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# Modelling household finances: A Bayesian approach to a multivariate two-part model

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## ABSTRACT

We contribute to the empirical literature on household finances by introducing a Bayesian multivariate two-part model, which has been developed to further our understanding of household finances. Our flexible approach allows for the potential interdependence between the holding of assets and liabilities at the household level and also encompasses a two-part process to allow for differences in the influences on asset or liability holding and on the respective amounts held. Furthermore, the framework is dynamic in order to allow for persistence in household finances over time. Our findings endorse the joint modelling approach and provide evidence supporting the importance of dynamics. In addition, we find that certain independent variables exert different influences on the binary and continuous parts of the model thereby highlighting the flexibility of our framework and revealing a detailed picture of the nature of household finances.

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## 1. Introduction

Over the last three decades, there has been growing interest in the financial economics literature in the nature of financial portfolios at the household level. Such interest has coincided with significant changes in debt and asset accumulation at the household level. Over the last decade, for example, there has initially been a considerable increase in consumer debt in the U.S. followed by a decline in household leverage, the ratio of debt to disposable income, with the onset of the recession towards the end of 2007, [Glick and Lansing \(2009\)](#) and [Brown et al. \(2013\)](#). In general, in the existing literature, economists have focused on specific aspects of the financial portfolio including the demand for risky financial assets such as stocks and shares (for example, [Bertaut, 1998](#), [Hochguertel et al., 1997](#) and [Shum and Faig, 2006](#)), savings (for example, [Browning and Lusardi, 1996](#)) or debt (for example, [Brown et al., 2005, 2008](#), and [Crook, 2001](#)).

Policy-makers have, however, commented on the importance of analysing household financial assets and liabilities together, which is at odds with the approach generally taken in the academic literature which explores specific aspects of household finances in isolation of other aspects of the household balance sheet. In particular, Alan Greenspan, the former chairman of the U.S. Federal Reserve Board, has argued that unless one simultaneously considers financial assets along with liabilities it is hard to ascertain the true burden of debt.<sup>1</sup> Similarly, the Monetary Policy Committee in Great Britain has acknowledged the

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<sup>1</sup> Remarks made by Alan Greenspan "Understanding Household Debt Obligations" at the Credit Union National Association, Government Affairs Conference, Washington, D.C. February 23, 2004.

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importance of establishing whether the same households have been accumulating financial assets as well as debt over the recent years (Bank of England, Minutes of the Monetary Policy Committee, 2002 and Brown and Taylor, 2008).

One exception in the academic literature is Cox et al. (2002), who explore financial pressure across households in Great Britain, and find that households with the highest absolute levels of debt also tend to have the highest income and net wealth, implying that these households may be relatively well disposed towards coping with adverse financial shocks. On the other hand, the findings of Brown and Taylor (2008), who jointly model household debt and assets, suggest that the youngest households and those households who are in the lowest income quartile are the most vulnerable to changes in their financial circumstances since a high proportion of them hold debt yet no financial assets, i.e. they have negative net worth. Such findings highlight the importance of further research in this area. Moreover, it is apparent that, in order to predict the influences of changes in economic policy at the household level, such as changes in the interest rate, it is important to adopt a holistic approach to analysing household finances including both assets and liabilities.

In order to contribute to the literature on household finances, we analyse panel data from the U.S. Panel Study of Income Dynamics (PSID), for 1984, 1989, 1994, 1999, 2001, 2003, 2005, 2007, 2009 and 2011, with our period of analysis covering pre and post the recent financial crisis. The PSID provides detailed information at the household level as well as allowing us to track households over time. In addition to providing empirical analysis of household finances during this period, we develop a flexible empirical framework, which reveals a detailed picture of liability and asset holding at the household level and allows us to uncover interdependencies across the various aspects of household finances. We adopt a Bayesian approach, which is highly flexible in the context of complex models. Hence, given the complicated nature of household finances, it is surprising that there is a lack of Bayesian analysis in the existing literature. Many of the statistical models used in the existing literature treat the level of household debt or assets as censored variables since they cannot have negative values. Consequently, a Tobit approach has been commonly used to allow for this truncation (see, for example, Bertaut and Starr-McCluer (2002) and Brown et al. (2005, 2008)). In studies, where a joint modelling approach has been adopted, a bivariate Tobit model has been used allowing for the possibility of inter-dependent decision-making with respect to financial assets and liabilities (see, for example, Brown and Taylor (2008), where the findings endorse the joint modelling approach indicating interdependence between the holding of assets and debt).<sup>2</sup> One problem with the Tobit approach, however, lies in the possibility that the decision to hold debt or financial assets and the decision regarding the level of debt or financial assets held may be characterised by different influences. In terms of evaluating the level of financial pressure faced by households, there is a significant difference, for example, between being in debt and holding high amounts of debt.

A double-hurdle model is an alternative econometric specification, which allows independent variables to have different effects on the probability of holding debt or financial assets and on the level of debt or financial assets if it is non-zero. Such an approach allows for a two-stage decision-making process: for example, a household decides whether to hold a particular asset and, conditional on the decision to hold a particular asset, the household then decides how much of that asset to hold, where there is potential correlation between the two decision-making processes (see, for example, Yen et al. (1997), in the context of analysing financial donations). The double-hurdle model has not, however, been extended to the multivariate case. Thus, studies adopting the double-hurdle approach have been restricted to focusing on one aspect of household finances. It is clearly important to allow for different aspects of household finances: for example, as stated above, it may not be problematic in terms of levels of financial vulnerability if households holding debt simultaneously hold assets to draw upon if an adverse event arises.

In this paper, we develop a flexible Bayesian multivariate two-part model for the joint modelling of four aspects of household finances, namely unsecured debt, secured debt, non-housing financial assets and housing assets. With correlated random effects, our approach allows for the potential interdependence between household liabilities and asset holding and, hence, allows for potential complex interactions between the various components of household finances, as well as persistence over time. This is important given that policy-makers have highlighted such interdependence as being relevant for ascertaining the true financial health of or burden faced by households, i.e. it is important to consider debt levels in the context of asset holdings and vice versa. In addition, our approach incorporates a two-part process which allows for differences in the effects of the explanatory variables on the decision to acquire assets or debt and on the amount of assets or debt held.

The results from our new framework endorse the joint modelling approach and provide evidence supporting dynamics in asset and debt holding at the household level. In addition, our results indicate that certain independent variables exert different influences on the binary and continuous parts of the model. The results are potentially interesting from a policy perspective. For example, we find evidence of strong persistence in the probability of households holding unsecured debt: if the head of household held unsecured debt in the previous period the likelihood of currently holding such debt increases by 126 percentage points. Hence, if alleviating the number of individuals in debt is a concern, policymakers may consider influencing the underlying behaviour of households or the mechanisms behind how credit is obtained, such as from a high street bank or a pay-day loan company, where the latter is likely to be more accessible but carries higher risk in terms of the rate of interest required, which may exacerbate future debt levels.

## 2. Empirical framework

In this section, we develop a Bayesian multivariate two-part model for the joint modelling of four aspects of household finances, namely unsecured debt, secured debt, non-housing financial assets and housing assets. By two-part model, we refer to data generated from a response which is a mixture of true zeros and continuously distributed positive values (Olsen and

<sup>2</sup> Where studies have explored the holding of particular financial assets, a probit or logit approach has been adopted given the discrete nature of the dependent variable. For example, Bertaut and Starr-McCluer (2002) use a multivariate probit approach to investigate household decisions relating to holding different financial assets.

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