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Oren Bar-Gill
Andrew Hayashi

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Harvard Law School
Cambridge, MA 02138

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Oren Bar-Gill and Andrew Hayashi *

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Abstract

There is concern that present-biased agents incur too much debt because of its deferred costs – concern that has influenced regulation of consumer credit. While this concern is valid when debt is used to finance current consumption, credit may increase efficiency when it is used to fund durable good purchases, which is the most common use of debt. Without debt, present-biased agents underconsume durable goods because of their deferred benefits. The deferred cost of debt can offset the deferred benefit from the durable good. We study the effects of purchase-financing on the demand for durable goods by present-biased agents. **JEL:** D90, K0, G51.

*Hayashi: University of Virginia School of Law, 580 Massie Road, Charlottesville VA 22903 (email: ahayashi@virginia.edu). For helpful comments and discussions, we thank Mihir Desai, Louis Kaplow, Botond Kőszegi, David Laibson, Ariel Porat and Steve Shavell.

Consumer credit entails deferred costs. The borrower obtains funds now and must repay in the future. Much debate about consumer credit is based on this deferred-cost feature. The concern is that the consumer-borrower will focus on the present consumption that borrowing enables without fully appreciating the future cost. When the future costs of credit are discounted, the argument goes, consumers will take on too much credit.

This argument is incomplete. The missing component is the reason for borrowing. If the consumer is borrowing to fund current consumption, then discounting the future costs of credit will result in excessive borrowing. But if the consumer is borrowing to buy a durable good, such as a house or a car, then even when the future costs of credit are discounted, borrowing may not be excessive. When debt is used to purchase a durable good, the deferred costs of debt are bundled with the deferred benefits of the durable good. Accounting for both, we show that the excessive borrowing conclusion for present-biased consumers must be qualified. And this qualification is significant, because household balance sheets are dominated by durable goods and the debt incurred to purchase them. The average share of household liabilities attributable to mortgage debt for a primary residence is 52.7%. Another 31.2% of household liabilities is debt used to finance vehicle purchases and education. Only 12.1% is for credit card debt, which can be used to fund both durable and non-durable good consumption. (Campbell, 2016).

In the absence of borrowing, present bias implies insufficient demand for durable goods. The biased consumer will be reluctant to give-up current-period consumption in order to pay for a durable good that will produce benefits in the

future. Borrowing allows for deferred costs that better match the deferred benefits. The discounted future costs of borrowing offset the discounted future benefits from the durable good. When credit is used to pay for a durable good, the discounting of the future costs of credit is no longer a bug; it's a potentially helpful feature.

We first develop these insights using a simple, two-period model, where a consumer with quasi-hyperbolic time preferences decides whether to purchase a durable good that will provide current and future consumption benefits. If purchase debt is not available, we show that the consumer will generally buy too few durables, because hyperbolic discounting leads to an underestimation of the future benefits of ownership. When borrowing is available, we have an additional force–underestimation of the discounted cost of loan repayment-–that pushes towards more durable purchases. Taken together, the two effects can result in either too much or too little purchasing of the durable good.

We next ask whether borrowing increases or decreases efficiency, relative to a world without borrowing. The availability of borrowing increases durable good purchases of three kinds: purchases that consumers inefficiently failed to make when borrowing was unavailable, purchases that are only efficient when credit is available, and purchases that should not be made–with or without borrowing. When the future benefits from the durable good exceeds the future costs of credit, the additional purchases fall into the first two categories and thus are all efficient. When the future costs of credit exceeds the future benefits from the durable good, the additional purchases include durable goods in all three categories; the relative

size of these three categories determines whether borrowing increases or decreases efficiency.

We then extend the model to allow for saving. Consumers generally save for large durable purchases in advance. When it comes time to buy the durable good, however, a naïve present-biased consumer may instead spend her accumulated savings on current consumption. This would be inefficient, as the consumer would have preferred not to save at all had she known she would not buy the durable. Debt can help the naïf follow through on her plan to purchase the durable good. A sophisticated consumer, aware of the temptation to consume her savings, will increase her savings beyond the first-best optimal amount, in order to induce her future self to purchase the durable good. Debt can help the sophisticate too. By increasing the likelihood of following through on the purchase plan, debt can reduce the need for extra savings and thus reduces the inter-temporal utility distortions created by such strategic saving.

When consumers borrow for immediate consumption, the traditional concerns about consumer credit are valid. When consumers borrow to pay for durable goods, the picture is more complicated. Consumer credit can facilitate a discounting of costs that offsets the discounting of benefits produced by the durable good. Accordingly, purchase debt can help consumers by reducing the likelihood that they inefficiently fail to purchase a durable good. Debt can also reduce excessive or wasteful savings. But debt can also inflate the demand for durable goods. The normative assessment is contingent. The regulation of consumer credit should account for the nuanced normative evaluation.

The paper is organized as follows. Section 1 uses a two-period model to show how introducing purchase financing affects demand for durables by present-biased consumers. Section 2 extends the model by one period to examine the effects of purchase debt on biased consumers' decisions about saving up to buy the durable. Section 3 concludes.

Related Literature. — An established literature considers the effects of present bias on inter-temporal decisionmaking. See, e.g., Strotz (1955), Laibson (1997) and O'Donoghue and Rabin (1999). DellaVigna (2009) provides a review of the empirical literature on present bias. Important contributions have focused on firms' responses, especially contract design responses, to present-biased consumers (e.g., DellaVigna and Malmendier (2004), Kőszegi (2005), Eliaz and Spiegler (2006) and Heidhues and Kőszegi (2010)). Present biased agents have time-inconsistent preferences. Models with present-biased agents distinguish between sophisticated agents who are aware of their time-inconsistent preferences and naïve agents who mistakenly believe that their future self will share their present self's preferences. Sophisticates may take action to prevent their future selves from acting in a shortsighted manner but naïfs won't.

Present bias has been specifically invoked in the context of consumer credit. Ausubel (1999) and Shui and Ausubel (2004) find evidence of present-bias in consumer credit markets. Self-control problems and impatience are correlated with credit card debt (Meier and Sprenger, 2010). And present-bias has been used to justify regulation of consumer credit markets ((Campbell et al., 2011) and Bar-Gill and Warren (2008)).

And yet we are not aware of prior analyses of debt-financed purchasing of durable goods with present-biased consumers.[1] DellaVigna and Malmendier (2004) consider the general category of "investment goods" that have current costs and future benefits - a category that includes durable goods. But they do not consider debt-financed investment goods. Nocke and Peitz (2003) examine the effect of secondary trading markets with present-biased consumers on the allocation and pricing of durable goods, but they too do not consider debt-financing. Closest to our analysis is Heidhues and Kőszegi (2010), which recognizes the deferred-benefits feature of durable goods and notes the tension between this delayed-benefits feature and the concern about excessive borrowing. However, they focus on consumers' undervaluation of future credit costs, whereas we emphasize the interplay between undervaluation of future credit costs and undervaluation of the future benefit produced by the durable good. Moreover, while Heidhues and Kőszegi (2010) assume that the consumer has already decided to purchase the durable good, our focus is precisely on how the availability of financing affects the purchase decision itself.

1 The Effect of Purchase Debt

We begin with a two-period model to illustrate the effect of adding purchase financing. An agent earns m in each period $t = 1, 2$. In the first period, the agent can purchase a durable good, at price $p \leq m$, that produces a constant consump-

[1] Conjectures made in Hayashi (2020) motivate our analysis, but that paper does not draw general conclusions as we do here.

tion flow, d in both periods and is worthless at the end of period 2. All income not spent to buy the durable good is spent on current-period consumption. If the agent does not buy the durable good, then period 1 consumption is $C_1 = m$ and period 2 consumption is $C_2 = m$. If the agent buys the durable good without borrowing, then period 1 consumption is $C_1 = d + m - p$ and period 2 consumption is $C_2 = d + m$. If the agent buys the durable good, after taking out a loan l at an interest rate r, then period 1 consumption is $C_1 = d + m + l - p$ and period 2 consumption is $C_2 = d + m - l(1 + r)$. The utility in period t, u_t, is a function of period t consumption, $u_t = u(C_t)$, where $u'(C_t) > 0$ and $u''(C_t) < 0$.

If the consumer buys the durable good she is in the "buying" (B) scenario. If she does not buy the durable good she is in the "renting" (R) scenario. We adopt a broad notion of renting, which includes taking the bus, a taxi or an Uber if you don't own a car, using a laundromat if you don't own a washer, or printing at work or at FedEx Office if you don't own a printer. When $p < 2d$, the net benefit from buying exceeds the net benefit from renting. There are multiple reasons why buying can be more attractive than renting: a–perhaps temporary–difference in market prices for owning and renting the same good, the greater security, certainty, or convenience that ownership provides, or an idiosyncratic taste for ownership.

The agent has quasi-hyperbolic (β, δ) time preferences, where β is the parameter of short-run discounting and δ is the parameter of long-run discounting (Laibson (1997), O'Donoghue and Rabin (1999)). In general, the inter-temporal utility function representing these preferences, evaluated at time s, is given by

$$U_s = u_s + \beta \sum_{t=s+1}^{\infty} \delta^{t-s} u_t$$

The short-run discount factor β generates inconsistency in the agent's preferences over time. To focus on present bias, we assume that $\delta = 1$. We introduce a third, ex ante time-period, $t = 0$. No actions are taken at $t = 0$. The consumer's ex ante utility is $U = u_1 + u_2$, and her utility in period 1 is: $U_1 = u_1 + \beta u_2$.[2] Following O'Donoghue and Rabin (2015), our welfare assessments compare the consumer's actual choices with her ex-ante preferences. We first present the Without Debt benchmark and then consider the effect of introducing purchase debt.

1.1 Without Debt

From an ex ante perspective, the utility from renting is $U^R = u(m) + u(m)$. If the agent buys the durable good, then her utility is $U^B(p) = u(d+m-p) + u(d+m)$. The agent prefers to buy if $U^B(p) > U^R$. Buying is preferred to renting at $p = 0$, and we assume that $U^B(m) < U^R$ so that renting is preferred when buying the durable requires spending all period 1 income. Since $dU^B(p)/dp < 0$, there exists a threshold price, $\hat{p}$, implicitly defined by the equation $U^B(\hat{p}) = U^R$, such that the consumer should purchase the durable good if $p < \hat{p}$.

We turn now to the agent's actual behavior. In period 1, the utility from renting is $U_1^R = u(m) + \beta u(m)$ and the utility from buying is $U_1^B(p) = u(d+m-p) + \beta u(d+m)$. The agent will only purchase the durable good if $U_1^B(p) > U_1^R$. A

[2]The $t = 0$ utility is actually $U = \beta(u_1 + u_2)$, but since β affects the period 1 and period 2 utilities in the same way, it can be omitted.

similar argument to the one made with respect to the agent's ex ante preferences implies that there exists a threshold price $\hat{p}_1$, implicitly defined by the equation $U_1^B(\hat{p}_1) = U_1^R$, such that the agent will purchase the durable good only if $p < \hat{p}_1$.[3] We can now state the following proposition.

Proposition 1 (Underconsumption of Durable Goods)**.** *If $\beta < 1$ then $\hat{p}_1 < \hat{p}$ and the consumer inefficiently fails to purchase durable goods priced at $p \in [\hat{p}_1, \hat{p})$.*

Proof. The ex ante threshold price $\hat{p}$ is such that $U^B(\hat{p}) = U^R$ or $u(m) - u(d+m-\hat{p}) = u(d+m) - u(m)$. The period 1 threshold price $\hat{p}_1$ is such that $U_1^B(\hat{p}_1) = U_1^R$ or $u(m) - u(d+m-\hat{p}_1) = \beta\,(u(d+m) - u(m))$. If $\beta < 1$ then $u(d+m-\hat{p}_1) > u(d+m-\hat{p})$. Since $u'(\cdot) > 0$, then $\hat{p}_1 < \hat{p}$. $\square$

1.2 With Debt

Suppose that the agent can take out a purchase loan $l \in [0, L]$, where $L \leq p$ is an exogenously given credit limit. In period 1, the agent chooses to either rent, or buy with the proceeds from loan l and an amount $p - l$ from her period 1 income. The loan must be repaid in period 2 at interest rate r, so $L \leq m/(1+r)$. This setup embeds the "without debt" scenario as a special case where $L = 0$. From an ex ante perspective, the agent's utility from renting is $U^R = u(m) + u(m)$. The agent's ex ante utility from buying, at price p and with loan l, is $U^B(p,l) = u(d+m+l-p) + u(d+m-l(1+r))$. The optimal loan, for a given price p, is

[3] It is immediate that $U_1^B(0) > U_1^R$, and $U^B(m) < U^R$ implies $U_1^B(m) < U_1^R$. And $dU_1^B(p)/dp < 0$.

$l^*(p) = \arg\max U^B(l;p)$. If there is an interior solution $l^*(p) \in (0,L)$,[4] then it solves the implicit equation

$$u'(d+m+l^*-p) = (1+r)u'(d+m-l^*(1+r)) \tag{1}$$

From an ex ante perspective, the consumer should purchase the durable good if $U^B(p,l^*(p)) > U^R$. Again, buying is preferred to renting when $p = 0$ and we assume that renting is preferred when $p = m$. Since $dU^B(p,l^*(p))/dp < 0$, there exists a threshold price for credit limit L, denoted $\hat{p}^L$ and implicitly defined by the equation $U^B(\hat{p}^L,l^*(\hat{p}^L)) = U^R$, such that the consumer should purchase the durable good if $p < \hat{p}^L$.

Turning to the agent's actual choices, the period 1 utility from renting is $U_1^R = u(m) + \beta u(m)$ and the utility from buying, at price p with loan l, is $U_1^B(p,l) = u(d+m+l-p)+\beta u(d+m-l(1+r))$. The optimal loan is $l_1^*(p) = \arg\max U_1^B(l;p)$. If there is an interior solution $l_1^*(p) \in (0,L)$,[5] then it solves the implicit equation

$$u'(d+m+l_1^*-p) = \beta(1+r)u'(d+m-l_1^*(1+r)) \tag{2}$$

Lemma 1. *Hyperbolic discounting results in excessive purchase debt, i.e.,* $l_1^*(p) > l^*(p)$.

[4] If $l^* = L$ then $u'(d+m+L-p) > (1+r)u'(d+m-L(1+r))$ and the agent would benefit from borrowing more than L, if that were possible. If $l^* = 0$ then $u'(d+m-p) < (1+r)u'(d+m)$ and the agent should save, not borrow.

[5] If $l_1^* = L$ then $u'(d+m+L-p) > \beta(1+r)u'(d+m-L(1+r))$ and the agent would borrow more than L. If $l_1^* = 0$ then $u'(d+m-p) < \beta(1+r)u'(d+m)$ and the agent would like to save, not borrow.

Proof. Let $f(l) \equiv u'(d+m+l-p)/u'(d+m-(1+r)l)$. Since $u'(\cdot) > 0$, then $f'(l) < 0$. Now, equation (1) can be written as: $f(l^*(p)) = (1+r)$; and equation (2) can be written as: $f(l_1^*(p)) = \beta(1+r)$. Since $\beta(1+r) < (1+r)$ and $f'(l) < 0$, we have: $l_1^*(p) > l^*(p)$. □

Importantly, the excessive borrowing result does not imply excessive purchasing. In period 1, the agent will purchase the durable good if $U_1^B(p, l_1^*(p)) > U_1^R$. Once again, buying is preferred at $p = 0$ and we assume that renting is preferred at $p = m$. Since $dU_1^B(p, l_1^*(p))/dp < 0$,[6] there exists a threshold price, $\hat{p}_1^L$, implicitly defined by the equation $U_1^B(\hat{p}_1^L, l_1^*(\hat{p}_1^L)) = U_1^R$, such that the agent will purchase the durable good if $p < \hat{p}_1^L$. The comparison between ex ante optimal purchasing and ex post actual purchasing decisions is summarized in the following proposition.

Proposition 2 (Over or Under Consumption)**.** *With hyperbolic discounting, $\hat{p}_1^L$ can be either greater or less than $\hat{p}^L$. When $d < l^*(\hat{p}_1^L)(1+r)$, we have $\hat{p}_1^L > \hat{p}^L$ and the consumer inefficiently purchases durable goods priced at $p \in (\hat{p}^L, \hat{p}_1^L]$. When $d > l^*(\hat{p}_1^L)(1+r)$, we have $\hat{p}_1^L < \hat{p}^L$ and the consumer inefficiently fails to purchase durable goods priced at $p \in [\hat{p}_1^L, \hat{p}^L]$.*

Proof. In period 1, the threshold price $\hat{p}_1^L$ satisfies $U_1^B(p, l_1^*(p)) = U_1^R$. Differentiating the net utility from buying, $U_1^B - U_1^R$, with respect to β and applying the envelope theorem yields $d(U_1^B - U_1^R)/d\beta = u(d+m-l^*(\hat{p}_1^L)(1+r)) - u(m)$. If $d < l^*(\hat{p}_1^L)(1+r)$, then this derivative is negative at $\beta = 1$, implying that buying is more attractive for a biased agent than an unbiased agent. Intuitively, when the

[6] Using the envelope theorem, this derivative is $-u(d+m+l^*-p) < 0$.

period 2 cost of repaying the loan exceeds the period 2 benefit from the durable good, there is a net future cost of $l^*(\hat{p}_1^L)(1+r)-d$. The biased agent undervalues this cost and thus overvalues the durable good, so $\hat{p}_1^L > \hat{p}^L$. On the other hand, if $d > l^*(\hat{p}_1^L)(1+r)$, then the derivative is positive at $\beta = 1$, implying that buying is less attractive for a biased agent than an unbiased agent. When the period 2 benefit from the durable good exceeds the period 2 cost of repaying the loan, there is a net future benefit of $d - l^*(\hat{p}_1^L)(1+r)$. The biased agent undervalues this benefit and thus undervalues the durable good, so $\hat{p}_1^L < \hat{p}^L$. $\square$

Without borrowing, present bias leads to an underestimate of the benefits from the durable good and thus to insufficient purchases. With borrowing, an underestimate of the discounted cost of loan repayment pushes towards more purchases. In the aggregate, we can get either too much or too little purchasing of the durable good. We are more likely to get excessive purchasing of the durable good, when the benefit from the durable good, d, is larger and when the interest rate, r, is smaller.

1.3 Welfare Effects of Debt

We now turn to the welfare effects of purchase debt. We first describe the effects of borrowing on the ex ante optimal purchasing decision and on the actual period 1 purchasing decision.

Lemma 2. *From an ex ante perspective, the availability of purchase loans should result in more durable good purchases, i.e., $\hat{p} \leq \hat{p}^L$. In period 1, the availability*

of borrowing results in more durable good purchases, i.e., $\hat{p}_1 \leq \hat{p}_1^L$.

Proof. The threshold price $\hat{p}$ is implicitly defined by $U^B(\hat{p}) = U^R$ or $u(d+m-\hat{p})+u(d+m) = 2u(m)$. The threshold price $\hat{p}^L$ is implicitly defined by $U^B(\hat{p}^L, l^*(\hat{p}^L)) = U^R$ or $u(d+m+l^*(\hat{p}^L)-\hat{p}^L)+u(d+m-l^*(\hat{p}^L)(1+r)) = 2u(m)$. If $l^*(\hat{p}^L) = 0$, then $U^B(\hat{p}^L, l^*(\hat{p}^L) = 0) = U^B(\hat{p})$ and thus $\hat{p} = \hat{p}^L$. For any price p, a positive loan amount $l > 0$ will be chosen if and only if $U^B(p,l) > U^B(p,0)$. Therefore, $U^B(\hat{p},l) > U^B(\hat{p},0) = U^B(\hat{p}) = 2u(m)$. To get $U^B(\hat{p}^L, l^*(\hat{p}^L)) = 2u(m)$, we need $\hat{p}^L > \hat{p}$ because $dU^B(p, l^*(p))/dp < 0$. We thus have $\hat{p} \leq \hat{p}^L$. Similar reasoning shows that $\hat{p}_1 \leq \hat{p}_1^L$. □

The availability of credit allows the agent to buy the durable good at higher prices and provides consumption smoothing benefits. From an ex ante perspective, if the additional purchases are undesirable then the agent should choose $l = 0$ and credit will not affect the optimal purchasing decision. If additional purchases are desirable, the agent will choose $l > 0$ and credit will result in more purchases. From an ex post, period 1 perspective, if additional purchases are unattractive, the agent will choose $l = 0$ and debt will not affect the decision o buy. If additional purchases are attractive, the agent will choose $l > 0$ and debt will result in more purchases. The question is whether these additional actual purchases are efficient, from an ex ante perspective.

The availability of purchase debt leads to the additional purchases of durable goods priced at $p \in [\hat{p}_1, \hat{p}_1^L)$. These additional purchases can be either efficient or inefficient, as described in the following proposition.

Proposition 3 (The Efficiency Effects of Borrowing)**.** *When $d \geq l^*(\hat{p}_1^L)(1+r)$, we have $\hat{p}_1^L \leq \hat{p}^L$ and the additional purchases induced by borrowing, $p \in [\hat{p}_1, \hat{p}_1^L)$, are all efficient. When $d \leq l^*(\hat{p}_1^L)(1+r)$, we have $\hat{p}_1^L \geq \hat{p}^L$ and the additional purchases induced by borrowing include efficient purchases, $p \in [\hat{p}_1, \hat{p}^L]$, and inefficient purchases, $p \in (\hat{p}^L, \hat{p}_1^L)$.*

Proof. From Proposition 1, we know that $\hat{p}_1 \leq \hat{p}$. From Lemma 2, we know that $\hat{p} \leq \hat{p}^L$. Therefore, $\hat{p}_1 \leq \hat{p} \leq \hat{p}^L$. We also know, from Lemma 2, that $\hat{p}_1 \leq \hat{p}_1^L$. When $d \geq l^*(\hat{p}_1^L)(1+r)$ and $\hat{p}_1^L \leq \hat{p}^L$ (from Proposition 2), we have either $\hat{p}_1 \leq \hat{p} \leq \hat{p}_1^L \leq \hat{p}^L$ or $\hat{p}_1 \leq \hat{p}_1^L \leq \hat{p} \leq \hat{p}^L$. For all the additional purchases induced by borrowing, $p \in [\hat{p}_1, \hat{p}_1^L)$, we have $p < \hat{p}^L$ and thus the additional purchases are efficient. When $d \leq l^*(\hat{p}_1^L)(1+r)$, we have $\hat{p}_1^L \geq \hat{p}^L$ (from Proposition 2), we have $\hat{p}_1 \leq \hat{p} \leq \hat{p}^L \leq \hat{p}_1^L$. The availability of purchase debt leads to additional purchases of durable goods priced at $p \in [\hat{p}_1, \hat{p}_1^L)$. For durable goods priced at $p \in [\hat{p}_1, \hat{p}^L]$, we have $p < \hat{p}^L$ and thus these additional purchases are efficient. For durable goods priced at $p \in (\hat{p}^L, \hat{p}_1^L)$, we have $p > \hat{p}^L$ and thus these additional purchases are inefficient. □

The availability of purchase debt means that more durable goods will be purchased. Proposition 3 confirms the traditional concerns about excessive borrowing/purchasing—some of the additional purchases will be inefficient, at least under certain conditions. But Proposition 3 also shows that borrowing can be advantageous, reducing the likelihood that the consumer will inefficiently fail to purchase the durable good. The additional purchases can be divided into three categories: (1) durable

goods that the consumer inefficiently failed to purchase when borrowing was unavailable ($p \in [\hat{p}_1, \hat{p})$); (2) durable goods that should be purchased only when borrowing is available ($p \in [\hat{p}, \hat{p}^L)$); and (3) durable goods that should not be purchased, with or without borrowing ($p \in [\hat{p}^L, \hat{p}_1^L)$). When the period 2 benefit from the durable good exceeds the period 2 cost of repaying the loan, the additional purchases fall into categories (1) or (2) and thus are all efficient. When the period 2 cost of repaying the loan exceeds the period 2 benefit from the durable good, the additional purchases fall into all three categories and the relative size of these categories determines whether borrowing increases or decreases efficiency.[7]

2 Purchase Debt and Saving

In the previous Section, we examined the effect of purchase debt on the decision to purchase the durable good, where the agent could only pay for the durable good by foregoing current or future consumption. But consumers often save up to pay for durable goods. In this section, we explore the effect of purchase debt on the agent's pre-purchase saving decision. We continue to use the $t = 0$ perspective as the normative benchmark but, in this extension, at $t = 0$ the consumer earns income m and chooses an amount $s \leq m$ to save; the rest, $m - s$, is consumed at $t = 0$. The agent's savings generate no return. In period 1, the agent can either rent or buy a durable good. If she rents, then in period 1 she consumes her income

[7]With more complex loan structures that defer repayment further into the future, there might be greater undervaluation of repayment costs and the efficiency advantages of borrowing might be reduced. Our model can be extended to accommodate alternative assumptions about the temporal distribution of costs and benefits.

and any savings from period 0, and in period 2 she consumes her income. If she buys, then she enjoys the consumption benefit d generated by the durable good in periods 1 and 2. In the Without Debt scenario, the agent pays for the durable good using her $t = 1$ income and any savings from period 0. In the With Debt scenario, she pays for the durable good using her $t = 1$ income, any savings from period 0 and a loan $l \in [0, L]$. She then consumes, in period 1, any income, savings and loan proceeds left after paying for the durable good. In period 2, the agent repays the loan at interest rate r and consumes what is left of her income.[8]

2.1 Without Debt

In period 0, the utility from renting is $U^R = u(m - s(p)) + \beta[u(m + s(p)) + u(m)]$, and the utility from buying is $U^B = u(m - s(p)) + \beta[u(d + m + s(p) - p) + u(d + m)]$. The agent chooses how much to save as a function of the price of the durable good, $s(p)$. We first note that the agent should not save if she expects to rent in period 1. For any price at which the agent expects to buy in period 1, the optimal savings amount $s^B(p)$ maximizes the period 0 utility from buying. For very low values of p, the agent will prefer not to save and to buy the good entirely out of her period 1 income. Let $\tilde{p}$ be such that $s^B(p) = 0$ for $p \leq \tilde{p}$, and $s^B(p) > 0$ for $p > \tilde{p}$, in which case $s^B(p)$ satisfies $\beta u'(d + m + s^B(p) - p) = u'(m - s^B(p))$.[9]

[8] We assume that the agent cannot save some income from period 1 to consume in period 2. Loosening this assumption would not change our qualitative conclusions.

[9] We focus on the scenario where, at the $\tilde{p}$ threshold, the agent buys in period 1. We retain the assumption that $p < m$, and thus saving is not necessary to purchase the durable good in period 1. Still, the consumer may want to save in order to smooth consumption. When $p > d$ and the consumer buys the durable good, period-1 consumption falls below period-0 consumption, and it is welfare enhancing to save as long as β is not too small. When $p \leq d$, saving necessarily reduces

This implies that $s^B(p)$ is weakly increasing. Let $\hat{p}|_{s^B(p)}$ be the threshold price below which the agent wants to buy, given the savings function $s^B(p)$.

In period 1, the agent's utility from renting is $U_1^R = u(m+s(p)) + \beta u(m)$ and her utility from buying is $U_1^B = u(d+m+s(p)-p) + \beta u(d+m)$. As in Section 1, there exists a threshold price $\hat{p}_1$, implicitly defined by $U_1^B(\hat{p}_1, s(\hat{p}_1)) = U_1^R(s(\hat{p}_1))$, such that the agent will purchase the durable good if $p < \hat{p}_1$. If the price of the durable good is greater than d, then $dU_1^B/ds > dU_1^R/ds$.[10] As a result, the more the agent saves in period 0 the more attractive buying becomes in period 1, increasing the $\hat{p}_1$ threshold.

Naïve agent. A naïve agent who observes a price of $p < \hat{p}|_{s^B(p)}$ will choose $s^B(p)$ and expect to buy in period 1. Thus, the naïf's savings function is:

$$s^{naive}(p) = \begin{cases} s^B(p) & \text{if } p < \hat{p}|_{s^B(p)} \\ 0 & \text{if } p \geq \hat{p}|_{s^B(p)} \end{cases}$$

However, when period 1 arrives, the agent will buy only at prices below $\hat{p}_1|_{s^B(p)}$, which is strictly less than $\hat{p}|_{s^B(p)}$. For prices between these values, the naïf will impulsively consume her savings from period 0 and continue renting.

Sophisticated agent. The sophisticated agent anticipates that she will be tempted to consume her savings in period 1 rather than follow through on her plan to buy the durable good. Because an agent who expects to rent will not save in period 0, the sophisticate will not choose $s^B(p)$ for $p \in [\hat{p}_1|_{s^B(p)}, \hat{p}|_{s^B(p)})$. How-

ex ante welfare.

[10] If the price of the good is less than d then the agent will not save in period 0 and always buy the good.

ever, if the agent wants to buy at prices in this range, she can induce her period 1 self to do so by increasing her period-0 savings. Let $s^{IB}(p)$ be the savings function that represents the smallest savings amount necessary to incentivize buying (IB) in period 1 at each price p, so that it satisfies $U_1^B(s^{IB}(p), p) = U_1^R(s^{IB}(p))$. In the relevant price range between $\hat{p}_1|_{s^B(p)}$ and $\hat{p}|_{s^B(p)}$, the agent has to save more than she would prefer to ensure that she follows through on her plan to buy, so $s^{IB}(p) > s^B(p)$.

At $\hat{p}_1|_{s^B(p)}$, the agent is indifferent in period 1 between renting and buying, given $s^B(p)$, but strictly prefers buying to renting in period 0. Increasing her savings above $s^B(p)$ by an arbitrarily small amount will induce her period 1 self to buy at that price, and so she will do so. But at $\hat{p}|_{s^B(p)}$, the agent is indifferent in period 0 between buying and renting given $s^B(p)$, so she will not want to increase her savings to ensure that she buys. Between these two prices there is a threshold price $\hat{p}^R$ such that the agent will choose $s^{IB}(p)$ for $p < \hat{p}^R$ and choose not to save for $p \geq \hat{p}^R$. This threshold is implicitly defined by: $U^B(s^{IB}(\hat{p}^R), \hat{p}^R) = U^R(s = 0)$. The consumer trades-off the benefit from an additional efficient purchases against the inter-temporal utility distortion caused by the additional savings. Above the threshold, the extra savings that are needed to induce buying reduce the ex ante utility from buying so much that renting becomes more attractive. The sophisticate's optimal savings function is:

$$s^{soph}(p) = \begin{cases} s^B(p), & \text{if } p < \hat{p}_1|_{s^B(p)} \\ s^{IB}(p), & \text{if } \hat{p}_1|_{s^B(p)} \leq p < \hat{p}^R \\ 0, & \text{if } p \geq \hat{p}^R \end{cases}$$

The sophisticate is strictly better off than the naïf, but the effects of sophistication on savings are ambiguous. For $p < \hat{p}_1|_{S^B(p)}$ and for $p \geq \hat{p}|_{S^B(p)}$, the naive agent will save the same amount as the sophisticated agent. For $p \in [\hat{p}_1|_{S^B(p)}, \hat{p}^R)$, the sophisticated agent will save more than the naive agent because the additional savings are necessary to ensure that she follows through on her plan to buy in period 1. But for $p \in [\hat{p}^R, \hat{p}|_{S^B(p)})$, the naive agent will save more than the sophisticated agent, mistakenly thinking that her savings will be used to buy the durable good in period 1.

Lemma 3. *A naïve agent chooses $s^{naive}(p)$ and purchases durable goods priced at $p < \hat{p}_1|_{s^B(p)}$. For goods priced between $\hat{p}_1|_{s^B(p)}$ and $\hat{p}|_{s^B(p)}$, the naïve agent saves in anticipation of buying but ends up renting. A sophisticated agent chooses $s^{soph}(p)$ and purchases durable goods priced at $p < \hat{p}^R$. The sophisticated agent make more efficient purchases of durable goods than the naïve agent, but must incur excess savings to do so. The effect of sophistication on savings is ambiguous.*

2.2 With Debt

We now introduce debt, and allow the agent to borrow a modest amount $L < p - d$ in period 1 if she buys the durable good. We assume that this borrowing constraint

is binding so that an agent who buys the good will borrow L. In period 0, the utility from renting is $U^R = u(m-s) + \beta[u(m+s) + u(m)]$ and the utility from buying is $U^B = u(m-s) + \beta[u(d+m+s+L-p) + u(d+m-L(1+r))]$. We start with the optimal savings function, $s^B(p,L)$, for an agent who expects to buy in period 1 with loan L. As in the Without Debt case, there exists a threshold $\tilde{p}^L$, such that for $p \leq \tilde{p}^L$ the agent will not save in period 0, and for $p > \tilde{p}^L$ the agent will save an amount $s^B(p,L) > 0$ that satisfies $\beta u'(d+m+L+s^B(p,L)-p) = u'(m-s^B(p,L))$.[11] Debt increases the threshold for saving from $\tilde{p}$ to $\tilde{p}^L$ and, in the interior solution, debt reduces the optimal savings amount, i.e., $ds^B(p,L)/dL < 0$. Intuitively, debt helps smooth consumption, and thus serves as a substitute for savings. By allowing the agent to spread the cost of the durable good between period 1 and period 2, debt increases the ex ante, period 0 threshold price for buying to $\hat{p}^L|_{s^B(p,L)} > \hat{p}|_{s^B(p)}$.

In period 1, the agent's utility from renting is $U_1^R = u(m+s) + \beta u(m)$, and her utility from buying is $U_1^B = u(d+m+s+L-p) + \beta u(d+m-L(1+r))$. As in Section 1.2, the availability of debt increases the threshold price at which the agent will buy the durable good to $\hat{p}_1^L|_{s^B(p,L)} > \hat{p}_1|_{s^B(p)}$.

Naïve agent. Without debt, the naïve agent succumbs to temptation and consumes, in period 1, savings of $s^B(p)$, when the durable good is priced at $p \in (\hat{p}_1|_{s^B(p)}, \hat{p}|_{s^B(p)})$. Debt partially solves the naïf's time inconsistency problem. With debt, the agent will choose $s^B(p,L)$ and follow through on her plan

[11] As before, we focus on the scenario where, at the $\tilde{p}^L$ threshold, the consumer buys in period 1. In this scenario, $\hat{p}_1^L|_{s^B(p,L)} > \tilde{p}^L$.

to buy durable goods priced at $p \in (\hat{p}_1|_{s^B(p)}, \hat{p}_1^L|_{s^B(p,L)})$. In this price range, the availability of debt increases period 1 purchases and reduces the amount of savings that are inefficiently consumed. However, by increasing the ex ante, period 0 threshold for buying the durable good from $\hat{p}|_{s^B(p)}$ to $\hat{p}^L|_{s^B(p,L)}$, debt also creates a new range of prices in which the naïve agent will save in anticipation of buying but fail to follow through.

Sophisticated agent. With debt, the ex ante, period 0 decision to buy at $p \in (\hat{p}_1|_{s^B(p)}, \hat{p}_1^L|_{s^B(p,L)})$ becomes time consistent. The sophisticate can save for these purchases using her optimal savings function $s^B(p,L)$ rather than saving strategically to ensure that her period 1 self buys the durable good. In addition, debt reduces the amount of excess savings, $s^{IB}(p,L) > s^B(p,L)$, needed to induce the period 1 self to follow through on the period 0 plan to buy at $p \in (\hat{p}_1^L|_{s^B(p,L)}, \hat{p}^R)$,[12] Finally, debt creates a new range of prices, $p \in (\hat{p}^R, \hat{p}^{R,L})$, in which the sophisticated agent will find it worthwhile to save $s^{IB}(p,L)$ and induce her period 1 self to buy (where $\hat{p}^{R,L}$ is the threshold price below which the agent will save extra when purchase debt is available).

Proposition 4. *For a naïf, a modest amount of debt makes buying at* $p \in (\hat{p}_1|_{s^B(p)}, \hat{p}_1^L|_{s^B(p,L)})$ *time consistent, so her savings* $s^B(p,L)$ *in this price range are used for efficient purchases rather than being consumed impulsively in period 1. However, debt*

[12] To see this, we show that $s^{IB}(p,L)$ is decreasing in L. For ease of notation, let $\underline{s} \equiv s^{IB}(p,L)$. Recall that $\underline{s}$ is defined such that $u(m+\underline{s}+d+L-p)+\beta u(m+d-L(1+r))-u(m+\underline{s})+\beta u(m)=0$. Fully differentiating with respect to L and setting to 0, we have that $\frac{\partial \underline{s}}{\partial L} = \frac{\beta(1+r)u'(m+d-L(1+r))-u'(m+\underline{s}+d+L-p)}{u'(m+\underline{s}+d+L-p)-u'(m+\underline{s})}$. On the right hand side, the numerator is strictly negative because we have assumed that L is binding and the denominator is positive because $L < p-d$. Therefore, $\partial \underline{s}/\partial L < 0$.

also tempts the naïf to plan a durable good purchase at $p \in (\hat{p}|_{s^B(p)}, \hat{p}^L|_{s^B(p,L)})$*, which she will fail to do. The welfare effect of modest purchase debt on naïfs is ambiguous. For a sophisticated agent, a modest amount of debt makes purchases at* $p \in (\hat{p}_1|_{s^B(p)}, \hat{p}_1^L|_{s^B(p,L)})$ *time consistent, thus eliminating the need for extra savings to induce efficient purchases. Debt reduces the amount of excess savings needed to ensure time consistent purchasing. And debt creates a new range of prices,* $p \in (\hat{p}^R, \hat{p}^{R,L})$*, for which the sophisticated agent will efficiently buy the durable good. The welfare effect of debt for the sophisticate is positive.*

The overall welfare effect of debt depends on the distribution of durable good prices and the share of naïfs and sophisticates in the population. When a significant share of durable goods are priced at $p \in (\hat{p}_1|_{s^B(p)}, \hat{p}_1^L|_{s^B(p,L)})$, the availability of purchase debt increases welfare for both naïve and sophisticated agents.

3 Conclusions

Present-biased agents undervalue the benefits from a durable good as well as the cost of financing the durable good. Given these countervailing effects, it is unsurprising that purchase financing can lead to either too much, or too little, durable good consumption. Contrary to conventional wisdom, the availability of purchase financing can help present-biased consumers and increase welfare.

The availability of purchase financing can also improve savings decisions. For naïfs, purchase financing increases the number of efficient purchases, preventing the present-biased agent from impulsively consuming savings that were set aside

to buy durable goods. But financing also tempts present-biased agents to save for more expensive durables that they will ultimately not buy. For sophisticated agents, purchase debt reduces the amount of strategic savings needed to make buying incentive compatible. Debt also increases the range of durable good prices for which efficient purchases are possible.

The contingent benefits of purchase debt for present-biased agents reveals the importance of distinguishing between unsecured revolving debt, such as credit card debt, and purchase debt for durable goods–such as home mortgages and car loans. Credit used to finance durable good purchases can be welfare-enhancing, but only under certain conditions. Our conclusions are nuanced and contingent. Credit regulation must be as well.

Affiliations: Oren Bar-Gill, Harvard Law School; Andrew Hayashi, University of Virginia School of Law

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