{5,j} I(h = 60 \text{ and lastsector}_t = j) \\
&\quad + \psi_{6,j} \text{ed}_t \\
\Psi_t^{jh} &= I(\mu_t^{JA,jh} + \varepsilon_{jt}^{JA} \geq 0) \qquad (2)
\end{aligned}$$

Under the assumption that ε_{jt}^{JA} is a standard normal random variable, these equations imply that the probability of an individual receiving a job offer in sector j for hours h is $\Phi(\mu_t^{JA,jh})$.

Own Labor Income

Monthly own labor income is defined in terms of weekly hours worked and an hourly wage that can differ by sector:

$$y_t^L = 4.3 \sum_{j=1}^{3} h_t^j * w_t^j$$

Following standard practice, log hourly wage offers in each sector are a linear function of several factors. These factors include age, age squared, education, health status, hours worked, and a scalar unobserved factor (λ):

$$\begin{aligned}
\log w_t^j &= \gamma_{0,j} + \gamma_{1,j} \text{age}_t + \gamma_{2,j} \text{age}_t^2 + \gamma_{3,j} \text{ed}_t + \gamma_{4,j} I(M_t = \text{good}) \\
&\quad + \gamma_{5,j} I(h_t = 20) + \gamma_{6,j} I(h_t = 60) + \gamma_{7,j} \lambda + \varepsilon_{jt}^W \qquad (3)
\end{aligned}$$

Wage offers can decline with poor health (M_t is a binary measure of health and is described in more detail below). Age enters the function as a proxy for experience and age-related declines in productivity that may not be captured by the health measure. A direct measure of experience does not enter the equation for several reasons. First, aggregate experience would be collinear with age and education. Second, small differences in experience make little difference in productivity at this stage of life. Third, the data set used to estimate the model does not contain complete experience measures. Note that while the parameters in the wage equations have important effects on the work decisions made by individuals, they are also identified by their effects on the observed wages.

Time-invariant unobserved heterogeneity of individuals is modeled with a scalar factor structure where the return to the unobserved factor can differ in each of the three sectors. One would expect this return to differ across sectors since the factor includes difficult to measure individual attributes such as ability or motivation. The unobserved factor is modeled as a discrete random variable with a finite number of points of support. Because the scale of the random factor is not separately identified from its return, I assume the distribution of the random factor is on the interval from zero to one. The random factor also enters the equations determining family financial support, and its distribution as well as the returns to the factor are identified primarily by the strong intertemporal correlation of these quantities within individuals. The per-period individual-level shocks (ε_{jt}^{W}) are assumed to be independent of the state variables and are normally distributed with mean 0 and variance σ_{Wj}^2.

Other Labor Income and Transfers

Labor decisions of the other members of the household are modeled as static responses to the work decision and characteristics of the older individual. This individual takes the response function of the other household members into account when choosing his own labor supply. In effect, this imposes a Stackelberg structure on the strategic behavior of the members of the household where the older individual is the leader, the other members of the household are followers.[9]

This assumption about strategic behavior is most realistic in rural households where younger

[9] Keane and Wolpin (2001) use a similar method to model parental transfers to young adults in the United States.

members may be hoping to inherit the assets of the patriarch when he dies, but may be less applicable in urban settings where older and younger members of the household may act more like peers. Nonetheless, imposing this structure on household behavior is one way to capture the endogeneity of other family members' decisions to work.

Labor income from other members of the household is measured per-capita and depends on age, health, the individual's unobserved factor, and whether the individual chooses to work during the period. Because education levels are highly correlated within families, the schooling of the older individual is also included in the specification as a proxy for the education of other members of the household.

While the model does not explicitly say anything about the coresidence decisions of family members, changes in household structure do enter indirectly through their impact on per-capita labor income. For example, if non-coresident children of the older individual respond to his retirement by inviting him into their household, this could be reflected as an increase in the labor income of his household's other members.

Sometimes the older individual is the only member of the household who works. To capture this possibility, other labor income is modeled as a mixture of zero and a lognormal random variable. That is, a selection equation determines whether or not other labor income is zero. Note that the formulation shown in (4) is a Type II Tobit (Amemiya 1985) with the additional assumption that the error terms in the two equations are independent.

$$
\begin{aligned}
\mu_t^{OL1,h} &= \delta_{10} + \delta_{11}\text{age}_t + \delta_{12}\text{age}_t^2 + \delta_{13}\text{ed}_t + \delta_{14}I(M_t = \text{good}) + \delta_{15}I(h_t > 0) + \delta_{16}\lambda \\
\mu_t^{OL2,h} &= \delta_{20} + \delta_{21}\text{age}_t + \delta_{22}\text{age}_t^2 + \delta_{23}\text{ed}_t + \delta_{24}I(M_t = \text{good}) + \delta_{25}I(h_t > 0) + \delta_{26}\lambda
\end{aligned}
$$

$$
y_t^{OL} = \begin{cases} 0 & \text{if } (\mu_t^{OL1,h} + \varepsilon_t^{OL1}) < 0, \\ \exp(\mu_t^{OL2,h} + \varepsilon_t^{OL2}) & \text{otherwise.} \end{cases} \tag{4}
$$

Per-capita transfers into the household are handled similarly to other labor income in (5). Family members outside the household decide how much money to give to the household based on the labor force participation decision and characteristics of the older individual. The older individual takes this response function into account when deciding whether or not to work. In this context, the mixed zero lognormal specification is even more important than in the case of other labor income because of the large number of households that receive no transfer payments.

$$
\begin{aligned}
\mu_t^{TR1,h} &= \xi_{10} + \xi_{11}\text{age}_t + \xi_{12}\text{age}_t^2 + \xi_{13}\text{ed}_t + \xi_{14}I(M_t = \text{good}) + \xi_{15}I(h_t > 0) + \xi_{16}\lambda \\
\mu_t^{TR2,h} &= \xi_{20} + \xi_{21}\text{age}_t + \xi_{22}\text{age}_t^2 + \xi_{23}\text{ed}_t + \xi_{24}I(M_t = \text{good}) + \xi_{25}I(h_t > 0) + \xi_{26}\lambda
\end{aligned}
$$

$$
y_t^{TR} = \begin{cases} 0 & \text{if } (\mu_t^{TR1,h} + \varepsilon_t^{TR1}) < 0, \\ \exp(\mu_t^{TR2,h} + \varepsilon_t^{TR2}) & \text{otherwise.} \end{cases} \tag{5}
$$

Pension Income

The model incorporates most of the rules of Indonesia's civilian government employee pension system as described above. The rules of the civilian pension program are applied to members of the military as well because there are far fewer military than civilian pension recipients and the rules are quite similar. Individuals who work at least one year for the government are eligible for a monthly inflation-adjusted pension after age 55 equal to 2% of their final month's salary multiplied by their total number of years of service, up to a maximum of 35 years. Because the actual final month's salary is not observed for most retirees in these data, it is approximated as the expected salary of a healthy 55 year-old government worker with the same number of years of schooling and unobservable factor as the retiree. This expectation can be computed easily from the hourly wage equation (3) above. If government workers leave service before age 50, they lose eligibility. These rules are formalized in (6) below where the number 172 refers to the number of hours a full-time government employee works in a month:

$$\begin{aligned}
\text{FMS} &\equiv \text{Final Month's Salary} \\
\text{FMS} &\approx 172 \cdot E[w^3 | \text{age} = 55, \text{ed} = \text{ed}_t, M = \text{good}, h = 40, \text{factor} = \lambda] \\
&\approx 172 \cdot \exp(\gamma_{0,3} + \gamma_{1,3}55 + \gamma_{2,3}55^2 + \gamma_{3,3}\text{ed}_t + \gamma_{4,3} + \gamma_{7,3}\lambda) \\
\text{GPE}_t &= I(\text{Worked in government at age 50 by year } t) \\
\text{yserv}_t &\equiv \text{Total years of government service by year } t
\end{aligned}$$

$$y_t^P = \begin{cases} 0.02 \cdot \text{yserv}_t \cdot \text{FMS} & \text{if age}_t > 55 \text{ and GPE}_t = 1 \text{ and } h_t^3 = 0, \\ 0 & \text{otherwise.} \end{cases} \tag{6}$$

Private pension programs are ignored in the model because of the low level of participation and the comparatively small value of these pensions. In addition, the rules of private pension programs can vary substantially, and these details are not observed in the data used to estimate the model. Because the model only considers the wages offered by private sector jobs when computing the positive impact of working in these jobs on utility, the model under-counts the benefits that come from the small number of private sector jobs that offer pensions. This will result in small biases in the estimates of the job offer equations to explain the slightly higher participation in the private sector driven by these unobserved benefits.

Consumption and Utility

Because the model describes behavior of individuals and it is especially hard to measure consumption or saving at the individual level, the model makes the simplifying assumption that the fraction of income consumed is constant relative to labor supply. In addition, we know that even household saving is only weakly correlated with labor supply in these data so using measures of household assets as a proxy would most likely not change the predictions of the model substantially.

In particular, I assume that individuals consume exactly 90% of income.[10] The model is agnostic about what happens to the part of income that is not consumed. This may be invested in household assets or simply shared with other members of the household.

Utility depends on consumption, health, and hours worked:

$$
\begin{aligned}
U(c_t, h_t, s_t) \quad = \quad & \frac{1}{1-\alpha_0} c_t^{1-\alpha_0} - \alpha_{11} I(h_t = 20) - \alpha_{12} I(h_t = 40) - \alpha_{13} I(h_t = 60) \\
& -\alpha_2 I(M_t = \text{bad}) \\
& -\alpha_{31} I(h_t = 20 \text{ and } M_t = \text{bad}) - \alpha_{32} I(h_t = 40 \text{ and } M_t = \text{bad}) \\
& -\alpha_{33} I(h_t = 60 \text{ and } M_t = \text{bad}) \\
& -\alpha_{41} I(h_t = 20 \text{ and } \text{age}_t > 55)(\text{ age}_t - 55) \\
& -\alpha_{42} I(h_t = 40 \text{ and } \text{age}_t > 55)(\text{ age}_t - 55) \\
& -\alpha_{43} I(h_t = 60 \text{ and } \text{age}_t > 55)(\text{ age}_t - 55) \qquad (7)
\end{aligned}
$$

I assume that utility is additively separable in consumption and leisure because finding a convincing identification strategy for models that relax this assumption is notoriously difficult, especially in a society where households are large and complex. α_0 is the coefficient of relative risk aversion with respect to consumption. While there are several studies that estimate coefficients of relative risk aversion for individuals in the United States using portfolio allocations (e.g., Halek and Eisenhauer 2001), this measurement, and collecting portfolio data in general, is much more difficult in the developing world. At the same time, there is a large body of research that shows that individuals in the developing world do exhibit risk-averse behavior (e.g., Binswanger 1980; Townsend 1994)). Based on this research, I fix α_0 to a conservative positive value of 0.50 for the estimation. The discount factor (β) is a measure of inter-temporal substitutability of utility, and in this paper, I fix it to 0.95. In practice, I find that my results are not very sensitive to these

[10] In practice, the results shown below are robust to changes in this fraction.

particular normalizations and that I get similar results for a fairly wide range of values.

By including interaction terms, the functional form allows the disutility of work to be higher when the individual is in poor health. Different coefficients on the different choices of hours allow utility to depend non-linearly on the number of hours worked and allow for a high fixed cost of working, which has been found to be important in retirement models where hours are chosen (French 2005). Just as binary health status does not fully capture age-related declines in productivity in the wage equation, it does not fully capture the age-related changes in the direct effect of work on utility. For this reason, the utility function includes an interaction of age and hours. The direct effect of health status on utility (α_2) is poorly identified due to the exogeneity of health status in the model and is fixed at 5.0 for the estimation.

Health and Mortality

Transitions between the two states of health (M_t = good, M_t = bad) and death depend on age and education, but not on current or past labor supply choices. That is, given an individual in a particular health state in period t at age a with education ed, there is a fixed probability of reaching each of the other destination states. The positive correlation of good health and measures of income and wealth is well-documented (Marmot et al. 1997) and is captured in this model by letting health influence the decision to work (and gain income) through several channels including the effect of health on productivity and its direct effect on utility.

5 The Data

I estimate the model using data from the first two waves of the Indonesia Family Life Survey (IFLS) conducted in 1993 and 1997 (Frankenberg and Karoly 1995; Frankenberg and Thomas

2000).[11] The IFLS interviewed individuals in 13 of Indonesia's 26 provinces in 1993 and represents 83% of the country's total population. This longitudinal survey of over 7,200 households contains comprehensive data on demographics, work experience, health, household assets and consumption, and transfer payments from non-coresident family members. The work histories include annual information about wages, hours, and job sectors going back to 1988. The health data include both self-assessed measures such as general health status and ability to perform activities of daily living (ADL's) as well as several objective measures including height, weight, pulse rate, and blood pressure. I provide a detailed discussion of the construction of variables for work choices, transfer payments, labor income, pensions, health, and mortality in the appendix.

The full sample of 3,415 men between age 40 and 75 were first interviewed in 1993. I exclude 428 individuals (13%) who did not provide basic demographic information, job histories, and health information, leaving a final sample of 2,987 men. The model implicitly treats these individuals as heads of household.[12] For individuals with missing choices in their work history, I use all information on that individual up to the first time period where information is missing.

As discussed above, urban and rural areas of Indonesia are quite different. Table 1 reaffirms this, showing that older men in urban areas have more education, receive higher wages, and are more likely to receive pensions than comparably aged men in rural areas. And while most self-employed individuals in rural areas are farmers, the informal sector in urban areas is much more diverse. To account for these differences, I estimate the model separately for urban and rural subsamples.

[11] Additional surveys of these households were conducted in 1998 and 2000, after the late 1997 financial crisis. This crisis changed (at least temporarily) prices and wages and is likely to have affected people's expectations about the future. To avoid the complexities of this structural change, the current analysis is confined to the pre-crisis period.

[12] Less than 2% of the households contain more than one man over 40 and in 96% of households that contain at least one man over 40, a man over 40 is designated as the household head.

6 Estimation Methods

Estimation of the model is broken into two discrete steps: computation of annual health and mortality transition rates and estimation of the dynamic discrete choice model using simulated maximum likelihood (SML).[13] This two step approach simplifies the estimation and, because the health/mortality process is assumed to be exogenous, produces unbiased estimates. This section describes the methods used to estimate the discrete choice model while the estimation of the health/mortality process is outlined in the appendix.

Maximizing the likelihood function implied by the dynamic model requires solving the individual dynamic programming problem for a large number of candidate sets of parameters. For each set, the value function is computed using backwards recursion. The state space implied by the model contains over 500,000 discrete points and I compute the value function explicitly for a large subset and use linear interpolation to approximate other values as needed. Because of the large number (10) of unobserved error terms, expectations are taken over future value functions using Monte Carlo integration.

Several observed variables (choices, wages, other labor income, and transfers) are determined by the model in each period, conditional on the state, and the log likelihood function, $\mathcal{L}(\cdot)$, is the log joint probability/density of observing these outcome variables in the sample. Except for the choice made, any or all of these variables may be unobserved for a given time period. The only wage offer observed is the one for the sector and hours chosen. Observed pension amounts are used to derive pension eligibility and number of years of government service, and are not used to estimate the model directly.

Because of the assumption of independence of individuals, the likelihood function for the entire sample is the product of each individual likelihood function. The distribution of the unobserved

[13] In this context, the term "simulated maximum likelihood" refers to the use of simulation to approximate probabilities of observed choices as the corresponding likelihood function does not have a closed form solution.

factor (λ) is integrated out for each individual:

$$\mathcal{L}(\cdot) = \log \int_\lambda \prod_t^T f(\text{choice}_t, w_t^j, y_t^{OL}, y_t^{TR} | s_t) f(\lambda) d\lambda$$

This individual joint probability/density can be factored into two more easily computed pieces using the following notation:

$$\begin{aligned} w_t^{j,h} &\equiv \text{wage in sector } j \text{ given total hours worked } h \\ y_t^{OL,h} &\equiv \text{other labor income given total hours worked } h \\ y_t^{TR,h} &\equiv \text{transfers given total hours worked } h \end{aligned}$$

$$\mathcal{L}(\cdot) = \log \int_\lambda \prod_t^T Pr(\text{choice}_t | w_t^{j,h}, y_t^{OL,h}, y_t^{TR,h}, s_t) f(w_t^{j,h}, y_t^{OL,h}, y_t^{TR,h} | s_t) f(\lambda) d\lambda$$

Each of the observed non-choice outcomes either identifies one of the error terms, imposes a restriction on an error term, or both. For example, if the individual worked full-time and received positive transfers, then we know the following:

$$\begin{aligned} \varepsilon_t^{TR1} &< \mu^{TR1,40} \\ \varepsilon_t^{TR2} &= \log y^{TR,40} - \mu^{TR2,40} \end{aligned}$$

Based on these restrictions, I approximate the choice probability with Monte Carlo integration and sampling from the restricted distribution of error terms.

Computing the unconditional distribution of the non-choice outcomes is straight-forward, as assuming independence of the error terms allows the density to be factored in the following way:

$$f(w_t^{j,h}, y_t^{OL,h}, y_t^{TR,h} | s_t) = f(w_t^{j,h} | s_t) f(y_t^{OL,h} | s_t) f(y_t^{TR,h} | s_t)$$

If a wage offer is observed, then it contributes the density of a log normal since $\log w_t^{j,h} \sim \mathcal{N}(\mu_t^{W,jh}, \sigma_{Wj}^2)$:

$$f(w_t^{j,h}|s_t) = \phi\left(\frac{\log w_t^{j,h} - \mu_t^{W,jh}}{\sigma_{Wj}}\right)\frac{1}{w_t^{j,h}\sigma_{Wj}}$$

$y_t^{OL,h}$ and $y_t^{TR,h}$ have the same two-tiered log-normal structure:

$$f(y_t^{OL,h}|s_t) = \left[\Phi(-\mu_t^{OL1,h})\right]^{I(y_t^{OL,h}=0)}\left[(1-\Phi(-\mu_t^{OL1,h}))\phi\left(\frac{\log y_t^{OL,h} - \mu_t^{OL2,h}}{\sigma_{OL2}}\right)\frac{1}{y_t^{OL,h}\sigma_{OL2}}\right]^{I(y_t^{OL,h}>0)}$$

$$f(y_t^{TR,h}|s_t) = \left[\Phi(-\mu_t^{TR1,h})\right]^{I(y_t^{TR,h}=0)}\left[(1-\Phi(-\mu_t^{TR1,h}))\phi\left(\frac{\log y_t^{TR,h} - \mu_t^{TR2,h}}{\sigma_{TR2}}\right)\frac{1}{y_t^{TR,h}\sigma_{TR2}}\right]^{I(y_t^{TR,h}>0)}$$

Health status is only observed for years 1993 and 1997. Since the likelihood function is defined conditional on health status, I integrate over the distribution of possible health histories conditional on the years when health is observed. This allows the use of all nine years in the sample (1989-1997) instead of restricting the estimation to two years. For an individual:

$$\mathcal{L}(\theta) = \int_M L(\theta|M)f(M|M_{1993}, M_{1997})dM$$

To compute this integration, I use the Markov structure of the health-mortality process to draw a representative sample of complete health histories that are consistent with the observed data and compute the mean likelihood over this set of complete histories.

Because computing analytic derivatives of the model's likelihood function is impossible, and computing accurate numeric derivatives is very expensive, I use a combination of two derivative-free optimization methods to maximize the likelihood. First, I use asynchronous parallel pattern search to identify a local maximum (Gray and Kolda 2004; Kolda 2004). Second, I use a parallel simulated annealing algorithm to search the parameter space starting at the proposed solution to provide evidence for it being a global maximum. While direct search methods in general require more function evaluations to converge to a solution than derivative-based methods, the ability to run each algorithm in parallel more than makes up for the loss in serial efficiency.

7 Results and Discussion

Tables 2–5 show the results of estimating the dynamic programming model for rural and urban subsamples, while the results of estimating the health/mortality process are reported in the appendix. Table 2 reports the estimated coefficients from the utility function (7). In both urban and rural areas part-time work and full-time work contribute similar amounts of disutility, while working more than 55 hours a week contributes more disutility. In rural areas, being in poor health increases disutility of work for all choices of hours, but in urban areas, poor health increases the disutility of part-time and over-time jobs more than full-time jobs. This may be due to differences in the type of part-time and over-time work that is available. Full-time urban jobs may be more sedentary and thus easier to manage for a person in poor health. The disutility of work, especially over-time work, increases with age after 55 years in both rural and urban areas.

Table 3 derives some representative job offer probabilities from the parameters of the job offer equations (2). These are the probabilities in a given year that an individual will have the option of choosing a job with a certain number of hours in a certain sector.[14] These per-period offer probabilities are computed for individuals with six years of schooling, but in most cases these are similar across different levels of schooling. In general, education has only a negligible effect on the probability of getting a job offer in any sector. The only exception is that urban individuals with more schooling are less likely to get a job offer in the informal sector. The only job offers that these highly educated individuals can draw are highly paid, and there are very few of these jobs available in self-employment.

In both rural and urban areas, the estimates show that all sectors are difficult to enter. It is far easier to keep a job in the sector than to enter from either unemployment or another sector. It

[14] See the appendix for the actual coefficient estimates for the job offer equations.

is relatively easier to get a new job offer in self-employment than the private sector. Government jobs offer high wages and benefits but are scarce, and thus entry without a previous foothold in that sector is especially difficult. The self-employed sector is the easiest place to find a new part-time job. 13% of rural individuals not already in the self-employed sector and 9% of their urban counterparts get these job offers.

Estimates of the wage parameters from equation (3) are shown in Table 4. Wages for self-employment decline with age in both rural and urban areas, dropping faster in rural areas than urban (4% per year at age 55 in rural areas versus 2% in urban areas). The informal sector in rural areas is primarily agricultural, and often requires physically strenuous labor that becomes more burdensome with age. In contrast, the informal sector in urban areas is more heterogeneous and fewer jobs are physically demanding (although certainly many still are). Wage offers also decline with age in the rural private sector (3% per year at age 55), but are actually still increasing with age (4%) in the urban private sector at age 55. In the government sector, wages increase about 2% per year in rural areas and are not significantly related to age in urban areas. This is consistent with an environment where productivity is more related to experience than physical ability and regular salary increases are more likely.

The relationship between wage offers and health in the self-employed and private sectors tells a similar story: Good health (which is more common at younger ages) is associated with higher wages except in the case of the rural self-employed where the relationship is neutral. In the government sector, the effect of good health is insignificant in the rural areas, but negative in the urban areas. One possible explanation is that individuals in poor health are selecting into these jobs because of their more sedentary nature, and perhaps the model does not fully capture this selection process. Except for this anomalous case, the coefficients on health and age are consistent with productivity declining during the latter part of the life course, either through observed health or other unobserved mechanisms.

Part-time wages in the self-employed sector are moderately higher than those for full-time work with a 17% premium in rural areas and a 3% premium in urban wages. In the private sector, part-time jobs offer much higher wages (78% for rural, 91% for urban higher wages), but, as discussed above, these jobs are very difficult to find, even for individuals already working in the private sector. Jobs requiring more than 55 hours per week have significantly lower wages in both the self-employed and private sectors, but these jobs do still pay more total income than the part-time jobs.

The large and significant estimated returns to the unobservable factor in all sectors show that these factors are an important part of the model. Both the distributions and the returns are very similar across urban and rural areas and the factor's return is highest in the self-employed sector. The factor includes qualities like ability, motivation, and creativity that are not captured by years of education. The returns to these qualities are likely to be higher in self-employment than in sectors with more rigid salary structures.

Table 5 shows parameter estimates for the equations that determine other labor income (4) and transfer payments (5). These estimates show that on average, families adjust their behavior to accommodate older members who choose not to work and are more likely to contribute labor income when an older household member is in poor health. In each equation, age has a significantly positive or neutral effect on expected contributions by either increasing the likelihood of a contribution or increasing the amount. Good health significantly reduces the likelihood of other members contributing labor income to rural households, and has a negligible effect on transfers. The model predicts that outside family members will increase both frequency and amounts of transfer payments to older men in urban areas when these men choose not work. While the frequency of payments decreases with unemployment in rural areas, the net effect remains positive.

Goodness of Fit

Figures 3–6 compare patterns observed in the data with simulated distributions generated from the model. These graphs reflect the overall fit of the model. To assess fit, I draw samples of

20,000 individuals from the distributions of older men observed in 1993 in rural and urban areas. For each individual in each sample, I successively draw from the estimated error distributions and predict individual outcomes and choices for 1993, 1994, 1995, 1996, and 1997. I then compare the distributions of labor force participation and wages in the 1997 simulated samples with the distributions observed in the actual 1997 data. Note that this is a much more rigorous test than comparing predictions for the 1993 data, which the model fits exceedingly well. The black circles in the figures correspond to the age-specific means observed in the data while the gray circles are the age-specific means predicted by the simulations. The solid black lines are locally weighted regression predictions for the actual 1997 data while the gray lines are locally weighted regression predictions for the simulated 1997 data.[15]

Figure 3 shows that the predictions of aggregate labor force participation by age and participation by age and health status are accurate in rural areas, but that the model under-predicts participation before 55 and over-predicts participation after 55 in urban areas. Similarly, the model predicts well the sector-specific and hours-specific labor force participation rates shown in Figures 4 and 5 with some minor exceptions. Specifically, predicted participation in the rural private sector should be slightly higher at all ages, and in urban areas, the model predicts too much full-time participation at older ages. The rates of government employment in the data and the simulations match closely. In particular, we see similar sharp drops in government participation at age 55 when these workers can retire with a pension. Figure 6 shows that the model fits age patterns in log wages by urban/rural status and sector almost perfectly.

8 Potential Effects of Demographic Change and Pension Reform

One of the primary benefits of estimating a structural model is the ability to evaluate the potential effects of changes in the environment faced by individuals without actually observing those changes

[15] I use the Stata *lowess* command with a bandwidth of 0.4 to fit the locally weighted regressions.

in the real world. This can be done by simulating individuals both in the current environment and under a new scenario and comparing the choices made in the two cases. In this section, I use the estimated model to evaluate three scenarios. First, I consider the effects of a substantial reduction in family support for the elderly. Second, I consider a major pension reform that replaces the existing defined-benefit pension program for government workers with a unified defined-contribution plan that covers all government and private sector workers. Third, I combine the two experiments to see how a large, but affordable, pension program expansion might address some of the problems brought on by reductions in family support.

A key component of this analysis is to measure the welfare effects of these three scenarios. I do this by computing the subsidy or tax on wages that would be required to equate the mean expected utility of individuals in the scenario with that of individuals in the existing environment. If the scenario is welfare-improving, a tax would be required, but if the scenario is welfare-diminishing, wages would need to be subsidized to bring mean utility to its pre-intervention levels.

Reductions in Family Support for the Elderly

As families get smaller and older people live longer, it is possible that Indonesians will experience considerable declines in the amount of financial support that families provide to their older members. For example, even if the amount that each child provides individually does not decline, there will be fewer children to make such transfers. Alternatively, modernization may bring with it a decline in bonds of obligation and individual children may choose to contribute less to their aged parents. In either case, to measure the potential effect of a decline in family support for the elderly, I conduct a simulation experiment in which older individuals receive half as much family support as they would normally. In this simulation I draw (with replacement) samples of 20,000 individuals from the observed 1993 urban and rural subsamples. I randomly assign a value for the unobserved factor to each individual using the estimated distribution. I then simulate each individual's complete life course in the current environment by drawing from the error distributions and predicting health status and work choices made in each time period using the parameters estimated above. Next, I simulate these same individuals' life courses under the assumption that each individual can rationally expect to receive exactly half as much family support, in the form of other labor income and transfers, as he received in the base scenario.[16]

The implied changes in labor force participation as well as the welfare effects of all the scenarios are summarized in Table 6. First note that individuals over age 55 clearly increase their aggregate labor force participation in both rural and urban areas in order to compensate for the reduction in family support. In both urban and rural areas, the mean difference for individuals over age 55 is about 3%. That is, 3% of each sample over age 55 choose to work when faced with reduced family support when they would not work otherwise. These increases at older ages are concentrated among the unhealthy with an additional 5% of those in poor health choosing to work after after 55 compared to an increase of 1% of those in good health. The lack of any noticeable effect below age 55 is due to the already very high rates of participation at these ages.

In both urban and rural areas, the increases in participation come mostly in self-employment, with little increase in private sector and government employment. These results are consistent with the job offer probabilities estimated above and shown in Table 3. Self-employment is the easiest sector to enter and stay employed in, and it allows the most flexibility in terms of hours. In contrast, the private and government sectors are much more difficult to enter. Moreover, those in the government sector can afford some decline in family support, given that they receive significant pension benefits after age 55.

The welfare effects of the simulated 50% decline in family support are large. One would need to increase wages by 27% in the rural areas and 22% in the urban areas to compensate individuals for the utility lost through the decline in family support even after allowing them to increase their

[16] To maximize comparability across scenarios, I use the same set of draws when simulating all scenarios including the base scenario, so all differences are due to differences in the environment. This leaves open the possibility that the differences observed are due to measurement error in the parameters.

labor supply. Overall then, the experiment suggests that the labor supply and welfare effects of declines in family support could be substantial. In practice, future reductions in family support may be higher or lower than the across-the-board 50% reduction evaluated here, and may vary substantially across subgroups. However, the experiment provides a benchmark for assessing the effects of shrinking family sizes and declines in traditional forms of support.

Pension Reform

If family support of the elderly is not seen as meeting the needs of its large and aging population, Indonesia may be compelled to implement significant expansions in formal pension coverage. The modest benefits and compliance rates for the existing government-sponsored private sector pension program (JAMSOSTEK) have led many to call for its substantial overhaul or complete replacement (Leechor 1996; Holzmann et al. 2000; Brodjonegoro and Simanjuntak 2002). Here, I examine the consequences of moving Indonesia to a defined-contribution pension program similar to those common in Latin America which would replace Indonesia's existing defined-benefit program and cover both government and private sector workers.

Recent events in Latin America have shown that very generous broad coverage defined-benefit pension programs are unsustainable in the long-term. Several countries had unfunded programs and as the populations aged and the ratio of retired workers to active workers became too high, the net costs (i.e., above and beyond contributions) were enormous. For example, just prior to its reform the Chilean pension system ran a deficit equal to 2.7% of GDP (Edwards 1998). Chile was the first such country to address their problem in 1981 when they converted their public pension system to one based on private accounts. Under the new program, workers are required to deposit a fixed percentage of their wages into an interest-earning account that is inaccessible until retirement. Upon retirement, most individuals use their account balance to purchase an annuity that guarantees a fixed income for the rest of their life. Individuals who were already participating in the old system at the time of the reform are given "recognition bonds" that are worth about as much as they had contributed under the old system and are paid upon retirement. The management of the private accounts is highly regulated and returns are relatively low risk compared to the pure equity market (Diamond and Valdes-Priéto 1994).

The reform I simulate for Indonesia here is very similar to that implemented in Chile. Individuals in the formal labor market (government and private sector) are required to deposit 15% of their wages into a private account. These accounts accrue interest at a 5% real annual rate. Individuals can choose to retire from the formal labor market when they reach age 55 or later. Once they retire, they cannot return to the formal labor market. They can, however, work in the informal sector while receiving a pension as it would be difficult to enforce a ban on this.

Upon retirement, individuals purchase an actuarily fair annuity that pays them a constant, inflation-adjusted amount each year until they die. I compute this annual payment using the standard annuity formula and life expectancy conditional on education and age of retirement. I derive the life expectancies from the transition probabilities used in the model.[17] Agents in the model and annuity providers have consistent and rational expectations.[18] If an individual is over 55 and has worked at least three years in either the private sector or the government, but has not accumulated significant savings in their private account, the proposed program pays a minimum pension upon retirement equal to half of what an average private sector worker with no education would receive working full-time. In the rural areas, this is 200,000 rp per year and in urban areas it is about 500,000 rp per year.

Currently retired government workers continue to receive their existing pension. I transfer active government workers to the new plan by converting their existing years-of-service to an account balance in a manner similar to Chile's "recognition bonds." To compute this balance, I first determine what each individual under 55 with any government experience would receive as a

[17] Life expectancies are computed separately for urban and rural areas.

[18] The annual payment (w), is a function of the account balance (P), the real interest rate (r) and life expectancy (n): $w = (P(1+r)^{n-1}r]/((1+r)^n - 1)$.

government pension if he stopped working for the government at that moment in time and started receiving benefits at age 55. His account balance is the amount that would buy an annuity that guarantees this annual payment starting at age 55. After the conversion, these government workers (like other formal sector workers) are required to deposit 15% of their wages each year into their private account.

The retirement benefits associated with a government job are almost identical under the two systems.[19] Including the private sector in the pension reform results in large labor supply effects, as shown in Table 6. These results are computed using the same method described above to assess a reduction in family support. That is, samples of 20,000 individuals from 1993 are simulated for five years in the current environment and in the proposed pension environment.

Aggregate labor supply rates decline by 5% after age 55 in rural areas and by 10% in urban areas and the declines are similar by health status. This decline is almost entirely concentrated in the private sector, as one might expect given the new pension benefits. In the urban areas, retirement from the private sector is accompanied by a small increase in participation in the self-employed sector as some private sector retirees transition to working in the informal sector rather than exit the labor market. There is almost no new entry into the private sector by workers hoping to take advantage of the program, but this may be more a consequence of the difficulty of obtaining a private sector job rather than a sign of the undesirability of the pension. The value of the pension program is better measured by its effect on welfare. Under the program, the mean expected utility of individuals increases and taxes of 4% in the rural areas and 5% in the urban areas would be required to bring mean utility back to its original level.

In the third simulation I assess how this pension reform might interact with a decline in family support and determine if it can address some of the gaps created by such a decline. Unfortunately,

[19]When I simulate a defined-contribution program that applies only to government workers, labor supply behavior in the population is almost unchanged. Similarly, the mean expected utility of these individuals under the two systems is almost identical.

the results suggest that giving private sector workers the ability to shift resources later in life when they might be more dependent on their families still leads to substantial utility loss. The aggregate effects of combining the two treatments are shown in Table 6. The net effect in rural areas is a 2% decline in labor supply of men over 55 and a 6% decline of the same group in urban areas. In both samples, the effect is similar by health status. The bulk of the decline is in the private sector and it is offset by small increases in employment in the informal sector. While combining pension reform with declines in family support substantially reduces the labor force participation of individuals relative to the base case, it requires a 23% wage subsidy to bring utility back to pre-reform levels in rural areas and a 18% subsidy in urban areas.

The results above are based on one possible implementation of a pension reform, and should be interpreted with caution. An alternative, perhaps more realistic pension reform might include variation in the rate of return, since individuals bear a certain amount of risk when participating in most existing defined-contribution pension programs. In addition, the experiment does not account for general equilibrium labor market effects. For example, it is likely that wages in the informal sector would adjust to account for the influx of older workers and that private sector jobs might become even more difficult to obtain. Similarly, if employers were required to pay a share of the employees' contribution to the program, some employers (and thus their workers) might be driven into the informal sector. Finally, it is also possible that a broad-based pension reform would cause "crowd-out" of family support payments.

Nonetheless, the results suggest that implementing a defined-contribution pension program for private sector workers would be an inexpensive way to moderately increase the utility of a large fraction of the population. That said, the analysis also suggests that the self-employed may bear the brunt of potential declines in family support and that the proposed pension program would do little to address their needs since they are largely unable to move into the private sector to take advantage of this program.

9 Conclusion

Like many developing countries, Indonesia is in the middle of major demographic and economic change. When older people either cannot or choose not to work, most rely on their families for support as very little formal support for retirement exists. But as life expectancies increase and the families that old people depend on become smaller and more fragmented, this traditional system may not be sustainable. In this context, many people look to formal old age support as a way to protect the welfare of a growing aging population. This paper assesses the determinants of old labor supply and the effects of demographic change and pension reform on labor force participation and welfare of older men in Indonesia.

To do this, I use panel data to estimate a dynamic structural model of labor supply that takes into account forward thinking, health, family support, a multi-sector labor market, government pensions, and uncertainty about the future. While the model is a discrete choice dynamic programming model and has a structure that is similar to that used in the U.S. retirement literature, the model breaks new ground in several important ways. For example, the U.S. literature pays little attention to the role of the family or to the effect of health on productivity. These factors, however, are important determinants of old age labor supply in a developing country context. The results above show that family financial contributions increase with age and are generally higher for older men in poor health and older men who choose not to work. Simulating the effects of a 50% reduction in family support shows that large numbers of older men would choose to make up this income by working when they would otherwise stay out of the labor force.

The results show that poor health significantly lowers productivity, especially in the private sector, and is associated with much higher disutility from work. Furthermore, at least in the context of Indonesia, labor market sectoral differences play an important role in determining work choices of older men. Wages, pension benefits, the ability to enter the sector, and the relative availability of part-time employment differ substantially by sector. These sector-specific features affect labor supply decisions and transitions between sectors, and highlight the importance of the underlying structure of the labor market in shaping behavior.

The model's dynamic nature has allowed me to simulate the effects of a major defined-contribution pension reform. The results show that such a program would improve the welfare of workers in the private sector and reduce their dependence on family for support in the latter years of life. However, this type of program, which is typical of those recently implemented in many Latin American countries, leaves individuals who tend to work in the informal sector highly vulnerable to declines in family support. This suggests that other methods need to be considered to protect men's welfare in old age.

The model presented here contains a few potentially important limitations. First, household composition enters the model only through its effect on the labor income of other family members. Explicitly modeling household structure including the decision of older men to coreside with their children would allow more direct estimation of the effects of changes in family size on the behavior and welfare of older people. Another avenue for future work is to compare predictions of the model with data that was collected after 1997. This could include data from the Indonesia Family Life Survey's 2000 wave as well as the upcoming 2007 wave, giving the opportunity to assess model accuracy ten years out of sample.

Despite these areas for improvement, the current work advances our understanding of old age labor supply decisions in a developing setting. It suggests a framework for thinking about an environment that is in many ways more complex than that in the United States. In addition, pension systems are very expensive to implement and difficult to test on a small scale before national implementation. The simulation strategy used here provides an alternative strategy for assessing the effects of demographic trends and government initiatives that are being considered to meet the needs of an aging population.

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Table 1: Sample Means of Selected Variables by Age Group

	Age Group					
	41-50	51-55	56-60	61-65	66-70	71-75
RURAL:						
Sample size in 1993	707	293	270	177	135	96
Sample size in 1997	463	283	225	213	157	136
Labor Force Participation	0.98	0.95	0.91	0.87	0.79	0.64
Years of education	4.9	4.0	3.4	3.0	2.9	2.3
Good Health	0.89	0.82	0.72	0.63	0.54	0.41
Hourly Wage (general)	0.84	0.81	0.59	0.48	0.38	0.45
Hourly Wage (Self Emp.)	0.65	0.66	0.57	0.48	0.36	0.46
Hourly Wage (Priv. Sec.)	0.66	0.60	0.41	0.46	0.43	0.34
Hourly Wage (Gov.)	2.61	2.74	1.88	.	.	.
per cap. other labor income	17.5	22.3	17.4	17.7	19.5	14.6
per cap. transfers	7.3	8.0	9.1	14.4	19.0	8.8
Pension income	0.0	2.7	12.6	13.3	20.8	10.4
URBAN:						
Sample size in 1993	626	229	163	141	98	52
Sample size in 1997	385	214	189	138	101	83
Labor Force Participation	0.97	0.89	0.72	0.63	0.51	0.38
Years of education	8.3	7.6	6.4	5.4	5.0	3.9
Good Health	0.91	0.87	0.75	0.65	0.57	0.43
Hourly Wage (general)	2.01	2.43	1.68	1.05	1.15	0.85
Hourly Wage (Self Emp.)	1.63	1.82	1.27	0.96	1.14	0.97
Hourly Wage (Priv. Sec.)	1.87	2.53	1.74	1.09	1.27	0.52
Hourly Wage (Gov.)	2.78	3.22	3.61	.	.	.
per cap. other labor income	29.0	41.6	42.9	46.9	41.2	39.4
per cap. transfers	8.3	40.9	17.2	36.3	23.9	37.5
Pension income	0.0	6.6	63.9	55.9	67.9	51.6

Notes: All amounts are means computed including zeros. All amounts are measured in thousands of real Rp; Base year=1997. Wage is not reported if fewer than 10 observations.

Source: IFLS 1993

Table 2: Parameter Estimates for Utility Function

	RURAL		URBAN	
	Estimate	(Std. Error)	Estimate	(Std. Error)
Utility:				
α_{11} (Disutility of PT)	1.47	(0.09)	2.32	(0.25)
α_{12} (Disutility of FT)	1.41	(0.12)	2.27	(0.25)
α_{13} (Disutility of OT)	1.52	(0.13)	9.82	(0.66)
α_{31} (Disutility of PT in Poor Health)	6.92	(0.02)	16.26	(1.25)
α_{32} (Disutility of FT in Poor Health)	6.82	(0.13)	3.69	(0.74)
α_{33} (Disutility of OT in Poor Health)	6.71	(0.13)	11.21	(1.41)
α_{41} (Disutility of PT per year after 55)	0.06	(0.01)	0.14	(0.07)
α_{42} (Disutility of FT per year after 55)	0.06	(0.002)	0.15	(0.01)
α_{43} (Disutility of OT per year after 55)	0.08	(0.006)	0.27	(0.06)

Notes: The estimation for both the rural and urban cohorts was conducted with the following normalizations: α_0 (Coef. of Relative Risk Aversion) = 0.50, α_2 (Disutility of Poor Health) = 5.00, and β (Discount Factor) = 0.95. For more detail on these normalizations, see Section 4. PT is part-time work (0-25 hrs/week), FT is full-time work (26-55 hrs/week), and OT is over-time work (56+ hrs/week). Standard errors of the parameter estimates are computed using BHHH (Berndt et al. 1974).
Source: IFLS 1993, 1997

Table 3: Selected Per-period Job Offer Probabilities Derived from Parameter Estimates

		RURAL			URBAN		
		Self-Emp.	Priv. Sec.	Gov.	Self-Emp.	Priv. Sec.	Gov.
Part-Time	new job	0.13	0.00	0.00	0.09	0.00	0.00
	cont. job	0.99	0.09	0.96	0.99	0.06	0.97
Full-Time	new job	0.06	0.03	0.00	0.03	0.04	0.00
	cont. job	0.52	0.57	0.88	0.50	0.57	0.92
Over-Time	new job	0.08	0.05	0.00	0.08	0.05	0.01
	cont. job	0.84	0.97	0.19	0.88	0.96	0.19

Notes: Probabilities are computed for individuals with 6 years of education.
Source: IFLS 1993, 1997

Table 4: Parameter Estimates for Wage Functions

	RURAL		URBAN	
	Estimate	(Std. Error)	Estimate	(Std. Error)
Wage, self-employed:				
γ_{01} (Constant)	-0.47	(0.04)	-1.55	(0.01)
γ_{11} (Age)	-0.06	(0.0006)	-0.02	(0.0002)
γ_{21} (Age^2)	0.0002	(0.00001)	0.00	(0.000)
γ_{31} (Education)	0.10	(0.01)	0.17	(0.003)
γ_{41} (Good Health)	-0.02	(0.03)	0.11	(0.01)
γ_{51} (PT)	0.17	(0.001)	0.03	(0.07)
γ_{61} (OT)	-0.41	(0.004)	-0.37	(0.02)
γ_{71} (Random Factor)	1.42	(0.02)	1.42	(0.03)
Wage, private sector:				
γ_{02} (Constant)	-1.11	(0.03)	-3.55	(0.03)
γ_{12} (Age)	-0.03	(0.0006)	0.09	(0.001)
γ_{22} (Age^2)	0.00	(0.00001)	-0.0009	(0.00001)
γ_{32} (Education)	0.10	(0.01)	0.11	(0.004)
γ_{42} (Good Health)	0.24	(0.03)	0.19	(0.04)
γ_{52} (PT)	0.78	(0.005)	0.91	(0.05)
γ_{62} (OT)	-0.44	(0.03)	-0.46	(0.07)
γ_{72} (Random Factor)	1.31	(0.03)	1.05	(0.03)
Wage, government:				
γ_{03} (Constant)	-2.46	(0.06)	-0.40	(0.05)
γ_{13} (Age)	0.02	(0.002)	0.002	(0.001)
γ_{23} (Age^2)	0.00	(0.00003)	0.00	(0.00002)
γ_{33} (Education)	0.19	(0.01)	0.10	(0.005)
γ_{43} (Good Health)	0.00	(0.06)	-0.25	(0.04)
γ_{53} (PT)	0.00	(0.12)	0.02	(0.12)
γ_{63} (OT)	0.00	(0.12)	0.00	(0.02)
γ_{73} (Random Factor)	0.47	(0.11)	0.16	(0.04)
Random Factor Distribution (2 types):				
Prob(Factor=0)	0.69		0.66	
Prob(Factor=1)	0.31	(0.02)	0.34	(0.03)

Notes: PT is part-time work (0-25 hrs/week), FT is full-time work (26-55 hrs/week), and OT is over-time work (56+ hrs/week). Standard errors of the parameter estimates are computed using BHHH (Berndt et al. 1974).

Source: IFLS 1993, 1997

Table 5: Parameter Estimates for Other Labor Income and Transfers Functions

	RURAL		URBAN	
	Estimate	(Std. Error)	Estimate	(Std. Error)
Other Labor Income, selection:				
δ_{10} (Constant)	-3.32	(0.06)	-3.25	(0.03)
δ_{11} (Age)	0.11	(0.001)	0.13	(0.001)
δ_{12} (Age^2)	-0.0009	(0.00002)	-0.001	(0.00001)
δ_{13} (Education)	0.01	(0.01)	-0.02	(0.004)
δ_{14} (Good Health)	-0.30	(0.04)	-0.08	(0.06)
δ_{15} (Worked this period)	1.00	(0.00004)	0.10	(0.02)
δ_{16} (Random Factor)	0.00	(0.05)	-0.08	(0.06)
Other Labor Income, amount:				
δ_{20} (Constant)	-0.22	(0.20)	-0.36	(0.13)
δ_{21} (Age)	0.05	(0.004)	0.12	(0.002)
δ_{22} (Age^2)	-0.0003	(0.00003)	-0.001	(0.00003)
δ_{23} (Education)	0.09	(0.01)	0.09	(0.01)
δ_{24} (Good Health)	-0.05	(0.07)	-0.06	(0.07)
δ_{25} (Worked this period)	-1.02	(0.05)	-0.39	(0.02)
δ_{26} (Random Factor)	2.15	(0.08)	0.09	(0.06)
Transfers, selection:				
ξ_{10} (Constant)	-3.44	(0.09)	-2.36	(0.05)
ξ_{11} (Age)	0.13	(0.001)	0.09	(0.001)
ξ_{12} (Age^2)	-0.001	(0.00002)	-0.001	(0.00001)
ξ_{13} (Education)	0.00	(0.007)	-0.006	(0.006)
ξ_{14} (Good Health)	-0.04	(0.05)	-0.05	(0.06)
ξ_{15} (Worked this period)	0.18	(0.06)	-0.17	(0.05)
ξ_{16} (Random Factor)	-0.09	(0.06)	-0.14	(0.04)
Transfers, amount:				
ξ_{20} (Constant)	-0.49	(0.18)	-2.49	(0.13)
ξ_{21} (Age)	0.03	(0.003)	0.11	(0.001)
ξ_{22} (Age^2)	-0.0001	(0.00004)	-0.001	(0.00002)
ξ_{23} (Education)	0.10	(0.01)	0.08	(0.01)
ξ_{24} (Good Health)	-0.05	(0.09)	-0.03	(0.10)
ξ_{25} (Worked this period)	-0.26	(0.06)	-0.43	(0.01)
ξ_{26} (Random Factor)	0.19	(0.10)	0.26	(0.12)

Notes: Standard errors of the parameter estimates are computed using BHHH (Berndt et al. 1974).

Source: IFLS 1993, 1997

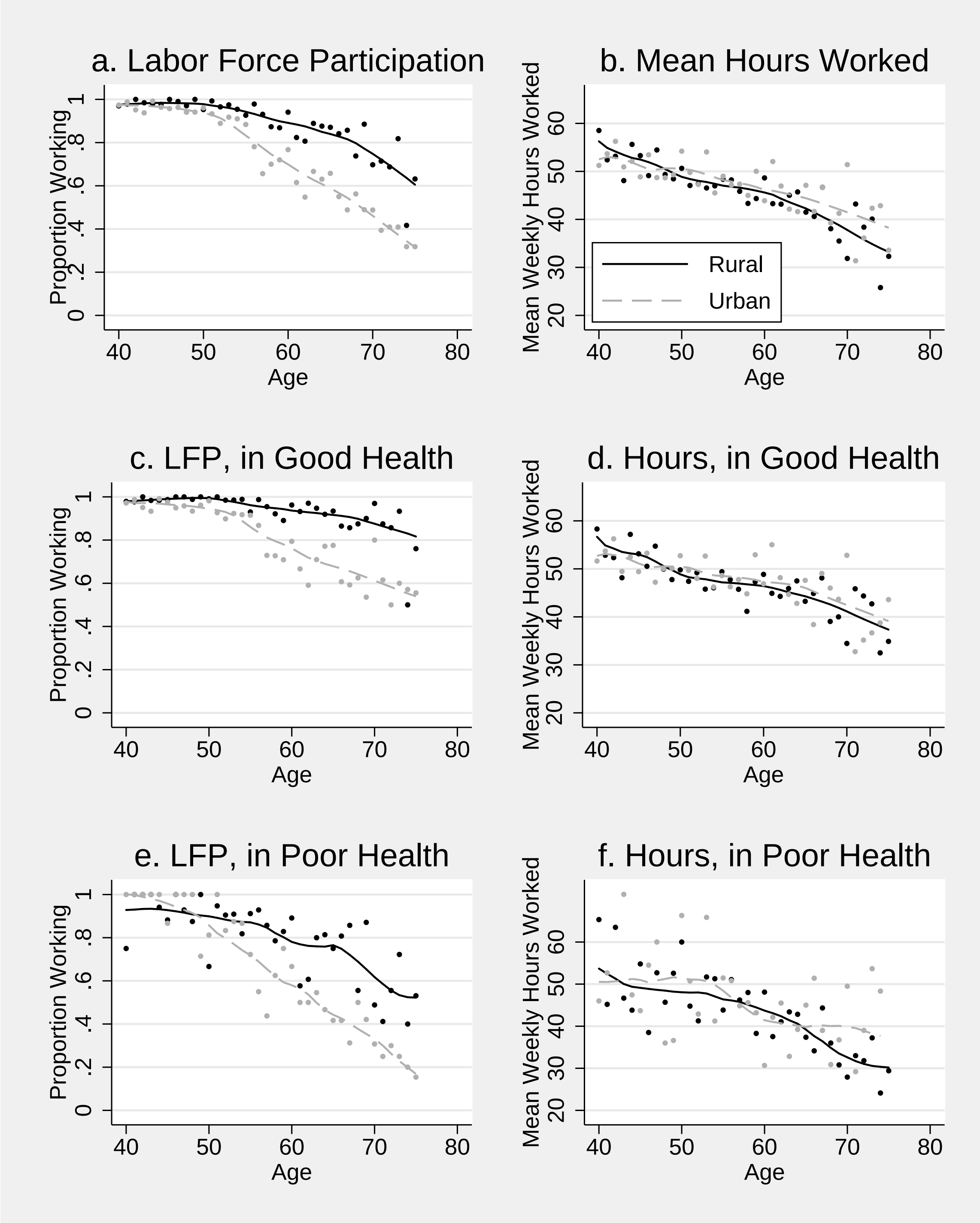
Table 6: Changes in Behavior and Welfare Induced by Changes in Family and Pension Support

	RURAL			URBAN		
	Reduced Family Support	Pension Reform	Combined Treatment	Reduced Family Support	Pension Reform	Combined Treatment
Δ prop. working						
Age 40–55	0.00	-0.01	-0.01	0.00	0.00	0.00
Age 56–75	0.03	-0.05	-0.02	0.03	-0.10	-0.06
Δ prop. working (good health)						
Age 40–55	0.00	-0.01	0.00	0.00	0.00	0.00
Age 56–75	0.01	-0.04	-0.03	0.01	-0.10	-0.08
Δ prop. working (poor health)						
Age 40–55	0.00	-0.01	-0.01	0.00	-0.01	0.00
Age 56–75	0.05	-0.06	-0.01	0.05	-0.10	-0.05
Δ prop. working in Self-Emp.						
Age 40–55	0.00	-0.01	0.00	0.00	0.00	0.00
Age 56–75	0.03	0.02	0.05	0.02	0.03	0.06
Δ prop. working in Priv.						
Age 40–55	0.00	0.00	0.00	0.00	0.00	0.00
Age 56–75	0.00	-0.08	-0.08	0.00	-0.14	-0.13
Δ prop. working in Gov.						
Age 40–55	0.00	0.00	0.00	0.00	0.00	0.00
Age 56–75	0.00	0.01	0.01	0.00	0.01	0.01
Wage tax needed to equate mean welfare	-0.27	0.04	-0.23	-0.22	0.05	-0.18

Notes: Standard errors of the parameter estimates are computed using BHHH (Berndt et al. 1974).

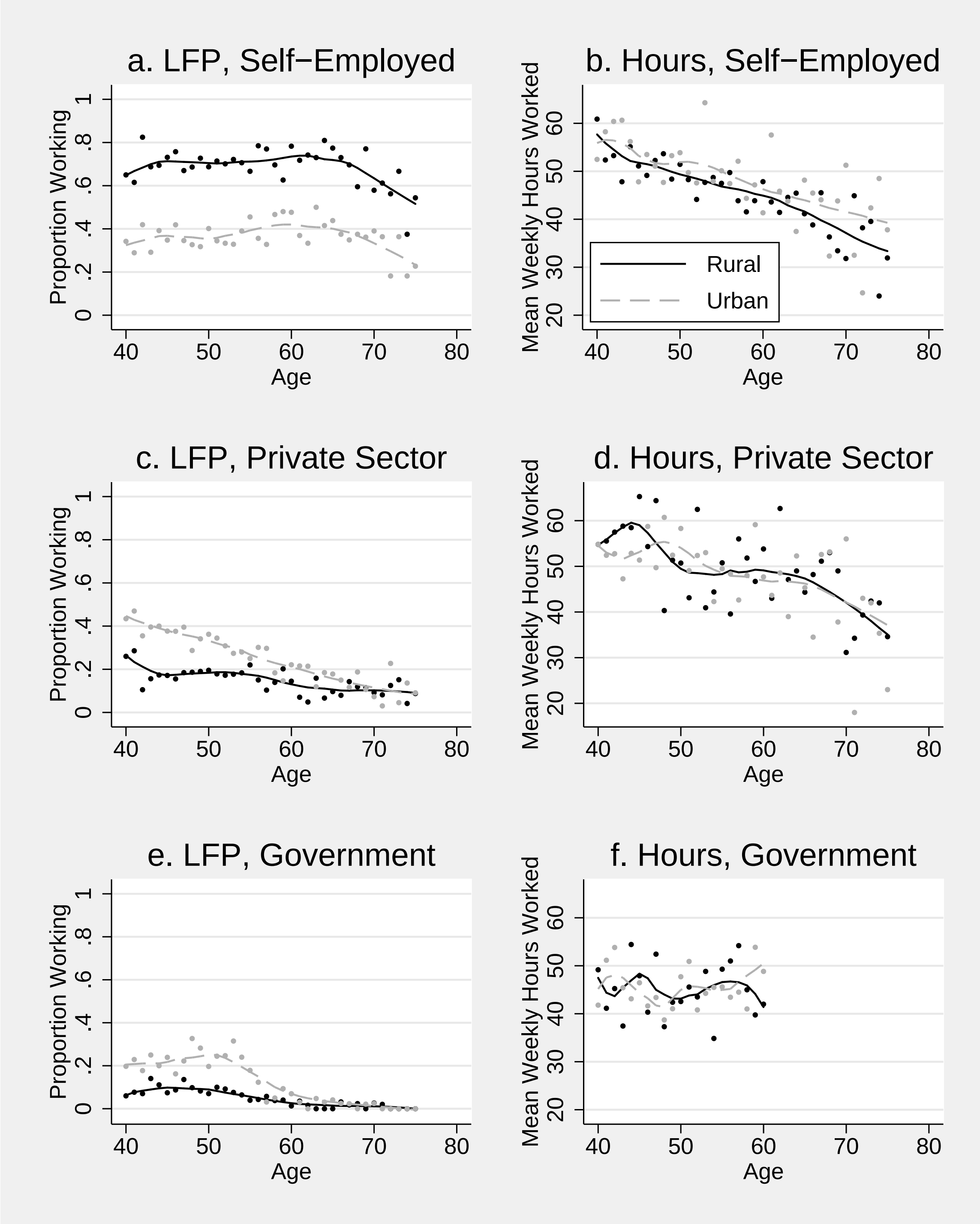
Source: IFLS 1993, 1997

Figure 1: Men's Labor Supply, Age 40 to 75*



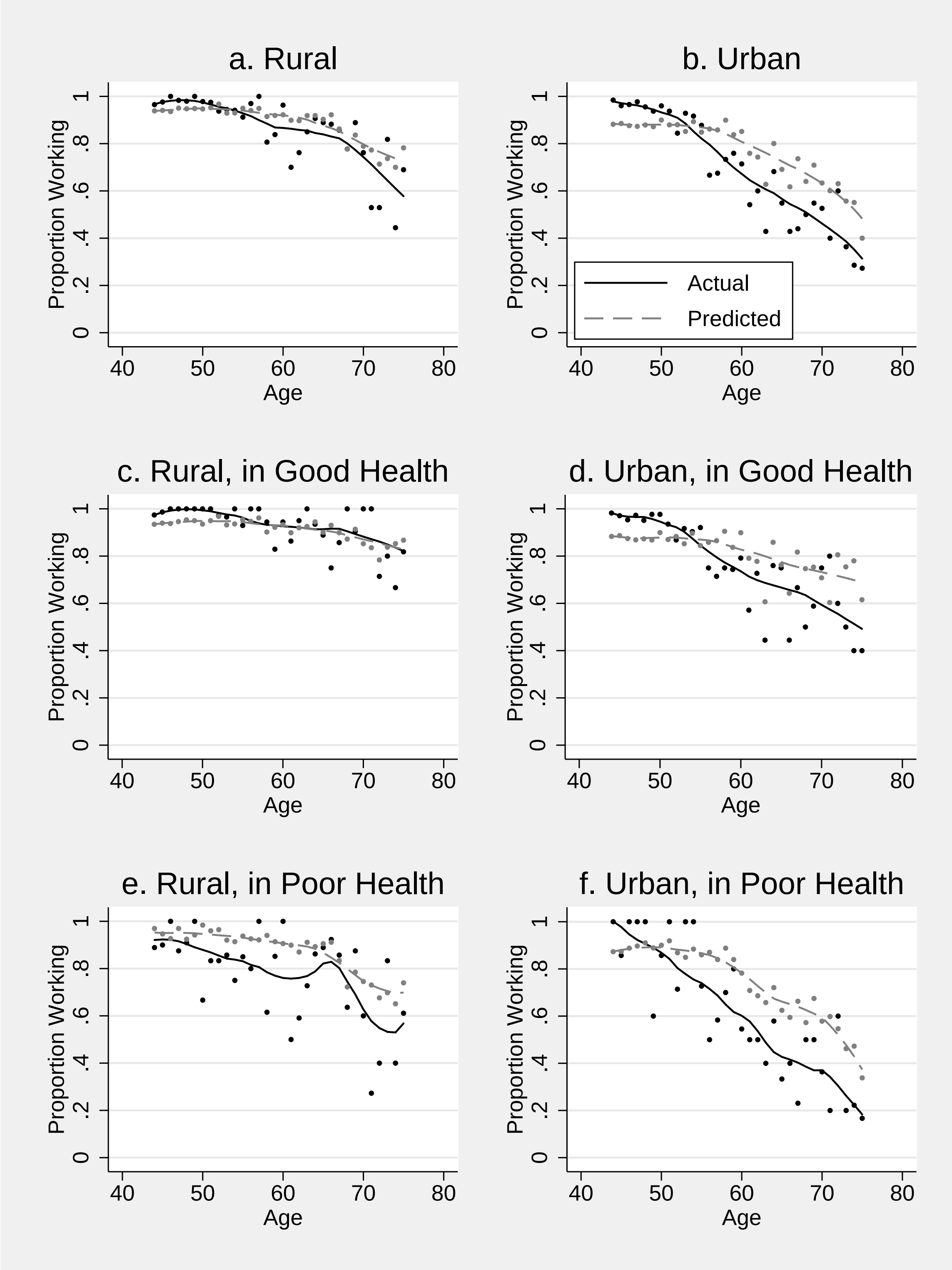
*Hours worked are conditional on working.
Source: IFLS 1993, 1997

Figure 2: Men's Labor Supply by Sector, Age 40 to 75*



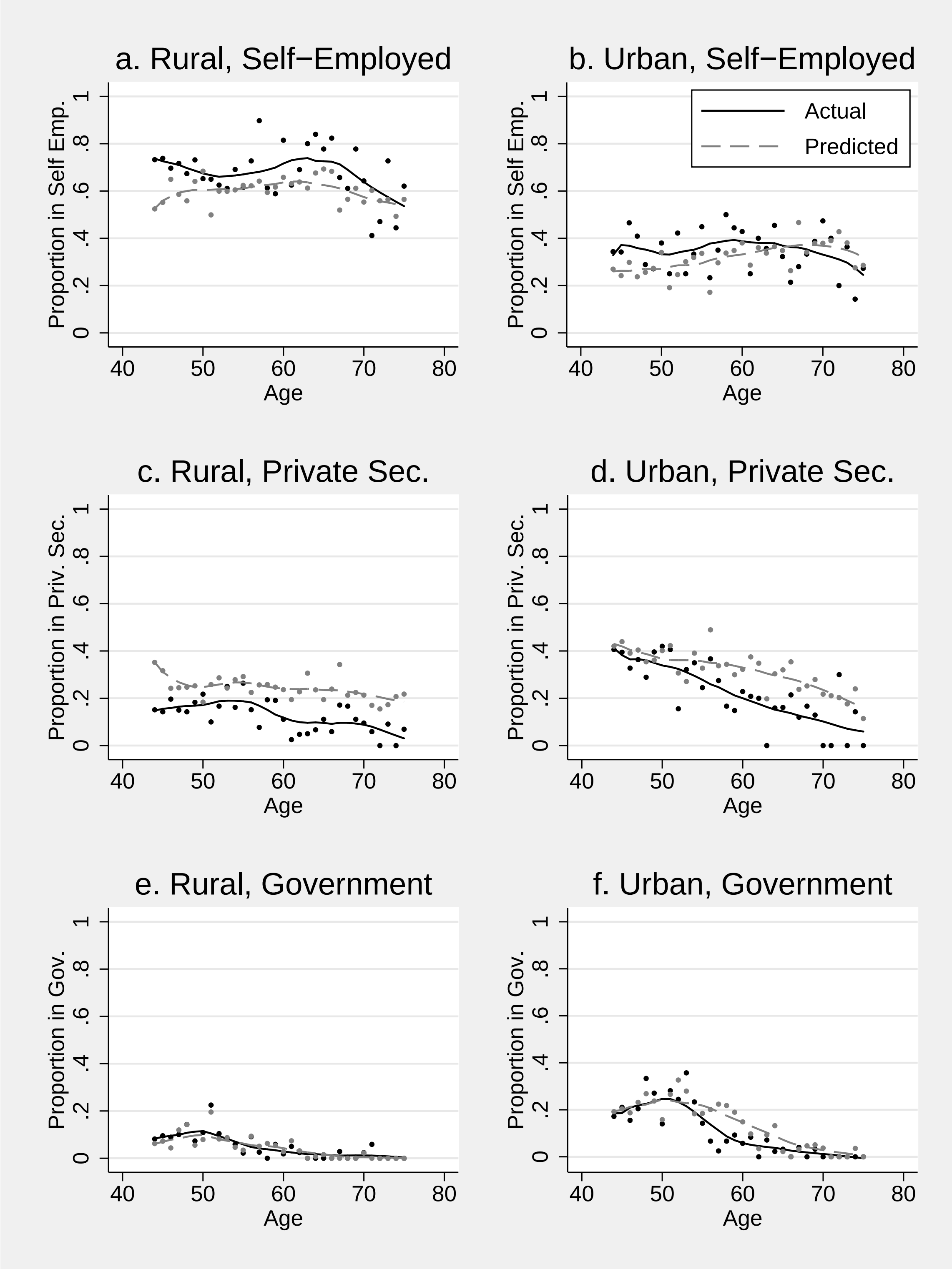
*Rates shown in panels (a), (c), and (e) are fractions of the total population of men employed in each sector by age. Hours worked are conditional on working.
Source: IFLS 1993, 1997

Figure 3: Graphs of Model Fit for Labor Force Participation



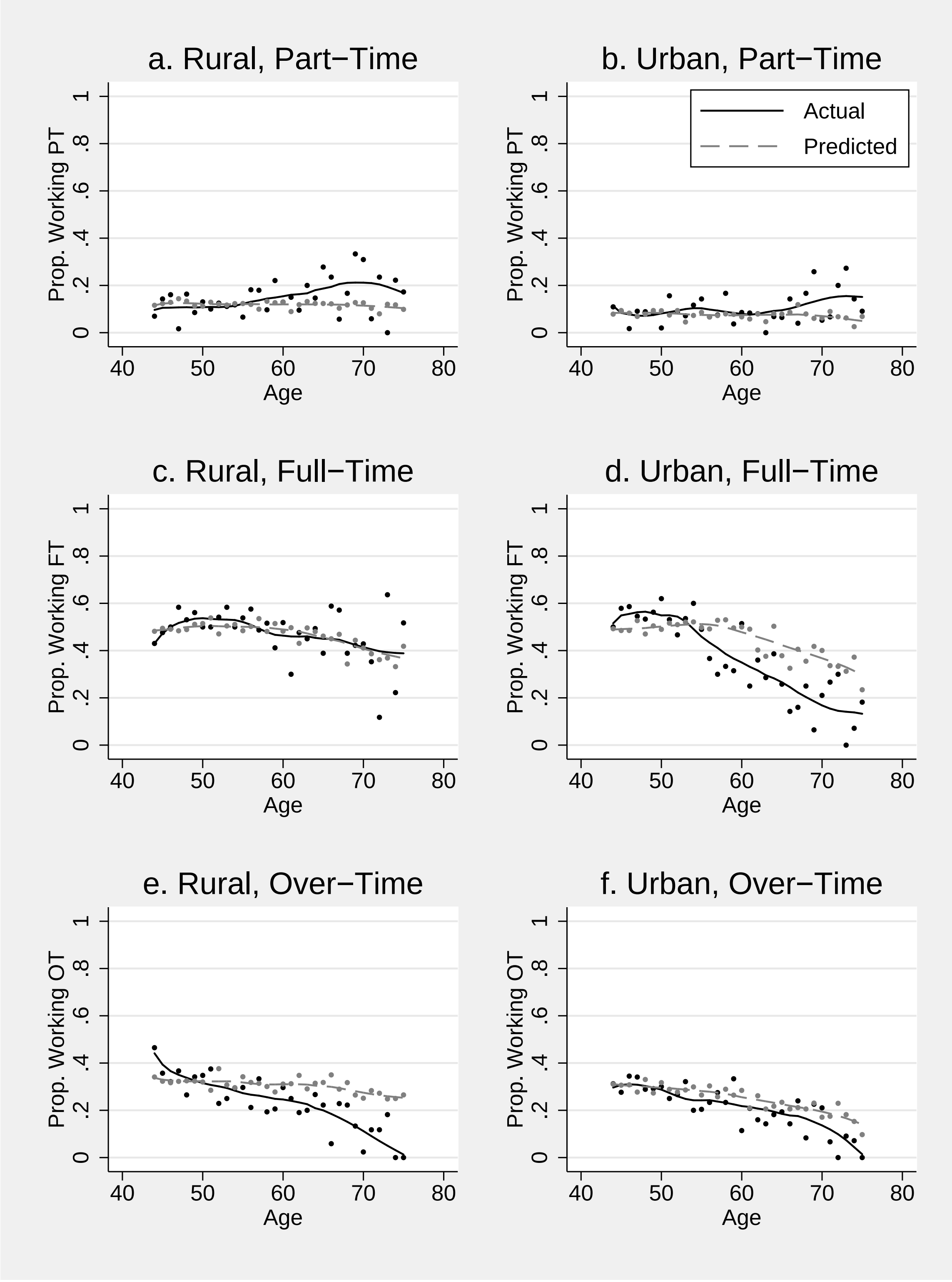
Source: IFLS 1993, 1997

Figure 4: Graphs of Model Fit for Labor Force Participation by Sector



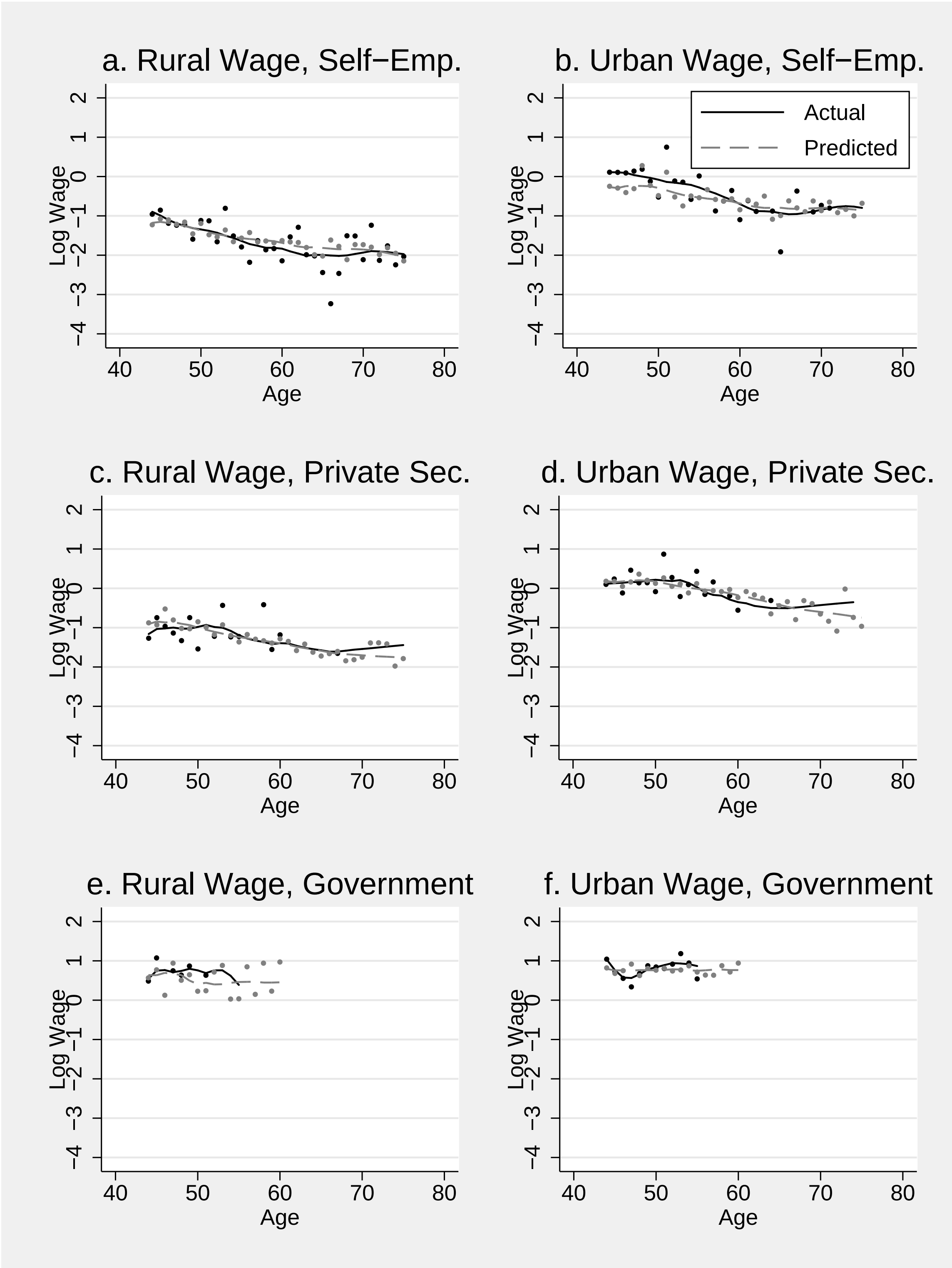
Source: IFLS 1993, 1997

Figure 5: Graphs of Model Fit for Labor Force Participation by Hours Worked



Source: IFLS 1993, 1997

Figure 6: Graphs of Model Fit for Wages



Wages are hourly and are measured in log thousands of real Rp; Base year=1997.
Source: IFLS 1993, 1997

A Appendix

This appendix has three parts. First, it contains a detailed description of how each of the variables used in the analysis was constructed. Second, it describes the methods used to estimate the health/mortality process and reports the results of estimating this process. Third, it includes a table of parameter estimates for the dynamic discrete choice model's job offer equations that was not included in the body of the paper.

A.1 Data

This section describes the construction of work histories and wages, family support and pension variables, and health measures.

Work

I construct a time series of work choices for each individual in the sample using the yearly job history data from the 1993 and 1997 waves of the survey. This yields observations for each year from 1988 to 1997. IFLS records up to two jobs per year per person and classifies each job into four categories: self-employed, government, private sector, and unpaid family work. I collapse these into the three sectors defined in the model by classifying both self-employed and unpaid family workers as working in the self-employed sector, a distinction that is often artificial in the first place. In many cases, a single individual in the household is arbitrarily designated the self-employed business owner and other members are considered unpaid family workers.

When an individual reports having two jobs in one time period, I combine information from these jobs to form a composite choice. If the sectors of the two jobs differ, I assign the sector of the primary job. I sum the hours worked in each job as well as any income received from each job to get an aggregate measure of weekly hours and monthly income. I classify jobs as part-time if the individual reports a normal work week between one and 25 hours, full-time if he worked 26 to 55 hours, and over-time if he worked more than 55 hours per week. Wages are computed by dividing total income by normalized hours worked.

Using a method similar to Thomas et al. (2003), I spread the income of the self-employed household members to the other "unpaid" family workers in the household. I pool the income of any self-employed workers in the household and redistribute it to all self-employed and unpaid family workers weighting by hours worked and the wage that the individuals might have received in the private or government sectors.[20]

If individuals have difficulty recalling details of previous labor force activities, especially those several years in the past, then retrospective measures of labor force participation may include additional measurement error (e.g., see Duncan and Hill 1985; Bound and Krueger 1991). Fortunately, the IFLS is an excellent setting in which to evaluate these concerns because the retrospective histories collected in the later waves overlap with the concurrent measures of earlier waves. In a study using IFLS data from 1993, 1997, 1998, and 2000, Maruyama (2002) finds that retrospective reports of income are strongly positively biased. In my sample, I too find large positive errors in retrospective reports of income, and therefore use only concurrent measures of wages from 1993 and 1997 in the analysis. While hours worked are very poorly recalled, there is significantly less recall error in reports of participation and sector.[21] I use information on participation and sector (but not hours) for the years 1989 to 1992 and 1994 to 1996. This is combined this with the fully observed choices (which include hours) for 1993 and 1997 when estimating the model.

Family Support and Pensions

I build a measure of per capita other labor income by summing the labor income of all household members except the older man and dividing by the total number of household members. Because

[20]The weighting wage chosen for an individual is the median observed market sector wage for the individual's sex, age, education, and location. Age is broken into three categories (16-24, 25-55, 56-) and years of education in two (0-5, 6-). Location is defined at the most specific level that yields at least 10 observations in a cell, and ranges from kecamatan (smallest) to kabupatan to province (largest).

[21]Concurrent and retrospective measures of labor force participation decisions matched in 89% of cases. Among those individuals who reported working, the sector matched in 81% of cases. In contrast, only 52% of cases matched on hours where hours were coded in the three categories defined above.

labor income was not collected for all household members in 1993, I use the retrospective measures of income in 1993 from IFLS2 for those household members who were not interviewed in 1993. The IFLS also contains data for 1993 and 1997 on any transfer income that enters the household, but because IFLS2 did not collect retrospective data on transfers, I cannot compute the total transfers entering the household in 1997. Instead, I compute the amount of transfers received by each individual who was interviewed in 1993 and their spouse. Because 97% of my sample was the designated household head in 1993, almost every spouse was also interviewed in 1993. Using this information I compute a per-capita measure of transfers to the couple if the individual is married or an individual measure if the individual is unmarried. While this is not ideal, it does capture the transfers that the individual will have the most control over.

Because the IFLS does not contain complete job histories, it is necessary to impute pension eligibility and total years of government service for some individuals. If individuals are observed to receive a pension after age 50, I assume they became pension eligible at age 50. To estimate years of service for these individuals, I first regress the log of wages of current government workers on age, age squared, and years of education. I use this equation to approximate each retiree's last wage by predicting the wage the retiree would have received at age 55. I then solve backwards for years of service using the civilian government pension formula. Individuals younger than 55 are assumed to have become pension eligible at age 50 if they work for the government at any point between the age 50 and 55. To estimate the years of service for individuals younger than 55, I use the retrospective measures available in the IFLS including whether they worked for the government in 1973, 1983, and 1988.[22]

[22] In particular, individuals who report working for the government in 1973 and 1983 are assumed to have 35 years of experience by 1993. Individuals who work for the government in 1983 but not in 1973 are assumed to have 15 years of experience, and individuals with government experience in 1988 but not in 1973 or 1983 are assumed to have 5 years. Individuals not observed to have worked for the government before 1989 are assumed to have 0 years of service in 1989. For the remaining years, I compute years of service using observed choices.

Health

The IFLS contains several candidate health measures that could be used to create the binary measure of health required to estimate the model. Ideally, this summary measure would be subject to minimal self-reporting bias and would be a good indicator of the health characteristics affecting labor force participation. In the United States, there has been some concern that self-reported health measures among retired workers may be biased because the tying of benefits to a reported inability to work gives some individuals an incentive to report poorer health (Parsons 1991). The empirical research on this point has been mixed with some researchers finding significant bias (Bound 1991; Kreider 1999) and more recent work finding no evidence of such bias (Benítez-Silva et al. 2004). This issue may be less of a problem in Indonesia where the vast majority are not covered by any disability insurance. At the same time, research on Indonesia has shown that self-reported measures of health are still affected by socio-economic characteristics above and beyond actual health differences between socio-economic groups (Thomas and Frankenberg 2000).

In this paper I define good health as reporting no difficulties with any activities of daily living (ADL) and bad health as reporting at least one ADL. Because this measure is more specifically defined than general health status and does not depend on an unstated reference group, it should be subject to less reporting bias. It has the added advantages that it should be quite relevant to the decision to work because many jobs in Indonesia require physical labor and that it is available in both the 1993 and 1997 survey waves.[23]

The particular activities asked about in the IFLS are to carry a heavy load for 20 meters, to sweep the house floor or yard, to walk for five kilometers, to draw a pail of water from a well, to bow, squat, kneel, to dress without help, and to stand up from sitting position in a chair without help. It should be noted that, by this definition, many individuals in poor health are able to work.

[23] The 1997 wave of the IFLS added several physical health assessments that might be combined to form a good objective indicator including lung capacity, blood pressure, and a timed test of moving from sitting to standing. Unfortunately, these measures are not available in the 1993 data.

In fact, 52% of older men (age 40 to 75) in poor health in 1993 report difficulty only with walking five kilometers or drawing a pail of water from a well, and 13% of all older workers in 1993 report being in poor health.

A.2 The Health/Mortality Process

The IFLS contains the year of death for every individual in the household in 1993 who subsequently died before the second wave of the survey in 1997. This sample includes the deaths of 205 men who were between the ages of 40 and 75 in 1993. Combining this information with observations of health state in 1993 and 1997, I estimate the following two multinomial logits to predict good health, bad health, or death, and use the resulting equations to predict 4-year health/mortality transition probabilities for every possible age, education and health status combination:

$$\begin{aligned} Pr(M_{t+4} = m | M_t = \text{good}) &= f(\zeta_{10} + \zeta_{11}\text{age}_t + \zeta_{12}\text{ed}_t + \epsilon_t^g) \\ Pr(M_{t+4} = m | M_t = \text{bad}) &= f(\zeta_{20} + \zeta_{21}\text{age}_t + \zeta_{22}\text{ed}_t + \epsilon_t^b) \end{aligned}$$

To derive the annual transition probabilities, let $Q_{a,ed}$ be the 3×3 four-year transition probability matrix for each starting age a and education level ed predicted above for ages 36 to 81. Let $A_{a,ed}$ be the corresponding annual transition matrix. For each education level, I assume that the annual transition matrices for ages 36, 37, 38, and 39 are approximately equal, and solve the following system of equations to get $A_{36,ed}, \ldots, A_{84,ed}$:

$$\begin{aligned} Q_{36,ed} &= A_{36,ed}A_{37,ed}A_{38,ed}A_{39,ed} \\ Q_{37,ed} &= A_{37,ed}A_{38,ed}A_{39,ed}A_{40,ed} \\ &\vdots \\ Q_{81,ed} &= A_{81,ed}A_{82,ed}A_{83,ed}A_{84,ed} \end{aligned}$$

This system can be solved iteratively, starting with the equation for $Q_{36,ed}$, and each matrix equation corresponds to a set of 6 simultaneous quartic equations with 6 variables. The solution must also satisfy the constraints that each variable (i.e., probability) must lie between 0 and 1 and each row of the matrix must sum to 1. While it is not obvious that there is a unique solution to this constrained optimization problem, there is at least one reasonable solution (see below) and any solution is, by construction, consistent with the observed 4-year transitions.

Figure A-1 graphs some representative annual health transition rates predicted by model. The columns of Figure A-1 correspond to the three most common educational attainments in the joined rural and urban samples: No education (19%), 6 years (26%), and 12 years (10%). The first row shows age-specific probabilities of healthy individuals transitioning to poor health over the next year. As expected, these probabilities increase with age, and at least for the urban sample, they decrease as education increases. Most striking is the fact that uneducated men in rural areas seem healthier than the uneducated in urban areas, while those with high levels of education in urban areas are less likely to transition to poor health. This could be caused by the fact that individuals in urban areas with no education are a relatively select group (9% of the urban sample vs. 26% in rural areas) and that better health care is available to the wealthy in urban areas.

The second row shows that the model predicts very low annual mortality of healthy men. Almost all mortality of healthy people observed in the data between 1993 and 1997 is explained by the healthy first transitioning to poor health and subsequently dying.[24] The third row in Figure A-1 shows annual mortality rates of those in poor health. These rates do not depend on education level and are consistently higher for the urban sample. The last row aggregates the transition rates and combines them with the results of estimating a simple static model of health state to form unconditional annual age and education-specific mortality rates that can be compared to publicly reported rates.[25] The rates look reasonable, although the large increase in urban mortality at later ages may be a spurious result of the relatively small sample size.

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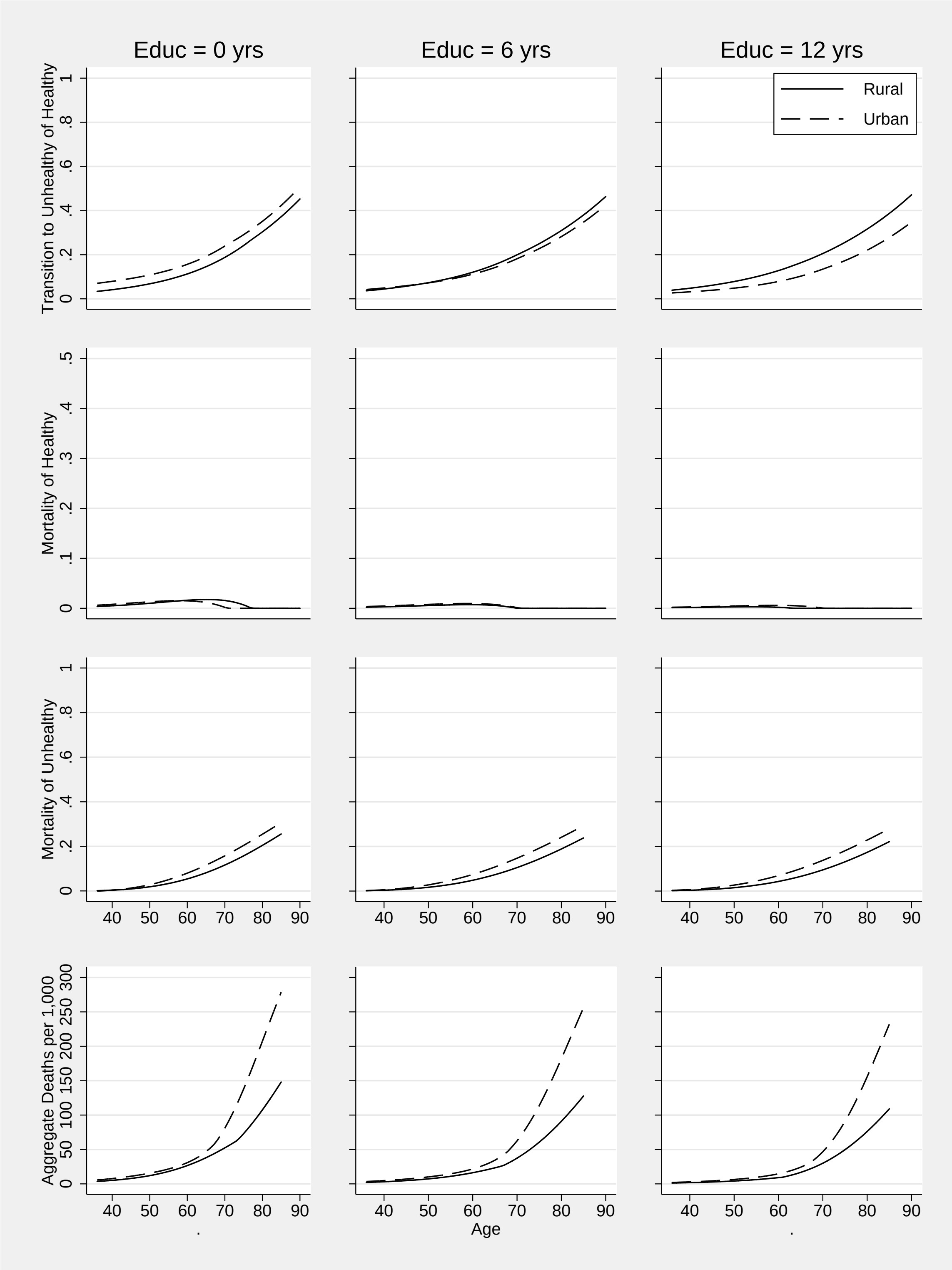
[24]While this pattern may be an artifact of the estimation strategy (see Section 6), it is still consistent with the observed 4-year transitions and should have minimal impact on the estimation of the dynamic model.

[25]I estimate and predict a logit for good or bad health for both urban and rural samples using as covariates age, age^2, and education.

Figure A-1: Predicted Annual Health/Mortality Transitions and Aggregate Mortality Rates



Source: IFLS 1993, 1997

Table A-1: Parameter Estimates for Job Offer Functions

	Rural		Urban	
	Estimate	(Std. Error)	Estimate	(Std. Error)
Job Offers, self-employed:				
ψ_{01} (PT and Last Sector $\neq$ self-employed)	-1.15	(0.01)	-0.76	(0.01)
ψ_{11} (FT and Last Sector $\neq$ self-employed)	-1.61	(0.02)	-1.35	(0.07)
ψ_{21} (OT and Last Sector $\neq$ self-employed)	-1.39	(0.02)	-0.82	(0.01)
ψ_{31} (PT and Last Sector = self-employed)	2.45	(0.01)	2.79	(0.03)
ψ_{41} (PT and Last Sector = self-employed)	0.05	(0.02)	0.61	(0.04)
ψ_{51} (OT and Last Sector = self-employed)	1.00	(0.03)	1.80	(0.03)
ψ_{61} (Education)	0.001	(0.001)	-0.10	(0.001)
Job Offers, private sector:				
ψ_{02} (PT and Last Sector $\neq$ self-employed)	-3.54	(0.16)	-3.21	(0.15)
ψ_{12} (FT and Last Sector $\neq$ self-employed)	-1.90	(0.05)	-1.78	(0.04)
ψ_{22} (OT and Last Sector $\neq$ self-employed)	-1.64	(0.01)	-1.61	(0.002)
ψ_{32} (PT and Last Sector = self-employed)	-1.32	(0.08)	-1.57	(0.07)
ψ_{42} (PT and Last Sector = self-employed)	0.21	(0.06)	0.18	(0.02)
ψ_{52} (OT and Last Sector = self-employed)	1.87	(0.03)	1.81	(0.04)
ψ_{62} (Education)	-0.01	(0.003)	-0.001	(0.001)
Job Offers, government:				
ψ_{03} (PT and Last Sector $\neq$ self-employed)	-3.36	(0.33)	-3.69	(0.62)
ψ_{13} (FT and Last Sector $\neq$ self-employed)	-2.79	(0.01)	-4.20	(0.65)
ψ_{23} (OT and Last Sector $\neq$ self-employed)	-3.98	(0.35)	-2.53	(0.02)
ψ_{33} (PT and Last Sector = self-employed)	1.70	(0.02)	1.87	(0.01)
ψ_{43} (PT and Last Sector = self-employed)	1.15	(0.09)	1.37	(0.05)
ψ_{53} (OT and Last Sector = self-employed)	-0.90	(0.09)	-0.89	(0.07)
ψ_{63} (Education)	0.002	(0.000)	0.001	(0.001)

Notes: Standard errors of the parameter estimates are computed using BHHH (Berndt et al. 1974).

Source: IFLS 1993, 1997