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Household Debt and Borrower-based Measures in Finland: Insights from a Heterogeneous Agent Model

Fumitaka Nakamura

WP/23/262

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Prepared by Fumitaka Nakamura

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ABSTRACT: We analyze the effects of borrower-based macroprudential tools in Finland. To evaluate the efficiency of the tools, we construct a heterogeneous agent model in which households endogenously determine their housing size and liquid asset levels under two types of borrowing constraints: (i) a loan-to-value (LTV) limit and (ii) a debt-to-income (DTI) limit. When an unexpected negative income shock hits the economy, we find that a larger and more persistent drop in consumption is observed under the LTV limit compared to the DTI limit. Our results indicate that although DTI caps tend to be unpopular with lower income households because they limit the amount they can borrow, DTI caps are beneficial even on distributional grounds in stabilizing consumption. Specifically, DTI caps mitigate the consumption decline in recessions by restricting high leverage, and thus, they can usefully complement LTV caps.

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Introduction

In the wake of the Global Financial Crisis (GFC), the need for the macroprudential policy has been widely recognized. The crisis demonstrated that systemic risks, such as sharply rising indebtedness and risk taking, can accumulate under the surface of economic tranquility and threaten to severely amplify the effect of adverse financial shocks. Vulnerabilities in the housing sector have repeatedly posed significant concerns for financial systems around the world. The use of macroprudential policy tools can help mitigate downside risks and prevent credit crunches. A variety of macroprudential policy tools are available in the household sector, such as sectoral capital requirements and caps on loan-to-value ratios (LTV), debt-to-income ratios (DTI), and debt-service-to-income ratios (DSTI). There is no "one-size-fits-all" approach, and each policy has pros and cons. Therefore, the proper selection of macroprudential tools is essential for policymakers to contain systemic risks.

Household indebtedness in the Nordic-Baltic region has increased since the GFC, creating concerns about potential financial vulnerabilities. Finland is no exception; the household debt-to-disposable income ratio has risen from 111 percent in 2010 to 133 percent in 2021. To contain the vulnerabilities coming from housing mortgage loans, Finnish authorities have tightened macroprudential policy tools. For example, the maximum LTVratio allowed for housing loans has been reduced to 85 percent, except for first-time home buyers.[1] Income-related borrower-based measures, however, like the DTI ratio are still not available as macroprudential policy tools, despite a recent proposal by a Ministry of Finance working group (see e.g., Asplund and Topi 2022). Although LTV and DTI caps are both borrower-based measures, their usefulness in containing systemic risks may be quite different. Limits on the LTV ratio can cap the size of loans relative to collateral values, while DTI and DSTI caps can restrict the amount of debt to a fixed share of household incomes. In cases where housing prices tend to increase significantly relative to wages, the DTI caps can be more effective compared to the LTV caps in limiting household leverage (see e.g., Aastveit et al. (2023)).

Given the differences between borrower-based measures, it is natural to question whether introducing a cap on the DTI ratio would be useful in further mitigating the risks associated with mortgage loans in Finland. To answer this question, it is useful to assess a DTI's economic impact in adverse economic scenarios. Macroprudential policy tools are typically effective at preventing significant disruptions in credit markets during times of financial distress. Once a negative economic shock hits the economy, households must reduce consumption significantly to meet their debt obligations. In this regard, DTI cap could mitigate a severe contraction in consumption because the amount of household debt is limited by a household's current income.[2]

In this paper, we evaluate the relative usefulness of different macroprudential policy tools. Specifically, we quantitatively compare the impact of LTV caps and DTI caps on household consumption in response to negative economic scenarios.[3] We use a simulation based on a household model to compare the welfare effects on households in future recessions because a theoretical model allows a counterfactual analysis of

[1] In Finland, the relevant metric is called the loan-to-collateral (LTC) ratio. It is similar to the LTV ratio, but LTC also accepts collateral (in addition to housing property). During the Covid-19 pandemic, the LTC limit was raised to support the flow of credit to the real economy and the proper functioning of the housing market.

[2] Dirma and Karmelavičius (2023) and Gross and Poblacion (2017) find that DTI or Debt service-to-income (DSTI) caps are better at mitigating default probability, which is in line with our results, since we find that DTI is useful in limiting the leverage.

[3] One of the main objectives of the macroprudential policy is to limit systemic risk coming from macro-financial feedback, and consumption is one of the main transmission channels, given that we focus on household sector tools. Reduction in consumption can further reduce output, which will decrease wages. These sets of responses have a negative impact on the financial sector because it reduces the repayment capacity of households.

different policies which is not feasible with an empirical analysis using past data series.[4] Moreover, we use a heterogeneous agent model, which allows us to incorporate household inequality and analyze distributional consequences. This heterogeneous setting is especially useful when assessing the effectiveness of macroprudential policy toolkits because it can, for example, help address potential concerns that a new macroprudential policy tool may make it more difficult for lower income households to purchase new housing.

Our main finding is that LTV limits result in a larger and more persistent drop in consumption than DTI limits. This is mainly driven by middle-income households. In the LTV scenario, households are able to borrow as much as possible to purchase homes by using the value of the home as collateral, regardless of their income. Down payments are still required, but households are able to take on larger debts to purchase larger homes, leading to the higher leverage and larger debt burden. But when household borrowing is limited by a DTI cap, debt size is limited by its affordability. Thus, when there is an unexpected negative economic shock in the economy, households reduce their consumption significantly in the LTV scenario but less so in the DTI scenario. DTI limits can also play an important role for households who are prone to becoming lower income (e.g., unemployed) when a negative shock hits the economy. The decrease of these households' consumption is larger in the LTV scenario due to its higher leverage compared to DTI. The policy implication here is that although income-related borrower-based measures tend to be unpopular with lower income households because they limit the amount they can borrow, a DTI cap is nonetheless useful to mitigate the potential contraction in consumption in a recession, and thus, it can complement LTV cap to stabilize consumption.

Literature Review

This paper is related to several strands of the literature. The first strand covers theoretical work quantifying the effectiveness of macroprudential policy tools in house price boom-bust episodes. This strand includes papers by Alpanda and Zubairy (2017), Chen et al. (2020), Ferrero, Harrison, and Nelson (2018), Greenwald (2018), Justiniano et al. (2019), Ingholt (2022), and Lambertini, Mendicino, and Punzi (2013).[5] In particular, Chen et al. (2020) examine the effects of various borrower-based macroprudential tools, including LTV and DTI, under the condition that both real and nominal interest rates are low. They find that LTV tightening is more contractionary than DTI tightening when debt is high and monetary policy cannot accommodate. Compared to this study, this paper analyzes the usefulness of macroprudential policy tools without tightening under the economic downturn scenarios, and finds the DTI cap more useful than the LTV cap.

The second strand of literature consists of empirical work investigating the usefulness of various macroprudential policy toolkits. It includes papers by Acharya et al. (2022), Albacete, Fessler, and Lindner (2018), Alam et al. (2019), Brandao-Marques et al. (2020), Giannoulakis et al. (2023), Nier et al. (2019) and Vandenbussche, Vogel, and Detragiache (2015). Among these studies, Alam et al. (2019) assess the effectiveness of various policy tools, including LTV and DSTI, using a comprehensive data set of macroprudential policies. They found that macroprudential policy tools are effective in reducing household credit and consumption. Compared to these studies, this present paper employs a simulation based on the theoretical model to investigate the mechanisms in which macroprudential policy works in times of financial turmoil.

[4] To make the model as simple as possible, we focus on the household decision problem and do not require the market clearing condition, meaning that housing prices and interest rates are fixed.

[5] While most of the previous studies focus on the analysis of the U.S. economy, we provide a quantitative estimation of the Finnish economy. One characteristic of the Finnish economy is that income inequality is small compared to that in the U.S.

In addition, two studies focus directly on the Finnish economy. Kärkkäinen and Nyholm (2021) find that replacing LTV with DTI has only minor effects on the macroeconomy in the long run based on the two-agent model. Eerola, Lyytikäinen, and Ramboer (2021) examine the impact of the implementation of a LTV limit in Finland in 2016 and also consider the potential effects of introducing DTI based on the distribution of debt statistics during the 2000s. As for the introduction of DTI, Eerola, Lyytikäinen, and Ramboer (2021) point out that DTI would be binding for young, single, and highly educated first-time buyers in urban areas. Compared to these studies, the present paper analyzes the benefits of the tools in negative economic scenarios using a heterogeneous agent model and finds that the DTI cap is more useful in mitigating the consumption reduction than the LTV cap.

Model

In this section, we build a model to assess the effectiveness of macroprudential policy measures. We incorporate housing as assets and borrower-based measures as borrowing limits into an otherwise standard continuous time heterogeneous agent model. In this paper, we focus on the household decision problem without market clearing condition to make the model as parsimonious as possible. Thus, the interest rate and housing prices are fixed. Labor productivity is idiosyncratic, uninsurable, and follows an exogenous Markov process that we describe in detail in the calibration section.

3.1 Household Sector

A continuum of households is indexed by their holdings of liquid assets b, housing h, and their labor productivity z.[6] As we use continuous time, the joint distribution (density function) of households can be described at each instant time in t as $g_t(a, h, z)$. Labor productivity is idiosyncratic, uninsurable, and follows an exogenous three-state Markov process $z_t \in \{z_1, z_2, z_3\}$. We describe the calibration of this income process in section 4.

Households can possess two types of assets: liquid assets and housing. Liquid assets can be used to save or borrow at interest rate r. Liquid asset borrowings must be above the borrowing limit set by either LTV or DTI, which is described in the following section. Housing is desired by households because they can hold it as wealth and because they also derive utility from it. We assume there are restrictions on the minimum size of the housing, denoted as h_{min}. In other words, each household can either not own a house, $h_t = 0$, or own the housing which is equal to or larger than the minimum amount. Formally, this can be described as:

$$h_t \in \{0, [h_{min}, \infty)\}.$$

Household utility comes from consumption c_{it} and housing h_{it}, with discount rate ρ. Households maximize their utility as such:

$$\mathbb{E}_0 \int_0^\infty e^{-\rho t} U(c_{it}, h_{it}) dt,$$

[6] We follow Achdou et al. (2022) for the basic setup of the household problem.

where $\mathbb{E}_0$ is the expectation operator at time 0, taken over the idiosyncratic productivity shocks. The household budget constraint is:

$$\dot{b}_{it} + p_t \dot{h}_{it} = z_{it} + r b_{it} - c_{it}.$$

Here, p_t is housing prices at time t.[7] The over-dot operator is used to denote the time derivative. For example, $\dot{b}_{it}$ represents $\frac{db_{it}}{dt}$. When solving this problem, we assume that households have a quasi-linear instantaneous utility function represented as

$$q = c + f(h),$$

where

$$f(h) = \eta(h - h_{min})^{\alpha}.$$

Here, η and α are parameters of household preferences. By using this quasi-linear assumption, the optimal housing choice is separated from the consumption-saving problem, which enables us to easily solve the household problem. In addition, because of this assumption, the optimal housing choice is independent from the wealth effect. The utility is assumed to be a standard constant-relative-risk-aversion (CRRA) type with the elasticity of substation as $1/\sigma$:

$$U(c, h) = u(q) = \frac{q^{1-\sigma}}{1-\sigma}.$$

3.2 Macroprudential Tools

Here, we introduce two kinds of macroprudential tools: the LTV cap and the DTI cap. LTV is the borrowing limit set by the value of the collateral.[8] The higher the value of housing, the larger the debt limit accessed by households, irrespective of their income level. Formally, we set the borrowing limit based on the following equation:

$$-b_{it} \leq \theta p_t h_{it},$$

where some fraction $\theta \in [0, 1]$. This θ determines the down payment of the housing. In other words, the down payment must be greater than the $1 - \theta$ fraction of the housing value.

The alternative macroprudential tool is the DTI cap. In this setting, the borrowing limit of each household is imposed based on their current income level. With some constant γ, this DTI constraint can be described as:

$$-b_{it} \leq \gamma z_{it}.$$

With this DTI constraint, high-income households can gain access to a larger borrowing limit. Please note that we do not impose these tools simultaneously. In other words, we set up the model using either the LTV limit or

[7] We use household decision problem in which the housing price is fixed. However, even if we use the market clearing condition with fixed supply of housing, the change in housing prices is limited, and we obtain almost the same results as in the baseline.

[8] These macroprudential policy tools are imposed all the time, rather than at the origination. Some readers might consider this constraint as too restrictive because, in reality, these measures are only imposed at the origination of the loan. However, as noted in the calibration section, we use the income shock as a negative economic scenario and fix the housing price, which implies that this measure is costly for households' consumption in the DTI cap rather than in the LTV cap. Thus, the bottom line is that although these macroprudential tools are imposed all the time, which could potentially reduce households' consumption in the DTI scenario in our setting, the DTI cap is still useful to mitigate the consumption drop in response to negative income shocks.

the DTI limit, and then compare the consumption changes in response to the negative economic shocks under these two scenarios.

3.3 Solutions in Steady State

Stationary equilibrium can be characterized by two equations: the Hamilton-Jacobi-Bellman (HJB) equation and the Kolmogorov Forward (KF) equation.[9] Before describing these equations, we would like to define the useful variables. First, the net worth a_{it} is defined by $a_{it} = b_{it} + p_t h_{it}$. Also, we use the parameter $\phi = 1/(1-\theta)$. When the LTV limit is in place, the set of admissible housing choices can be characterized by the following equation:

$$\mathcal{H}_{LTV}(a,z) = \{h: ph \leq \phi a\} \cap \{0, [h_{min}, \infty)\}.$$

Alternatively, when the DTI limit is imposed, the housing choice can be represented by:[10]

$$\mathcal{H}_{DTI}(a,z) = \{h: ph \leq \gamma z + a\} \cap \{0, [h_{min}, \infty)\}.$$

Using these notations, a stationary equilibrium is characterized by a system of equations. First, HJB equation is given by:

$$\rho v(a,z) = \max_{c,h \in \mathcal{H}_k} U(c,h) + v_a(a,z)\,(z + r(a-ph) - c) + \sum_{z' \neq z} \lambda(z,z')\{v(a,z') - v(a,z)\},$$

where k could be either LTV or DTI; $v(a,z)$ is value function of households with assets a and labor productivity z; and $v_a(a,z)$ is the derivative of the value function with respect to a. Households switch from state z to z' according to the Poisson process with arrival rate $\lambda(z,z')$.[11] This equation provides the household's optimal decision of consumption and savings.

The Kolmogorov forward equation is given by:

$$0 = \frac{d}{da}[s(a,z)g(a,z)] + \sum_{z' \neq z} \{-\lambda(z,z')g(a,z) + \lambda(z',z)g(a,z')\},$$

where $g(a,z)$ is the stationary density function and $s(a,z_j)$ is the optimal saving policy function, which determines the amount of savings when households select the choice variables optimally. This can be given by:

$$s(a,z) = z + r(a-ph) - c.$$

The Kolmogorov forward equation provides the household's joint distribution with respect to asset holdings and labor productivity.

When solving the HJB equation, we use the assumption that the utility is quasi-linear. As we discussed in the previous section, this assumption is useful because housing choice can be separated from the consumption-saving problem. Thus, HJB equation can be represented as:

[9] We have omitted the subscript of each individual i to ease the notation.

[10] Here, $\mathcal{H}(a,z)$ depends on z in the DTI case (not for the LTV case). However, for simplicity, we denote this constraint as $\mathcal{H}_k(a,z)$ in both cases.

[11] Note that the last term in this equation does not include the derivative with respect to z, since z is discrete variable.

$$\rho v(a,z) = \max_q u(q) + v_a(a,z)\,(z + F(a,z) - q) + \sum_{z' \neq z} \lambda(z,z')\{v(a,z') - v(a,z)\},$$

$$F(a,z) = \max_{h \in \mathcal{H}_k} f(h) + r(a - ph).$$

From the latter problem, the optimal housing choice is determined based on the three conditions: minimum housing quantity, macroprudential constraints, and optimal housing choice. If households cannot afford to purchase a minimum amount of housing, the housing choice is 0.[12] If households can afford to purchase housing, but do not hold enough savings or income, the amount of housing is constrained by either LTV or DTI. Finally, if households can afford to purchase housing, they choose the optimal amount described in this equation:

$$h_{opt} = h_{min} + \left(\frac{\eta\alpha}{rp}\right)^{\alpha}.$$

When solving this problem computationally, we use upwind scheme following Achdou et al. (2022).

3.4 Solutions in Transition Dynamic

The dynamic version of the HJB equation and the KF equations are given by:

$$\rho v(a,z,t) = \max_q u(q) + v_a(a,z,t)\,(z + F(a,z) - q) + \sum_{z' \neq z} \lambda(z,z')\{v(a,z',t) - v(a,z,t)\} + \frac{\partial v}{\partial t}(a,z,t),$$

$$F(a,z) = \max_{h \in \mathcal{H}_k} f(h) + r(a - ph).$$

$$\frac{\partial g}{\partial t}(a,z,t) = \frac{d}{da}[s(a,z)g(a,z,t)] + \sum_{z' \neq z} \{-\lambda(z,z')g(a,z,t) + \lambda(z',z)g(a,z',t)\}.$$

When estimating the transition dynamic, we assume that the aggregate shock itself is unexpected, but once the shock is realized, households know the future path of the aggregate variables. The only uncertainty households face is idiosyncratic income shocks. In this exercise, we use income transition probability. Specifically, households are more likely to move to a low-income state at time t=0. We explain this shock in more detail in the next section.

Calibration

To begin with, we align the value of the income variables with Finnish data from Statistics Finland, which gives us the distribution of household income. We discretize productivity z into three states: low z_1, middle z_2, and

[12] In this case, consumption is greater compared to the case where a minimum housing constraint is not introduced. This additional consumption can be regarded as additional utility from renting. While this minimum size restriction is introduced to capture the market transaction in the real world, the results are overall the same even if we do not impose this restriction.

high z_3. Three income states represent average of each fraction $1/3$ in the data from Statistics Finland.[13] The exact value we use is 0.05 for low income z_1, 0.2 for middle income z_2, and 0.4 for high income z_3.

Next, we set the transition probability between these three income states based on Suoniemi and Rantala (2010). This study uses Finnish income panel data, which includes detailed information on the composition of income for 10 percent of the population, to study income mobility in Finland. To begin with, we align the value of the income variables with Finnish data from Statistics Finland, which gives us the distribution of household income. It provides the transition probability matrices for equivalent disposable income in five-year income panels. We use 2000–2004 data, aggregating up the transition probability to correspond to three income states. Also, we assume that the transition between income states is symmetric so that each state represents one third fraction of households in steady state. For simplicity, we assume that no low-income households suddenly become high income; they must first become middle income, and vice versa. The estimated transition probability between middle and low income λ_{LM} is 0.057, and between high and middle income λ_{MH} is 0.063.

Other parameter values are presented in Table 1. As for the parameters on borrower-based measures, θ, the borrowing limit for households, compared to the value of collateral, is set at 0.85. This means that households can borrow up to 85 percent of the value of their housing and must make a down payment of at least 15 percent. This 85 percent threshold is based on Finnish mortgage loan regulations, which set the maximum LTV at 85 percent for residential mortgages other than first-home loans. We use the value of DTI parameter γ as 5, meaning the households can borrow up to 5 times their current annual income. This rate is comparable to one recommended by a working group of the Ministry of Finance in October 2019. It recommended that any new loan, combined with any existing loans, not exceed 450 percent of the gross annual income of the loan applicant. As a robustness check, we also conduct the simulation analysis on different parameter values in macroprudential policy, which is described in Appendix A. When deciding the housing preference parameter α, the target value we use is the share of constrained households (0.40) in the LTV scenario,[14] which is from Kaplan and Violante (2022).[15] Moreover, we set the η to match the housing wealth-to-income ratio at 4.1 percent, which is based on data from Statistics Finland. Other parameters are standard values.

In this paper, we examine how household consumption changes in response to the negative economic shocks compared to its steady state value. In the simulation, we use a negative income shock as a negative economic scenario. Specifically, households are more likely to move to a low-income state from a middle-income state in the first three years. This rise in the share of low-income households is consistent with the rise in unemployment rate in recessions.

[13] Statistics Finland provides the income information of households divided into 10 groups based on their income level. In this paper, low, middle, and high income corresponds to the average income of the lower one third, middle one third, and higher one third of households, eliminating top level income. Even though we eliminate the lowest income households instead, the results are very similar to the baseline ones. Our approach is similar to Nakamura (2019).

[14] The LTV scenario is used for setting this parameter value because only LTV is in place in Finland.

[15] This value is the share of hand-to-mouth households from Kaplan and Violante (2022) and is based on U.S. data. Kaplan, Violante, and Weidner (2019) provide international comparisons of hand-to-mouth households across North America and Europe and find a similar rate. Kärkkäinen and Silvo (2023) reported that this share is around 0.23 in Finland. Even if we use this low hand-to-mouth share, we obtain similar results overall as long as other parametrization targets are the same.

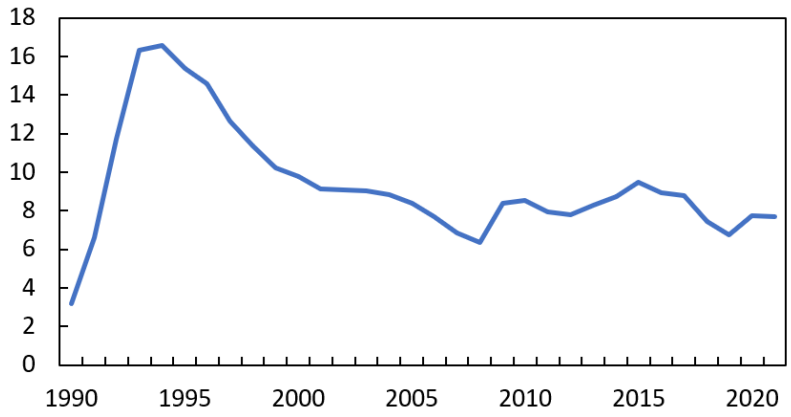
Table 1: Parameter Values

Parameter	Description	Value
σ	Intertemporal elasticity of substitution	2
α	Preference on housing	0.26
η	Preference on housing	0.20
ρ	Discount factor	0.057
θ	LTV parameter	0.85
γ	DTI parameter	5
h_{min}	Minimum amount of housing	1
r	Interest rate	0.025
p	Housing price	1
z_1	Productivity for low income	0.05
z_2	Productivity for middle income	0.2
z_3	Productivity for high income	0.4
λ_{LM}	Transition probability between low and middle income	0.057
λ_{MH}	Transition probability between middle and high income	0.063

Source: IMF staff estimates.

We calibrate the value of the transition probability, λ, so that low-income households increase by 3 percent in the steady state. This level was used in bank stress tests scenarios in IMF (2023). Figure 1 illustrates the unemployment rate in Finland from 1990 and shows that a 3 percent increase in unemployment is similar to the rise during the GFC but smaller than the rise in the 1990s during a financial crisis related to the housing sector in Finland. Based on this calibration, we change λ_{LM}, the transition probability between middle and low income, from 0.057 to 0.102, almost doubling the likelihood of moving to the low-income state.

Figure 1: Unemployment Rate in Finland



Source: Finnish authorities.

Simulation Results

In this section, we present the simulation results. First, we compare the housing choice between LTV and DTI (the first two charts in Figure 2). These charts describe the holdings of housing as a function of total wealth, which h_1, h_2, and h_3 corresponding to the housing policy functions of low-, middle-, and high-income states, respectively. The housing choice in the LTV scenario (upper left chart of Figure 2) shows that it consists of three regions. The left region comes from the minimum amount restriction of the size of housing. Due to this restriction, households need to accumulate wealth to purchase the minimum amount of housing. The second region comes from the LTV cap. Although the size of borrowing is proportional to the collateral, households require a 15 percent down payment. Thus, households need to store their wealth to purchase large housing. The third region represents the optimal amount of housing. This optimal size of housing is independent of the asset size because of the assumption of a quasi-linear utility function. Importantly, the housing choice does not depend on income states. This is due to the LTV limit. The borrowing limit is capped by the size of the collateral and does not depend on the income states. This contrasts with the housing choice in DTI (upper right). While housing choice consists of three regions in DTI scenario as well, it clearly depends on the income states. Thus, even if asset holdings are the same, the optimal housing choices are different between income groups. This is because high-income households can borrow larger amounts proportional to their income, and thus, they can afford to purchase larger housing even if they do not currently have high levels of wealth. However, the debt size of low-income households is limited due to the DTI cap, and thus, they first need to accumulate wealth to purchase housing.

The second row in Figure 2 show the consumption policy functions. These charts describe the consumption as a function of holdings of total wealth, with c_1, c_2, and c_3 corresponding to the consumption policy functions of low-, middle-, and high-income states, respectively. As we can see from the charts, consumption increases with income, as well as holdings of assets, in both LTV and DTI scenarios.[16]

The third row in Figure 2 show the distribution of households as a function of holdings of total wealth, with g_1, g_2, and g_3 corresponding to the household distribution of low-, middle-, and high-income states, respectively. The charts show that households endogenously chose to own housing because it provides them with additional utility. Moreover, lower-income households are more likely to be constrained by borrower-based measures such as the LTV limit and DTI limit, while higher-income households tend to possess the optimal amount of housing. In this simulation exercise, aggregate consumption is calculated through aggregating each consumption policy function times the households' distribution function.

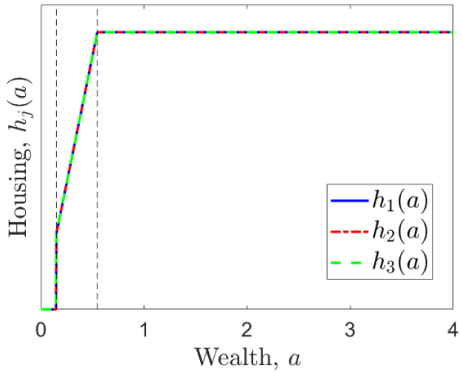
In Figure 3, the consumption response to a negative economic shock is compared between the LTV scenario and the DTI scenario. The horizontal axis is time (annual) and the vertical axis is the consumption response compared to the steady state. When time is negative, the economy is in the steady state. At t=0, there is an unexpected increase in the transition probability of moving to the low-income state for three years, after which this probability returns to the baseline. We assume that the shock is unexpected, but households anticipate a

[16] As shown in Figure 2, household consumption is higher when there is no home ownership. In particular, the consumption of low-income households exceeds that of middle-income households when the wealth holding is small in the DTI scenario due to the fact that middle-income households purchase housing, while low-income households do not because of the existence of borrowing constraints. We can interpret this higher rate of consumption as including housing services such as rental apartments rents into the consumption in this region.

recession that will last for three years, leading to the change in transition probability once the negative shock is realized.

Figure 2: Policy Functions and Distribution

Housing choice in LTV



Housing choice in DTI

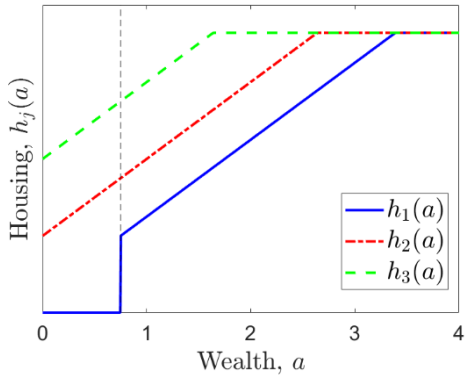
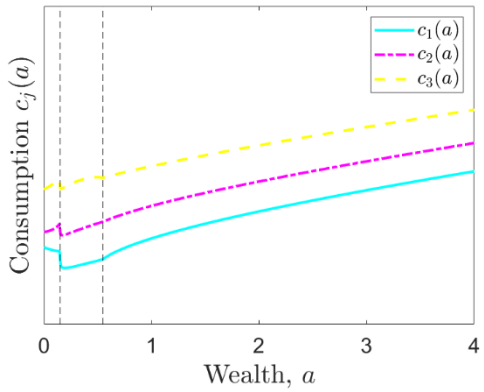
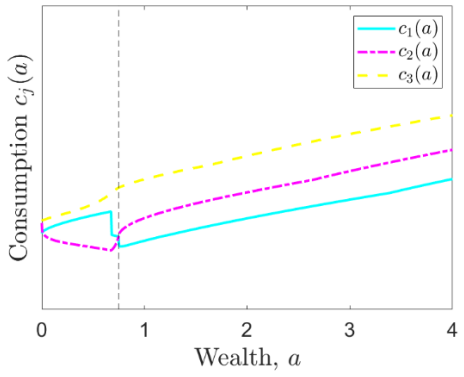


Figure 2: Policy Functions and Distribution (concluded)

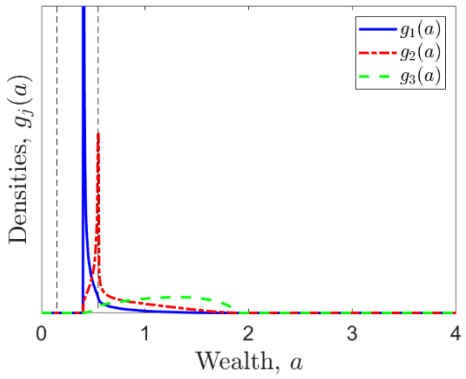
Consumption policy function in LTV



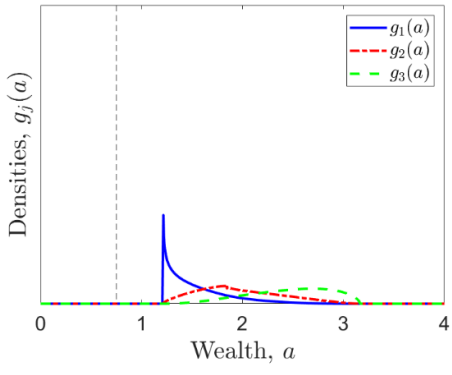
Consumption policy function in DTI



Distribution in LTV



Distribution in DTI

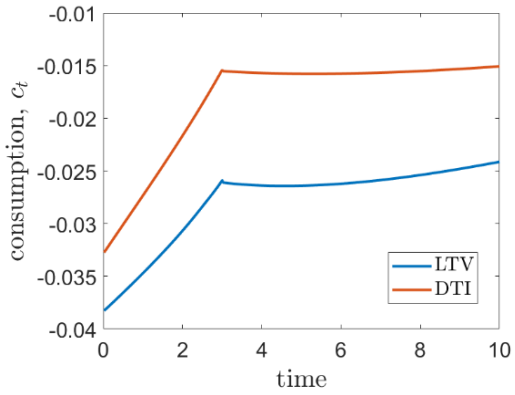


Source: IMF staff estimates.

Figure 3 shows that there is a large decline in consumption, especially in the first three years. It then slowly returns to the steady state consumption in both scenarios. Despite the transition probability returning to the steady state after three years, it takes time for households' consumption to recover to its steady state value due to the distributional changes caused by three years of negative income shocks. Notably, the decline in consumption is greater in the LTV scenario compared to the DTI scenario. Specifically, the consumption decrease in the DTI scenario is around -3.2 percent at t=0, while that of the LTV scenario is around - 3.8 percent. Moreover, the consumption drop is persistent, at around -2.5 percent at t=6 in the LTV scenario and around -1.5 percent in DTI scenario. Thus, the contraction of the consumption is milder in the DTI scenario.

The difference in the consumption response of the DTI and LTV scenarios stems from leverage. Specifically, when we compare the debt service-to-income ratio, it is 0.29 in LTV scenario and only 0.09 in the DTI scenario. Thus, households need to reduce their consumption to repay their larger interest burden in the LTV scenario amid the unexpected negative aggregate income shock.

Figure 3: Consumption Transition Compared to Steady State



Source:IMF staff estimates.

Moreover, the heterogeneous setting enables us to investigate which income level is the main driver of the consumption reduction. Our findings suggest that the contraction in consumption can be attributed to the consumption drop of middle-income households in two ways. First, anticipating a higher probability of becoming low income, middle-income households endogenously choose a smaller consumption policy function. Moreover, they have to reduce their consumption when the negative income shock is realized.[17] On the other hand, the consumption change in low-income households is limited, which indicate that they are indifferent between LTV and DTI. Table 2 illustrates the contribution of the consumption policy function, which reveals that middle-income households are the primary contributor to the reduction in consumption, accounting for over 80 percent of the reduction in both cases. Since the reduction in consumption is milder in DTI cases, the reduction in the total is smaller in DTI scenarios.[18]

[17] This is partly due to the fact that we only change the transition probability from middle to low income as an aggregate shock in the negative economic scenario. However, this practice is similar to that in Jaimovich and Siu (2009) and Nakajima and Smirnyagin (2019), which find that lower income households are more likely to be unemployed.

[18] We only show the policy function changes because assessing the impact of distributional change poses significant challenges. Because our model does not have the ability to label households and track them (households exist continuously), we are unable to accurately determine the distributional impact. Our estimation shows that low-income household consumption increases following a negative income shock due to an increase in the number of households and some households gaining larger assets as a result of transitioning from middle-income status. The initially middle-income households need to reduce their consumption when negative income shocks hit while this pushes the low-income households consumption as a whole, because they possess larger asset sizes.

Table 2: Each Income Level's Contribution to Consumption Decline Based on Policy Functions

	LTV (in percent)	DTI (in percent)
Low	1.5	2.5
Middle	83.5	82.7
High	15.0	14.8

Source: IMF staff estimates.

Simulation results indicate that having DTI in place would benefit households by mitigating the reduction in their consumption. In the LTV scenario, households are more leveraged because they have an incentive to purchase larger housing and because they can use the housing as a collateral, irrespective of their income. Seemingly, this is not a big concern when the economy is in tranquil times. However, an unexpected negative aggregate shock in the economy will require these leveraged households to reduce their consumption significantly to meet more challenging debt obligations. Middle-income households with large mortgage debt are especially hard hit. Therefore, the LTV measure may not be effective in limiting the borrowing of highly leveraged households, while the DTI measure allows households to borrow based on their income. This may help mitigate the economic downturn in recessions.

Conclusion

We constructed a simple heterogeneous agent model. Households endogenously chose their asset positions, namely housing and liquid assets. Parameters were calibrated based on the Finnish economy. We compared the consumption responses in two scenarios, LTV and DTI, during negative economic shocks where the transition probability to a low-income state was greater. We found that households experienced a larger and more persistent drop in consumption when the LTV cap was imposed, compared to the DTI cap. Therefore, introducing the DTI cap may be effective in mitigating the contraction in consumption caused by unexpected negative economic shocks in Finland, by limiting the number of highly leveraged households.

There are three caveats to this analysis. First, it's important to note that this simple model may not fully capture the complexity of the Finnish economy, and therefore, the results of this simulation should not be interpreted as a prediction or outlook for what would happen in the event of a recession. For example, realizing the potential vulnerabilities coming from housing indebtedness, the Finnish authorities issued a nonbinding recommendation to lenders to originate mortgage loans only if borrowers can keep debt-service-to-income (DSTI) ratios under stressed conditions at or below 60 percent in June 2022, which entered into force on January 1, 2023. This could prevent households from very high leverage even though DTI is not explicitly imposed. However, this simulation results based on the simple model explains the mechanism of how DTI work in negative economic scenario, showing the usefulness of hard power of imposing DTI when households are likely to experience unexpected negative income shocks.

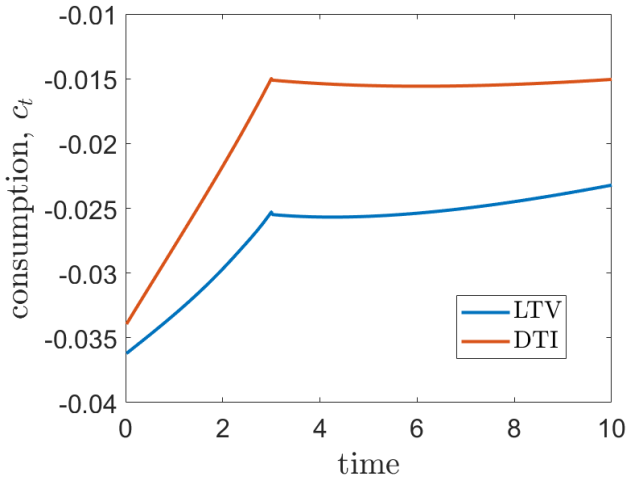
Second, our model ignores general equilibrium effects by focusing exclusively on household decision making. But these effects can have important implications. For instance, the reduction in consumption will decrease the output of firms and further reduce wages. Also, interest rate hikes due to high inflation rates in the Euro area could weight on the consumption of households, which could increase the repayment burden. Furthermore, this could cool the housing market and reduce home prices, thereby exacerbating consumption decisions of households who may want to sell their homes.

Third, this analysis only considers the consumption drop in the negative economic scenario. However, imposing DTI could directly impact home purchase decisions, potentially changing the utility of households in normal times. Therefore, it would be useful to conduct a comprehensive utility analysis, which may require the model to be carefully calibrated based on households' preferences for housing.

Appendix I. Results with Other Calibration

In this appendix, we calibrate the model, using other macroprudential policy parameters to show that our results are robust in other calibration.[1] Here, we use LTV parameter $\theta = 0.80$, which means that households can use 80 percent of housing value as collateral. Also, we set DTI parameter $\gamma = 6$, which means that households can borrow up to 6 times their income. Under these assumptions, the LTV is tighter while DTI is looser (compared to the baseline scenario). Figure A-1 illustrates the results, which suggest that even with this different calibration, DTI is still effective in mitigating the decline in consumption.

Figure 1: Consumption Responses Under Different



Source:IMF staff estimates.

[1] Even if we use other parameter settings in interest rates, similar results can be obtained (larger consumption contraction in LTV scenario) as long as the calibration strategy is the same.

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