Welfare Effects of Adverse Selection due to Rate Regulation in Annuities

Proposal for Presentation at the ARIA 2016 Annual Meeting

Abstract

We analyze the welfare effects of adverse selection due to rate regulation in the German annuity market. We use a life cycle model on consumption, savings and annuity demand to derive a hypothesis on the possible effect of rate regulation on adverse selection in the market. We then proceed to test this hypothesis using a unique data set from a large European life insurance company. This proposal outlines our research methodology, the model used for analysis and the data available to us.

Keywords: Rate regulation, annuities, adverse selection

1 Motivation

The impact of rate regulation in insurance markets has been discussed intensively over the last decades. Specifically, the issue of gender-neutral tariffs, i.e., the use of unisex tariffs, has been an ongoing issue in policy debates. Such legislation induces non-adequate pricing of contracts and thus has the potential to cause adverse selection, which produces inefficiencies from a welfare perspective (Hoy, 1982; Crocker and Snow, 1986; Rea, 1987; Rothschild, 2011). There is, however, no study providing empirical evidence of the adverse selection caused by such legislation. In this paper, we use life insurance contracts in the form of variable annuities and aim to provide such evidence of regulation induced adverse selection. Based on a formal life-cycle model, we form expectations about behavior of individuals pre- and post regulation. This theoretically predicted behavior provides us with a hypothesis of how adverse selection will appear in the market and what degree of severity it will have. We then use data from the variable annuity portfolio of a large European life insurance company to calculate the ratio of expected discounted present value (EPDV) to the price of the annuities bought in the market. Using the difference in the EPDVs pre- and post regulation, we can estimate the degree of adverse selection introduced by the regulation. Using the life-cycle model, we can also determine the welfare cost of the regulation. We additionally have access to individual demand data for contracts which have been unaffected by the regulation but are otherwise similar to the affected contracts. With this control group we can correct for possible time effects. Though we are analyzing the EU gender directive and thus European legislation, the underlying issue is a global one. With our analysis, we thus hope to provide guidelines for policymakers on the quantitative impact of unisex regulations globally.

In this proposal, we will first give a brief discussion of the literature on gender neutral tariffs and adverse selection. We will then outline the research agenda of the project. We further provide a description of the data available from the insurance company and an overview of the model set-up to be used for hypothesis development.

2 Related Literature

Rate regulation banning gender-based tariffs exists both in the United States and the European Union due to fairness considerations.[1] In the U.S., two Supreme Court decisions in 1978 and 1983 prohibit the use of separate mortality tables for men and women in pension benefit calculations due to the legal definition of discrimination in the Civil Rights Act of 1964 (McCarthy and Turner, 1993). In the E.U., gender-neutral premiums for private insurance have been mandatory since December 21st 2012 for all newly issued insurance policies. In contrast, the Japanese automobile insurance market was deregulated in 1998 such that bisex tariffs were reintroduced, to a certain extent, into the market (Saito, 2006). Unisex tariffs are thus a continuing issue in policy debates in insurance markets globally. Nevertheless, even though such regulation is often discussed, there is very limited empirical evidence on its economic

[1] An interesting point to this regard is raised by Finkelstein et al. (2009). They show that natural market reactions to the introduction of unisex tariffs will lead to contract designs that will prohibit effective redistribution between genders to a certain degree.

consequences.

Rate regulation has most commonly been criticized on the basis of adverse selection. However, while several theoretical treatment of the issue exist (see Dionne and Rothschild, 2016, and the references therein), there is almost no empirical evidence on it. Saito (2006) considers the heavily regulated Japanese automobile insurance market and finds no difference in coverage levels among risk classes; he thus concludes that no causal effect of rate regulation, adverse selection or moral hazard can be found in his data. However, since he considers a static regulatory environment, no direct causal inferences can be made. Additionally, pricing in car insurance is not particularly dependent on gender except in the case of very old and very young drivers (Aseervatham et al., 2016). Gender differences in the expected pay-outs of annuities, however, are significant due to significantly different mortalities of men and women in developed countries (Felder, 2006).

Independent of rate regulation, empirical evidence for adverse selection has been documented for the annuity market (e.g., Mitchell and McCarthy, 2002; Finkelstein and Poterba, 2004). A common procedure for this is the calculation of the ratio of an annuity's EPDV to its price. As laid out by Mitchell et al. (1999), the EPDV depends on three primary input factors: the amount paid out by the annuity every period, the interest rate used for the discount and the mortality rate of the individual. The ratio of the EPDV to the price of the annuity is often below 1. This is explained by two factors, the costs of annuitization charged by the insurance company and adverse selection. To determine how much of this effect is due to adverse selection, Finkelstein and Poterba (2002) use data from the UK annuity market. They take advantage of variation in the third input factor of the EPDV: the mortality table. They compare the EPDV/price ratio when calculated with a population mortality table with its counterpart calculated with the annuitant mortality table published by the UK institute of actuaries. This second table takes the selection into annuities by longer living individuals into account. Thus, by comparing the two EPDV/price ratios, they can quantify the share of market inefficiency due to adverse selection.

Calculations of the overall welfare loss due to adverse selection in the annuity market show substantial possible losses. Using a life-cycle model Palmon and Spivak (2007) estimate these losses to be around one percent of wealth compared to the first best equilibrium. Einav et al. (2010) use actual choice data from UK annuity contracts to calibrate a life-cycle model including a bequest motive and find welfare losses of about two percent of annuitized wealth or £127 million per year.

The literature thus provides theoretical treatments of rate regulation and empirical evidence on adverse selection in annuity markets. We combine these streams of research. With this, we are the first to provide empirical evidence on the selection effects of rate regulation in annuity markets and the first to analyze the effects of the E.U. Gender Directive empirically. Prior studies of such regulation in insurance markets were limited to simulations (Dahlby, 1983), theoretical analyses (von Gaudecker and Weber, 2006), or the use of pre-regulation data (Aseervatham et al., 2016).

3 Research Program

We will outline here how we approach the theoretical and empirical analysis of rate regulation and adverse selection. Annuities are bought for several different reasons. Some people use them as a protection against longevity, while others use them primarily as savings vehicles or as a possibility to reduce taxes. This complex role of annuities in the individuals lifetime consumption and savings decisions makes predictions about behavior without a theoretical basis difficult (Brown, 2001). Additionally, the different possible choices in an annuity contract and the corresponding changes in the premium make predictions about behavior due to changed mortality tables even more complicated.

To alleviate these concerns, we use a life-cycle consumption and savings model which closely emulates the annuity product observed in our data to derive predictions on behavior. Using this model, we will predict the demand for variable annuities by a population of men and women with heterogeneous preferences for risk and bequest. This heterogeneity allows us to model purchasing behavior before and after the regulation due to the different possible motives for buying annuities. We set up the model such that no adverse selection exists in the market before the regulation is implemented. The EPDV/price ratio will thus equal one minus the share of administrative costs of the insurer. Then, we run the model again using a unisex mortality table for pricing the annuity rather than different mortality tables for men and women. The selection by individuals to buy annuities will then let us calculate the new

EPDV/price ratio. This post regulation ratio will be the basis for our hypothesis in the data analysis.

For the empirical analysis, we will use the official population and annuitant mortality tables of the German Actuarial Society to calculate the EPDV/price ratio before and after the regulation. We will do this for men and women separately and then take the average weighted by the sum insured. In contrast to the studies by Mitchell et al. (1999) and Finkelstein (2002), we consider the demand for deferred annuities with multiple premium payments over time. As such our ratios will be with respect to discounted prices. By comparing the ratios before and after the regulation, we can find the impact of the regulation on adverse selection in the market. Using a separate set of contracts unaffected by the regulation, we can then also control for a possible time effect. Having established the change in the average EPDV/price ratio due to the regulation, we can estimate a welfare effect of the regulation by calculating the change in "annuity equivalent wealth" (Brown, 2001) necessary to alleviate the effect of having an annuity with a changed EPDV/price ratio. We outline the data from the insurance company available to us for this analysis in the section below.

4 Data and Descriptive Statistics

Variable Annuities are unit-linked annuity contracts with one or more guaranteed minimum benefits.[2] For our entire analysis, we will focus on deferred annuities. This means that prior to the collection period of the annuity, there is a period of regular premium payments, which can often be quite lengthy. The duration of the contract, i.e., the time between the commencement date and maturity of the contract is often longer than 30 years. The premium payments are continuously invested into funds, the returns of which are accumulated throughout the saving period. Unlike traditional unit-linked insurance plans, where the policyholder bears the entire financial risk of the returns, minimum guarantees in variable annuities provide downside risk protection.

Our analysis focuses on products with a guaranteed minimum income benefit (GMIB) and the possibility for an annuity guarantee period (AGP). These products function as follows:

[2] For a detailed overview of variable annuities see Bauer et al. (2008).

The savings component of the premium is invested periodically, e.g., on a monthly basis, into managed funds. At the commencement date, policyholders choose among three funds and therefore determine the risk-return profile of the investment. They can choose among a low-risk fund with 30% stocks and 70% bonds as a target value, a medium-risk fund with equal shares and a high-risk fund with 70% stocks and 30% bonds.

At maturity, the periodic annuity payment resulting from the annuitized fund value is compared to the GMIB, a guaranteed minimum annuity payment, and the higher value is paid out from then on. Once the annuity payment is determined, it is fixed and therefore no longer under financial risk. The financial risk resulting from the choice of the fund strategy is thus completely realized at maturity of the contract. The GMIB is known to the customer at commencement date and depends on the savings premium, duration until maturity and the customer's life expectancy. It does not change over the duration of the contract, unless the customer conducts contractual amendments.[3] For this downside protection, a guarantee fee that differs with the fund choice and the AGP must be paid. The exact pricing mechanism is explained below.

Aside from the risk of the underlying portfolio, insureds can also choose their annuity guarantee period at the commencement date. It can vary between 0 and 30 years.[4] Without an AGP, the periodic annuity payment ends with the death of the insured person. An AGP provides a guaranteed period over which the annuity will be paid, even if the insured person dies within this period. An annuity guarantee period therefore only makes sense if the policyholder has a bequest motive. If the insured person is still alive at the end of this guarantee period, the annuity payments end with the death of the insured person.

In addition to the choice of fund strategy and AGP, policyholders also have the typical choices in contract design that are known from traditional annuity products. They can choose the maturity of the contract, the amount of money they wish to contribute each year and the payment of the premium in monthly or annual installments. We are able to observe all of

[3]Though the possibility for costless contract amendments exists for policyholders, it is very rarely carried out. Since we hardly see any activity in the data, we ignore the possibility for contract amendments in the model.

[4]Technically, the AGP can last until the insured is 90 years old. In our data, this commonly implies a maximum AGP of 30 years or less.

Table 1 – Variable description

Variable	Value	Description
Dependent variables		
Risk	discrete	share of risky asset in portfolio (30%; 50%; 70%)
AGP	continuous	length of guaranteed annuity payment
Independent variables		
$t_{\geq 21.12.2012}$	dummy	1, if commencement date after regulation took effect
treat	dummy	1, if contract is in the treatment group
female	dummy	1, if insured person is female
age	continuous	age at commencement date
duration	continuous	period between commencement and maturity
ln(premium)	continuous	logarithm of the savings premium
invoice	dummy	1, if payment on invoice
year	categorical	year of contract signing

The table reports all descriptive variables in the data. Variables are reported as continuous even when they are only quasi-continuous with a large number of categories such as the guarantee period which is an integer variable.

these choice variables.

We use data from the German portfolio of a large European life insurer. The dataset covers the period 2011 to 2014 and contains 18,764 observations.[5] The unit of observation is the contract and includes information about the choice of the underlying fund, the annuity guarantee period, several contract characteristics such as the premium, and the demographic characteristics age and gender (regardless of whether the contract was bought pre- or post regulation). Table 1 provides an overview of all variables in the data.

The product is sold in two major categories: Riester contracts and non-Riester contracts. In our main analysis, we will focus on the non-Riester contracts as they are switched from bisex tariffs to unisex tariffs after December 21st 2012. This does not mean that contracts sold before December 21st 2012 were changed in the pricing, but rather that all contracts sold from this date on had to be priced unisex. In theory, several possible scenarios exist on how the pricing could be organized. A regulatory system in which the risk type cannot be used for pricing insurance policies is hypothesized to lead to adverse selection. Economic intuition would thus suggest that the insurers price the policies such that either a separating equilibrium (Rothschild and Stiglitz, 1976) or a pooling equilibrium (e.g., Wilson, 1977) is obtained. The

[5] Due to confidentiality issues we use a high quantile random sample of the original dataset to conceal the actual portfolio size.

insurance company which provided our data uses neither of the two approaches. Instead, they use a linear interpolation between the two survival probabilities. This corresponds to the equilibrium concept developed by Arrow (1970), which was analyzed in detail by Pauly (1974) and Schmalensee (1984). In this so called linear-pricing equilibrium, the different risk types pay the same constant price per unit of coverage, which yields pooling contracts. Therefore, there is no price discrimination. Both genders pay the same price per unit of coverage for the two contract choices, and any additional amount of coverage has the same price as the first amount of coverage, i.e., there is no loading that depends on the coverage. Furthermore, this means that there is no quantity rationing, i.e., the levels of purchasable coverage do not change compared to the full information setting.

We use the Riester contracts as a robustness check. They have been regulated by the German federal government to be priced unisex since 2006 and therefore over our entire observation period. We can thus use them to control for a possible time effect.[6] Since the Riester product was priced in a unisex regime for the entire observation period, it was unaffected by the European legislation. Furthermore, as in the other products, there were no changes in the product design, i.e., there is absolutely no pricing difference between Riester contracts sold before and after the regulatory change.

We now present some preliminary evidence on the effect of the regulatory change on adverse selection. As we can see in Table 2, the share of women in the regular (non-Riester) group increases significantly after the implementation of unisex tariffs. This is in contrast to the group of Riester contracts in which almost no change in the share of women is observable. Since women buy annuities at a cheaper price after the regulation than before the regulation, this major shift in the share of women indicates a negative price elasticity towards annuities and an increase in adverse selection in the market. However, without a model on consumptions

[6]For a detailed overview of the design of Riester contracts see Börsch-Supan and Wilke (2005) or von Gaudecker and Weber (2006). Riester contracts have a slightly higher administration fee than the other products, but the premium payments are partially subsidized by the German government. Furthermore, there are minor differences in the calculation of the GMIB between Riester and non-Riester contracts. The exact level of the subsidy depends on numerous factors, e.g., the number of children, the age of the children, whether the child was born before or after 2008, the age of the insured person, or whether the insured person was born before or after 1982. A certain percentage of the individual's earnings (up to a threshold) has to be paid into the Riester contract to receive the full subsidy. Not everybody can purchase a Riester product; especially self-employed workers and individuals receiving payments from the German statutory pension insurance scheme have to be mentioned here.

Table 2 – Share of women in regular and Riester contracts

	Regular	Riester	$\boldsymbol{\Sigma}$
$<$ *Dec* 21^{st} 2012	34.34%	52.61%	47.38%
$\geq$ *Dec* 21^{st} 2012	47.67%	52.91%	50.65%
$\boldsymbol{\Sigma}$	38.06%	52.66%	48.05%

The table shows the share of female policyholders with commencement date before and after December 21^{st} 2012. The shares are relative to the total population of each group as indicated by the column headings.

and savings, it is hard to evaluate the significance of this evidence. Since the annuitants can choose portfolio composition and AGP in the contracts and have the opportunity to save money through vehicles other than the annuity, it is unclear how strong the effect of the regulation on adverse selection really is. To consider this effect more throughly, we set up a life-cycle consumption and savings model in the next section. We will use this model to make predictions about the effect of rate regulation on the market for annuities and then test these predictions by calculating the EPDV/price ratios in our data.

5 Model

5.1 Decision Problem and Contract Specification

Suppose an individual that is male or female (m, f) lives for a maximum of T periods with a probability vector of death probabilities $d_t^{m,f}$ for each period. The individual has purchased an annuity with premium π to be paid in every period up until but not including retirement in τ. The annuity guarantees a pay-out of a in every period starting from τ. It also guarantees a time-dependent pay-out $G_t \geq 0$ into the estate of the individual should she die in period t. The individual values consumption in each period with CRRA utility function $u(c_t) = \frac{c_t^{1-\gamma}}{1-\gamma}$ where γ is the coefficient of relative risk aversion. In case of death, the individual draws utility from bequeathing wealth with $\beta u(w_t + G_t)$.[7] The value function of an individual who

[7] Modeling a bequest motive by adding a function of the form $bv(x)$ where v has the same curvature as utility over consumption is a pragmatic way to reduce complexity that is common in the literature (see, e.g., De Nardi, 2004; Einav et al., 2010).

purchased an annuity $A(t_g, e_A)$ and has initial wealth w_0 reads:

$$V^{A(\pi,t_g,e_A)}(w_0; e_I, \gamma, \beta) = max_{c_t,w_t} E_0 \left[\sum_{t=0}^{T} s_t^{m,f} \delta^t u(c_t) + d_t^{m,f} \delta^t \beta u(w_t + G_t) \right] \quad (1)$$

Here, $s_t^{m,f} = \prod_{j=0}^{t} (1 - d_t^{m,f})$ is the probability of being alive to consume in period t and $\delta < 1$ is the exponential discount factor. The index on the expectation operator denotes expectations at the time of the index. Wealth progresses as follows. In every period, the individual realizes returns of the wealth saved from the prior period, gains wealth from income and possibly annuities and then pays for consumption and possibly annuity premiums. Consumption in every period is restricted such that wealth can never be negative ($w_t \geq 0 \; \forall \; t$).

$$w_{t+1} = \begin{cases} (1 + e_I \psi_t + r_f)(w_t + y - \pi - c_t) & \forall \;\; t \in \{0, 1, ..., \tau - 1\} \\ (1 + e_I \psi_t + r_f)(w_t + \eta y + a(e_A, t_g) - c_t) & \forall \;\; t \in \{\tau, ..., T - 1\} \end{cases} \quad (2)$$

The risk free rate is determined by r_f and the risky return of stocks, ψ_t, is distributed i.i.d. by $N(\mu, \sigma)$. y is the income generated by the individual which is turned into a pension with factor $\eta < 1$ upon retirement. The individual makes two choices on asset allocation, e_A and e_I, which denote the share of equities in the annuity unit link product and the savings portfolio, respectively. As is described above, the annuity portfolio is limited to three choices of equity share $e_A \in \{0.3; 0.5; 0.7\}$. Similarly, we restrict the choices in the savings portfolio to the same options both for the sake of tractability and in order not to introduce additional variation between the two means of providing savings. This is not an overly unrealistic restriction. Even though optimal investment behavior in life cycle models with annuities is often described by very large equity shares (Horneff et al., 2009), we commonly see very few people this heavily invested in stocks (Mehra and Prescott, 1985; Bertaut and Starr, 2000). Additionally, behavioral motives such as left-digit bias (Lacetera et al., 2012) could make people drawn to distinct equity shares in their portfolios rather than choosing a fraction down to several digits. This is further corroborated by the anecdotal evidence that banks often offer different risk profiles for private wealth management which have remarkably similar equity shares as are available in the annuity product analyzed here.

The annuity product is structured as follows. Should the individual die before retirement, she gets the current value of the invested funds reduced by relative administrative cost $(1-\theta)$ paid into her estate. Should she die after retirement, but before t_g, she receives the discounted annuity payments outstanding up until period t_g. The period between retirement and t_g is thus called the annuity guarantee period (AGP) since the annuity payments are guaranteed for the time up to t_g. In notation:

$$G_t \equiv \begin{cases} \theta\pi \sum_{t=0}^{t-1} \prod_{j=t}^{t-1} (1 + e_A\psi_t + r_f) & \text{if } t < \tau \\ a \sum_{j=t}^{t_g} \delta^{j-t} & \text{if } t \geq \tau \end{cases} \tag{3}$$

In case the annuitant lives longer than t_g, she collects annuity payments a until death. The size of these payments is determined by the development of the invested premiums. They accumulate over time with the progression of ψ_t. However, the annuitant has a guaranteed minimum investment benefit (GMIB), which implies a minimum rate of return r_g. Should the return on the invested funds fall below the hypothetical return of a portfolio constantly returning r_g, then the annuitant would receive the value of the hypothetical portfolio instead. At retirement, the invested funds thus have the value:

$$AnnInv_\tau = \pi \max \left\{ \sum_{t=0}^{\tau-1} (1 + r_g)^{\tau-t+1} ; \sum_{t=0}^{\tau-1} \prod_{j=t}^{\tau-1} (1 + e_A\psi_t + r_f) \right\} \tag{4}$$

The annual annuity payment is set by a conversion factor fixed at $t = 0$. This factor $\phi(e_A, t_g)$ is a function of both the equity share in the annuity investment and the guarantee period. The equity share determines the volatility of the underlying portfolio. The guarantee of the GMIB leads to a pay-out profile similar to a default put-option. The value of this option is increasing in the volatility of the underlying asset and thus the price of the GMIB increases in e_A making ϕ a decreasing function in e_A. The length of the annuity guarantee period also decreases the conversion factor. Since from the viewpoint of the insurance company, the probability of death in that period is zero, the expected number of annuity payments increases in t_g making each payment smaller as a consequence. As before, the insurance company charges relative administration costs $(1-\theta)$. The conversion factor thus reads (suppresing arguments for legibility):

$$\phi = \left(1 - \frac{\sum_{t=0}^{\tau-1}(1+r_g)^{\tau-t+1} - E_0\left[\sum_{t=0}^{\tau-1}\prod_{j=t}^{\tau-1}(1+e_A\psi_t+r_f) \middle| \sum_{t=0}^{\tau-1}\prod_{j=t}^{\tau-1}(1+e_A\psi_t+r_f) \leq \sum_{t=0}^{\tau-1}(1+r_g)^{\tau-t+1}\right]}{E_0\left[\max\left\{\sum_{t=0}^{\tau-1}(1+r_g)^{\tau-t+1}; \sum_{t=0}^{\tau-1}\prod_{j=t}^{\tau-1}(1+e_A\psi_t+r_f)\right\}\right]} \right)$$
$$\times \left(\sum_{t=\tau}^{t_g} \delta^{t-\tau} + \sum_{t=t_g+1}^{T}\prod_{j=\tau}^{t} s_j^{m,f}\delta^{t-\tau} \right)^{-1} \times \theta \quad (5)$$

The program is a maximization problem in the parameter vectors c_t and w_t. We rewrite it as the Bellman equation:

$$V_t^{A(\pi,t_g,e_A)}(w_t; e_I, \gamma, \beta) = max_{c_t,w_t} E_t\left[s_t^{m,f}u(c_t) + d_t^{m,f}\beta u(w_t+G_t) + \delta V_{t+1}^{A(t_g,e_A)}(w_{t+1}; e_I, \gamma, \beta)\right] \quad (6)$$

This can now be solved for a given set of gender and preference parameters $(m/f, \gamma, \beta)$ and choices about the purchasing of an annuity, portfolio composition and AGP (π, e_I, e_A, t_g) by discretizing the wealth space and using backward induction. By finding the set of contract and investment choices with the highest value as given by (1), we have the optimal selection for each individual in our simulated population.

5.2 Calibration

We are considering the purchasing decision of a 35 year old individual with retirement at age $\tau = 65$. The individual has an initial wealth of $w_0 = 200$ and generates an income $y = 100$ every period until retirement. We assume a pension conversion factor of $\eta = 0.7$ which is about the mean value for the German population. Regarding the capital market, we assume a risk free rate of $r_f = 0.02$ which is close to the average of German 10 year government bonds return for the time of our data[8]. We assume an equity premium of $\mu = 0.04$ and a volatility of $\sigma = 0.15$. Our capital market calibration is thus a simpler version of the model in Yao and Zhang (2005).

For our analysis, it is important to consider a heterogeneous population of individuals.

[8]The average daily closing prices in the period between January 2011 and December 2014 indicate an average return of 0.0176.

There are several ways of introducing variation in the population of annuitants. However, as described above, we are interested in heterogeneity due to different motives for buying annuities. This heterogeneity can best be implemented by using different values for risk aversion (γ) and bequest motive (β). As mentioned above, we are not interested in adverse selection before the regulation which is why we do not introduce heterogeneity in mortality. We also assume stable time preferences in accordance with the capital market such that $\delta = 1/(1+r)$ as is the case in other models of annuity demand such as Einav et al. (2010) or Lockwood (2012).

We use the official annuitant mortality tables published by the German Actuarial Society to model $d_t^{m/f}$ and $s_t^{m/f}$. When modeling the time after the regulation, we use the pricing table utilized by the insurance company after the regulation. This is a linear interpolation of the two annuitant mortality tables of men and women. As stated above, the official tables will also be used for the calculations of the EPDV/price ratios in the empirical analysis. This leads to consistency between the model and the empirical analysis.

6 Next Steps

Since we are already in possession of the data and the mortality tables, the next steps of the project are the implementation of the model outlined above and the analysis of the data. The model will be implemented computationally in Matlab or Fortran should Matlab prove to be too slow for the size of the state space. The data analysis will be programmed and carried out in Matlab. We expect a preliminary working paper version to be complete by early April.

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