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The economics of nuclear decontamination: assessing policy options for the management of land around Fukushima dai-ichi

Alistair Munro *

National Graduate Institute for Policy Studies, 7-22-1 Roppongi, Minato-ku, Tokyo 106-8677, Japan

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ABSTRACT

In the light of the Japanese government's intensive efforts to decontaminate areas affected by radioactive Caesium from Fukushima dai-ichi nuclear power plant, I create a framework for assessing the merits of management options. In particular I consider delayed intervention as a possible policy. Delay can be optimal because allowing the natural decay of radiation can lower significantly the costs of achieving targets for exposure. Using some benchmark data for Japan I estimate that optimal delay is positive for most reasonable parameter values. Optimal delay generally lies in the range of 3–10 years with a central figure of 8.8 years. There is however considerable uncertainty over some of the key parameter values, particularly with regard to the behaviour of currently evacuated inhabitants.

1. Introduction

For large-scale nuclear accidents such as Chernobyl or Fukushima a major part of the economic cost arises from the on-going evacuation of contaminated land and cities, together with the abandonment and destruction of capital and infrastructure. Lost assets typically include physical assets (e.g. the reactor, machinery, housing abandoned or destroyed), natural assets such as forests and fisheries as well as human capital in the form of increased morbidity and in some cases, increased mortality. Large-scale accidents are significant shocks and can of course have spill over consequences throughout the economy, through demand changes and the disruption of the supply chain. In addition a major unforeseen event may be followed by a period of increased uncertainty which itself affects economic activity (Bloom, 2009). In this context, decontamination is one of a number of possible strategies that can be employed to mitigate the costs of an accident. Prior to Fukushima it has not been used on a significant scale. For instance, around Chernobyl, management has been by containment, evacuation, abandonment and exclusion from the affected zone (United Nations, 2002). Attempts at decontamination have been limited (WHO, 2005) although some partial attempts at have taken place in neighbouring countries (Tveten et al., 1998; Strand et al., 1990). In the case of Fukushima the national government has made decontamination a priority and is

* Tel.: +81 364396169.
E-mail address: alistair-munro@grips.ac.jp.

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devoting several billions of dollars (US) each year to the exercise (MOF, 2011).

In this paper I create a basic model to assess decontamination and resettlement strategies for land affected by the release of radioactive materials. In particular, I focus on the merits of delaying decontamination and resettlement of evacuated areas.[1] While there are other important aspects of nuclear accidents that await a policy analysis, this particular issue seems especially pertinent given the firm commitment made by the Japanese government to the quick, but potentially costly, clean-up of the regions that neighbour Fukushima dai-ichi nuclear power plant (MOE, 2011a). Delayed intervention might seem a counterintuitive policy, because deferring resettlement means also postponing the benefits that come once land and houses, etc. are used again. However, because the costs of clean-up are increasing in the level of contamination, delay also reduces the costs of intervention. Of course there are many ongoing costs associated with evacuation, but if radioactive decay is relatively rapid and site cleaning is costly, waiting can be optimal. The argument is illustrated by Fig. 1 which is based on the numbers used later in the paper. In this figure the present value of resettlement declines with time, but radioactive decay means that the present value of costs falls more quickly than benefits and, as a result, there is an optimum delay before resettlement of approximately 8.75 years.

Although it has not received academic analysis, this possibility of delayed intervention seems an important margin for policy decisions, especially given the simultaneous need to rebuild other parts of Tohoku affected by the 2011 earthquake and tsunami. One major lesson of the paper is that while the exact period of optimal delay varies according to parameter values, it is almost always optimal to take advantage of the fact that radiation levels decay naturally and quite rapidly in the case of Caesium 134. This result seems to be robust, but it should not mask the fact that there is considerable uncertainty over the value of critical variables.

A secondary aim of the paper is methodological: to present an analysis of policy options within a standard cost benefit analysis framework. In the sixty or so years in which nuclear power has been used to generate electricity, there have only been 2 events that merit a '7' on the International Atomic Energy Authority's (IAEA) event scale for accidents. There is relatively little work done on assessing policy options in their wake. Moreover, much of that work (e.g. United Nations, 2002; Chernobyl Forum, 2006 or WHO, 2005) is inappropriate at least in terms of its economic methodology, because it often omits important costs, measures benefits by costs and treats transfers inconsistently.

2. Background

Nearly all of the current dose exposure around Fukushima is by isotopes of Caesium (134 and 137) which were originally deposited in the ratio 1:1 (Stohl et al., 2011). The former has a 30.17-year half-life whereas Caesium-134 has a half life of 2.06 years. Because of the short half-life of Caesium-134, exposure falls rapidly (see Fig. 2). After 10 years or so, Caesium 137 becomes the dominant isotope and as a result the average rate of decay falls.

The pattern of restrictions and evacuations on human activity is shown in Fig. 3. The Evacuation prepared area notice was removed in September 2011, but evacuation and restricted access was still in force as of April 2012 and for the foreseeable future, with approximately 90,000 people moved out of the area (some families in adjacent areas have also relocated). There are approximately 500 km^2 where radiation dose levels are above 20 mSv/year (mSv/a) and about 1300 km^2 where levels are between 5 mSv/a and 20 mSv/a (IAEA, 2011). As Yoshida and Kanda (2012) note there are a number of other areas of large scale deposition of radionuclides south and west

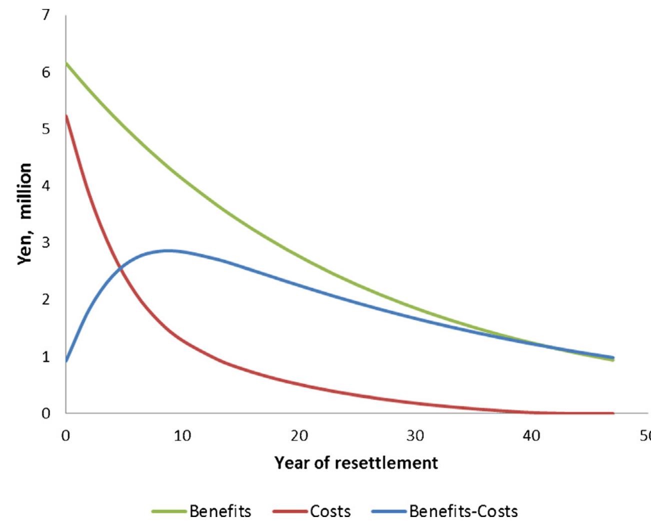

Fig. 1 – Costs and benefits as a function of delay time. *Source*: Own calculations.

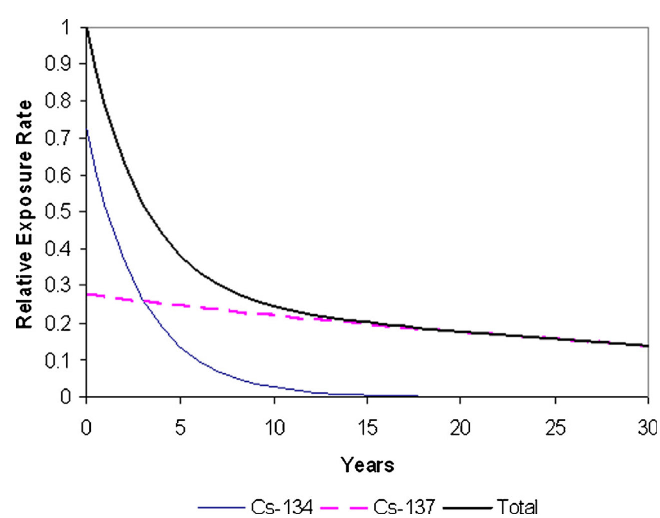

Fig. 2 – Reduction of the relative external exposure rate subsequent to deposition of Cs-134 and 137 (original ratio = 1:1) due to radioactive decay. *Source*: IAEA (2011).

[1] I am not here concerned with the decommissioning of the plant itself, but with policy towards the surrounding towns and villages, many of which are currently evacuated.