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Habit Formation and Persistence in Individual Asset Portfolio Holdings: The Case of Italy

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Habit Formation and Persistence in Individual Asset Portfolio Holdings: The Case of Italy

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Abstract

This paper uses six waves of the Bank of Italy Survey of Households Income and Wealth to explore the dynamics of asset portfolio ownership. The household asset portfolio decision is a choice among discrete alternatives, and I model the problem in a multinomial framework. I focus on a particularly important feature of household portfolio behavior: the infrequency of portfolio allocation changes. I find evidence of strong unobserved heterogeneity through time-varying error components, which I interpret as taste persistence in both the risky and safe asset participation decisions. I estimate the model using the method of maximum smoothly simulated likelihood.

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Contents

I. Introduction 4

II. Habit Formation in Household Portfolios 5

III. The Model: Multiperiod Multinomial Probit with Autocorrelated Errors and Unobserved Heterogeneity 8
A. Cross-Sectional Multinomial Logit (MNL) 9
B. Allowing for Alternatives Across Different Branches to Have Different Substitutabilities: Nested Multinomial Logit (NMNL) Model 10
C. Allowing for Differing Substitutabilities Between Alternatives and Adding Intertemporal Linkages: Multiperiod Multinomial Probit (MPMNP) . 12

IV. Empirical Results 15
A. Data 15
B. Changes in Portfolio Allocations 18
C. Estimation Results 22

V. Conclusion 30

Appendix: Data and Statistics 31
A. Definition of Variables 31
B. Eight-State Transition Probabilities 34

References 40

Tables

Table 1. Portfolio Choice, by Year, with a Narrow Measure of Risky Assets 16
Table 2. Portfolio Choice, by Year, with a Broad Measure of Risky Assets 16
Table 3. Portfolio Choice with a Narrow Measure of Risky Assets 17
Table 4. Portfolio Choice for a Broad Measure of Risky Assets 17
Table 5. Portfolio Choice, by Education 18
Table 6. Portfolio Choice, by Age 18
Table 7. Portfolio Choice, by Sex 18
Table 8. Portfolio Choice per Year Using a Balanced Panel (1991–2000) for Narrow Measure of Risky Assets for Four Categories. 19
Table 9. Portfolio Choice per Year Using a Balanced Panel (1991–2000) for Narrow Measure of Risky Assets for Eight Categories 19
Table 10. Unrestricted Empirical Transition Probabilities in Different Horizons: Narrow Definition 21
Table 11. Unrestricted Empirical Transition Probabilities for One Wave to Next: Narrow Definition 22

Table 12. Nested Multinomial Logit 23
Table 13. Multiperiod Multinomial Probit with Autoregressive Errors (Three–Alternative Model) 28
Table 14. Multiperiod Multinomial Probit with Autoregressive Errors (Five–Alternative Model) 37
Table 15. Unrestricted Empirical Transition Probabilities for One Wave to Next: Narrow Definition. 38
Table 16. Unrestricted Empirical Transition Probabilities in Different Horizons: Narrow Definition. 39

Figures

Figure 1. Choice Problem Tree 11

I. Introduction

In most developed countries, a large fraction of households do not own risky financial assets. This fraction is, however, decreasing slowly over time. In Italy, for instance, 89 percent of households did not hold any risky financial asset in 1991, but this fraction had decreased to 73 percent by 2000. Since there was previously strong persistence in portfolio decisions, some analysts have even suggested that the shift from safe assets to risky assets could be destabilizing to the economy and financial markets.

The stockholding puzzle has been widely studied in the literature, although no study has focused on the role of habit formation on household portfolio decisions in a multinomial context. I believe that it is important to model the choice this way because households may stay inside or outside of the stock market even if it is not appropriate at that point in time. In addition, since households may get a taste for certain investments and keep them, habit formation introduces state dependence. The contribution of this paper is to show that habit formation plays a role in the decision to shift from zero financial assets to safe financial assets (checking accounts, savings accounts, certificates of deposits, postal deposits, postal bonds, treasury bonds, and treasury certificates) and to risky financial assets (long-term government bonds, corporate bonds, investment funds, and equities). To estimate the model, I first aggregate assets into two categories: risky and safe. Since a high level of aggregation is problematic–important differences exist among assets–I also consider a more disaggregated model where I differentiate among risky bonds, and stocks, and safe assets. In doing so, I am able to investigate the dynamics of the interaction between these kind of assets.

To this end, maximum smoothly simulated likelihood estimation is used for a multinomial probit with autocorrelated errors, as developed by Börsch-Supan and Hajivassiliou (1993). The autocorrelated errors–unobserved heterogeneity through time-varying error components–allow for the habit formation or taste persistence that households exhibit when deciding whether to buy safe assets or risky assets. The model allows us to distinguish taste persistence from time-invariant unobserved heterogeneity.

In order to study this dynamic participation problem, panel data are required. Because the existence of incomplete markets and heterogeneity of preferences affects portfolio choices directly, household data are necessary for this analysis of the dynamics of portfolio choice behavior. The Bank of Italy Survey of Household Income and Wealth (SHIW) has complete information on portfolio decisions over time through six waves for the period 1989 to 2000. The panel is unbalanced, with 22,591 observations and 7,588 households who participate in at least two waves. To the best of my knowledge, there is only one other panel dataset with detailed information on ownership of assets over time, the Dutch CenTER Savings Survey.[2]

[2]Ameriks and Zeldes (2001) use the TIAA-CREF (Teachers Insurance and Annuity Association-College Retirement Equities Fund) panel dataset. These data have the drawback that the sample is endogenous and

The paper is organized as follows: Section II reviews those papers that model household asset portfolio decisions, including the limited participation in financial markets. It also introduces the importance of habit formation in household financial decisions. Section III presents the estimation procedure, and Section IV describes the data and reports the results. I start with a simple benchmark model before moving to the multiperiod multinomial probit model with heterogeneous and autoregressive unobservables. Section V presents conclusions.

II. Habit Formation in Household Portfolios

The financial asset allocation decision of households has been extensively studied in the last two decades. While some of the studies discuss the rapid increase in the fraction of households owning equities (United States and United Kingdom), others analyze the stockholding puzzle (for example Mankiw and Zeldes (1991), Poterba and Samwick (1995), Haliassos and Bertaut (1995), Vissing-Joergersen (2002), and Bertaut and Starr-McCluer (2002)). However, these studies are based on cross-sectional data, ruling out dynamic considerations.

An interesting feature of household portfolio choice is the infrequency of portfolio allocation changes. This trend is in contrast with the standard portfolio choice model (without transaction costs) inherited from Samuelson (1969) and Merton (1969, 1971), which implies that individuals rebalance their portfolios each period. This rebalancing can be done by changing the allocation of the asset holdings or by changing the allocation of the flow of new contributions. A recent study of the United States by Ameriks and Zeldes (2001) finds that almost one half of their sample made no active changes to their portfolio allocations for a period of 10 years. They show that households make few changes in either the allocation of stocks or flows, which they interpret as owing to the presence of transactions costs or inertia. They consider different types of transactions costs: minimum balance requirements, per-trade fees and information costs (costs of purchasing assets and monitoring costs).

The reluctancy of households to switch from holding one basket of assets to another may be associated with household specific historical characteristics. For example, the probability that a household holds safe assets may depend on the probability that it had already held safe assets in the previous period, the current realization being a function of the past one. The same type of state dependence may apply to the holdings of risky assets. These intertemporal linkages can be of two types: True (observable) state dependence and (unobservable) taste persistence, which can be confused with spurious state dependence. The former can happen as a consequence of an event that has marked

unrepresentative. In addition, they do not contain information on household characteristics, so it would not allow the current analysis to be undertaken.

the behavior of a specific household and makes it allocate holdings in a certain way. Another household in the same position but not having experienced such an event will behave differently. The latter is related to household tastes for certain assets, hence may be interpreted as habit formation or taste persistence.

In order to relate the above intertemporal linkages to the portfolio allocation decision it might be helpful to go back to the standard model of lifetime consumption and portfolio choice of Samuelson (1969) and Merton (1969, 1971). In this model agents live off income generated by their invested wealth, and thus non-participation in the stock market, or entry or exit into that market, over time is not observed. The optimal portfolio of risky assets, and the split between risky and riskless assets, will vary across agents with different preferences, wealth and investment horizon. Conditions on return distribution/utility functions were derived, under which differences in investment horizon and wealth across agents should not lead to differences in portfolio choice. As shown by Samuelson (1969) investment horizons are irrelevant if agents face a constant investment opportunity set (i.i.d returns). CRRA preferences are sufficient for wealth not to matter. While return unpredictability and deviations from CRRA utility could explain some of the heterogeneity in the share of financial wealth invested in stocks across households and time, it is unlikely that these features can explain all such differences. While return predictability can generate large changes in the optimal share of financial wealth invested in equities over time, such changes would affect all households, in contrast to the considerable idiosyncratic (household specific) movements in equity portfolio shares.

So differences in risk aversion and transactions costs can help explain the remaining heterogeneity in observed portfolio choices. It is well-known that the parameter α in the standard CRRA utility function: $u(c) = \frac{c^{1-\alpha}}{1-\alpha}$ controls both the relative risk aversion and the elasticity of intertemporal substitution (EIS), which are different aspects of individuals' tastes. Much evidence documents significant heterogeneity in the EIS across the population. It has been argued that the non-participation phenomenon, due to transaction cost, should be considered part of the solution to the equity premium puzzle because the consumption growth of nonstockholders covaries substantially less with the stock return than the consumption growth of stockholders (see Mankiw and Zeldes (1991), Vissing-Jorgensen (2002), Attanasio, Banks and Tanner (2002)). However, heterogeneity in relative risk aversion has been not studied. The number of households who choose to enter the stock market or to change the number of stocks held in response to a shock to nonfinancial income, will depend on how many households are close to the point where it becomes worthwhile to adjust according to their taste preferences.

Miniaci and Weber (2002) review the methodological issues surrounding estimation of portfolio choice models from survey data. They point out that a panel structure is necessary to estimate portfolio choice models, propose the use of binomial probit models, and state the different mechanisms that can lead to limited participation. These are state dependence, unobserved heterogeneity, serial correlation in shocks, and time-varying observable characteristics including demographics. They then illustrate the significance of the second, third and fourth reasons for limited participation by estimating a binomial probit/logit with random effects/fixed effects for three waves of the SHIW. Guiso and Jappelli (2002) also estimate a binary probit model with random effects to study participation in risky financial assets using three waves of the SHIW. However, they ignore any state dependence in their analysis.

Vissing-Joergense (2002) estimates the first type of state dependence, namely true state dependence. In this sense, Vissing-Joergense (2002) introduces four different costs of stock market participation in the model: an entry cost, a fixed transaction cost, a proportional transaction cost, and a per period participation cost. The first three costs lead to true state dependence in the stock market participation decision and in the proportion of financial wealth invested in stocks. In the empirical part she uses the two waves of the Panel Study of Income Dynamics (PSID) with portfolio data (1984, 1989), adds the lag of participation in 1984 in a simple probit regression for 1989 and finds a significant positive coefficient for true state dependence. In other words, she finds that the likelihood of participation in the stock market in one period is strongly correlated with participation in the previous one. When she accounts for unobserved individual effects, the covariance of the error term for participation in 1984 and 1989 is not significant. The problem with her estimation is that she imposes a binary choice model and uses only two points of observation. The panel structure is too short to allow for taste persistence, which is well known to suggest state dependence when it is in fact absent.

Alessie, Hochguertel, and van Soest (2001) also estimate the first type of state dependence using the Dutch CentER Saving panel survey. They use dynamic binary choice panel data models to explain the dynamics of mutual fund and stock ownership. In their model, correlated random effects account for unobserved heterogeneity, and dummies for lagged ownership of each asset type capture genuine state dependence. Errors, however, are assumed to be independent over time (the authors point out that first order autocorrelation was allowed for in some specifications but turned out to be insignificant).

Miniaci and Ruberti (2001) estimate a model of random effects suggested by Arellano and Carrasco (2003) using Generalized Method of Moments (GMM), where the assumption of strict exogeneity of income is relaxed. They find very strong true state dependence.

One drawback of these studies is that they treat household portfolio choices as a binomial problem when they are by nature multinomial. In contrast, Perraudin and Sorensen (2000) implement a multinomial logit model in order to study the demand of risky assets. They assume that all households hold some quantity of money and that households choose to hold either money alone, money and bonds, or stocks, bonds and money. The logistic model does not allow for some portfolios to be closer substitutes than others; and this property is justified on the grounds of the computational complexity of the multinomial probits. Moreover, since U.S. cross-sectional data are used, the existence of time-varying correlation is ruled out.

Consequently, none of these approaches include both time-invariant unobserved heterogeneity (household effects) and time-varying unobserved heterogeneity (habit formation). Both features can explain why ownership of assets in period t is correlated with ownership of assets in period $t+1$ and a less restrictive model could suggest the extent to which this correlation is due to one or the other. In addition, the previous literature has imposed the assumption of irrelevant alternatives (IIA) -zero correlation among alternatives- when it often seems unlikely. Modelling these features is the purpose of what follows.

III. The Model: Multiperiod Multinomial Probit with Autocorrelated Errors and Unobserved Heterogeneity

This section of the paper starts with a benchmark model similar in spirit to Perraundin and Soerensen (2000) and uses cross-sectional data multinomial logit with three alternatives to estimate a model of asset holdings. I then proceed to relax key assumptions that have been made in the literature. One can think of the decision of holding assets as a discrete choice problem in which households see some choices as closer substitutes than others (see Börsh-Supan and others (1992) for a similar discussion of elderly living arrangements). Hence correlation among unobserved determinants of financial asset holding at a point in time is likely. The existence of *intratemporal correlation between unobserved determinants* is a violation of the assumption of the independence of irrelevant alternatives (IIA).

Another assumption that has been imposed in papers on household portfolio choices is that of no *intertemporal correlation of unobserved determinants.* The decision of whether to hold assets or not is clearly an intertemporal choice. Because of transaction and information costs, households hold or do not hold assets even if it is not appropriate at that point of time. That is, households may be substantially out of long-run equilibrium if a survey interview occurs shortly before or after the switch between asset holdings. In addition, households may get a taste for certain investments and keep them. This kind of habit formation may introduce taste dependence.

Börsh-Supan and others (1992) distinguish between two components of intertemporal linkages: First, linkages through unobserved person-specific attributes: that is, *unobserved heterogeneity through time-invariant error components.* Second, *unobserved heterogeneity through time-varying error components*, for example, an autoregressive error structure. The focus of this paper will be the second, since my interest is in habit formation or taste persistence.

To my knowledge, all studies of household portfolio allocation that use multinomial probit or logit models have assumed no intertemporal correlation between unobserved determinants of the portfolio allocation decision. In my first model, households face a choice of three alternatives: holding risky financial assets; safe financial assets; or no assets. In order to cope with aggregation problems, my second model features households choosing between five alternatives: stocks and risky bonds; stocks; risky bonds; safe assets; or no assets.

A. Cross-Sectional Multinomial Logit (MNL)

In order to describe the dynamic nature of the participation decision I start from a static multinomial model and build up to a multiperiod multinomial model.

The multinomial logit model can be derived from the theory of random utility maximization. We assume that consumers are rational, so that they make choices that maximize their perceived utility subject to constraints on expenditures. Let us suppose that the consumer faces M_i choices and define y^*_{jit} as the level of indirect utility associated with the jth choice. The underlying response variable y^*_{jit} is defined by the regression relationship:

$$y^*_{jit} = x'_{jit}\beta_j + \epsilon_{jit} \tag{1}$$

where x_{jit} is the vector of individual characteristics for individual i and ϵ_{jit} is a residual that captures unobserved variations in attributes of alternatives and errors in the optimization strategy of the consumer.

The maximization vector in this case is:

$$y_i = argmax_k\{y^*_{i1}, .., y^*_{ik}, ..., y^*_{iM_i}\}, \tag{2}$$

In other words, I observe the index of which ever alternative gives the highest utility for individual i.

For full efficiency maximum likelihood methods need to be used. The probability density function (PDF) for an individual i choosing alternative k is as follows:

$$f(y_i|x_i) = prob(y_i = k|x_i), \tag{3}$$

Since this means that the utility of the k'th option was the highest, I can express the probability of a choice sequence in terms of integrals over the differences between the unobserved utility components and the chosen alternative:

$$f(y_i|x_i) = prob\begin{pmatrix} y^*_{i1} - y^*_{ik} \leq 0 & \\ ... & | \, x_i \\ y^*_{iM_i} - y^*_{ik} \leq 0 & \end{pmatrix} = \\ = \int_{D(y_i)} f(y^*_i|x_i, \beta, \sigma) dy^*_i. \quad (4)$$

where $D(y_i) \equiv \{y^*_i | y^*_{i1} - y^*_{ik} \leq 0, ..., y^*_{iM_i} - y^*_{ik} \leq 0\}$.

To overcome the problem of high-dimensional integrals in limited dependent variable (LDV) models, McFadden (1974) showed that under the assumption that ϵ_{jit} is distributed iid, "extreme-value of Type II" implies a closed form expression for equation 4:

$$prob(y_i = k|x_i) = \frac{exp(x_i'\beta_k)}{\sum_{j=1}^{M_i} exp(x_i'\beta_j)}. \quad (5)$$

which is the probability that an individual with characteristics i will choose the k'th alternative with some normalization (such as $\beta_{M_i} = 0$).

The MNL model generalizes the McFadden (1974) logit model and allows agent-specific characteristics to determine the choice probabilities. To prevent terms that do not vary across alternatives from falling out of the choice probability, I will create a set of dummy variables for the choices and then allow the coefficients to vary across the choices rather than the characteristics.

The main shortcoming of the MNL model is that it possesses the IIA assumption (zero correlation among alternatives). It predicts "too high a joint probability of selection for two alternatives that are in fact perceived as similar rather than independent by the individual".[3] This is inappropriate for modelling the household portfolio allocation problem.

B. Allowing for Alternatives Across Different Branches to Have Different Substitutabilities: Nested Multinomial Logit (NMNL) Model

The nested multinomial logit (NMNL) model developed by McFadden (1981) partially solves the problem stated above since it allows for alternatives across different branches to have different substitutabilites by involving the sequential combination of the multinomial logit model. In order to clarify terms, Figure 1 shows the choice problem that households

[3] Maddala (1983), p. 62.

face in the model.[4] This tree has two branches, financial assets and no financial assets. The first branch has two elemental alternatives: risky assets and safe assets. The second branch has only one elemental alternative: no financial assets. Other trees were tried but this one gave the most consistent results. Therefore, the household may decide whether to hold financial assets or not, and then if he chooses to hold financial assets he may decide to buy only safe assets, or risky and safe assets.

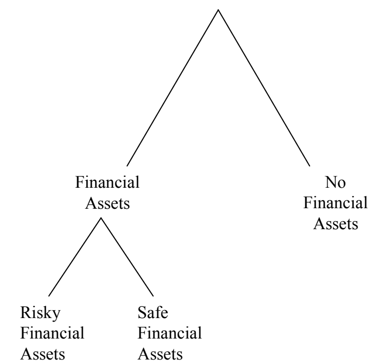

Figure 1: Choice Problem Tree

Let us suppose a household faces a portfolio problem, with the choice of being a financial assetholder or not (i=1,...,C=2) and the possibility of holding risky assets or safe assets (j=1,...,N=2) in the first case and no financial assets in the second case. A consumer will therefore have a utility U_{ij} for alternative (i, j), which is a function of the consumer's characteristics (such as age, family size, and disposable income) and each consumer will choose the alternative that maximizes his utility.

The probability P_{ij} that the (i,j)'th alternative will be chosen is as follows:

$$P_{ij} = \frac{exp(x_{ij}\acute{}\beta)}{\sum_{m=1}^{c}\sum_{n=1}^{N_m} exp(x_{mn}\acute{}\beta)}, \tag{6}$$

I can write

$$P_{ij} = P_{j/i} \cdot P_i, \tag{7}$$

and define an *inclusive value* I_i as follows:

[4]Section 1.4.3. will analyse a more disaggregated model where a tree with five alternatives is modelled. The household faces the choice of holding stocks and risky bonds, stocks, risky bonds, safe financial assets and no financial assets.

$$exp(I_i) = \sum_{j=1}^{N_i} exp\left(x_{ij}'\beta\right). \tag{8}$$

The two terms of equation 7 can then be written as follows:

$$P_{j/i} = \frac{exp(x_{ij}'\beta)}{exp(I_i)}, \tag{9}$$

$$P_i = \frac{exp(I_i'\theta)}{\sum_{m=1}^{c} exp(I_i'\theta)}. \tag{10}$$

I will maximize P_{ij} with respect to the two parameters β and θ. The nested multinomial logit model is obtained by allowing the inclusive values to have a coefficient θ in the unit interval.

McFadden (1978) showed that the nested multinomial logit model is also consistent with stochastic utility maximization provided $0 < \theta \leq 1$, and that the coefficient of the inclusive value gives an estimate of the similarity of the observed choices at the lower level of the tree structure.

The main advantage of the NMNL is that while being computationally no more involved than the MNL model, it allows for alternatives across different branches to have different substitutabilities, that is, the IIA property holds only for alternatives on the same branch.

C. Allowing for Differing Substitutabilities Between Alternatives and Adding Intertemporal Linkages: Multiperiod Multinomial Probit (MPMNP)

A natural alternative to the Nested Multinomial Logit is a Multinomial Probit (MNP) model. This allows differing substitutabilities between all asset holding alternatives faced by the household, rather than being constrained by hierarchical structures (like the NMNL model). It is computationally burdensome, however, both because of the difficulty of computing the multinomial integral and the difficulties involved in estimating the covariance matrix caused by the fact that the likelihood function is often found to be ‘flat’ in the region around the maximum likelihood estimates. In addition, extending the household portfolio choice problem to a multiperiod context requires the estimation of a multinomial choice model with unobserved determinants that are correlated across alternatives and over time. This leads to an even higher dimensional integration of the associated likelihood functions. A simulation estimation method is then necessary to tackle the problem.

I follow Börsch-Supan and others (1992) and assume in this case that the space of possible outcomes is the set of N^T different choice sequences $\{i_t\}, t = 1, ..., T.$, and y_{it} is the maximal element over the utilities in $\{y_{jt} \mid j = 1, ..., t\}$. As above, what will be important for the household portfolio decision is the difference in utility levels between the best choice and any other choice, since the optimal choice delivers maximum utility. Let us define D error differences stacked in a vector z with joint cumulative distribution function F. Then:

$$z_{jt} = \epsilon_{jt} - \epsilon_{it} \text{ for } i = i, j \neq i_t. \tag{11}$$

where $D = (N - 1) \times T$.

By comparing two indirect utilities (see equation 1), I obtain:

$$y_{it} > y_{jt} \longleftrightarrow x_{it}\beta + \epsilon_{it} > x_{jt}\beta + \epsilon_{jt},$$

$$x_{it}\beta - x_{jt}\beta > \epsilon_{jt} - \epsilon_{it} \longleftrightarrow x_{it}\beta - x_{jt}\beta > z_{jt}.$$

so that the maximum error differences can be as large as the difference in the deterministic utility components. The area of integration is

$$A_j(i) = \{z_{jt}| - \infty \leq z_{jt} \leq x_{it}\beta - x_{jt}\beta\} \; for \; j \neq i, \tag{12}$$

and the probability of choice sequence $\{i_t\}$ is

$$P\left(\{i_t\} \,|\, \{X_{it}\}\,; \beta, F\right) =$$

$$\int_{\{z_{j1} \,\in\, A_j(i_1)|j=1,...,I,j\neq i_1\}} \times ... \times \int_{\{z_{jT} \,\in\, A_j(i_T)|j=1,...,j\neq i_T\}} dF(z), \tag{13}$$

where the area of integration is $A_j = A_j(i_1) \times ... \times A_j(i_T)$, and where F is the cumulative distribution function that is assumed to be multivariate normal.

The likelihood function is

$$\pounds\left(\beta, M\right) = \prod_{n=1}^{N} P\left(\{i_{t,n}\} \mid \{X_{it,n}\}\,; \beta, M\right),$$

where n denotes an observation in a sample of N individuals and M is the covariance matrix.

The integral in 13 does not have a closed-form solution and its calculation will involve at least one D-dimensional integral for each observation and each iteration in the maximization process.

Moreover, I am assuming a multivariate normal distribution of the z_{jt} in equation 11 with a covariance matrix M that has up to $(D+1) \times D/2 - 1$ parameters to identify.[5] These covariance elements are the correlations among the z_{jt} and the variances.[6] Consequently, as noted above, I adopt the method of Smoothly Simulated Maximum Likelihood (SSML) estimation using the Geweke algorithm described in Börsch-Supan and Hajivassiliou (1993).[7]

The covariance matrix M can be specified in different ways:

1. $M = I$

This specification leads to a pooled cross-sectional probit model, ignoring intertemporal linkages and subject to IIA. The $D = (I-1) \times T$ dimensional integral of the choice probabilities factors into D one-dimensional integrals and there are no unknown parameters in M.

2. Interalternative correlation

M will be a block diagonal structure with $T \times (I-1)$ dimension blocks. In this case, $(I-2)$ variances and $(I-1) \times (I-2)/2$ covariances can be identified in M.

3. Intertemporal linkages: Random Effects

M will have a block-diagonal equicorrelation structure and $(I-1)$ variances of the random effects can be identified. This one factor structure leads to a one-dimensional-factorization of the integral in equation 13, which can be approximated accurately through Gaussian Hermite Quadrature.

4. Intertemporal linkages: Autorregressive Errors

M will be a block-diagonal structure where each block has the structure of an AR(1) process with $(I-1)$ parameters (ρ_i) to be identified.

The combination of (2), (3) and (4) leads to the following error structure:

[5] Much fewer in practice due to the modelling of M.

[6] With the exception of the restrictions due to the invariance of a discrete choice model to the scale of the indirect utilities (only differences of indirect utilities can be identified) and a single restriction due to the general non-identification of the scale of the vector β in discrete choice models.

[7] The Geweke algorithm is used to derive unbiased estimates of the choice probabilites.

$$\epsilon_{i,t} = \alpha_i + \eta_{i,t},\ \eta_{i,t} = \rho_i \cdot \eta_{i,\,t-1} + \nu_{i,t},\quad i = 1, ..., I-1, \tag{14}$$

with

$$corr\,(\nu_{i,t}, \nu_{j,s}) = \begin{cases} 0 & if \quad t \neq s \\ \omega_{ij} & if \quad t = s \end{cases}$$

and

$$cov\,(\alpha_i, \alpha_j) = \sigma_{ij},$$

which implies

$$cov\,(\epsilon_{i.t}, \epsilon_{j,s}) = \sigma_{ij} + \rho_i^{(t-s)} \frac{\sqrt{(1-\rho_i^2)} \cdot \sqrt{\left(1-\rho_j^2\right)}}{1-\rho_i \rho_j} \omega_{ij}. \tag{15}$$

All parameters in equation 15 are identified if $/\rho_i/ < 1$, $i = 1, ..., I-1$.

An interesting and important feature for my analysis are the two components of the covariance matrix. The first term is the random household effect component which reflects unobserved time-invariant individual heterogeneity or idiosyncracies. The second term can be interpreted as habit formation that slowly fades away.

IV. Empirical Results

A. Data

In order to model the intertemporal linkages mentioned above panel data is needed. To this end, I use the SHIW dataset. This survey is run every 2 or 3 years and has complete information on household portfolios.

For the remainder of the paper, and following Guiso et al. (1996)'s classification, I define three categories of financial asset holdings:

1. Safe financial assets (SF): checking accounts, savings deposits, certificates of deposit, postal deposits, postal bonds, treasury bills up to one year maturity (BOTs), and floating-rate Treasury credit certificates (CCTs).

2. Risky financial assets (RK): long-term government bonds (BTPs and CTZs, the latter of which refers to zero-coupon bonds), corporate bonds, foreign bonds, investment fund units, domestic and foreign stocks, shareholdings in limited companies and in partnerships.[8]

3. No financial assets (NOA).

Few Italian households hold risky assets (see first two rows of Table 1), so I also show a broader definition of risky assets, following Guiso et al. (1996) by adding savings deposits, postal bonds, treasury bills to one year maturity (BOTs) and floating-rate treasury credit certificates (CCTs). For the econometric analysis that follows, however, I retain the narrow but more precise definition.

Tables 1 and 2 show the distribution of household portfolios of the unbalanced SHIW panel using the narrow (RISK0) and broad (RISK1) definition of risky assets respectively. Households are classified by their choice of assets: holdings of risky assets and safe assets (rksf), only risky assets (rknosf), only safe assets (sfnork) and no assets (noa).

risk0	1989	1991	1993	1995	1998	2000	Total
rksf	109	385	535	549	909	908	3,395
rknosf	1	3	1	1	4	1	11
sfnork	1,078	3,279	3,409	2,925	3,136	2,422	16,249
noa	158	489	591	543	613	542	2,936
Total	1,346	4,156	4,536	4,018	4,662	3,873	22,591

Note: Figures in the table give the count.

Table 1: Portfolio Choice, by Year, with a Narrow Measure of Risky Assets

risk1	1989	1991	1993	1995	1998	2000	Total
rksf	466	1,563	1,925	1,773	2,012	1,539	9,278
rknosf	200	615	579	447	370	162	2,373
sfnork	522	1,489	1,441	1,255	1,667	1,630	8,004
noa	158	489	591	543	613	542	2,936
Total	1,346	4,156	4,536	4,018	4,662	3,873	22,591

Note: See Table 1.

Table 2: Portfolio Choice, by Year, with a Broad Measure of Risky Assets

Tables 3 and 4 show the total number of observations for the unbalanced and balanced panels. I have excluded from the following analysis the risky asset and no safe asset category (rknosf) from the narrow measure since it only represents 0.05 percent of the

[8]Long-term government bonds are included due to the risk of default in Italy since public debt is substantial.

population (11 observations). The big difference between the balanced and unbalanced panel is that the latter contains between two and six waves and the former contains only households that were followed for six waves.

1989/91/93/95/98/00	Unbalanced Panel			Balanced Panel		
Financial assets? (narrow def.)	freq	percent	cum	freq	percent	cum
rksf	3395	15.04	15.04	294	18.92	18.92
sfnork	16249	71.96	87.00	1130	72.72	91.63
noa	2936	13.00	100.00	130	8.37	100.00
Total	22580	100.00		1554	100.00	

Table 3: Portfolio Choice with a Narrow Measure of Risky Assets

1989/91/93/95/98/00	Unbalanced Panel			Balanced Panel		
Financial assets? (broad def.)	freq	percent	cum	freq	percent	cum
rksf	9278	41.09	41.09	790	50.84	50.84
rknosf	2362	10.46	51.55	137	8.82	59.65
sfnork	8004	35.45	87.00	497	31.98	91.63
noa	2936	13.00	100.00	130	8.37	100.00
Total	22580	100.00		1554	100.00	

Table 4: Portfolio Choice for a Broad Measure of Risky Assets

A notable feature of the data is that only 15 percent of households held risky assets in the narrow definition.

Tables 5, 6, and 7 illustrate the proportion of financial asset holders with different demographic characteristics: education, age and sex.

Table 5 classifies households depending on their degree of education in 2000. Forty-five percent of households that have a university degree held risky assets and only 1 percent did not hold any financial assets. By contrast, only 3 percent of households with no schooling held risky assets and 44 percent held no assets. In general, the more years of education the larger the proportion of households holding risky assets. The majority of households held only safe assets.

In the same fashion, Table 6 shows that at any age, the majority of households held only safe assets in 2000. However, households between 35 and 55 years old were more likely to hold risky assets. The highest proportion of households that held no assets are either below 35 years old or above 65 years old.

Table 7 presents the distribution of financial asset holdings by the sex of the household head in 1989 and 2000. The proportion of both male and female heads that held risky assets increased from 9 percent to 26 percent for male heads and from 6 percent to 17

risk0 2000	no schooling	elementary school	high school	university
rksf	2.73	11.33	28.75	45.45
sfnork	53.52	67.63	62.37	53.29
noa	43.75	21.03	8.84	1.25
total	100.00	100.00	100.00	100.00

Note: Figures in the table give percentages.

Table 5: Portfolio Choice, by Education

risk0 2000	<35	35-45	45-55	55-65	65+
rksf	21.94	28.69	27.99	25.27	15.46
sfnork	64.56	62.95	59.94	61.97	64.38
noa	13.50	8.36	12.07	12.64	20.16
Total	100.00	100.00	100.00	100.00	100.00

Note: See Table 5.

Table 6: Portfolio Choice, by Age

percent for female heads, so the gender difference remains.

risk0	1989		2000	
	Male	Female	Male	Female
rksf	8.71	5.76	26.06	17.55
sfnork	80.71	77.70	62.08	63.56
noa	10.49	16.55	11.82	18.89
Total	100.00	100.00	100.00	100.00

Note: See Table 5.

Table 7: Portfolio Choice, by Sex

In order to get a clearer picture of the determination of financial asset portfolios, the dynamics of participation in financial markets need to be analyzed. This is done in the next section.

B. Changes in Portfolio Allocations

This section aims to give a descriptive analysis of the transition frequencies between financial asset holding states. The SHIW panel contains portfolio choice observations for six years, which will allow us to analyze patterns of participation and changes in/out of the financial markets in the 1990s. Household portfolios exhibit dramatic variation. In 2000, 63 percent of household with safe assets did not hold stocks or risky bonds, 6 percent held stocks, risky bonds and safe assets, 18 percent held stocks and safe assets but no risky bonds, and 3 percent held risky bonds and safe assets but not stocks. Nobody is observed having no holdings of safe assets, and holding risky bonds, stocks or both. Finally, 10 percent held no safe assets, risky bonds or stocks (See Table 9). Similarly striking results were reported by Vissing-Joergense (2002) for the 1994 PSID dataset. She found that 42.4 percent of those with positive financial wealth held neither stocks nor bonds. An additional 29.1 percent held stocks but not bonds, whereas 13.5 percent held bonds but not stocks. Only 15 percent held both stocks and bonds.

Year	risk0			
	rksf	rknosf	sfnork	noa
1991	10.52	0.08	81.39	8.01
1993	13.75	0.00	77.35	8.90
1995	16.10	0.00	74.35	9.55
1998	24.92	0.00	65.94	9.14
2000	26.78	0.00	63.19	10.03

Note: Households are divided into those holding 4 categories of financial assets. Figures in the table give percentages per year.

Table 8: Portfolio Choice per Year Using a Balanced Panel (1991–2000) for Narrow Measure of Risky Assets for Four Categories.

Table 8 illustrates the proportion of households in each of the four categories of the dependent variable "risk" for the narrow (risk0) definition of risky assets. Referring to the narrow definition of risky assets, during the 1990s the first category (people holding risky and safe assets) rose from 10 percent to 27 percent while the proportion of households that held safe assets but not risky assets - the majority - fell from 81 to 63 percent. Finally, the proportion of households that held no assets remained more or less constant.

Year	risk4							
	rbstsf	nrbstsf	rbnstsf	rbstnsf	rbnstnsf	nrbnstsf	nrbstnsf	nbnstnsf
1991	1.21	5.26	4.05	0.00	0.00	81.39	0.08	8.01
1993	3.48	7.36	2.91	0.00	0.00	77.35	0.00	8.90
1995	3.64	7.36	5.10	0.00	0.00	74.35	0.00	9.55
1998	6.07	14.32	4.53	0.00	0.00	65.94	0.00	9.14
2000	6.07	17.88	2.83	0.00	0.00	63.19	0.00	10.03

Note: Households are divided into those holding 8 categories of financial assets. Figures in the table give percentages per year.

Table 9: Portfolio Choice per Year Using a Balanced Panel (1991–2000) for Narrow Measure of Risky Assets for Eight Categories

Table 9 gives additional insights into the portfolio structure by showing the behavior of participation in risky bonds and stocks. RBSTSF refers to households holding risky bonds, stocks and safe assets simultaneously, NRBSTSF refers to households holding stocks and safe assets (but not risky bonds). RBNSTSF refers to households holding risky bonds, no stocks and safe assets. RBSTNSF refers to households holding risky bonds, stocks but no safe assets. RBNSTNSF refers to households holding risky bonds alone. NRBNSTSF refers to households holding safe assets alone. NRBSTNSF refers to households holding stocks alone. Finally, NBNSTNSF refers to households holding no financial assets.

In 1991, only 1 percent of households held risky bonds, stocks and safe assets. However, the percentage rose to 6 percent by 2000. Interestingly, the proportion of households that held stocks (and safe assets) but not risky bonds rose from 5 to 18 percent, but the proportion that held risky bonds and no stocks decreased slightly. The percentage of households holding only risky bonds fluctuated around 4 per cent, increasing in 1995 but declining since then. The highest proportion remains households holding only safe assets, but it has decreased over time.

Tables 10 and 16 describe the dynamics of ownership patterns using unrestricted empirical transition probabilities. They illustrate a measure of persistence by showing the proportion of households that switch from holding one basket of assets to another during the five years available. This approach does not illustrate changes in amounts held or changes within each category, but focuses instead on transitions for households that switch to, or stay with one category of financial assets.

I consider two different discretizations of the "risk" variable, focusing here on a 4-state model and leaving the 8-state model for the appendix. In 1991, 10 percent of households held risky assets, 81 percent held only safe assets, and 8 percent held no assets. Table 10 presents estimates of the unrestricted transition probabilities for risk0. Each matrix describes the changes in household portfolio choice from 1991 to 1993 ($T^{risk0}_{1991\rightarrow 1993}$), from 1991 to 1995 ($T^{risk0}_{1991\rightarrow 1995}$), from 1991 to 1998 ($T^{risk0}_{1991\rightarrow 1998}$), and from 1991 to 2000 ($T^{risk0}_{1991\rightarrow 2000}$) respectively. For instance, looking at $T^{risk0}_{1991\rightarrow 1993}$, for the one year horizon, 7 percent of households that were holding safe assets in 1991 switched to risky assets in 1993. Overall, in both the 4-state and 8-state models, the one-year horizon transition behavior shows a tendency for households to remain in their original states (the diagonals are uniformly the highest entries in each row), with households holding only safe assets showing the highest persistence. Table 10 effectively shows the existence of persistence. Households with no assets or risky assets show similar persistence. There is little mobility and the off-diagonal entries are very small. The largest move is from safe assets to risky assets, followed by a move from safe assets to no assets and from risky to safe assets, and finally the move from no assets to safe assets. Over the two- and three-year horizon, the persistence decreases for safe asset holders, but remains the same for risky asset holders.

$$T^{risk0}_{1991\rightarrow1993} = t \begin{array}{l} rksf \\ rknosf \\ sfnork \\ noa \end{array} \overset{t+s}{\begin{array}{cccc} rksf & rknosf & sfnork & noa \end{array}} \begin{pmatrix} 0.06 & 0.00 & 0.04 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 \\ 0.07 & 0.00 & 0.70 & 0.04 \\ 0.00 & 0.00 & 0.03 & 0.05 \end{pmatrix}$$

$$T^{risk0}_{1991\rightarrow1995} = t \begin{array}{l} rksf \\ rknosf \\ sfnork \\ noa \end{array} \overset{t+s}{\begin{array}{cccc} rksf & rknosf & sfnork & noa \end{array}} \begin{pmatrix} 0.06 & 0.00 & 0.04 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 \\ 0.09 & 0.00 & 0.67 & 0.05 \\ 0.00 & 0.00 & 0.03 & 0.04 \end{pmatrix}$$

$$T^{risk0}_{1991\rightarrow1998} = t \begin{array}{l} rksf \\ rknosf \\ sfnork \\ noa \end{array} \overset{t+s}{\begin{array}{cccc} rksf & rknosf & sfnork & noa \end{array}} \begin{pmatrix} 0.06 & 0.00 & 0.04 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 \\ 0.18 & 0.00 & 0.57 & 0.05 \\ 0.00 & 0.00 & 0.04 & 0.04 \end{pmatrix}$$

$$T^{risk0}_{1991\rightarrow2000} = t \begin{array}{l} rksf \\ rknosf \\ sfnork \\ noa \end{array} \overset{t+s}{\begin{array}{cccc} rksf & rknosf & sfnork & noa \end{array}} \begin{pmatrix} 0.06 & 0.00 & 0.04 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 \\ 0.20 & 0.00 & 0.55 & 0.06 \\ 0.00 & 0.00 & 0.04 & 0.03 \end{pmatrix}$$

Note : Entries may not add up to 1.00 due to rounding.

Table 10: Unrestricted Empirical Transition Probabilities in Different Horizons: Narrow Definition

The above matrices describing households' transition from one financial asset state to another suggest long-run stability with interim short-run changes. To see the latter, Table 11 classifies the mobility histories from one wave to the next. There is an increasing tendency for households to switch from holding only safe assets to holding risky and safe assets simultaneously. At the same time, there is a smaller but growing tendency for households to move from holding risky and safe assets to focus only on safe assets. The diagonal elements show very high persistence in holdings of safe and risky assets.

I therefore conclude that there is persistence in household portfolio decisions. Whether this persistence is due to taste persistence or some other heterogeneity is the issue that I analyze in the next section. The same exercise for the 8-state model is shown in the Appendix.

$$T^{risk0}_{1991\to1993} = t \begin{array}{l} \\ rksf \\ rknosf \\ sfnork \\ noa \end{array} \begin{array}{c} \overset{t+s}{\begin{array}{cccc} rksf & rknosf & sfnork & noa \end{array}} \\ \begin{pmatrix} 0.06 & 0.00 & 0.04 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 \\ 0.07 & 0.00 & 0.70 & 0.04 \\ 0.00 & 0.00 & 0.03 & 0.05 \end{pmatrix} \end{array}$$

$$T^{risk0}_{1993\to1995} = t \begin{array}{l} \\ rksf \\ rknosf \\ sfnork \\ noa \end{array} \begin{array}{c} \overset{t+s}{\begin{array}{cccc} rksf & rknosf & sfnork & noa \end{array}} \\ \begin{pmatrix} 0.09 & 0.00 & 0.04 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 \\ 0.07 & 0.00 & 0.68 & 0.03 \\ 0.00 & 0.00 & 0.02 & 0.07 \end{pmatrix} \end{array}$$

$$T^{risk0}_{1995\to1998} = t \begin{array}{l} \\ rksf \\ rknosf \\ sfnork \\ noa \end{array} \begin{array}{c} \overset{t+s}{\begin{array}{cccc} rksf & rknosf & sfnork & noa \end{array}} \\ \begin{pmatrix} 0.11 & 0.00 & 0.05 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 \\ 0.14 & 0.00 & 0.57 & 0.04 \\ 0.00 & 0.00 & 0.04 & 0.06 \end{pmatrix} \end{array}$$

$$T^{risk0}_{1998\to2000} = t \begin{array}{l} \\ rksf \\ rknosf \\ sfnork \\ noa \end{array} \begin{array}{c} \overset{t+s}{\begin{array}{cccc} rksf & rknosf & sfnork & noa \end{array}} \\ \begin{pmatrix} 0.15 & 0.00 & 0.09 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 \\ 0.11 & 0.00 & 0.50 & 0.04 \\ 0.00 & 0.00 & 0.04 & 0.05 \end{pmatrix} \end{array}$$

Note : See Table 10.

Table 11: Unrestricted Empirical Transition Probabilities for One Wave to Next: Narrow Definition

C. Estimation Results

The presentation of results is organized according to the progressive relaxation of assumptions.

Nested multinomial logit results Table 12 presents the results of estimating a NMNL model. Notice first that the coefficient on theta is highly significant and below 1, meaning that the model exhibits statistically significant nesting; that is, it violates the IIA property of the regular MNL model.

The R^2 of McFadden tests the model against the alternative of only a constant and no real explanatory variables on the right-hand side. The relatively high value of 0.50

Dependent variable: i_{nt} :	1: rksf, 2:sfnork, 3:noa	
Variables[2]	Estimate[1]	t-Stat.
age1	0.000	0.00
age2	0.001	0.06
ms1	-0.217	-1.11
ms2	-0.094	-0.51
educ1	0.713***	7.20
educ2	0.391***	4.22
emplh1	0.437**	2.53
emplh2	0.162	0.98
fsize1	-0.258***	-4.42
fsize2	-0.213***	-3.89
sex1	-0.346**	-1.99
sex2	-0.322**	-1.98
housevalue1	0.287***	2.68
housevalue2	0.261*	1.76
wage1	0.628***	8.23
wage2	0.525***	6.81
wealth1	0.014**	2.22
wealth2	0.012**	1.95
houseloan1	-0.277	-1.02
houseloan2	-0.441*	-1.69
self1	-0.997***	-4.96
self2	-0.780***	-4.00
unrt1	-0.836***	-9.40
unrt2	-0.577***	-7.11
$i_{n,t-1}1$	-3.665***	-28.70
$i_{n,t-1}2$	-2.670***	-21.59
cte1	10.346***	12.477
cte2	10.140***	12.602
theta[3]	0.494***	15.52
McFadden R^2	0.50	
Log Likelihood	-714.9126	
No. of observations[4]	1295	

[1] *, **, and *** correspond to the 10 , 5 and 1 percent significance levels, respectively.
[2] Each explanatory variable is interacted with choice 1 (rksf) and choice 2 (sfnork), while choice 3 (noa) is the base category.
[3] Coefficient of the inclusive value.
[4] Balanced panel (1989/91/93/95/98/00)

Table 12: Nested Multinomial Logit

supports the joint significance of the explanatory variables. Hence when I apply a generalized approach to selectivity bias in a joint decision to hold risky and safe assets, I find a significant positive correlation. Ignoring the relationship between these two decisions would therefore lead to biased estimates.

I control for demographics (marital status: married (MS), gender (SEX), family size (FSIZE)) as proxies for observed heterogeneity; real labor income (WAGE) and real financial wealth (WEALTH) as measures of the initial endowment; and housing equity (HOUSEVALUE) as a measure of nontraded or illiquid asset. I also control for self-employment (SELF) and add the unemployment rate of the region in which the household lives (UNRT). EMPLH indicates the labor status of the head of the household, HOUSELOAN indicates whether the household is indebted, AGE is an indicator of planning horizon, and WEALTH and education (EDUC) are indicators of financial information.

The way to interpret the results is as follows. For each explanatory variable, (1) the relative influence on the likelihood of holding risky financial assets (and safe assets) relative to the likelihood of holding no assets (e.g. educ1), and (2) the relative influence on the likelihood of holding safe assets to the likelihood of holding no assets (e.g. educ2), are measured.

Table 12 illustrates that the parameter estimates for EDUC are positive and significant. Education can be interpreted as a measure of the ability to process information about the market and investment opportunities. More highly educated household heads are more likely to be assetholders because the information is cheaper. The coefficient on EDUC1 is larger than the one on EDUC2, meaning that for risky asset holders the probability of entering the market increases more with higher education. This builds on the King and Leape (1998) hypothesis that information about more sophisticated financial assets plays a role in participation. It reflects financial knowledge or interest in financial issues. Lack of participation can sometimes be explained in terms of unawareness of the existence of particular assets among certain households.

EMPLH1 is highly significant, meaning that having a job in the survey year increases the probability of holding risky assets and is not essential for holding safe assets. FSIZE turn out to be highly significant and important, indicating that larger families hold fewer assets. SEX is significant and negative, indicating that male household heads are more likely to hold no assets (the same result is achieved by Perraundin et Soerensen (2000)). HOMEVALUE is particularly significant for risky asset holders, hinting that real estate could be used as collateral to invest in risky assets. The positive coefficient of WAGE (higher for WAGE1 than WAGE2) implies that the percentage of households that hold financial assets increases with the average of labor income because they are more willing to pay for the fixed information and transaction costs of risky assets. WEALTH gives the same result, implying that wealthier households will typically have more to invest, making the relatively large fixed costs of acquiring or holding individual stocks less important.

UNRT accounts for labor risk. When households are faced by unavoided risk such as unemployment, they are less willing to hold risky assets. UNRT is negative and highly significant even controlling for age, wealth, and demographics. Participation therefore depends on background risk.

Following Heckman (1981), I introduce $\mathrm{i}_{n,t-1}$(lagged value of the dependent variable $\mathrm{i}_{n,t}$)[9] to account for the effect of past experience on choices made in period t and to allow for the possibility of true state dependence. Since the three options on the choice variable are ordered in terms of risk, I decided to report only the results with the lagged ordered variable, though I experimented with entering separate dummy variables for each holding. Both versions for entering the lagged choice variable gave very similar results in terms of significance of lagged terms and the autocorrelation terms as well as the values of the other estimated coefficients and their t-statistics and standard errors.[10]

The assumption that I use concerning the initial conditions is that those are truly exogenous. In this case, the ML estimator is consistent if N (or N and T) goes to infinity. Since are not serially independent, I assume that a new process is observed (with respect to the past) when we start to sample the individuals; otherwise the initial state is determined by the process generating the panel. With respect to the decision to invest in risky assets, individuals started to hold more risky assets at the beginning of the 1990s due to privatization, etc. when the sampling period starts, so we can treat initial conditions as exogenous. In any case, the impact of the exact way the initial conditions are treated loses importance the larger T is. In our case T is 5 which implies the econometric treatment of the initial conditions may not be critical.

By looking at the coefficient of the lagged dependent variable, I can infer something about the existence of state dependence among financial asset holdings. The coefficient is large and significant. The sign is negative, meaning that a household holding no financial assets in the previous period (choice 3) is less likely to hold risky financial assets in the current period (choice 1), while a household holding risky financial assets last period is more likely to hold them in the current period.

MS and SELF are insignificant as reported in other studies (See Perraudin and Soerensen (2000)). AGE turns out to be insignificant but, as is shown later, this is not necessarily the case. The initial idea was to test for non-linearity in age by including a squared term in age. Unfortunately the squared term in age was highly correlated with other variables and altered the specification. Therefore I chose to exclude it from the model. The same kind of problem is stated in Perraudin and Soerensen (2000). HOUSELOAN is only

[9]I define the lagged dependent variable as the lagged value of the dependent variable coded 1, 2, 3 where 1: risky assets and safe assets, 2: safe assets only, 3: no assets.

[10]Even when the dependent variable is completely ordered, it may be preferable to model the whole setup as an ordered probit as opposed to a multinomial probit one. However, when using an ordered probit (as opposed to MNP) one cannot simply condition on the lagged value directly in case of serial correlation. The joint probability of choice (i,t) and choice(i,t-1) must be taken into account in the likelihood function calculation. I leave this alternative modeling approach to future research.

weakly significant for the case of holding safe assets.

Multiperiod multinomial probit results (three–alternative model) Our estimated Multiperiod-Multinomial Probit (MPMNP) model is

$$i_{nt} = \arg\max_{j=1...I} (y_{jnt} = x_{nt}\beta_j + \epsilon_{jnt}) \tag{16}$$

where

i_{nt}: observed discrete choice by household n in time t, $i = 1...I, t = 1...T_i$

y_{jnt}: latent utility of alternative j as perceived by household n in time t

x_{nt}: agent-specific characteristics of household n in time t [11]

ϵ_{jnt}: multivariate normal error with covariance $\text{cov}(\epsilon_n) = \Omega \ \left(\epsilon_n = (\epsilon_{jnt})_{j=1...I,\ t=1...T^i}\right)$

where Ω is $I \times T_i$, allowing interalternative and intertemporal correlation between ϵ_{jnt} and ϵ_{kns} for the same observation n.

I analyze the following covariance structures in the model:

- Contemporaneous correlations and heteroscedasticity of $\epsilon_{nt} = (\epsilon_{jnt})_{j=1...I}$, therefore deviating from the i.i.d. assumption within a given period (see equation 14, ν_i in Table 13).
- Intertemporal correlations between $\epsilon_n = (\epsilon_{jnt})_{j=1...I,\ t=1...T^i}$
  - Random effects which account for *household effects (*see equation 14, α_i in Table 13).
  - First-order autoregressive errors which account for *habit formation or taste persistence (*see equation 14, ρ_i in Table 13)

An incorrect specification of the covariance matrix of the errors biases the structural coefficients β apart from the standard errors of the estimated coefficients. In what follows I explore combinations of these error processes. The parameters of the first model with three alternatives to be estimated are β_j and Ω and are shown in Table 13.

[11] Note that there are not alternative specific attributes for each alternative (risky financial assets, safe financial assets and no financial assets). Hence the explanatory variables will be interacted with alternative dummy variables to achieve identification.

Dependent variable: i_{nt} :	(1)		(2)		(3)	
1: rksf, 2:sfnork, 3:noa	Estimate[1]	t-Stat.	Estimate[1]	t-Stat.	Estimate[1]	t-Stat.
Household-specific variables[2]						
age1	0.626***	4.82	0.626***	4.82	0.663***	4.63
age2	0.111	1.07	0.111	1.07	0.129	1.10
ms1	-0.616	-1.30	-0.616	-1.30	-0.647	-1.30
ms2	-0.002	-0.01	-0.002	-0.01	-0.025	-0.06
educ1	0.941***	3.93	0.941***	3.93	1.112***	4.30
educ2	0.424***	2.61	0.424***	2.61	0.495***	2.85
emplh1	0.058	0.14	0.058	0.14	0.114	0.30
emplh2	-0.374	-1.13	-0.374	-1.13	-0.360	-1.10
fsize1	-0.253**	-1.98	-0.253**	-1.98	-0.275*	-1.88
fsize2	-0.206**	-1.96	-0.206**	-1.96	-0.234**	-2.00
sex1	-0.266	-0.70	-0.266	-0.70	-0.112	-0.29
sex2	-0.269	-0.85	-0.269	-0.85	-0.135	-0.40
homevalue1	0.010	0.05	0.010	0.05	-0.083	-0.44
homevalue2	-0.087	-0.47	-0.087	-0.47	-0.148	-0.82
wage1	0.288**	2.11	0.288**	2.10	0.309**	2.35
wage2	0.137	1.17	0.137	1.17	0.174	1.48
wealth1	0.053***	3.89	0.053***	3.89	0.055***	4.26
wealth2	0.053***	4.00	0.053***	4.00	0.055***	4.28
houseloan1	-0.337	-0.71	-0.337	-0.71	-0.509	-1.10
houseloan2	-0.482	-1.15	-0.482	-1.15	-0.530	-1.23
self1	-0.428	-1.15	-0.428	-1.15	-0.710**	-1.96
self2	0.095	0.32	0.095	0.32	-0.103	-0.34
unrt1	-1.274***	-5.62	-1.274***	-5.62	-1.374***	-6.07
unrt2	-0.722***	-4.80	0.722***	-4.80	-0.771***	-4.65
$i_{n,t-1}1$	-2.774***	-6.38	-2.774***	-6.38	-0.507*	-1.89
$i_{n,t-1}2$	-1.494***	-6.94	-1.494***	-6.94	-0.498**	-2.30
cte1	1.620	0.91	1.619	0.91	-2.487	-1.30
cte2	1.779	1.18	1.779	1.18	-0.042	-0.03

(continued on next page)

Error structure[3]						
$SD\ (\nu_1)$ (Heteroskedasticity)	1.992***	4.09	1.992***	4.09	2.13***	7.72
$corr\ (\nu_1, \nu_2)$ (Interalternative corr)	0.738***	2.96	0.738***	2.96	0.98***	5.81
$SD\ (\alpha_1)$ (Household effects)	-	-	0.0001	0.99	0.00009	1.00
$SD\ (\alpha_2)$ (Household effects)	-	-	0.0001	0.97	0.0001	.998
$corr(\alpha_{1,}\alpha_2)$ (Household effects)	-	-	-0.00001	0.000	0.000	0.00
ρ_1 (Habit formation)	-	-	-	-	0.731***	13.66
ρ_2 (Habit formation)	-	-	-	-	0.909***	13.75
Log Likelihood[4]	-716.2914		-716.2914		-691.5662	
No. of observations[5]	1295		1295		1295	

[1] *, **, and *** correspond to the 10, 5 and 1 percent signficance levels, respectively.

[2] Each explanatory variable is interacted with choice 1 (rksf) and choice 2 (sfnork), while choice 3 (noa) is the base category.

[3] Three different specifications of correlations are employed: (1) $corr\ (\nu_i, \nu_j)$: unobserved time-specific utility components correlated, (2) $corr(\alpha_{i,}\alpha_j)$: random effects correlated, and (3) ρ_i: first-order autocorrelation.

[4] Significance is measured by the likelihood ratio statistic.

[5] Balanced panel (1989/91/93/95/98/00).

Table 13: Multiperiod Multinomial Probit with Autoregressive Errors (Three–Alternative Model)

I present results of three specifications. Column (1) controls for contemporaneous correlations and heteroscedasticity. Column (2) also allows for random effects. Column (3) allows for autoregressive errors.

First, there are significant differences with respect to the NMNL model. AGE1 is now highly significant, increasing the probability of holding risky assets. EMPL1 is no longer significant while WAGE1 shows that high labor income is especially important for risky asset holders only. HOMEVALUE, HOUSELOAN2 and SEX lose their significance. Only SELF1 remains significant after controlling for the variability of the covariance matrix.

By looking at the components of the covariance matrix, the IIA assumption is clearly rejected since $SD\ (\nu_1)$ and $corr\ (\nu_1, \nu_2)$ are highly significant. The introduction of random effects (household effects) does not affect the model since they are not significant - the log likelihood value remains unchanged. The introduction of the autoregressive error component however dramatically lowers the log likelihood value. The autocorrelation coefficients are highly significant, implying strong persistence in both decisions of holding risky and safe assets. This is consistent with the negative coefficient found for the lagged variable. However, as in the case of Börsch-Supan and others (1992), the panel is too short to separate the two error structures precisely.

By looking at the difference between the three columns of the MPMNP, it is clear that in general coefficients are underestimated when the panel structure is ignored, especially EDUC. WEALTH is remarkably stable across the different specifications of the covariance matrix. SELF1 turns out to be negatively significant, decreasing the likelihood of holding risky assets. Most interestingly, the coefficient on $\mathrm{i}_{n,t-1}$ turns out to be overestimated by 1/7 when allowing for persistence, and is relatively less significant. This could be explained by the fact that the lagged financial holding variable was partially capturing the effect of the omitted $\rho_{i.}$

Final model: Multiperiod multinomial probit results (Five–Alternative Model)
In order to shed light on the differences between holding risky bonds and stocks and to avoid aggregation problems, I consider a second discretization of the "risk" variable (risk2) as follows[12]:

1. Risky bonds, stocks and safe assets (rbstsf)
2. No risky bonds, stocks and safe assets (nrbstsf)
3. Risky bonds, no stocks and safe assets (rbnstsf)
4. No risky bonds, no stocks and safe assets (nrbnstsf)
5. No risky bonds, no stocks and no safe assets (nbnstnsf). This is the normalized category.

Table 14 provides the estimation results of the model. EDUC is more important for households who only hold stocks (EDUC2 has the highest coefficient). The same applies for WAGE and WEALTH. FSIZE is more a worry for households that hold a diversified portfolio with a combination of stocks, risky bonds and safe assets (FSIZE1 is highly significant). Highly indebted households tend to have fewer safe assets (HOUSELOAN4 is significant). AGE does not seem to matter as much for households holding risky bonds (AGE3 is insignificant). Interestingly, background risk (UNRT) strongly decreases the likelihood of holding risky bonds (UNRT3 has the highest coefficient).

Several alternative versions were run in terms of lagged terms. All versions produced high significance of lagged terms and autocorrelation terms and very similar parameter estimates and t-statistics for the other coefficients. I do not present the individual lagged dependent variable dummies themselves since the results would have been too cluttered and messy for the 5-way classification.

[12]Categories rbstnsf, rbnstnsf, and nrbstnsf are excluded since there were no households with these holdings in Table 9.

V. Conclusion

This paper analyzes the household portfolio decision of shifting from no financial assets to safe financial assets, risky financial assets, or both. To this end, I use the SHIW panel dataset for Italian households. The novelty of this paper is the inclusion and modeling of habit formation in a multinomial model of household portfolio participation. The estimation requires maximum smoothly simulated likelihood techniques for a multiperiod multinomial probit model.

The results show that household portfolio behavior is better explained by infrequent decisions than by the continuous adjustments that standard theory predicts. Moreover, the unobserved utilities determining the household portfolio choice clearly include significant time-varying components. Since this model works mainly through time-varying components rather than time-invariant ones, habit formation is driving the behavior of households. In other words, households develop a taste for the assets that they hold and do not change their portfolios very frequently. This result is essential for understanding the main reason for nonparticipation.

I also consider the existence of true state dependence in financial assets decisions and find true state dependence in the decision to hold risky and safe financial assets. More interestingly, holdings of risky and safe assets are also affected by persistence that fades away slowly. The finding of taste persistence in household portfolio choice is particularly relevant for policymakers, since household portfolios are an additional element in their social security systems.

In addition, it also appears that ignoring intertemporal linkages biases some estimation coefficients - for example, by underestimating the effects of education and overestimating true state dependence in holding no financial assets. Lastly, education levels, labor income, age, and wealth turn out to be more important for holding stocks than risky bonds. The larger the family, the less diversified the portfolio is. A high unemployment rate strongly decreases the likelihood of holding risky bonds.

A caveat is that the panel is short, only six waves. However, the differences in goodness of fit (log-likelihood values) indicate the importance of persistence in the model.

Appendix: Data and Statistics

A. Definition of Variables

The following variables were constructed from questions from the Bank of Italy Survey of Household Income and Wealth.

AGE: Age of the head of the household.

MS: Marital status:

1=married

2=single, separated/divorced or widowed/widow

EDUC: Highest education earned:

1=none

2=elementary school

3=middle school or professional secondary school diploma (3 years of study) or high school or associate's degree or other course university degree

4=bachelor's degree or post-graduate qualification

EMPLH: Whether or not the head of the household was employed for the greater part of the year:

1=employed

2= non-employed

FSIZE: Number of persons living in the household.

SEX: Gender:

1=male

2=female

HOMEVALUE: The value of the household's dwelling.

WAGE: Real labor income in millions of 1989 lira.

WEALTH: Real financial wealth in millions of 1989 lira.

HOUSELOAN: Debts for real state purchasing or renewal at the end of the year:

1=yes

2=no

SELF: Self-employed head of household:

1=member of the arts or professions, sole proprietor, freelance worker, owner or member of a family business, active shareholder/partner, contingent worker not employed on any account or other.

2=employee or not employed

RISK: Participation variable. The empirical part of the paper uses two different discretizations of the dependent variable:

Risk0:

1=holdings of risky assets and safe assets (rksf)

2=only safe assets (sfnork)

3=no financial asset (noa). This is the normalized category.

Risk2:

1=Risky bonds, stocks and safe assets (rbstsf)

2=No risky bonds, stocks and safe assets (nrbstsf)

3=Risky bonds, no stocks and safe assets (rbnstsf)

4=No risky bonds, no stocks and safe assets (nrbnstsf)

5=No risky bonds, no stocks and no safe assets (nbnstnsf). This the normalized category.

The survey reports participation in 20 financial assets:

1. Current accounts.

2. Savings accounts.

3. Certificates of deposit.

4. Repurchase agreements.

5. Postal accounts.

6. Postal bonds.

7. Treasury bills up to one year maturity (BOTs)

8. Floating-rate treasury credit certificates (CCTs).

9. Long-term government bonds (BTPs).

10. Zero-coupon bonds (CTZs).

11. Other government bonds.

12. Corporate bonds.

13. Mutual Funds.

14. Listed stocks.

15. Unlisted stocks (three categories).

16. Managed investment accounts (three categories).

17. Foreign corporate and government bonds.

18. Foreign stocks.

19. Other foreign assets.

20. Loans to cooperatives securities.

In each wave from 1991 the survey asks the respondent to report the amount held at the end of the year of each asset according to the following intervals:

- Up to 2 million lire.

- Between 2 and 4 million lire.

- Between 4 and 8 million lire.

- Between 8 and 12 million lire.

- Between 12 and 16 million lire.

- Between 16 and 24 million lire.

- Between 24 and 36 million lire.

- Between 36 and 70 million lire.

- Between 70 and 140 million lire.

- Between 140 and 300 million lire.

- Between 300 and 600 million lire.

- Between 600 million and 1 billion lire.

- Between 1 and 2 billion lire.

- Above 2 billion lire.

In addition, the following external variable from REGIO (Eurostat's harmonized regional statistical database) was linked to the survey data:

UNRT: Italian regional unemployment rate: Unemployment at NUTS (Nomenclature of Statistical Territorial Units) Level 3 over working population at NUTS Level 3.

B. Eight-State Transition Probabilities

In the eight-state model using the narrow definition of risky financial assets for 1991, only 1 percent of all households held simultaneously risky bonds, stocks and safe assets, 5 percent held stocks (and safe assets) but no risky bonds, 4 percent held risky bonds (and safe assets) but no stocks. A large majority (81 percent) were households that held only safe assets. The 8 percent remaining held no financial assets. Table 10 shows that the highest persistence is observed in the behavior of households holding only safe assets and then those holding only stocks and safe assets, or no financial assets. This persistence decreases slowly over time for households holding only safe assets. The very low persistence of the two extremes - holding risky bonds, stocks and safe assets and those holding no assets - do not change at all over time. The majority of the switchers from only safe assets went to stocks and safe assets (no risky bonds) and a smaller proportion to no financial assets. There was also an increase in the proportion of households switching from holding only safe assets to holding all financial assets. Table 15 confirms the above results.

Dependent variable: i_{nt} :	Estimate[1]	t-Stat.
1: rbstsf, 2:nrbstsf, 3:rbnstsf, 4:nrbnstsf, 5:nbnstnsf		
Household-specific variables[2]		
age1	0.141**	2.41
age2	0.120**	2.03
age3	0.031	0.41
age4	0.111**	2.39
ms1	-0.196	-1.08
ms2	-0.282	-1.55
ms3	0.020	0.09
ms4	-0.087	-0.61
educ1	0.816***	6.70
educ2	0.852***	7.52
educ3	0.773***	5.32
educ4	0.458***	6.15
emplh1	0.152	0.91
emplh2	0.150	0.93
emplh3	0.336	1.48
emplh4	-0.140	-1.07
fsize1	-0.142**	-2.38
fsize2	-0.112*	-1.87
fsize3	-0.117	-1.51
fsize4	-0.079*	-1.71
sex1	-0.221	-1.39
sex2	-0.132	-0.82
sex3	-0.269	-1.29
sex4	-0.181	-1.41
wage1	0.411***	7.14
wage2	0.444***	7.55
wage3	0.418***	5.95
wage4	0.301***	5.73
wealth1	0.031***	2.90
wealth2	0.031***	2.87
wealth3	0.019	1.42
wealth4	0.030***	2.83

(continued on next page)

houseloan1	-0.145	-0.66
houseloan2	-0.247	-1.19
houseloan3	-0.084	-0.34
houseloan4	-0.388**	-2.09
unrt1	-0.754***	-7.05
unrt2	-0.815***	-8.43
unrt3	-0.825***	-5.84
unrt4	-0.506***	-8.02
lagged terms interacted with choice[3]	_ [3]	_[3]
cte1	10.323***	11.25
cte2	10.504***	11.63
cte3	8.060***	5.97
cte4	10.498***	13.81
Error structure[4]		
$SD\ (\nu_1)$ (Heteroskedasticity)	0.886***	5.16
$SD\ (\nu_2)$ (Heteroskedasticity)	0.723***	3.37
$SD\ (\nu_3)$ (Heteroskedasticity)	1.570***	3.34
$corr\ (\nu_1, \nu_2)$ (Interalternative correlation)	-0.065	-0.18
$corr\ (\nu_1, \nu_3)$ (Interalternative correlation)	-0.090	-0.38
$corr\ (\nu_1, \nu_4)$ (Interalternative correlation)	0.564***	3.43
$corr\ (\nu_2, \nu_3)$ (Interalternative correlation)	-0.084	-0.35
$corr\ (\nu_2, \nu_5)$ (Interalternative correlation)	-0.087***	-2.03
$corr\ (\nu_3, \nu_4)$ (Interalternative correlation)	0.308***	2.07
$SD\ (\alpha_1)$ (Household effects)	0.0001	1.00
$SD\ (\alpha_2)$ (Household effects)	0.0001	1.00
$SD\ (\alpha_3)$ (Household effects)	0.0001	1.00
$SD\ (\alpha_4)$ (Household effects)	0.0001	1.00
$corr$ (Household effects)	-0.0002	0.00
$corr$ (Household effects)	0.0001	0.00
$corr$ (Household effects)	-0.000003	0.00
$corr$ (Household effects)	-0.00001	0.00
$corr$ (Household effects)	0.00001	0.00
$corr$ (Household effects)	-0.0001	0.00

(continued on next page)

ρ_1 (Habit formation)	0.026	0.27
ρ_2 (Habit formation)	0.595***	5.30
ρ_3 (Habit formation)	0.543***	6.43
ρ_4 (Habit formation)	-0.191**	-2.40
Log Likelihood	-3655.5749	
No. of observations[5]	4940	

[1] *, **, and *** correspond to the 10, 5 and 1 percent significance levels.
[2] Each explanatory variable is interacted with choice 1 (rbstsf), choice 2 (nrbstsf), choice 3 (rbnstsf), choice 4 (nrbnstsf), while choice 5 (nbnstnsf) is the base category.
[3]Several alternative versions were run in terms of lagged terms. All versions produced high significance of lagged terms and very similar parameter estimates and t-statistics for the other coefficients. See page 29 for details.
[4] Three different specifications of correlations are employed: (1) $corr\ (\nu_i, \nu_j)$: unobserved time-specific utility components correlated, (2) $corr(\alpha_{i,}\alpha_j)$: random effects correlated, and (3) ρ_i: first-order autocorrelation.
[5] Balanced panel (1991/93/95/98/00).

Table 14: Multiperiod Multinomial Probit with Autoregressive Errors (Five–Alternative Model)

$$T^{risk4}_{1991\rightarrow1993} = t \quad \begin{array}{l} rbstsf \\ nrbstsf \\ rbnstsf \\ rbstnsf \\ rbnstnsf \\ nrbnstsf \\ nrbstnsf \\ nbnstnsf \end{array} \overset{t+s}{\begin{pmatrix} 0.01 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.02 & 0.00 & 0.00 & 0.00 & 0.02 & 0.00 & 0.00 \\ 0.01 & 0.01 & 0.01 & 0.00 & 0.00 & 0.02 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.01 & 0.04 & 0.01 & 0.00 & 0.00 & 0.70 & 0.00 & 0.04 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.03 & 0.00 & 0.05 \end{pmatrix}}$$

$$T^{risk4}_{1993\rightarrow1995} = t \quad \begin{array}{l} rbstsf \\ nrbstsf \\ rbnstsf \\ rbstnsf \\ rbnstnsf \\ nrbnstsf \\ nrbstnsf \\ nbnstnsf \end{array} \overset{t+s}{\begin{pmatrix} 0.02 & 0.01 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.01 & 0.03 & 0.01 & 0.00 & 0.00 & 0.03 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.01 & 0.00 & 0.00 & 0.01 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.01 & 0.03 & 0.03 & 0.00 & 0.00 & 0.68 & 0.00 & 0.03 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.02 & 0.00 & 0.07 \end{pmatrix}}$$

$$T^{risk4}_{1995\rightarrow1998} = t \quad \begin{array}{l} rbstsf \\ nrbstsf \\ rbnstsf \\ rbstnsf \\ rbnstnsf \\ nrbnstsf \\ nrbstnsf \\ nbnstnsf \end{array} \overset{t+s}{\begin{pmatrix} 0.02 & 0.01 & 0.00 & 0.00 & 0.00 & 0.01 & 0.00 & 0.00 \\ 0.01 & 0.04 & 0.00 & 0.00 & 0.00 & 0.02 & 0.00 & 0.00 \\ 0.01 & 0.01 & 0.01 & 0.00 & 0.00 & 0.02 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.02 & 0.09 & 0.03 & 0.00 & 0.00 & 0.57 & 0.00 & 0.04 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.04 & 0.00 & 0.06 \end{pmatrix}}$$

$$T^{risk4}_{1998\rightarrow2000} = t \quad \begin{array}{l} rbstsf \\ nrbstsf \\ rbnstsf \\ rbstnsf \\ rbnstnsf \\ nrbnstsf \\ nrbstnsf \\ nbnstnsf \end{array} \overset{t+s}{\begin{pmatrix} 0.02 & 0.03 & 0.00 & 0.00 & 0.00 & 0.01 & 0.00 & 0.00 \\ 0.02 & 0.07 & 0.00 & 0.00 & 0.00 & 0.05 & 0.00 & 0.00 \\ 0.01 & 0.01 & 0.01 & 0.00 & 0.00 & 0.03 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.02 & 0.07 & 0.02 & 0.00 & 0.00 & 0.50 & 0.00 & 0.04 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.04 & 0.00 & 0.05 \end{pmatrix}}$$

Note : See Figure 10.

Table 15: Unrestricted Empirical Transition Probabilities for One Wave to Next: Narrow Definition.

$$T^{risk4}_{1991\rightarrow 1993} = t \begin{array}{l} rbstsf \\ nrbstsf \\ rbnstsf \\ rbstnsf \\ rbnstnsf \\ nrbnstsf \\ nrbstnsf \\ nbnstnsf \end{array} \overset{t+s}{\begin{pmatrix} 0.01 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.01 & 0.02 & 0.00 & 0.00 & 0.00 & 0.02 & 0.00 & 0.00 \\ 0.01 & 0.01 & 0.01 & 0.00 & 0.00 & 0.02 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.01 & 0.04 & 0.01 & 0.00 & 0.00 & 0.70 & 0.00 & 0.04 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.03 & 0.00 & 0.05 \end{pmatrix}}$$

$$T^{risk4}_{1991\rightarrow 1995} = t \begin{array}{l} rbstsf \\ nrbstsf \\ rbnstsf \\ rbstnsf \\ rbnstnsf \\ nrbnstsf \\ nrbstnsf \\ nbnstnsf \end{array} \overset{t+s}{\begin{pmatrix} 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.01 & 0.02 & 0.01 & 0.00 & 0.00 & 0.02 & 0.00 & 0.00 \\ 0.01 & 0.00 & 0.01 & 0.00 & 0.00 & 0.02 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.02 & 0.04 & 0.03 & 0.00 & 0.00 & 0.67 & 0.00 & 0.05 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.03 & 0.00 & 0.04 \end{pmatrix}}$$

$$T^{risk4}_{1991\rightarrow 1998} = t \begin{array}{l} rbstsf \\ nrbstsf \\ rbnstsf \\ rbstnsf \\ rbnstnsf \\ nrbnstsf \\ nrbstnsf \\ nbnstnsf \end{array} \overset{t+s}{\begin{pmatrix} 0.01 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.01 & 0.02 & 0.00 & 0.00 & 0.00 & 0.02 & 0.00 & 0.00 \\ 0.01 & 0.01 & 0.01 & 0.00 & 0.00 & 0.02 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.04 & 0.11 & 0.03 & 0.00 & 0.00 & 0.57 & 0.00 & 0.05 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.05 & 0.00 & 0.04 \end{pmatrix}}$$

$$T^{risk4}_{1991\rightarrow 2000} = t \begin{array}{l} rbstsf \\ nrbstsf \\ rbnstsf \\ rbstnsf \\ rbnstnsf \\ nrbnstsf \\ nrbstnsf \\ nbnstnsf \end{array} \overset{t+s}{\begin{pmatrix} 0.00 & 0.01 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.01 & 0.02 & 0.00 & 0.00 & 0.00 & 0.02 & 0.00 & 0.00 \\ 0.01 & 0.01 & 0.00 & 0.00 & 0.00 & 0.02 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.04 & 0.13 & 0.02 & 0.00 & 0.00 & 0.55 & 0.00 & 0.06 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.04 & 0.00 & 0.04 \end{pmatrix}}$$

Note : See Figure 10.

Table 16: Unrestricted Empirical Transition Probabilities in Different Horizons: Narrow Definition.

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