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Externalities in a life cycle model with endogenous survival☆

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ABSTRACT

We study socially vs individually optimal life cycle allocations of consumption and health, when individual health care curbs own mortality but also has a spillover effect on other persons' survival. Such spillovers arise, for instance, when health care activity at aggregate level triggers improvements in treatment through learning-by-doing (positive externality) or a deterioration in the quality of care through congestion (negative externality). We combine an age-structured optimal control model at population level with a conventional life cycle model to derive the social and private value of life. We then examine how individual incentives deviate from social incentives and how they can be aligned by way of a transfer scheme. The age-patterns of socially and individually optimal health expenditures and the transfer rate are derived. Numerical analysis illustrates the working of our model.

1. Introduction

Starting from the seminal work by Grossman (1972), economists have applied the life cycle model to examine how individuals allocate health care and consumption over their life course and what this implies for their health status, mortality and ultimately for longevity (e.g. Ehrlich and Chuma, 1990; Ehrlich, 2000). A related line of literature employs life cycle models to assess an individual's willingness to pay for survival – the value of life – and how it evolves over the life course (e.g. Shepard and Zeckhauser, 1984; Rosen, 1988; Johansson, 2002; Murphy and Topel, 2006). Both strands of the literature typically take a positive approach, i.e. they examine the determinants of individual health care choices and valuations but do not question their efficiency. In most of the models, efficient life cycle choices are guaranteed anyway, as the individual (i) faces perfect markets, in particular, a perfect annuity market, and (ii) acts as an isolated decision-maker who is not linked to other individuals (contemporary or future).[1] In the real world, neither of the (implicit) assumptions in (i) and (ii) is likely to hold. Markets are typically imperfect or even missing so that externalities may arise. Likewise, individuals are linked to others not only through altruistic ties but also through externalities. Thus, efficiency is by no means guaranteed. In this paper, we seek to shed some light on the implication of intra- and intergenerational externalities on the efficiency of the life cycle choices over health care and consumption as well as on the underlying valuations. Specifically, we focus on the effects of spill-overs related to medical spending.

1.1. Externalities in the provision of health care

Typically, individual mortality not only depends on the individual's own consumption of health care but also on the level of aggregate 'activity' within a health care system. One could think of

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[1] Note, however, a number of important departures from these assumptions: (i) Shepard and Zeckhauser (1984), Ehrlich (2000) and Johansson (2002) examine the case in which individuals do not have access to an annuity market. Davies and Kuhn (1992) and Philipson and Becker (1998) examine moral hazard on annuity markets. (ii) Basu and Meltzer (2005) examine a model in which the individual cares for a contemporary family member (partner), whereas Birchenall and Soares (2009) and Kuhn et al. (2010) allow for altruism towards descendants.

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a number of ways in which aggregate activity may either enhance or compromise individual efforts to reduce mortality. First, medical research has identified a positive relationship between volume of (surgical) activity and the quality of care, frequently measured by (lower) mortality (for an overview see Phillips and Luft, 1997). Thus, the effectiveness of individual health care increases in aggregate activity. Conversely, by contributing towards aggregate activity an individual also enhances the effectiveness of health care targeted at others. As long as these benefits are not internalised in the price of care – and there is no reason to believe they are, whatever the pricing arrangements – such spillovers constitute a positive externality.

Second, in as far as the provision of health care contains public good aspects, such as the provision of medical facilities, hospital bed capacity or emergency services, higher levels of aggregate health care spending may translate into a lower mortality risk at individual level. Similarly, higher aggregate spending levels may lead to greater scope for medical R&D or other quality enhancing activities that would not be lucrative in 'low spending' health care systems.[2]

Third, positive spillovers typically arise in the context of preventive activities. The most obvious example relates to vaccination, where individual mortality decreases in the degree to which the population is vaccinated against an infectious disease (for an overview see Philipson, 2000). The same applies to antimicrobial treatment of infectious disease, which is curative from the individual's perspective but also prevents further infections. Other preventive activities that lower both own and other people's mortality include the installation of safety devices such as Anti Lock Breaking in automobiles or fire detectors in tenement flats.

Finally, we may think of measures related to public health such as the cleaning of sewerage, proper disposal of household waste or the reduction of air pollution. Cutler and Miller (2005) show that in the early 20th century nearly half of the total mortality reductions in major US cities can be attributed to the introduction of clean-water technologies, i.e. the filtration and chlorination of water supplies.[3] 'Pure' public health measures constitute a polar case, where mortality reductions are exclusively due to cumulative expenditure.[4] Such a situation is equivalent to a public goods problem. But even in less extreme cases, the problem of private underprovision arises as long as a part of private health expenditure flows towards a public good (i.e. communal reductions in mortality).[5]

All of the above examples relate to positive spillovers, where higher activity translates into lower mortality. However, in a number of circumstances the converse may be true: aggregate activity may increase individual mortality. Negative spillovers could arise from congestion effects or from microbial resistance against antibiotics. Excessive demand for health care may lead to congestion in the presence of capacity constraints. Hospital crowding, for instance, is likely to hike up mortality due to increased infection risks or due to over-stretched clinical staff lowering the attention afforded to the care of each individual patient and being more prone to committing medical errors.[6,7] Moreover, it is well known that microbes tend to develop resistance against antimicrobial treatments. The probability that a resistant microbial strain develops increases in the level of exposure. Thus, individual use of antibiotics tends to curb individual mortality but may, in aggregate, lead to an increased mortality risk due to microbial resistance.[8] In the case of negative spillovers, there is a tendency towards an excessive consumption of care.

The empirical relevance of all of the above mechanisms has been well documented (in the literature referenced). While we are unaware of empirical evidence as to the distortionary effects of these spillovers on the level and pattern of individual health expenditure, in the light of their prominence, we would expect these effects to be of a non-trivial magnitude.[9]

1.2. Life cycle implications of health-related externalities

The general implications of health-related externalities are straightforward enough: under- (over-)consumption of health care in the case of positive (negative) externalities. The life cycle aspects of the problem, however, are far more intricate. First, a distinct life cycle pattern of health care spending translates into a distinct pattern at which externalities are generated. Second, through its influence on mortality and ultimately on life expectancy the externality generates an important feedback. This is because changes in life expectancy have a bearing on the individual's aggregate wealth and on the need to spread this wealth over a life span of changing length. Third, the extent/value of the externality is endogenous as it depends on the size and age-structure of the population, the latter being determined by age-specific mortality. Finally, a transfer policy aimed at internalising the spill-overs needs to reflect the above properties and, therefore, gives rise to a particular age-schedule of the transfer.

We analyse these issues by combining two variants of a life cycle model with endogenous mortality, depending both on individual health expenditure and on a measure of aggregate health expenditure:

1. an age structured optimal control model, where a social planner maximises welfare at population level (i.e. individual utilities aggregated over time and age groups). This model determines the socially optimal pattern of consumption and health expenditure.

2 Murphy and Topel (2007), for instance, model an R&D race for a pharmaceutical innovation and show that the overall probability of innovation increases in the share of the social value that the winning firm is able to capture. In our model the prize for innovation would correspond to the winner's share of aggregate health expenditure, thus establishing a link between aggregate health expenditure and individual mortality.

3 Watson (2006) studies the impact of public sanitation interventions in US Indian Reservations on the child mortality of Native Americans in the US as opposed to White infants. She finds that they were quite effective in reducing the mortality gap despite a sizeable externality on the health of neighbouring White children.

4 Easterlin (1999) argues that, indeed, most of the historical reductions in mortality due to preventive measures, vaccination and antimicrobials are not attributable to the market for reason of various forms of externalities.

5 An alternative but analogous interpretation is one in which health care is a good with (positive) network externalities.

6 Black and Pearson (2002) discuss the problems related with a recent bout in hospital congestion in the UK. Although congestion is predominantly a problem of public health care systems (see, however, footnote 7), this nevertheless implies the presence of negative spillovers within the system.

7 Clement et al. (2008) use DEA techniques to identify congestion, i.e. the production of undesirable outputs (higher risk adjusted mortality for five conditions) together with desired outputs (treatments). They find for year 2000 data that 67% of US hospitals were experiencing some level of congestion amounting to an average efficiency loss of 13%.

8 The positive correlation between intensity of antibiotic use and microbial resistance is well documented empirically (e.g. Cohen and Tartasky, 1997; Easterlin, 1999). See also Laxminarayan and Brown (2001) for an economic epidemiological model of optimal drug use in the presence of antibiotic resistance.

9 A number of the externalities discussed (positive and negative) could be avoided through appropriate supply side policies (e.g. hospital congestion). For the purpose of this paper we take their absence as given and ask how the demand for health care could be adjusted to optimal levels.