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Social Responsibility in Secondary Markets*

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Abstract

We study how secondary markets for durable goods interact with consumers' social-responsibility motives to mitigate environmentally harmful new production. On the positive side, secondary markets may allow responsible consumers to acquire used goods that would otherwise be discarded, reducing premature waste. On the negative side, secondary markets introduce two major harmful forces. First, the possibility of buying used goods and thereby causing less harm can raise the demand of responsible consumers, often increasing the production necessary to serve the market. Second, said demand can increase the price of used goods, encouraging purchases of new goods. These forces imply that if used goods have positive private consumption value, then secondary markets always erode the benefits of social responsibility. If, instead, used goods may have negative private value, then secondary markets can enhance or erode the benefits of social responsibility.

Keywords: socially responsible consumers, climate change, externalities, secondary markets, durable goods, used goods

JEL Codes: D01, D11, D50, D62, D64, D91

1 Introduction

Secondary markets for consumer durables are touted as an important tool for reducing environmentally harmful new production, making them a central component of many emerging government regulations and initiatives. One potential mechanism for their environmental benefit is based on their well-known allocative effect: transferring used items to higher-value consumers can raise the service flow from goods, reducing the demand for new production.

Intuition and discussions, however, suggest that secondary markets have another beneficial effect: they encourage socially responsible consumers — consumers who aim to reduce the externalities they cause — to forego otherwise appealing new products. Indeed, sustainability is one main motive that consumers cite for purchasing used products, and that second-hand retailers

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invoke in their marketing.[1] Furthermore, researchers and observers claim that outcomes improve as a result of substitution to second-hand goods (e.g., Sandin and Peters, 2018, Klooster et al., 2024). A tempting conclusion is that the prospect of socially responsible demand raises the value of secondary markets.

In this paper, we investigate the above intuitions regarding the positive interaction between secondary markets and social responsibility. We identify settings in which the common intuitions are correct, but also find an important class of situations in which, directly contradicting the same intuitions, secondary markets erode socially responsible behavior. The effects hinge on three main forces. First, by providing a less harmful purchase option, secondary markets raise the demand of responsible consumers, and because somebody must supply the used goods, this often raises new production. Second, the preceding demand can raise the price of used goods, which boosts resale values and thereby makes new purchases more appealing to less responsible consumers. Third, however, secondary markets may increase consumption of products that would otherwise be inefficiently discarded. If used goods have positive private consumption utility, then only the first two forces are present, so that secondary markets *always* erode responsible behavior. If used products may have significantly negative private consumption utility, then all three forces are present, and secondary markets can facilitate or erode responsible behavior.

We begin in Section 2 by introducing our model. In each period, consumers can buy new goods at a fixed price P, thereby causing a production externality, and trade used goods at market-determined prices, thereby not generating a direct externality. Between periods, all goods lose a portion f of their value through quality deterioration or breakage, and new goods become used, yielding an extra disutility of l per unit. To these private sources of utility, we add social concerns by building on Kaufmann et al. (2024): a consumer derives disutility in proportion $k \geq 0$ to the rise in production she causes through her purchases, both directly and through her (infinitesimal) effect on prices. The indirect effect depends on the behavior of other consumers, and is therefore endogenous. We look for steady-state competitive equilibria in which consumers' behavior and their effects are mutually consistent.

[1] Numerous papers investigate consumers' reasons for buying second-hand products or participating in the sharing economy, with sustainability consistently being important (e.g., Guiot and Roux, 2010, Turunen and Leipämaa-Leskinen, 2015, Edbring et al., 2016, Hamari et al., 2016, Styvén and Mariani, 2020, Rodrigues et al., 2023). This is reflected, for instance, in the marketing of major second-hand clothing retailers Vinted, Poshmark, and ThredUp. Vinted emphasizes that second-hand clothing "is better than new for the climate" (`https://company.vinted.com/sustainability`). Poshmark wants to make "shopping and selling simple, social, and sustainable" (`https://poshmark.com`). And ThredUp writes that buying second-hand is about "standing for sustainability" (`https://www.thredup.com/about`). All accessed June 1, 2025.

For most of the paper, we further assume that consumers have the same consumption utility, but differ in their "social coefficients" k. This strips the interaction between secondary markets and social responsibility from standard allocative considerations. Finally, in our main model we impose that consumers are either selfish ($k = 0$) or socially responsible with the same $k = \kappa > 0$, and focus on "strict" equilibria, in which both types have a strict preference between new and used products. Then, purchases have no indirect effects on production. Buying a used product can marginally affect the used market today, and buying a new product can (by increasing supply) marginally affect used markets in the future. But due to the strict preferences of consumers, neither purchase induces other consumers to make new purchases.

We analyze our main model in Section 3. We first consider situations in which the distaste l for used goods is modest ($l < (1 - f)P$), so that even without a secondary market, discarding a used item and buying new instead is privately suboptimal. This positive-value condition for used goods might, for instance, apply to higher-quality apparel, whose resale markets have grown tremendously in the last few years. We show that in any strict equilibrium, used goods are relatively expensive (albeit cheaper than new goods), and in each period selfish types buy new goods and sell their used goods to responsible types. Because used goods do not generate an externality, responsible types purchase more lavishly than without a secondary market, while the high resale price encourages selfish types to do the same, yielding higher production and lower welfare. This provides a new explanation for why sellers may like secondary markets, and suggests that promoting resale can even serve as a seemingly responsible, but actually harmful greenwashing strategy.

Now suppose that the distaste for used goods is more substantial ($(1-f)P < l < (1-f)(P+\kappa)$), so that a used item has negative private value. This condition might, for instance, apply to low-quality fast fashion and similar merchandise one sees at traditional thrift stores. In the absence of a secondary market, selfish consumers replace their used goods with new each period, while responsible consumers buy new goods only to replenish their stock. When a secondary market exists and the share of responsible consumers is sufficiently low, selfish consumers "sell" — or, rather, donate — some of their used goods at a price of zero to responsible consumers, who forego new goods to avoid generating an externality. The secondary market thereby reduces new production and waste, and improves welfare. For a higher share of responsible consumers, however, used goods sell at positive prices, encouraging selfish consumers to buy more new goods. Consequently, the welfare effect of the secondary market is now ambiguous.

Finally, if the private distaste for used goods is very large ($l > P + \kappa$), then all consumers discard used products in every period. Hence, the secondary market must remain dormant, and has no effect on production.

In Section 4, we consider one setting in which a classical allocative role for the secondary market is also present. We assume two groups, such as high-income fashion seekers and low-income price seekers, who have distastes l and 0 for used goods, respectively. If all consumers are selfish, then the secondary market facilitates allocative efficiency by transferring used goods to low-income consumers. As a contrasting example, however, suppose that high-income consumers are socially responsible (with $(1-f)\kappa > l$), and their distaste for used goods is relatively low ($l < (1-f)P$). Then, in any strict equilibrium the secondary market induces high-income types to buy used, and both types to increase consumption. Hence, it raises production while *lowering* allocative efficiency. In some situations, the secondary market lowers not only social welfare due to the increase in production externalities, but also total *private* consumption utility due to the decrease in allocative efficiency.

To conclude our analysis of the basic model, we assume that the share of high-income consumers is low, and their distaste for used goods is high ($l > (1-f)(P+\kappa)$). We use this version to illustrate both another force and the need for a general framework. Since there are many low-income consumers, they must purchase both new and used goods to clear the market, so that a strict equilibrium does not exist. Allowing for low-income consumers to be indifferent between new and used goods in turn means that a cross-market effect arises: used purchases raise production by displacing low-income consumers' used purchases. As a result, the secondary market raises production and lowers welfare by inducing high-income responsible consumers to buy more *new* goods. This occurs partly because of the cross-market effect: responsible consumers realize that by later selling on the secondary market, they reduce new purchases by low-income consumers.

In Section 5, we demonstrate the robustness of our main insights by allowing for a general continuous distribution of social coefficients k and investigating not just strict equilibria. The technically difficult case is when the distaste l for used goods is low, which for notational simplicity we analyze by setting $l = 0$. Unlike in strict equilibria, a consumer may now impact production in all future periods, so her total impact is not immediate. To obtain traction, we reformulate our equilibrium conditions in terms of the above cross-market effect of a used purchase on current production. Using this reformulation, we establish that the secondary market always weakly erodes responsible behavior. In particular, (i) there is always an equilibrium in which outcomes are as without the secondary market; and (ii) there is often also an equilibrium in which almost everyone's consumption and production are *strictly* greater than without the secondary market. We note that an increase in consumers' social coefficients k (in the sense of first-order stochastic dominance) can lower welfare by introducing an equilibrium of type (ii).

We conclude in Section 6 by highlighting areas for future research, including the analysis of policy interventions, consumer naivete, endogenous product durability, and responsible consumers' efforts to alter the beliefs of firms or policymakers. Proofs are in the Appendix.

Policy relevance and related literature Our analysis informs recent policy proposals and countless discussions in the business and popular press on secondary markets. For example, the European Union's (EU's) Circular Economy Action Plan of 2020, a comprehensive agenda to help achieve carbon neutrality, aims to engender widely available second-hand markets. One specific method is the creation "Digital Product Passports" containing information on the product's history, which may help engender trust in buyers. Similarly, California's Responsible Textile Recovery Act of 2024 mandates sellers to collect unwanted textiles and encourage second-hand and thrift stores.[2] Consistent with such steps, a McKinsey report by Gatzer et al. (2022) predicts that the EU market for used and recycled consumer goods will rise to €400-650 billion (22-38% of the total consumer-goods market) by 2030. Our findings suggest a potential for unintended consequences due to an interaction with consumers' social-responsibility motives.

The results we find may also be helpful for individual consumers thinking about their impacts from new versus used purchases when a secondary market is already in place. For instance, some audience members and friends have reacted to our results by expressing guilt about used purchases. Such reactions are unjustified: in all equilibria, buying used has a weakly lower externality impact than buying new, so it is the more responsible thing to do. This is the case even when establishing the secondary market is socially harmful, so that advocating for it is not a good idea.

Within economics, our paper contributes primarily to the theoretical analysis of social responsibility among consumers and to the understanding of durable goods and secondary markets. To the best of our knowledge, we are the first to combine these topics, as well as the first to analyze the effects of responsible consumers in a dynamic product market.

For modeling markets with socially responsible consumers, we build on the static framework of

[2] See, e.g., `https://www.eumonitor.eu/9353000/1/j9vvik7m1c3gyxp/vkwk8lwipmzm` and `https://environment.ec.europa.eu/strategy/textiles-strategy_en` on the Circular Economy Action Plan; `https://en.wikipedia.org/wiki/EU_Digital_Product_Passport` and `https://www.europarl.europa.eu/RegData/etudes/STUD/2024/757808/EPRS_STU(2024)757808_EN.pdf` on Digital Product Passports; and `https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202320240SB707` on the Responsible Textile Recovery Act. All accessed August 14, 2025.

Kaufmann et al. (2024), but our dynamic setting leads to different theoretical challenges and economic mechanisms.[3] In much of the other research on the market effects of responsible consumers and investors (Sobel, 2007, Dufwenberg et al., 2011, Pástor et al., 2021, Piccolo et al., 2022, Aghion et al., 2023, Arnold, 2023, Dewatripont and Tirole, 2024), a person's social concern depends exogenously on actions or outcomes, whereas in our setting it depends on the consumer's endogenous equilibrium impact. Furthermore, papers that do consider impact-based social preferences (e.g., Norwood and Lusk, 2011, Moisson, 2020, Green and Roth, 2021, Hakenes and Schliephake, 2021, Broccardo et al., 2022, Herweg and Schmidt, 2022, Krahnen et al., 2023, Trammell, 2023, Oehmke and Opp, 2025) study questions and use methods that are different from ours.

There is also an extensive body of classical theory on durable goods and secondary markets. This literature investigates questions such as the choice of durability by firms (e.g., Swan, 1970), time inconsistency (e.g., Coase, 1972), planned obsolescence (e.g., Bulow, 1982), and monopolists' incentives to interfere with secondary markets (e.g., Hendel and Lizzeri, 1999, 2002), but does not consider markets with socially responsible consumers.

On the empirical side, there is substantial evidence for the type of consumer we analyze. Many studies, including incentivized experiments by Meier et al. (2023), Rodemeier (2023), Schulze Tilling (2024), and Andre et al. (forthcoming), show that consumers care about their externality effects. The importance of social concerns in the purchase of second-hand goods is also well-documented in the literatures on sustainability (e.g., Borusiak et al., 2020, Varah et al., 2021, Rodrigues et al., 2023) and the sharing economy (e.g., Hamari et al., 2016).

2 Basic Framework

We consider an infinite-period economy with markets for new and used goods each period. New goods are available in perfectly elastic supply at price P, and their sale raises externality-generating production one-to-one. As a new good ages one period, it becomes used. As a used good ages one period, it loses a portion f of its value, so that one unit of a one-period-older good is equivalent to $1 - f$ units of a one-period-younger good. We measure the quantities of all used vintages in units of one-period-old products, allowing us to collapse used consumption into a single number.

[3] In fact, by assuming that new products are available in fully elastic supply, we abstract from the main effect on which Kaufmann et al.'s predictions rely, "dampening". Dampening means that when a consumer raises her consumption, she raises the market price and thus induces others to consume less, lowering the externality she brings about. This static effect does not appear to interact with the dynamic issues due to durability and secondary markets that we investigate in this paper.

Accordingly, if in one period a person consumes amounts $c_n \geq 0$ and $c_u \geq 0$ of the new and used goods, respectively, then she starts the next period with an amount $c_n + (1-f)c_u$ of used goods. Used goods can be bought and sold at a market-determined price p_u, and such trade does not generate direct externalities. There is free disposal, so that the used price p_u must be non-negative.

We define a *steady-state competitive equilibrium* as a situation satisfying five conditions. The first three pertain to outcomes and expectations: (i) there is a constant used price $p_u^* \geq 0$ as well as constant consumption; (ii) p_u^* balances the secondary market, i.e., the market features either $p_u^* = 0$ and excess supply or market clearing in each period; and (iii) a consumer takes a surprise deviation in the used price from p_u^* as idiosyncratic, expecting a return to p_u^* in the future.

The fourth condition defines individual behavior: a consumer observes the current used price $p_u \geq 0$, and chooses consumption amounts $c_n \geq 0$ and $c_u \geq 0$ to maximize

$$U_k(c_n, c_u) = u(c_n + (1-f)c_u) - lc_u - Pc_n - p_u c_u + p_u^*(c_n + (1-f)c_u) - k \cdot (c_n r_n^* + c_u r_u^*). \quad (1)$$

The first two terms represent gross consumption utility. Like its used counterpart, a new good loses a portion f of its value when it ages one period, so that one unit of a used good is substitutable with $1-f$ units of a new good. In addition, the consumer may have a further distaste $l \geq 0$ for used goods. The function $u(\cdot)$ is twice continuously differentiable, with $\lim_{c\to 0} u'(c) = \infty$, $u''(c) < 0$ for all $c \geq 0$, and $\lim_{c\to\infty} u'(c) = 0$. We call the quantity $c_n + (1-f)c_u$ that enters u a person's "total consumption." The next two terms are the payments for c_n and c_u, and the fifth is the expected secondary-market value of used goods next period. To these elements of standard private utility, the last term adds social concerns. A consumer's concern is proportional to her social coefficient k, which in our basic model is binary: a share g of consumers is selfish ($k = 0$), and a share $1-g$ is socially responsible with $k = \kappa > 0$. Furthermore, the consumer's concern derives from her equilibrium impact $c_n r_n^* + c_u r_u^*$ on total production over time, where r_n^* and r_u^* denote the impacts of new and used consumption, respectively.

As the fifth condition for equilibrium, we impose a consistency requirement on r_n^* and r_u^* by adapting Kaufmann et al.'s (2024) definition of competitive equilibrium with small rational consequentialist responsible consumers. To understand the condition, consider how a consumer's purchases affect production. Buying a new good has a direct, one-to-one effect on current production, while buying a used good can have an indirect effect by raising the used price p_u and thereby inducing others to buy new. Further, any current production caused by either purchase can have indirect effects on future production by raising the future supply of used goods and thus lowering future used prices. Kaufmann et al. show (in their setting) that such indirect effects on quantities are in general not negligible, even though a small consumer's effect on prices is. Consistency means that if consumers expect to have impacts r_n^* and r_u^*, then the effects of new and used consumption — which depend on demand and hence on r_n^* and r_u^* — indeed aggregate to r_n^* and r_u^*, respectively.

Because the general definition and analysis of consistency are cumbersome, we defer it to Section 5. For our basic model, we focus on "strict" equilibria, in which both selfish and responsible consumers have a strict preference between new and used products. Then, there are no indirect effects of consumption — a marginal change in used prices does not induce anyone to switch between products — so $r_n^* = 1$ and $r_u^* = 0$. In addition, checking consistency amounts to verifying that consumers maximizing (1) with $r_n^* = 1$ and $r_u^* = 0$ have strict preferences for both $k = 0$ and $k = \kappa$.

Several comments are in order. First, although we have assumed that used goods lose a share f of their value between periods, an equivalent model arises if a share f breaks, and the rest retain full value; or a total depreciation of f results from a combination of value loss and breakage. The assumption that depreciation is geometric is necessary for tractability. Second, we use the anchored belief imposed by condition (iii) only for vanishingly small price deviations a single consumer can cause. This is justified because noise in price determination (which we do not model but is present in reality) makes small deviations from equilibrium undetectable. Third, U_k omits the consumer's used goods from before because available consumption choices, their ranking, and (hence) optimal behavior are independent of it. Fourth, the same independence implies that while U_k is defined over current consumption only, maximizing intertemporal utility with discount factor δ approaching 1 is in the limit equivalent to maximizing U_k. Fifth, our specification implicitly imposes that upon deviation from equilibrium, a consumer still expects to have the equilibrium impacts r_n^* and r_u^*. Such an assumption is natural for consumers with anchored beliefs and a negligible price impact.[4]

We will compare outcomes with a secondary market to those without one. In the latter case, a consumer's steady-state consumption c_n^*, c_u^* solves

$$(c_n^*, c_u^*) = \underset{\substack{c_n, c_u: \\ c_u \le (c_n^* + (1-f)c_u^*)}}{\arg\max} \; u(c_n + (1-f)c_u) - lc_u - Pc_n + p_u^*(k)(c_n + (1-f)c_u) - k \cdot c_n. \tag{2}$$

[4] Note also that in our model, buying a new good raises production much like made-to-order manufacturing does. In reality, consumers buy previously produced goods from retailers, raising the question of how this is different from buying used goods. A simple modification clarifies. Suppose that small retailers order from producers at the beginning of each period, and sell to consumers afterwards. Each retailer has concave utility from the amount of leftover products at the end of the period. This captures, in reduced form, the incentives of retailers to keep a stockpile to cover demand shocks. Then, a consumer understands that if she consumes more, the retailer's stockpile decreases, so the retailer will order more next period to restock. Hence, consumers treat a retailer that obtains its ware directly from the producer as a make-to-order producer.

The absence of trade in used goods introduces three differences relative to (1): the term $-p_u c_u$ is absent, there are no indirect effects of consumption ($r_n^* = 1$, $r_u^* = 0$), and used consumption c_u is bounded by the amount of used goods available from before. Further, we impose that used goods have a shadow value of $p_u^*(k) = \max\{(1-f)(P+k) - l, 0\}$ in the next period. The first argument reflects that having one unit of the used good, rather than buying $1-f$ units of the new one, saves $(1-f)(P+k)$ in financial and social-concern costs next period, but it also lowers utility by l. The second argument reflects free disposal. Introducing a shadow value to account for these considerations is necessary because (2) is again defined over current consumption only. The same shadow value would emerge in the alternative specification with discounting mentioned earlier.

We assume that production has an exogenously given externality cost of $K > 0$ per unit. Hence, we define steady-state social welfare as per-period total gross consumption utility minus $P + K$ times per-period production. Moreover, we posit that $k < K$ and $l < (1-f)(P+K)$. The first inequality means that no consumer fully internalizes the social cost of the externality she causes. The second inequality implies that disposing of used goods and buying new goods instead is socially inefficient, i.e., it creates "premature waste."

For interpreting results, it is useful to distinguish premature waste from "unavoidable waste," which is socially inefficient to consume ($l > (1-f)(P+K)$). As we have mentioned, our framework accommodates the possibility that some used goods break each period. We can naturally interpret such broken items — which must be discarded — as unavoidable waste. The extent to which real-life waste is premature or unavoidable is unclear, so the existence of waste is consistent with all versions of our model below.[5]

Note that in our basic model, all consumers have the same consumption-utility function. If consumers had different inherent tastes, there would potentially be trade on the secondary market for purely private reasons. We abstract from this classical force to isolate effects due solely to social responsibility. Since with only selfish consumers ($g = 1$) the secondary market has no impact on outcomes, its welfare impact stems from how it influences responsible consumers; and conversely, the same impact reflects how responsible consumers influence the value of the secondary market. These interactions are impossible to cleanly isolate when there is also trade for purely private reasons, as social responsibility necessarily affects these trades too. Nevertheless, in Section 4 we briefly discuss a model with heterogeneity in consumption utility.

[5] Relatedly, while we focus on production externalities, any externalities from waste (e.g., environmental degradation from landfilling unwanted textiles) can be included in K. Since all new production eventually becomes waste when the products break, in steady state the two must equal in quantity.

3 Secondary Markets and Responsible Behavior

In this section, we characterize all strict equilibria, thereby allowing us to identify when secondary markets facilitate versus erode socially responsible behavior. As one practical illustration, we use apparel markets; other potential applications include electronics, electric vehicles, furniture, books, and sports or outdoor equipment. We consider three cases.

3.1 Trading Privately Valuable Goods

We first suppose that $l < (1-f)P$. The condition means that in the absence of a secondary market, discarding used goods to buy new goods is privately suboptimal. Indeed, replacing a unit of the former with $1-f$ units of the latter eliminates a consumption disutility of l, but also costs $(1-f)P$. Such privately valuable used goods appear to dominate many resale markets, for example in used apparel and mobile phones — sectors growing much faster than traditional donation and thrift stores.[6] Without the opportunity to resell, brand-name clothing may be worth keeping even if rarely worn, and an old mobile phone may be worth having as a backup.

Proposition 1 (Erosion of Responsible Behavior)**.** *There are* $\underline{g}$ *and* $\overline{g}$ *satisfying* $0 < \underline{g} < \overline{g} < 1$ *such that a strict equilibrium exists if and only if* $\underline{g} < g < \overline{g}$. *Any strict equilibrium features strictly higher total consumption by both consumer types, strictly higher production, and strictly lower social welfare, than without the secondary market. The used price satisfies* $(1-f)P - l < p_u^* < \min\{P, (1-f)(P+\kappa) - l\}$.

Proposition 1 says that in the current case, a secondary market can only erode responsible behavior. We sketch the argument under the notationally simple case of $l = 0$.

Idea of proof ($l = 0$) When $l = 0$, consumption utility depends only on total consumption $c = c_n + (1-f)c_u$. Equation (2) implies that without a secondary market, type $k \in \{0, \kappa\}$ chooses total consumption $c_k^{\neg sm}$ to solve $u'(c_k^{\neg sm}) - (P+k) + (1-f)(P+k) = 0$, or $u'(c_k^{\neg sm}) = f(P+k)$. Further, a consumer's steady-state consumption amounts must satisfy $c_u = c_n + (1-f)c_u$, so $c_n = fc_u = f(fc_u + (1-f)c_u) = f(c_n + (1-f)c_u) = fc$; intuitively, new purchases compensate for the depreciation f of products. Hence, total new consumption, which equals new production, is $f(gc_0^{\neg sm} + (1-g)c_\kappa^{\neg sm})$ in each period.

[6] See, for instance, ThreadUp (2024). The US apparel resale sector grew from \$3 billion in 2017 to \$22 billion in 2022, and is expected to reach \$42 billion by 2027. The same numbers for traditional donation and thrift stores are \$17 billion, \$22 billion, and \$28 billion, respectively.

In the presence of a secondary market, consider a candidate equilibrium with $(1-f)P < p_u^* < \min\{P, (1-f)(P+\kappa)\}$. Using that $r_n^* = 1$ and $r_u^* = 0$, Equation (1) implies that consistent with a strict equilibrium, selfish types strictly prefer new goods and responsible types strictly prefer used goods. Further, types $k = 0$ and $k = \kappa$ choose total consumption amounts c_0^* and c_κ^* to solve

$$u'(c_0^*) = P - p_u^* \quad \text{and} \quad u'(c_\kappa^*) = \frac{f}{1-f} \cdot p_u^*, \tag{3}$$

respectively. The equilibrium exists if g is such that the market-clearing condition $gc_0^* = (1-g)fc_\kappa^*/(1-f)$ holds, i.e., the amount selfish consumers sell each period — everything they bought new last period — equals the amount socially responsible consumers need to compensate for depreciation (since c_κ^* is responsible types' total consumption, their used consumption is $c_\kappa^*/(1-f)$).

In that case, production per period is $gc_0^* = fgc_0^* + (1-f)gc_0^* = fgc_0^* + f(1-g)c_\kappa^* = f(gc_0^* + (1-g)c_\kappa^*)$. Now $(1-f)P < p_u^* < (1-f)(P+\kappa)$ implies that $P - p_u^* < fP$ and $\frac{f}{1-f} \cdot p_u^* < f(P+\kappa)$, so $c_0^* > c_0^{\neg sm}$ and $c_\kappa^* > c_\kappa^{\neg sm}$. As a result, both types consume more and production is strictly higher than without the secondary market. □

Intuitively, responsible consumers understand that by buying used goods, they are not generating an externality — they merely crowd out used consumption by others. This liberates them to consume a lot, with their increased demand also driving up the used price p_u^*. Anticipating a high resale price in turn induces selfish consumers to consume a lot as well. Importantly, the latter is an equilibrium feedback effect that responsible consumers — unable to influence expectations regarding *future* prices — cannot mitigate by changing their current behavior. Since all purchases ultimately come from new production, the lavishness of everyone's consumption is harmful for the level of the externality and social welfare.

In some situations, the secondary market not only raises the harm that stems from the externality, but also lowers the population's average *private* consumption utility net of prices paid. As a notable extreme example, suppose that $l = 0$ and $p_u^* \approx (1-f)(P+\kappa)$. Then, responsible types' consumption utility is approximately the same as without the secondary market, while selfish types' consumption utility is strictly higher. But since $u'(c_0^{\neg sm}) = fP$, the latter increase is in the range where marginal utility is below fP, the per-period price of maintaining a unit of steady-state total consumption. Intuitively, the secondary market does nothing but act as a subsidy to selfish types that is inefficient even ignoring externalities.

While we have assumed perfectly elastic supply, a further point emerges with an increasing supply curve. Then, the secondary market may raise the new price, benefiting sellers.[7] This possibility provides a novel argument for why sellers may like secondary markets, and is consistent with the fast-growing tendency of brand-name apparel makers to embrace resale.[8] It also suggests that the promotion of resale may be a greenwashing strategy. Since in equilibrium used goods generate less of an externality than new goods, a firm with a resale program appears to be environmentally friendly. Yet having a secondary market raises new sales and is environmentally unfriendly.

3.2 Reducing Premature Waste

Next, we assume that $(1-f)P < l < (1-f)(P+\kappa)$, so that it is privately optimal to dispose of used goods and replace them with new goods in proportion $(1-f)$. This assumption may describe fast fashion and other types of low-quality merchandise that become an unexciting nuisance after a short period of use.

Proposition 2 (Fragile Facilitation of Responsible Behavior)**.**

A. [Equilibrium Characterization.] *There are* $\underline{g}, \overline{g}$ *satisfying* $0 \leq \underline{g} < \overline{g} < 1$ *such that:*

I. If $g > \overline{g}$*, then there is a unique strict equilibrium. In this equilibrium,* $p_u^* = 0$*, selfish types' total consumption is the same as without the secondary market and responsible types' total consumption is strictly higher, but the latter do not buy new products. Production is strictly lower and social welfare is strictly higher than without the secondary market.*

II. If $\underline{g} < g < \overline{g}$*, then there is a unique strict equilibrium. In this equilibrium,* $p_u^* \in (0, (1-f)(P+\kappa) - l)$ *and both types' total consumption is strictly higher than without the secondary market, but responsible types do not buy new products.*

III. If $g < \underline{g}$*, then a strict equilibrium does not exist.*

B. [Fragility of Welfare Gains.] *For any* $P, \kappa, l, K, g,$ *and* f *with* $f^2(1-g) > g(1-f)$*, there is a utility function* $u(\cdot)$ *such that in the unique strict equilibrium, total private consumption utility is strictly lower and production is strictly higher than without the secondary market.*

The proposition says that for privately less valuable products, secondary markets can facilitate

[7] E.g., suppose that the supply curve is a step function: it equals $P' < P$ up to quantity $q' < gc_0^*$, and P for higher quantities. This leaves the preceding equilibrium, including the new-good price P, unchanged. But if q' and P' are sufficiently close to gc_0^* and P, respectively, then the new-good price without a secondary market is P'.

[8] E.g., ThreadUp (2024), or Bhattarai ("Old clothes, new customers," Washington Post, January 31, 2020). The number of brands with resale programs increased from 4 in 2018 to 163 in 2023. Common intuition and some research (e.g., Rust, 1986, Waldman, 1996) suggests that a secondary market harms sellers by lowering demand for new products. Swan's independence result (Swan, 1970, Sieper and Swan, 1973) implies that a secondary market has no effect on sellers. Other research shows that a secondary market can benefit sellers by allowing them to expand the customer base or price discriminate (e.g., Anderson and Ginsburgh, 1994, Hendel and Lizzeri, 1999).

socially responsible behavior, albeit this beneficial effect is fragile. To begin, Part A characterizes strict-equilibrium outcomes. We sketch the argument for the most novel case, A.I., when the secondary market improves outcomes.

Idea of proof, Part A.I. Suppose first that there is no secondary market. Since $l > (1-f)P$, selfish consumers prefer new goods for all of their consumption each period, and face a shadow price of zero. This implies that they always toss their used goods from before. Since $l < (1-f)(P+\kappa)$, however, responsible consumers strictly prefer used goods they already have to new goods. Nevertheless, they do buy new goods each period to compensate for depreciation.

In the presence of a secondary market, consider a candidate equilibrium with $p_u^* = 0$. Setting $r_n^* = 1$ and $r_u^* = 0$, Equation (1) implies that, consistent with a strict equilibrium, selfish consumers strictly prefer new goods, and responsible consumers strictly prefer used goods. Now since selfish types face the same p_u^* as without the secondary market, they consume the same amount. With responsible types shunning new production, therefore, the secondary market lowers total production. Such an equilibrium exists if the share of selfish consumers, g, is sufficiently high for their supply of used goods to exceed the amount responsible consumers need to compensate for depreciation. □

Intuitively, a socially responsible consumer knows that if she buys a used product, she just reduces what selfish consumers discard, and does not affect current new production or future market outcomes. Hence, she makes a private sacrifice to decrease premature waste and thereby lower the need for new production. By facilitating this sacrifice, the secondary market raises welfare. But because $p_u^* = 0$ and market clearing fails, the exchange of used goods is more akin to donation than to market trade.

The above equilibrium is potentially consistent with the reality of apparel donations to thrift stores and other organizations, which are typically of the low-quality type mentioned above. Anecdotal evidence suggests that only a small share of the donated items is sold at the stores, much is sold in developing countries, and a significant portion ends up being downcycled, incinerated, or landfilled (e.g., Cobbing et al., 2022). This could reflect the mix of "sales" and waste in our model.[9] Another interpretation, however, is that donations often constitute unavoidable waste. In fact, the fast fashion that enters the donation ecosystem is not designed to last, so many items may no longer be socially useful.

[9] While our model predicts a used price of zero when there is excess supply, thrift stores typically have positive prices. Transaction costs can account for this difference. Suppose, for instance, that donating items requires an effort cost of e per item. Then, an equilibrium analogous to that above features $p_u^* = e$.

If socially responsible consumers are more numerous (II), their demand for used products pushes the used price p_u^* above zero. As in the previous subsection, the prospect of a higher resale price raises the total consumption of selfish types relative to that without the secondary market. This means that the effect of the secondary market is in general ambiguous.

In particular, Part B establishes that the secondary market can be doubly harmful again, both increasing production and lowering total private consumption utility. To show this, we construct a situation in which the secondary market leads responsible consumers to replace their new purchases with used products, making them privately worse off. To supply these used goods, selfish consumers inefficiently increase their own consumption of new goods. Furthermore, since the goods are quite fragile, satisfying responsible types' thirst for used goods requires a large volume of new purchases by selfish types. As a result, production is higher than without the secondary market.

3.3 Dumping Unpalatable Goods

Finally, we assume that $l > (1-f)(P+\kappa)$. This means that it is optimal to replace used goods with new even taking social responsibility into account.

Then, both selfish and responsible consumers strictly prefer new goods over used goods for any $p_u \geq 0$. Thus, there cannot be trade on the secondary market, and we get:

Observation 1 (Irrelevant Secondary Market)**.** *In any strict equilibrium,* $p_u^* = 0$*. Production and welfare are identical to those without the secondary market.*

4 Heterogeneity in Consumption Utility

In this section, we discuss some implications of relaxing our assumption that all consumers have the same consumption utility. We start from a baseline case in which all consumers are selfish, and fractions h and $1-h$ have disutilities from used consumption equal to $l > 0$ and 0, respectively, where $l < (1-f)P$. The former consumers could, for example, be high-income consumers who dislike used products, with the latter being low-income consumers who focus on prices.

Negative interaction with social responsibility In any strict equilibrium with a secondary market, $(1-f)P-l < p_u^* < (1-f)P$, low-income consumers buy used goods, high-income consumers buy new goods, both types' consumption is strictly higher than without the secondary market, and production is also higher. With no production externalities, this raises social welfare through the classical allocative benefit of the secondary market: that it channels used goods to consumers who value them relatively higher. When there are externalities, this allocative benefit is still present, but the externality from higher production lowers or reverses it.

Furthermore, the negative interaction between secondary markets and social responsibility we have identified in Section 3 is still operational. First, suppose that low-income consumers become socially responsible. This lowers consumption without the secondary market, but since used consumption does not increase production, it leaves consumption with the secondary market unchanged. Hence, the secondary market lowers the value of social responsibility and vice versa.

Second, suppose that high-income consumers become socially responsible with $k = \kappa > l/(1-f)$.

Observation 2. *In any strict equilibrium, we have $p_u^* > (1-f)P$, high-income consumers buy used goods, and low-income consumers buy new goods. Production is strictly higher, and social welfare is strictly lower, than without the secondary market.*

In equilibrium, high-income consumers buy used goods to avoid generating an externality, thereby raising used prices and encouraging low-income consumers to buy new. This means that the secondary market raises the total consumption of both types, increases production, and also *worsens* the allocation in the economy. In particular, if $p_u^* \approx (1-f)P$, then low-income consumers benefit minimally from the secondary market, while high-income consumers are (privately) harmed, despite consumption and production increasing. Furthermore, it is easy to show that the increase in production can be arbitrarily large and larger than with selfish consumers. Indeed, as κ becomes large, responsible consumers' total consumption without the secondary market declines, but their total consumption with the secondary market remains unchanged.

Cross-market effect We conclude our analysis of the basic model by discussing a case that both motivates the necessity of the general framework below and illustrates another implication of social responsibility. Suppose that high-income consumers are responsible with $k = \kappa$ satisfying $l > (1-f)(P+\kappa)$. Our analysis in Section 3 implies that if h is sufficiently high, then there is a strict equilibrium with $p_u^* < (1-f)P$. Consider, however, what happens when h is low. Then, low-income types' demand for used goods exceeds high-income types' supply even at the maximum used price the former are willing to pay, $p_u^* = (1-f)P$. For the markets to clear, therefore, low-income consumers must buy both goods. As a result, a strict equilibrium does not exist.

Instead, a new type of steady-state competitive equilibrium arises, in which $p_u^* = (1-f)P$ and low-income consumers are indifferent between one unit of the used good and $1-f$ units of the new good (which generate the same consumption utility). Then, if a consumer buys a used product, she decreases the supply available to others by one unit, leading the indifferent low-income types to purchase $1 - f$ more units of the new product. By the same logic, increasing used supply by one unit lowers production by $1 - f$ units. Consequently, the total production impacts of new and used consumption in a period are $r_n^* = f$ and $r_u^* = (1 - f)f$. Indeed, for instance, a consumer can increase new consumption in a period by buying a new product in that period and selling it used in the next period. The former raises production by a unit, but the latter lowers it by $1 - f$ units.

This example highlights that to define steady-state competitive equilibrium in general, it is natural to allow for purchases of a used good to increase contemporaneous production. Our general model below allows for such a cross-market effect. While cross-market effects leave the main qualitative insights unchanged, they do introduce new effects, of which we explain one:

Observation 3. *There is a $\overline{h}$ such that if $h < \overline{h}$, then there is a steady-state competitive equilibrium with $p_u^* = (1 - f)P$, $r_n^* = f$, and $r_u^* = (1 - f)f$. In this equilibrium, the secondary market strictly increases the total consumption of high-income types, leaves the total consumption of low-income types unchanged, strictly increases production, and strictly lowers social welfare.*

The secondary market is harmful because it encourages high-income types to consume more new goods through two channels. The first one is familiar: the relatively high resale price p_u^* makes new purchases more attractive financially. The second consideration is new. High-income consumers know that by selling used products, they lower new purchases by low-income consumers. Exactly because they are socially responsible, this further encourages new consumption. In particular, consumption and production are discontinuously higher than in a strict equilibrium with $p_u^* \approx (1 - f)P$. A high-income person may, for instance, more fully indulge her desire for new fashion because others will later buy her used clothes instead of new ones.

5 Generalization and Robustness

In this section, we generalize our model in two major ways. First, we allow for a general distribution G of social coefficients k, imposing only that G is supported on a finite interval $[\underline{k}, \overline{k}]$, on which it has continuous positive density g. Second, we look for all steady-state competitive equilibria, not just strict equilibria. We show that our main insights survive.

5.1 Definition of Consistency

We precisely define the notion of consistency introduced in Section 2, still building on Kaufmann et al.'s (2024) framework for competitive equilibria with vanishingly small consumers. Informally, r_n^* and r_u^* are consistent if consumers who take r_n^* and r_u^* as given respond in a way that generates r_n^* and r_u^*. To flesh out what this means, we take the following steps. (a) We use consumers' utility functions to determine per-period demand given r_n^* and r_u^*. (b) We model the effects of an individual's purchases — which are vanishingly small relative to the market — through small shifts in the preceding demand. In Appendix B, we present and modify part of Kaufmann et al.'s analysis to motivate such a definition of a consumer's impact. (c) We sum the market-balancing production effects of a small individual's current new and used consumption, and require that they equal r_n^* and r_u^*, respectively.

Formally, we say that r_n^* and r_u^* are consistent if all of the following hold. (a) The consumer's objective $U_k(c_n, c_u)$ defined in (1) has a maximum for each k on the support of G. This implies that in combination with G, consumer optimization generates a per-period per-person gross demand curve $(D_n(p_u), D_u(p_u)) = E_G\left[\arg\max_{c_n, c_u} U_k(c_n, c_u)\right]$, which in general is a correspondence. (b) For a shift in the *current* curve to $(\Delta_n + D_n(p_u), \Delta_u + D_u(p_u))$, the current market-balancing p_u and production are unique in a neighborhood of the equilibrium values $\Delta_n = \Delta_u = 0$ and steady-state level of gross used supply, and at the equilibrium values they are differentiable in Δ_n and Δ_u.[10] Any change in production also changes future used supply, whose effect equals minus the effect of a shock to used demand. Recursively, therefore, differentiability of the contemporaneous effects implies that production in each future period is also differentiable in Δ_n and Δ_u. (c) The intertemporal sums of the derivatives of production with respect to Δ_n and Δ_u exist, and equal r_n^* and r_u^*, respectively.

5.2 Harmful Secondary Markets

We now analyze our model when $l = 0$. Our methodology applies equally well, but the analysis is notationally more cumbersome, if $0 < l < (1 - f)P$. Our main result is:

Proposition 3 (Secondary Markets are Weakly Harmful)**.**

[10] The above uniqueness and differentiability hold whenever the market-balancing p_u and production are fully determined by market forces, i.e., when either $p_u^* > 0$, or $p_u^* = 0$ and almost all consumers have a strict preference between the products. Below, we briefly consider what happens with an alternative requirement for the case of $p_u^* = 0$ and indifference.

I. There is a steady-state competitive equilibrium in which $p_u^* = (1-f)P$, $r_u^* = (1-f)r_n^* = (1-f)f$, *and all consumers are indifferent between new and used goods. Each consumer's total consumption and social welfare are identical to that without the secondary market.*

II. In any other steady-state competitive equilibrium, $(1-f)P < p_u^* < P$, $r_u^* < (1-f)r_n^*$, *and almost all consumer type k's total consumption is strictly higher, while social welfare is strictly lower, than without the secondary market.*

III. The latter type of equilibrium does not exist if $g(k)$ *is sufficiently high for all* $k \in [\underline{k}, \overline{k}]$. *Fixing the other primitives, for any* G *there is a* $\hat{G}$ *arbitrarily close in the sup norm such that with* k *distributed according to* $\hat{G}$, *the latter type of equilibrium exists.*

By Part I, there is always an equilibrium that replicates outcomes without the secondary market. For an intuition, consider individuals' decision between consuming a unit of the used good and consuming $1-f$ units of the new good — which yield the same private consumption utility. If these two options also generate the same impact on production ($r_u^* = (1-f)r_n^*$), then everyone is indifferent between them, so that the secondary market equilibrates at the price $p_u^* = (1-f)P$ following any small shock Δ_n or Δ_u. As a result, a single individual's marginal effect on prices and hence others' total consumption is zero. Since the supply of used products is fixed, buying a unit of the used product and buying $1-f$ units of the new product must therefore raise production by the same amount ($r_u^* = (1-f)r_n^*$). This implies both that consistency is satisfied, and that an individual has the same incentives as without a secondary market — where any marginal consumption comes from new items — so she consumes the same total amount.

Part II says that if any other equilibrium occurs, welfare is lower than without the secondary market. Generalizing the logic from Section 3.1, a one-unit used-good purchase has a lower effect on production than a $1-f$-unit new-good purchase ($r_u^* < (1-f)r_n^*$). This fosters used consumption by more responsible types, pushing up the used price p_u^*. At the same time, less responsible types purchase new goods, and are encouraged in doing so by the relatively high level of p_u^*.

Part III states that the second, inferior kind of equilibrium does not exist if the distribution G of social coefficients k is sufficiently dense everywhere, but it always exists for some distributions close to G. If the density $g(k)$ is large everywhere, a small increase in the used price p_u pushes many consumers toward new goods, so that r_u^* is close to $(1-f)r_n^*$. But with everyone having similar social coefficients and the two products having similar impacts on production, the premium on used products cannot be maintained. Hence, for the inferior equilibrium to exist, $g(k)$ must be sufficiently small at least within a range, for instance due to a bimodal or widely dispersed distribution of k.

The range necessary to ensure existence of an inferior equilibrium can be arbitrarily narrow.

The proof of Proposition 3 proceeds by reformulating the conditions of steady-state competitive equilibrium in terms of the derivative of *current* production with respect to Δ_u. We denote this contemporaneous cross-market effect of used consumption on production by Q_c^*, which is also the negative of the derivative with respect to current used supply. We explain here how to write r_n^* and r_u^* as a function of Q_c^*, which allows us to characterize equilibrium in terms of a single implicit equation in Q_c^*. Indeed, let us trace out the effect of increasing today's production by one marginal unit on total production over time. This quantity is r_n^*; and since raising current used consumption by a unit raises current production by Q_c^* units and affects future production only through this channel, we have $r_u^* = Q_c^* r_n^*$. Now if current production rises by one unit, used supply next period rises by one unit. Hence, production next period decreases by Q_c^* units. Combining these effects, used supply in two periods rises by $(1-f) - Q_c^*$ units. This lowers production in two periods by $Q_c^*((1-f) - Q_c^*)$ units. Continuing this logic, the total impact of raising current production by one unit is

$$r_n^* = 1 - Q_c^* - Q_c^*(1-f-Q_c^*) - Q_c^*(1-f-Q_c^*)^2 - \cdots = 1 - \frac{Q_c^*}{1-(1-f-Q_c^*)} = \frac{f}{f+Q_c^*}. \quad (4)$$

The logic behind Proposition 3 has the interesting implication that outcomes may be non-monotonic in the population's overall degree of social responsibility:

Proposition 4. *Fix all primitives other than G and u, and take any $\epsilon > 0$ and $W > 0$. There are u, G_l, and G_h such that G_h first-order stochastically dominates G_l, and:*

(i) if $G = G_l$, then only the equilibrium in Part I of Proposition 3 exists;

(ii) if $G = G_h$, then there are at least two equilibria, with social welfare being within ϵ of that with $G = G_l$ in the best equilibrium and at least W lower in the worst.

The proposition says that an increase in the population's social coefficients can substantially lower welfare in the worst equilibrium without much affecting welfare in the best equilibrium. To see this, suppose that we start from a single-peaked distribution for which only the good equilibrium exists, and consider a slight increase in a small share's social coefficients that makes the distribution bimodal. As a result, an equilibrium may arise in which used consumption has a small effect on production, and almost all individuals consume more. Intuitively, if all consumers have similar social coefficients, then a meaningful secondary market cannot be maintained. But if some are more responsible, a market may arise in which these consumers buy from less responsible ones, raising everyone's consumption and production.

5.3 Beneficial Secondary Markets

We now assume that $l > (1-f)P$ — i.e., used goods are privately unpalatable — and show that the logic of the potential beneficial equilibrium with secondary markets applies unchanged. To do so, we look for an equilibrium in which $p_u^* = 0$ and there is an excess supply of used goods, yielding $r_u^* = 0$ and $r_n^* = 1$. Then, individuals with k satisfying $(1-f)(P+k) < l$ prefer new goods, consuming an amount c_k^* satisfying $u'(c_k^*) = P + k$ in each period. In contrast, individuals with k satisfying $(1-f)(P+k) > l$ prefer used goods, consuming an amount c_k^* satisfying $(1-f)u'((1-f)c_k^*) = l$ in each period. Using this to express that supply exceeds demand gives:

Proposition 5. *There is a steady-state competitive equilibrium with $p_u^* = 0$, $r_u^* = 0$, and $r_n^* = 1$ if and only if*

$$\int_{\underline{k}}^{l/(1-f)-P} u'^{-1}(P+k)g(k)dk > \frac{f}{1-f} \cdot \Big(1 - G\left(l/(1-f) - P\right)\Big)u'^{-1}\Big(l/(1-f)\Big).$$

In this equilibrium, production is strictly lower, and social welfare is strictly higher, than without the secondary market.

5.4 Equilibrium Non-Existence

To conclude our analysis, we return to the setting of Section 3.2: we assume that shares g and $1-g$ of consumers have $k = 0$ and $k = \kappa$, respectively, and $(1-f)P < l < (1-f)(P+\kappa)$. We do so to identify and discuss a potential non-existence of steady-state competitive equilibrium, and how the non-existence can be resolved.

Proposition 6. *Let $\underline{g}$ be as defined in Proposition 2. If $g < \underline{g}$, then a steady-state competitive equilibrium does not exist.*

If the share of socially responsible consumers is high, then — extending Proposition 2's result on strict equilibria — there is no equilibrium of any kind. Since responsible consumers have demand that exceeds used supply, in any equilibrium some of them must buy new goods, while others buy used. This would, however, create a free-riding situation in which responsible consumers strictly prefer to buy new and let others buy used, contradicting equilibrium. More precisely, if responsible consumers bought both new and used goods, they would have to be indifferent between a unit of the used good and $1-f$ units of the new good. Then, due to the cross-market effect, new production would not depend on which option a person chooses: if she buys one unit of the used good, she depletes used supply, so that others buy $1-f$ more units of the new good. Hence, for any $p_u \geq 0$ the person strictly prefers new goods.

Equilibrium does, however, exist under a minor relaxation of our requirements. Recall from Section 5.1 that equilibrium requires the market's reaction to a consumer's purchases to be uniquely determined by preferences and market balance. This is not satisfied when $p_u^* = 0$ and responsible consumers are indifferent between the two products, ruling out such equilibria. But it is natural to allow other ways of tying down trade in this specific situation. As an example, we can introduce the equilibrium object $\rho \in [0,1]$, which equals the effect of an individual's used consumption on others' used consumption. Such an effect can arise if a consumer looks for used goods through (costless) search, and her success rate depends on others' search intensities. As a result, a fraction $m(\rho)$ of gross used supply is consumed, where $m(\cdot)$ is a function exogenously determined by the environment.[11] Used items not consumed by anyone are discarded. Then, an equilibrium exists for any $g < \underline{g}$, and satisfies $p_u^* = 0$ and $(1-f)(P+\kappa) = \kappa(1-f)\rho^* + l$.[12] Intuitively, the free-riding problem above induces responsible types to lower used consumption and thereby reduce the used price to zero as well as waste some used products ($\rho^* < 1$). The resulting market slack makes responsible types indifferent between the products, ensuring that at least some used goods are consumed. Notice that $\rho^* = (P+\kappa-l/(1-f))/\kappa$ as well as $m(\rho^*)$ can be arbitrarily low. Therefore, the level of production can be higher than without the secondary market. The harmful effect now occurs because the secondary market facilitates free-riding. This example also demonstrates that an equilibrium used price of zero does not guarantee that the secondary market raises welfare.

6 Conclusion

Our analysis suggests several questions for future research that can be studied with modifications of the techniques we have developed. Most importantly, while we have considered the welfare effects of secondary markets, we have not analyzed policy interventions. It would be natural to study how primary-market policies, such as taxes, caps, or carbon tariffs, interact with the effects we have found, and to explore potential policies that are specific to the secondary market. As an example,

[11] A simple specification is $m(\rho) = \rho$: the group of responsible types consumes a share ρ of total used supply, and similarly, changing the amount of used goods available to others by a unit through buying or selling changes others' used consumption by ρ. In general, these marginal and average effects could be different.

[12] The latter imposes that a responsible consumer is indifferent between consuming $1-f$ units of the new good and 1 unit of the used good. The current disutility from $1-f$ units of the new good is $(1-f)(P+\kappa)$, and that from a used good is $\kappa(1-f)\rho^* + l$, where the first term comes from the cross-market effect $(1-f)\rho^*$ of used consumption on others' new consumption. Either choice increases future used gross supply by $1-f$ units, so their impacts on the future are identical.

some public or non-profit organizations distributing used goods may make a policy of charging no or minimal prices, and rationing if there is excess demand. On the one hand, this may improve outcomes by ruling out one main welfare- decreasing mechanism we have found, that a high used price encourages new purchases. On the other hand, it can lead to perverse effects of both new and old kinds. In particular, the knowledge that her donations will reduce new purchases by others encourages a responsible consumer to buy more new goods, while the availability of free goods encourages a recipient to consume more used goods.

There are also some ingredients that are natural and straightforward to add to our framework. One example is the inclusion of naive or deontological consumers, who believe that buying a new good is harmful or morally wrong, while buying a used good is not. As a first pass, these consumers generate similar effects as our rational consequentialist ones; in a strict equilibrium, for instance, they behave the same way. Moreover, we conjecture that market interaction between the different types of consumers can introduce further welfare-decreasing effects. Consider, for instance, a population of rational and naive consequentialist consumers with $l = 0$. If most are rational, then naive consumers are encouraged to buy used goods by a low used price p_u. And if most are naive, then rational consumers are doubly encouraged to sell used, and thus buy new, goods: first to obtain a high resale price p_u and second to lower naive consumers' new purchases.[13]

Going further, while we have considered resale, we have ignored recycling of used products. Recycling raises the novel issue of how consumers think about the recycled content of new goods, and more generally how they evaluate their impact in an economy with intermediate inputs. For instance, a consumer's purchase can affect the externality by changing the mix of inputs in the production of other units. Similarly, while we have taken the fragility f of products to be exogenous, it is fruitful to ask how this will be determined when the choice is endogenous. As an immediate point, socially responsible consumers dislike the harm they cause by replacing broken items, so they tend to prefer more durable products. But durability choices when consumers with different social coefficients or beliefs interact appears to be a non-trivial equilibrium phenomenon.

Finally, there are relevant questions that call for more fundamental modifications of our theory. Perhaps most importantly, our framework ignores socially responsible consumers' potential motive to alter the beliefs of firms, investors, innovators, and policymakers. In general, a consumer may buy expensive green products to signal that bringing these to the market is worth it. And in the

[13] One may also analyze other types of consequentialist motives, such as a preference to reduce premature waste rather than new production. We conjecture that such consumers can only raise the value of the secondary market.

context of secondary markets, a consumer may be reluctant to raise the price of used goods, lest she encourages future purchases of new goods. This can motivate responsible consumers to buy fewer or supply more used goods. To account for such motives, it is necessary to integrate uncertainty and inferences into our framework.

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A Proofs

Throughout the following proofs we will measure the total consumption of consumers and of the population in units of *new consumption*, denoted by $c_k := c_{k,n} + (1-f)c_{k,u}$. Since a unit of the used good has the same utility — absent the distaste factor l, which wee incorporate elsewhere — as $1-f$ units of the new good, it is rescaled. Denoted by $\hat{c}_u := (1-f)c_u$ units of rescale used goods. Now, rewrite the consumers' utility function (1) as $U_k(c_n, \hat{c}_u) = u(c_n + \hat{c}_u) - e_n^k c_n - e_u^k \hat{c}_u$ where $e_n^k = P - p_u^* + r_n^* k$ and $e_u^k = (1-f)^{-1}(l + p_u) - p_u^* + (1-f)^{-1} r_u^* k$, which do not depend on consumption choices. Using this rewriting, consider the policy function $C : \mathbb{R}_{>0} \to \mathbb{R}_{>0}$ that solves $u'(C(e)) = e$ for any $e > 0$. Given this specification optimal consumer behavior is straightforward (it's like a selfish consumers decision of non-durable perfect substitutes with different prices) and characterized as follows.

Fact 1. *In any equilibrium with a secondary market (1) if $e_n^k < e_u^k$, then the person strictly prefers new goods, and consumes $c_n = C(e_n^k)$ units of new goods; (2) if $e_n^k > e_u^k$, then she strictly prefers used goods, and consumes $\hat{c}_u = C(e_u^k)$ units of rescaled used goods or $c_u = (1-f)^{-1}C(e_u^k)$ units of used goods; and (3) if $e_n^k = e_u^k$, then she is indifferent, and consumes $C(e_u^k) = C(e_n^k) = c_n + \hat{c}_u$ in some combination.*

The bounds on l and k in the main text ensure the following, which we use implicitly throughout:

Fact 2. *Without the secondary market everyone consumes more than socially optimal. Moreover, consumption of used goods generates more welfare than throwing them.*

The next supporting lemma compares the total consumption with vs without a secondary market.

Lemma 1. *The total consumption of a consumer who is indifferent in an equilibrium with a secondary market is the same as without a secondary market. The total consumption of a consumer who strictly prefers either used or new goods is weakly higher and always strictly so if they consume used and new goods without the secondary market.*

Proof. Consider the following consumption plan. When buying 1 unit in total consumption $(c_n+\hat{c}_u)$, buy a fraction f of new and $1-f$ unit of rescaled used consumption. The effective price of this bundle is $fe_n^K + (1-f)e_u^k$, which equals

$$f(P - p_u^* + r_n^* k) + (1-f)((1-f)^{-1}(l + p_u) - p_u^* + (1-f)^{-1} r_u^* k) = fP - p_u^* + p_u + l + k(fr_n^* + r_u^*).$$

Now, in equilibrium $p_u = p_u^*$ and either $r_n^* = 1$ and $r_u^* = 0$ (in strict equilibria) or $r_n^* = \frac{f}{f+Q_c^*}$ and $r_u^* = \frac{Q_c^* f}{f+Q_c^*}$ (with a type distribution). In both cases, $fr_n^* + r_u^* = f$.

Therefore, the effective price is $f(P + k) + l$, the same as for a unit of consumption without secondary markets for the case when the consumer does not throw away used goods without a secondary market. In that case, a consumer can replicate any decision possible without a secondary market in any equilibrium with a secondary market. Moreover, this consumption bundle is optimal with secondary markets if and only if the consumer is indifferent between used and new goods, i.e., $e_n^k = e_u^k$. If instead $e_n^k > e_u^k$ or $e_u^k > e_n^k$, then the person can obtain a strictly lower effective price and thus consumes strictly more in total.

A consumer that throws used goods without a secondary market, can still only consume new and weakly benefits from $p_u^* \geq 0$ and the weakly lower externality impact. Hence, they consume weakly more with a secondary market.

□

Furthermore, the following lemma relates consumption and production.

Lemma 2. *Suppose that $l < (1-f)P$. If with the secondary market everyone's consumption is weakly higher than without and a positive share's consumption is strictly higher, then production is strictly higher.*

Proof. Without secondary markets, as $l < (1-f)P < (1-f)(P+k)$ with $k \geq 0$, all types prefer to keep used goods. Thus no goods are thrown away and in the steady state consumers exactly replace the fraction f of lost value each period by new products. Hence, production equals f times consumption. In any steady state equilibrium with secondary market, production has to be at least f times overall consumption: Again, consumed goods lose a proportion of f of their value the next period. To keep consumption levels steady (as required by equilibrium), at least that proportion of consumption has to be replaced by new goods. Thus, in the steady state, per production has to be at least f times steady state consumption. If consumption for all consumers is individually weakly higher and strictly for a positive mass with secondary market, then overall consumption is strictly higher. Finally, new production with a secondary market (being weakly higher than f times total consumption) is therefore strictly higher than production without secondary markets (equaling f times the total consumption without secondary markets, which is strictly lower). □

Proof of Proposition 1. With a secondary market and socially responsible consumers, a candidate separating equilibrium requires $(1-f)P < p_u^* + l < (1-f)(P+\kappa)$. Since $r_u^* = 0$ and $r_n^* = 1$, the first condition is equivalent to selfish strictly preferring new good. The second condition is equivalent to responsible ones strictly prefer used. Finally, the no-arbitrage condition $p_u^* < P$ implies that $(1-f)P - l < p_u^* < \min\{P, (1-f)(P+\kappa) - l\}$ is necessary in any strict equilibrium.

Next, since both consumer types prefer a type of good strictly, by Lemma 1 both consume strictly more and by Lemma 2 production is strictly higher. Since no used goods are wasted in either case and production is strictly higher, welfare is strictly lower with a secondary market.

Finally, the separating equilibrium exists if and only if g is such that the market-clearing condition holds.Consumers buying used demand $(1-f)^{-1}C((1-f)^{-1}l+\frac{f}{1-f}p_u^*)$ units of used goods and supply $(1-f)$ times that amount from their last periods consumption. Consumers preferring new consume $C(p-p_u^*)$ of new goods and supply that amount in used goods from their last period consumption. Hence, market clearing is given by $gC(p-p_u^*)=(1-g)\frac{f}{1-f}C((1-f)^{-1}l+\frac{f}{1-f}p_u^*)$ or $\frac{g}{1-g}=\frac{f}{1-f}\frac{C((1-f)^{-1}l+\frac{f}{1-f}p_u^*)}{C(P-p_u^*)}$. Notice that the right hand side of this equation is continuous and strictly decreasing in p_u^*. Now let $\underline{g}$ be such that this equation holds for $p_u^*=\min\{(1-f)(P+\kappa),P\}$ and $\bar{g}$ such that the equation holds with $p_u^*=(1-f)P-l$. We have $\underline{g}$, $\bar{g}\in(0,1)$, since the left-hand side is always finite and strictly positive. By the intermediate value theorem, for any g in between market clearing will be satisfied for some p_u^* in the admissible range. For any g equal or outside, market clearing would only be satisfied for a price that we already ruled out.

Proof of Proposition 2. A. First, we will identify which good the selfish and the responsible consumers buy. Since in every equilibrium $p_u^*\geq 0$ and $P<l$ is assumed, selfish ($k=0$)) consumers face effective prices $e_n^k=P-p_u^*\leq P<l\leq l+(1-f)^{-1}p_u^*-p_u^*=e_u^k$ and choose new. In any strict equilibrium $r_n^*=1$ and $r_u^*=0$, and thus socially responsible ($k=\kappa$) consumers prefer new iff

$$e_n^k=P-p_u^*+\kappa<(1-f)^{-1}l+(1-f)^{-1}p_u^*-p_u^*=e_u^k \iff (1-f)(P+\kappa)-l<p_u^*.$$

Notice that $(1-f)(P+\kappa)-l>0$ is assumed and hence socially responsible consumers prefer used when $p_u^*=0$. If they don't prefer used, then no consumers prefer used and there is an oversupply which is only consistent with $p_u^*=0$. Therefore, in any potential strict equilibrium $p_u^*\in[0,(1-f)(P+\kappa)-l)$ socially responsible consumers strictly prefer used buying $(1-f)^{-1}C(((1-f)^{-1}l+\frac{f}{1-f}p_u^*)$ units while selfish consumers strictly prefer new goods and buy $C(P-p_u^*)$ units.

As in in the proof of Proposition 1, market clearing is given by $\frac{g}{1-g}=\frac{f}{1-f}\frac{C((1-f)^{-1}l+\frac{f}{1-f}p_u^*)}{C(P-p_u^*)}$ here the right hand side is continuous and strictly decreasing in p_u^* and the left hand side is strictly increasing in g. Now, let $\bar{g}$ be such that $\frac{\bar{g}}{1-\bar{g}}=\frac{f}{1-f}\frac{C((1-f)^{-1}l)}{C(P)}$ and $\underline{g}$ be such that $\frac{\underline{g}}{1-\underline{g}}=\frac{f}{1-f}\frac{C((1-f)^{-1}l+\frac{f}{1-f}p_u^+)}{C(P-p_u^+)}$, where $p_u^+=(1-f)(P+\kappa)-l$.

I. If $g\in(\bar{g},1)$, then at $p_u^*=0$ the market clearing condition gives $\frac{g}{1-g}>\frac{\bar{g}}{1-\bar{g}}=\frac{f}{1-f}\frac{C((1-f)^{-1}l)}{C(P)}$. Hence there is oversupply, so that $p_u^*=0$ is an equilibrium. It is also clear that every $p_u^*>0$ leads to oversupply, and thus can't be part of an equilibrium. Selfish are consuming the same amount as without secondary markets, so their contribution to production is the same. Socially responsible consumers consume some new goods without a secondary market, whereas with a secondary market they consume none. Hence, their contribution to production is strictly lower. Moreover, since they strictly prefer used they also consume strictly more in total than without secondary markets by Lemma 1.

Overall, individual consumption levels are weakly higher and production strictly lower, and therefore welfare is strictly higher.

II. When $g \in (\underline{g}, \bar{g})$, then $\frac{g}{1-g} \in (\frac{\underline{g}}{1-\underline{g}}, \frac{\bar{g}}{1-\bar{g}})$. By the intermediate value theorem, there exists a unique $p \in (0, p_u^+)$ s.t. $D(p_u^*) = S(p_u^*)$ and thus market clearing holds. Since both consumers strictly prefer one type of good, both consumer types consume strictly more than without a secondary market by Lemma 1.

III. If $g < \underline{g}$, then $\frac{g}{1-g} < \frac{\underline{g}}{1-\underline{g}} < \frac{f}{1-f} \frac{C((1-f)^{-1}l + \frac{f}{1-f} p_u^*)}{C(P-p_u^*)}$ for any admissible p_u^*. Hence, for any possible price, there would be an undersupply of used goods, which is impossible.

B. Take any $p_u^* \in (0, (1-f)(P+\kappa) - l)$. We show that a $u(\cdot)$ exists such that the resulting equilibrium satisfies the statement and has used price p_u^*. We use the following fact:

Fact 3. *Suppose* $0 < c_1 < c_2 < c_3 < c_4$ *and* $e_1 > e_2 > e_3 > e_4 > 0$*. Then, there is a* $u(\cdot)$ *satisfying our assumptions such that* $C(e_m) = c_m$ *for each* $m = 1, 2, 3, 4$*.*

Consider any $M > 0$. By the above fact, for sufficiently small $\epsilon > 0$ we can choose a $u(\cdot)$ such that $C(f(P+\kappa) - l) = M$, $C(\frac{f}{1-f} p_u^* + (1-f)^{-1} l) = M + \epsilon$, $C(P) = M + 2\epsilon$, and $C(P - p_u^*) = M'$, where $M' \equiv (1-g)f(M+\epsilon)/(g(1-f)) > (M+\epsilon)/f > M/f$.

By construction, we are in Case II of Part A, so there is a unique equilibrium. Again by construction, in the equilibrium the used price is p_u^*, responsible types consume $M + \epsilon$, and selfish types consume M'.

Production per period is gM' with the secondary market, and

$$g(M + 2\epsilon) + (1-g)fM < g(M + 2\epsilon) + (1-g)f(M+\epsilon) = g(M+2\epsilon) + g(1-f)M'$$

without the secondary market. Since $fM' > M$, for a sufficiently small ϵ production is higher with the secondary market.

Total net private consumption utility with the secondary market is

$$g(u(M') - PM') + (1-g)(u(M+\epsilon) - l(M+\epsilon)),$$

and without the secondary market it is

$$g(u(M+2\epsilon)-P(M+2\epsilon))+(1-g)(u(M)-(1-f)lM-fPM)$$

For a sufficiently small ϵ, both components are larger than above: the first one because $u(M')-u(M+2\epsilon)<u'(M+2\epsilon)(M'-(M+2\epsilon))=P(M'-(M+2\epsilon))$, and the second one because $l>P$ and $u'(M)$ is finite. □

Proof of Observation 1. Notice that the effective price of a new good is at most $P+\kappa$. Moreover, the lowest effective price for a used good is $(1-f)^{-1}l$. When $l>(1-f)(P+\kappa)$, every consumer will prefer new goods to used goods. Hence, in any strict equilibrium used goods have to be thrown which is only possible when $p_u^*=0$. Moreover, $l>(1-f)(P+\kappa)$ also implies that used goods will be thrown without a secondary market. Hence, production, consumption, and welfare are identical across both settings. □

Proof of Observation 2. Suppose there exists a strict equilibrium. High-income, socially responsible consumers strictly prefer used goods iff $(1-f)(P+\kappa)-l>p_u^*$. Low-income consumers strictly prefer used goods iff $(1-f)P>p_u^*$. Recall that we assumed $l-(1-f)\kappa<0$ and hence, if $p_u^*>(1-f)(P+\kappa)-l$, no consumer buy used goods which contradicts $p_u^*>0$; if $p_u^*<(1-f)P$, both strictly prefer used, in which case there is no supply of used goods and thus no equilibrium. Therefore, $(1-f)P<p_u^*<(1-f)P+\kappa(1-f)-l$, and low-income, selfish consumers strictly prefer new and high-income, socially responsible consumers strictly prefer used goods. Since all consumers strictly prefer one type of good, consumption is strictly higher than without a secondary market by Lemma 1, and (since $l<(1-f)P$) production is strictly higher by Lemma 2. Moreover, the allocation efficiency is lower because used goods are only consumed by high-income consumers who receive additional disutility l while without a secondary market all consumers consume used goods. Since production is higher while allocation efficiency is lower, welfare is strictly lower than without a secondary market. □

Proof of Observation 3. Let us consider a potential equilibrium with $p_u^*=(1-f)P$. Then low-income consumers are indifferent between new and used. We first show $r_n^*=f$ and $r_u^*=(1-f)r_n^*$. Buying a used good today leads a low-income consumer to switch to buying $1-f$ units of the new by indifference. Hence $r_u^*=(1-f)r_n^*$. Next, suppose a consumer buys one new unit today. This causes extra production of one unit today. In addition, this leads to one extra unit of used goods tomorrow, which by the same argument leads a low-income consumer to buy $1-f$ less units of the new good tomorrow. Thus by the third day, the total stock of used is the same again, with the one unit of used depreciating in value by $1-f$, and the reduction in new goods tomorrow by $1-f$ reducing used by the same amount. Hence the total impact on production is $1-(1-f)=f$. Thus $r_n^* = f$, and $r_u^* = (1-f)f$.

For this to be an equilibrium in which low-income consumers buy some amount of new goods, the demand for used goods by low-income consumers must strictly exceed the supply by high-income consumers, i.e., $hC_h < (1-h)\frac{f}{1-f}C_l$, where C_h is the consumption of new goods of high-income (socially responsible) consumers given p_u^* and r_n^*, and C_l the consumption of used goods of low-income (selfish) consumers given p_u^* and r_u^*. Since p_u^* and the r^*'s are fixed, this provides the bound for h. Finally, since high-income consumers strictly prefer new, they consumer strictly more than without secondary markets and since the others are indifferent they have the same total consumption by Lemma 1. By Lemma 2 (using $l < (1-f)P$) this leads to an increase in production. Again, allocation efficiency is also lower and thus welfare is strictly lower than without a secondary market. $\square$

Preparation for Proposition 3 We now turn to Proposition 3. Recall that we assume $l = 0$ for this part. The proof proceeds as described on page 19 by expressing the equilibrium conditions in terms of the cross market effect Q_c^*, where $r_n^* = \frac{f}{f+Q_c^*}$ and $r_u^* = Q_c^* r_n^*$. We now consider when Q_c^* is consistent in equilibrium using the demand and supply in equilibrium as determined in fact 1.

First, consider the case $Q_c^* = 1-f$, so that $(1-f)r_n^* = r_u^*$. Then the impact on the externality per unit of equivalent consumption is the same, and hence all consumers only care about the (monetary) price of goods (applying Fact 1). Hence the market-balancing price p_u must satisfy $p_u = (1-f)P$; otherwise all consumers would strictly prefer one of the two products, violating market clearing. Now, all consumers are indifferent between used and new products, and so raising current used consumption by a unit raises current new consumption, and hence production, by $(1-f)$ units. Thus, this is consistent iff $Q_c^* = (1-f)$.

Next consider $Q_c^* < 1-f$.[14] Let k' be the unique consumer who is indifferent between new and used products ($e_n^{k'} = e_u^{k'}$):

$$k' = (p_u - (1-f)P)\frac{(f+Q_c^*)}{f((1-f)-Q_c^*)}.$$

[14]The case $Q_c^* > 1-f$, is analogous, but the resulting consistence condition will be such that $Q_c^* < (1-f)$ after all which would be a contradiction.

By fact 1, types $k < k'$ buy new and types $k > k'$ buy used. As a result,

$$D_n(p_u) = \int_{\underline{k}}^{k'} c_k g(k) dk \quad \Rightarrow \quad D_n'(p_u^*) = \frac{(f + Q_c^*)}{f((1-f) - Q_c^*)} g(k^*) c_{k^*},$$

where k^* is the equilibrium indifferent type. Similarly, noting that $\partial c_k / \partial p_u = 1/u''(c_k)$,

$$D_n(p_u) = \int_{k'}^{\overline{k}} c_u(k) g(k) dk = \int_{k'}^{\overline{k}} (1-f)^{-1} c_k g(k) dk \quad \Rightarrow$$

$$D_u'(p_u^*) = (1-f)^{-1} \left[-\frac{(f + Q_c^*) g(k^*) c_{k^*}}{f((1-f) - Q_c^*)} + \int_{k^*}^{\overline{k}} \frac{1}{u''(c_k)} g(k) dk \right].$$

By market clearing for used goods, we must have $k^* \in (\underline{k}, \overline{k})$, so $D_u'(p_u^*) < 0$. Since the current supply of used products is fixed, we also have that $\Delta_u + D_u(p_u)$ is constant, so that $\partial p_u / \partial \Delta_u = -1/D_u'(p_u^*)$, yielding $Q_c^* = \partial D_n(p_u)/\partial \Delta_u|_{p_u = p_u^*} = D_n'(p_u^*)/(-D_u'(p_u^*))$. Plugging in the above expressions, we conclude that

$$Q_c^* = (1-f) \left[\frac{(f + Q_c^*) g(k^*) c_{k^*}}{(f + Q_c^*) g(k^*) c_{k^*} - f((1-f) - Q_c^*) \int_{k^*}^{\overline{k}} (1/u''(c_k)) g(k) dk} \right], \tag{5}$$

is the condition on $Q_c \in (0, (1-f))$ to be consistent. Notice that $Q_c = (1-f)$ also satisfies this condition. We obtain the following Lemma, providing an alternative characterization for equilibria:

Lemma 3 (Equilibrium Characterization in Terms of Q_c^*)**.** *The following are equivalent.*

I. *There is a steady-state competitive equilibrium with $p_u^* \geq 0$, consistent externality impacts r_n^* and r_u^* giving rise to the cross-market effect $Q_c^* \in [0, (1-f)]$, a cutoff type $k^* \in (\underline{k}, \overline{k})$ such that types $k < k^*$ buy new and types $k > k^*$ buy used, and consumption levels c_k for $k \in [\underline{k}, \overline{k}]$ given by Fact 1 with $p_u = p_u^*$.*

II. *For (the same) p_u^*, Q_c^*, consumption levels c_k for $k \in [\underline{k}, \overline{k}]$ given by Fact 1 where types $k < k^*$ buy new and types $k > k^*$ buy used:*

1. *The cross-market effect Q_c^* satisfies Equation* (5)*.*
2. *The type k^* is indifferent: $f((1-f) - Q_c^*) k^* = (p_u^* - (1-f)P)(f + Q_c^*)$.*
3. *The secondary market clears: $(1-f) \int_{\underline{k}}^{k^*} c_k g(k) dk = f \int_{k^*}^{\overline{k}} c_k g(k) dk$.*

Furthermore, any steady-state competitive equilibrium is payoff equivalent (for all consumer types as well as social welfare) to one in I.

Proof. **I $\Rightarrow$ II.** Take an equilibrium described in I. Our above derivation establishes that Q_c^* in this equilibrium satisfies Condition (5). Further, we have shown that either $Q_c^* = (1-f)$ and

$p_u^* = (1-f)P$, or there is an indifferent consumer satisfies condition 2; but notice that for $Q_c^* = 1-f$ and $p_u^* = (1-f)P$, all types fulfill that condition, in which case k^* is determined by market clearing. Finally, since consumption levels are the same, market clearing is obvious.

II ⇒ I. Define $r_n^* = \frac{f}{f+Q_c^*}$ and $r_u^* = Q_c^* r_n^*$. Since Q_c^* satisfies Condition (5), the impacts r_n^* and r_u^* generate a cross-market effect equal to Q_c^*, and are consistent. Furthermore, fact 1 implies that if type k^* is indifferent, then types $k < k^*$ weakly prefer the new product, and types $k > k^*$ weakly prefer the used one. Hence, consumer behavior is consistent with equilibrium. Market clearing holds by construction.

We now prove the last statement. Again from our derivation, any steady-state competitive equilibrium implies a $Q_c^* \in [0, 1-f]$. Furthermore, if $Q_c^* < 1-f$, then there is a unique type k^* who is indifferent between new and used products, and types $k < k^*$ strictly prefer new, while types $k > k^*$ strictly prefer used. Hence, the equilibrium is described by I. If $Q_c^* = 1-f$, then $p_u^* = P$, and all consumers are indifferent between new and used products. In this case, each consumer's consumption level and utility are independent of which product she chooses, and so is production and social welfare. Hence, any such equilibrium is payoff-equivalent to one in which we choose k^* such that types $k < k^*$ buy new and types $k > k^*$ buy used, and market clearing holds. □

Proof of Proposition 3.

I. Assuming $Q_c^* = 1-f$ the first equilibrium condition is always fulfilled. The second condition

$$f((1-f) - Q_c^*)k^* = (p_u^* - (1-f)P)(f + Q_c^*) \iff f0k^* = (p_u^* - (1-f)P)1 \iff p_u^* = (1-f)P$$

is independent of k^*, i.e., in equilibrium every consumer is indifferent between new and used goods. Setting $p_u^* = (1-f)P$, the consumption levels given by fact 1 are independent of the type of good consumers consume. Denote the total consumption level by c_k (recall that this means scaling the consumption of used goods by $(1-f)$) and define

$$\Phi(l) = (1-f)\int_{\underline{k}}^{l} c_k g(k)dk - f\int_{l}^{\bar{k}} c_k g(k)dk$$

and notice that it is continuous and strictly increasing with $\Phi(\underline{k}) < 0$ and $\Phi(\bar{k}) > 0$. Hence, there is a unique l^* such that $\Phi(l^*) = 0$. Now setting $k^* = l^*$ ensures that the market clearing condition is satisfied. Since all consumers are indifferent between used and new goods, so is type k^*. This proves the existence of the proposed equilibrium.

Since all consumers are indifferent, their total consumption is as without a secondary market by Lemma 1 and since all used goods are consumed with and without the secondary market, so is welfare.

II. In any other equilibrium $Q_c^* < (1-f)$ so that $r_u^* < (1-f)r_n^*$. We also have that $(1-f)P < p_u^* < P$. The upper bound holds, since otherwise demand of new goods would be infinite. The lower bound holds with weak inequality, since otherwise demand for new goods would be zero and with equality demand is positive only if $Q_c^* = (1-f)$. There is also a unique indifferent consumer and all others strictly prefer one good. Therefore, the indifferent type must be $k^* \in (\underline{k}, \overline{k})$. Hence total consumption of almost all consumers is strictly higher than without a secondary market by Lemma 1. Hence, production is strictly higher by Lemma 2 an, since used goods are consumed either case, welfare is strictly lower than without a secondary market.

III. Let $\underline{g} = \inf\{g(x)|x \in supp(g)\}$.

In order to have an equilibrium with $Q_c^* < (1-f)$, the following condition needs to hold:

$$Q_c^* = \frac{(1-f)(f+Q_c^*)g(k^*)c_{k^*}}{(f+Q_c^*)g(k^*)c_{k^*} - f((1-f)-Q_c^*)\int_{k^*}^{\overline{k}}(1/u''(c_k))g(k)dk} = \frac{(1-f)A}{A+f((1-f)-Q_c^*)B}$$

Note that we moved the minus sign under the integral for convenience, so that both A and B are strictly positive. We will show that there is a $\underline{g}$ sufficiently large s.t. for every $Q_c^* < (1-f)$, the RHS strictly exceeds the LHS. That is, we will show that $Q_c^* < \frac{(1-f)A}{A+f((1-f)-Q_c^*)B}$. Thus, assume that $Q_c^* < (1-f)$, then we have:

$$Q_c^* < \frac{(1-f)A}{A+f((1-f)-Q_c^*)B} \iff Q_c^*A + Q_c^*f((1-f)-Q_c^*)B < (1-f)A$$
$$\iff Q_c^*f((1-f)-Q_c^*)B < ((1-f)-Q_c^*)A \iff Q_c^*fB < A$$

where the last equivalence follows because we assume that $Q_c^* < (1-f)$. Moreover, it is sufficient to show that $fB < A$. Spelling out A and B, we get that this is equivalent to

$$g(k^*) > \frac{f}{(f+Q_c^*)c_{k^*}}\int_{k^*}^{\overline{k}}(-1/u''(c_k))g(k)dk \tag{6}$$

Note that, independent of $\underline{g}$, c_{k^*} is bounded below by $c_{\overline{k}}$ and $f+Q_c^*$ is bounded below by f, so the first LHS term is strictly bounded and we only need to bound the integral. Let $m = \max_{\underline{k},\overline{k}}(-1/u''(c_k))$, which exists and is finite, since the function is continuous and c_k is bounded away from 0 for all k we consider, thus the term doesn't blow up. Hence the integral is strictly less than $\int_{\underline{k}}^{\overline{k}} mg(k)dk = m$. Thus the term on the right in equation (6) is bounded above, so if $\underline{g}$ exceeds this bound, we have no other equilibrium. This proves the first part of III.

Next, consider the following **claim**: For every $q \in [0,(1-f)]$, there is a unique $k(q)$ and $p_u(q)$ such that the indifference condition for $k(q)$ and market clearing are satisfied.

Proof of claim: Let $p_u(q,k)$ be the unique solution to $f((1-f)-q)k = (p_u(q,k)-(1-f)P)(f+q)$. Then we have that $S(q,\underline{k}) = 0$ and $D(q,\underline{k}) = \frac{f}{1-f}\int_{\underline{k}}^{\overline{k}} c_k g(k)dk > 0$, as $c_k > 0$ for all k. Similarly, $S(q,\overline{k}) = \int_{\underline{k}}^{\overline{k}} c_k g(k)dk > 0 = D(q,\overline{k})$. Moreover, $S(q,k)$ is strictly increasing in k, while $D(q,k)$ is strictly decreasing in k: first, the range over which we integrate is increasing for S and decreasing for D. Further, $p_u(q,k)$ is strictly increasing in k. Hence for $k' < k$, we have that $c_{k'}$ is increasing in $p_u(q,k)$, hence the integral - i.e., S – is strictly increasing in k. When $k' > k$, then $c_{k'}$ is decreasing in $p_u(q,k)$, since consumers have to pay the price of the used good. Thus $D(q,k)$ is strictly decreasing in k. Hence there is a unique k s.t. $S(q,k) = D(q,k)$ holds for $p_u(q,k)$. This is $k(q)$, and $p_u(q) = p_u(q,k(q))$, proving the claim.

Now pick any $q \in (0,(1-f))$. Then let $k_0 = k(0)$, and consider some $\varepsilon > 0$. We will construct $\hat{G}$ s.t. $\hat{k}(q) = k(q)$, $\hat{p}_u(q) = p_u(q)$, with $\hat{g}(k(q)) = \varepsilon$. To construct this $\hat{G}$, define

$$H_a(x,\varepsilon) = \begin{cases} 0 \text{ if } x \leq a-\varepsilon \\ 1 \text{ if } x \geq a+\varepsilon \\ \frac{1}{2\varepsilon}(x-a+\varepsilon) \text{ for } x \in (a-\varepsilon, a+\varepsilon) \end{cases}$$

Next we define $\hat{g}$ as follows, for some $\varepsilon_2 > 0$:

$$\hat{g}(x) = g(x) + (g(x)-\varepsilon)\left(H_{k(q)+\lambda\varepsilon}(x,\varepsilon_2) - H_{k(q)-\varepsilon}(x,\varepsilon_2)\right)$$

We will deal later with the fact that $\hat{g}$ is not a probabiliy density integrating to 1.

Except for buffer intervals of size ε_2 at the boundaries, this function equals $g(x)$ outside of $[k(q)-\varepsilon, k(q)+\lambda\varepsilon]$, and equals ε within. In what follows we denote with $R(\varepsilon_2)$ all terms coming from these buffers (this is a slight abuse of notation, since the terms vary). It is straightforward that as $\varepsilon_2 \to 0$ we have $R(\varepsilon_2) \to 0$. We pick λ s.t. market clearing holds under q, $k(q)$, and $p_u(q)$ with the new distribution. This is possible, since the new supply is

$$\hat{S}(q,k(q)) = \int_{\underline{k}}^{k(q)} c_k \hat{g}(k)dg = \left(\int_{\underline{k}}^{k(q)-\varepsilon} c_k g(k)dk + \int_{k(q)-\varepsilon}^{k(q)} \varepsilon c_k dk + R(\varepsilon_2)\right),$$

so that $S(q,k(q)) - \hat{S}(q,k(g)) = \int_{k(q)-\varepsilon}^{k(q)} c_k(g(k)-\varepsilon)dg + R(\varepsilon_2)$. As for the new demand, we have

$$\hat{D}(q,k(q)) = \frac{f}{1-f}\int_{k(q)}^{\overline{k}} c_k\hat{g}(k)dg = \frac{f}{1-f}\left(\int_{k(q)}^{k(q)+\lambda\varepsilon} c_k\varepsilon dg + \int_{k(q)+\lambda\varepsilon}^{\overline{k}} c_k g(k)dg + R(\varepsilon_2)\right)$$

so that $D(q,k(q)) - \hat{D}(q,k(q)) = \frac{f}{1-f}\int_{k(q)}^{k(q)+\lambda\varepsilon} c_k(g(k)-\varepsilon)dg + R(\varepsilon_2)$. Note that $D(q,k(q)) = S(q,k(q))$ by construction of $k(q)$ to satisfy market clearing, so

$$\hat{D}(q,k(q)) - \hat{S}(q,k(q)) = \int_{k(q)-\varepsilon}^{k(q)} c_k(g(k)-\varepsilon)dg - \frac{f}{1-f}\int_{k(q)}^{k(q)+\lambda\varepsilon} c_k(g(k)-\varepsilon)dg + R(\varepsilon_2).$$

For $\lambda = 0$, this difference is strictly positive for sufficiently small ε_2 (depending on ε). For sufficiently large λ, this difference is equal to $\int_{k(q)-\varepsilon}^{k(q)} c_k(g(k)-\varepsilon)dg - \frac{f}{1-f}\int_{k(q)}^{\overline{k}} c_k(g(k)-\varepsilon)dg + R(\varepsilon_2)$, with the terms depending on ε being strictly negative for sufficiently small ε.

Thus for all ε such that this holds, we can find ε_2 small enough and λ large enough so that the difference in demand and supply is given by the above, which is strictly negative. Hence for small enough ε_2, the difference is strictly positive at $\lambda = 0$ and strictly negative at some large λ, and continuous in between, hence there is some $\lambda(\varepsilon)$ such that the difference is 0. Moreover, $\lambda(\varepsilon)\varepsilon \to 0$ as $\varepsilon \to 0$. If this was not the case, then $\hat{D}(q, k(q))$ would be strictly lower than $D(q, k(q))$ as ε and ε_2 converge to 0, yet $\hat{S}(q, k(q))$ converges to $S(q, k(q))$, so that $\lim \hat{D}(q, k(q)) - \hat{S}(q, k(q)) < 0$ as $\varepsilon \to 0$, even though $\hat{D}(q, k(q)) = \hat{S}(q, k(q))$ for all $\varepsilon > 0$. This is a contradiction.

The indifference condition for $k(q)$ is not affected by changes in the distribution and since $\lambda(\varepsilon)$ is s.t. markets clear. Thus we have a new density function $\hat{g}$ s.t. the indifference condition for $k(q)$ and market clearing hold for the old values of $k(q)$ and $p_u(q)$. Moreover $\hat{g}(k(q)) = \varepsilon$.

As mentioned above, this $\hat{g}$ does not integrate to 1, but we can scale $\hat{g}$ by the same factor everywhere, to obtain $a^{-1} \cdot \hat{g}(k)$, where $a = \int_{\underline{k}}^{\overline{k}} \hat{g}(k)dg$, with $a \to 1$ as as $\varepsilon \to 0$. Let $\hat{h}(k) = a^{-1}\hat{g}(k)$. Then the indifference condition and market clearing hold under $\hat{h}$ with the old values of $k(q)$ and $p_u(q)$; the first since it doesn't depend on the distribution, the second since market clearing isn't affected by a multiplicative rescaling of the distribution.

Now we are ready to consider the final equilibrium condition which determines Q_c^*, but to do so for $\hat{h}$ instead of g:

$$Q_c^*(q) \equiv (1-f)\left[\frac{(f+q)\hat{h}(k(q))c_{k(q)}}{(f+q)\hat{h}(k(q))c_{k(q)} - f((1-f)-q)\int_{k^*}^{\overline{k}}(1/u''(c_k))\hat{h}(k)}\right]$$

Note that if we find a q s.t. $Q_c^*(q) = q$, then for this q we have that all the equilibrium conditions hold, and hence we have identified an equilibrium.

It is clear that $Q_c^*(0) > 0$ by plugging in $q = 0$. Moreover, plugging in the value of $q \in (0, (1-f))$ for which we constructed $\hat{h}$, we know that $\hat{g}(k(q)) = \varepsilon$, hence we have

$$Q_c^*(q) \equiv (1-f)\left[\frac{(f+q)\varepsilon c_{k(q)}}{(f+q)\varepsilon c_{k(q)} - f((1-f)-q)\int_{k^*}^{\overline{k}}(1/u''(c_k))\hat{h}(k)}\right]$$

The second term in the denominator, $-f((1-f)-q)\int_{k(q)}^{\overline{k}}(1/u''(c_k))\hat{h}(k)dk$ is strictly positive and strictly bounded away from 0, since market clearing requires that $k(q)$ cannot equal $\overline{k}$. Hence $Q_c^*(q) \to 0$ as $\varepsilon \to 0$, hence there is $\varepsilon > 0$ s.t. $Q_c^*(q) < q$.

But then, since $Q_c^*(q)$ is continuous in q, there must be some $q' \in (0, q)$ s.t. $Q_c^*(q') = q'$, and thus we have an equilibrium with $Q_c^* < (1-f)$. Finally note that $\hat{h}$ and g only differ by an arbitrary small amount except on an arbitrarily small range (where they differ a discrete amount). Hence, a suitable $\hat{H}$ can be chosen arbitrarily close to G. Note that since q was arbitrary, we can pick it arbitrarily small, so that we can ensure that there is such an equilibrium with q', and hence Q_c^*, arbitrarily small. □

Proof of Proposition 4. We first prove that there exists distributions where consumption in the best equilibrium differs by at most ϵ and in the worst equilibrium by at least W, where ϵ is arbitrarily small and W arbitrary large. Moreover, instead of working with the utility function $u(\cdot)$ we will construct the policy function $C(\cdot)$. On any set bounded away from zero and infinity, we can freely choose any function that is strictly decreasing, continuouslydifferentiable, and it will give rise to a utility function satisfying our assumptions.

Now, pick any $\overline{k}$ and $\underline{k}$ with $K > \overline{k} > \underline{k} > 0$ and let δ be (arbitrarily) close to zero. Consider the following $C(\cdot)$: on $[f(P+\underline{k}-\delta), f(P+\overline{k})]$ it is linearly decreasing with $C(f(P+\underline{k}-\delta)) = c$ and $C(f(P+\overline{k})) = c-\varepsilon$; $C(f(\underline{k}-2\delta)) = c^+ > c$; and this is extended smoothly and strictly decreasing on $[f(P+\underline{k}-2\delta), f(P+\underline{k}-\delta)]$.

Let $\hat{G}_h$ be uniformly distributed on $[\underline{k}, \overline{k}]$. Then, let G_h be the distribution (as constructed in the proof of Part III of Proposition 3) that is arbitrarily near to $\hat{G}_h$ in the sup norm, has the same support as $\hat{G}_h$, and for which an equilibrium with Q_c^* arbitrarily close to 0 exists. Let G_l be the uniform distribution on $[\underline{k}-\hat{\delta}, \underline{k}]$ where $\hat{\delta} < \delta$ and, possible by Part III of Proposition 3, sufficiently small that only the equilibrium with $Q_c^* = 1$ exists. It is clear that G_h first-order stochastically dominates G_l and that (i) holds. In the unique equilibrium under G_l consumers face an effective price of $f(P+k)$, where $k \in [\underline{k}-\hat{\delta}, \underline{k}]$. By construction of $C(\cdot)$, overall consumption is a most c.

In the best equilibrium under G_h everyone faces an effective price of $f(P+k)$, where $k \in [\underline{k}, \overline{k}]$. By construction, overall consumption is a least $c-\varepsilon$ and therefore within ε of the equilibrium consumption under G_l.

Consider the equilibrium under G_h with Q_c^* arbitrarily close to 0. In this equilibrium there is an indifferent type $k^* \in (\underline{k}, \overline{k})$, more selfish types prefer strictly new goods and consume $C(P + k - p_u^* - \varepsilon_1 k)$, and more responsible types prefer strictly used and consume $C(\varepsilon_2 k + p_u^* f/(1-f))$. Notice that the social coefficient enters by at most ε_1 and ε_2, which can be arbitrarily small, by picking Q_c^* arbitrarily close to 0.

Let $y = (1-f/2)\underline{k} + f/2\overline{k}$ — i.e., a fraction $1-f/2$ of types are above y and a fraction $f/2$

of types are below y (by near-uniform distribution of G_h). Then if $k^* \leq y$, a fraction $1 - f/2$ of types buy only used. Note that since the indifferent type consumes as much as without a secondary market (by Lemma 1), they face an effective price that is as if without secondary markets, i.e., $f(P + k^*)$. Since consumers with $k > k^*$ buy only used, they face the same effective price plus $\varepsilon_2(k - k^*)$. Hence, they all consume more than $c - \varepsilon_2'$, where ε_2' goes to zero as $\varepsilon_2 \to 0$ and $\epsilon \to 0$. Aggregate used consumption is therefore at least $(1 - f/2)(c - \varepsilon')$. Total consumption equals $1/(1 - f)$ of the aggregate used consumption, thus is at least $\frac{(1-f/2)}{1-f}c - \varepsilon_2''$ (where $\varepsilon_2'' \to 0$ as $\varepsilon_2 \to 0$ and $\epsilon \to 0$). The difference between it an c is at least $\frac{f}{2(1-f)}c - \varepsilon_2''$. Pick $\Delta = f/4(1 - f)$ so that for any ε_2 and ε small enough (as well as G_h near enough to $\hat{G}_h$), this difference is at least Δc.

If instead $k^* > y$, then all types with $k < k^*$ consume new, at an amount $C(P + k - p_u^* - \varepsilon_1 k)$. We know that $p_u^* \approx (1 - f)(P + k^*) > (1 - f)(P + y)$. The effective price of these consumers is $P + k - p_u^* - \varepsilon_1 k < P + k - p_u^*$, and $P + k - p_u^* < f(P + \underline{k}) \iff P + k - (1 - f)(P + k^*) < f(P + \underline{k}) \iff k < f\underline{k} + (1 - f)k^*$. Hence, if k is within at most $1 - f$ of the way between $\underline{k}$ and k^*, the effective price is lower than $f(P + \underline{k})$. Notice that the effective price is linear in k with coefficient close to 1. Hence, it is lower than $f(P + \underline{k} - 2\delta)$ if k is within at most $1 - f - \gamma$ of the way between $\underline{k}$ and k^* for a small γ ($\gamma \to 0$ as $\delta \to 0$). Since k is nearly uniformly distributed on this range, this corresponds to almost a fraction $1 - f$ of types below k^*, which is at least a fraction of $1 - f$ of types below y, i.e., at least $(1 - f)f/2 - \gamma'$ of total types. For sufficiently small δ this is greater than $(1 - f)f/4$. All of these types consume at least c^+ and thus the amount of new consumption is at least $(1 - f) \cdot f/4 \cdot c^+$. Overall consumption is $1/f$ times new consumption and, therefore, overall consumption is at least $(1 - f)/4 \cdot c^+$. Now pick c^+ such that this amount is greater than $(\Delta + 1)c$. Again, overall consumption is at least Δc greater than c.

Since c was arbitrary and Δ independent of c, we can choose it such that $\Delta c > W$. Then, the above shows that in the bad equilibrium consumption is at least W greater than c, which is greater than consumption under the equilibrium in G_l.

Now consider welfare. Notice that in all cases the gain of a unit of additional (compared to a situation without a secondary market) production is at most the additional consumption utility to the type consuming the least. Their benefit is at most the marginal utility at the initial point, which equals their effective price $f(P + \overline{k})$ (independent of all constructions after fixing $\overline{k}$). The social cost of producing equals $(P + K) > f(P + \overline{k})$. Therefore, any extra production lowers welfare by at least that amount, which is strictly positive. Similarly, the maximum welfare loss can be bounded in terms of production. Finally, Lemma 2 shows that production is proportional to consumption and hence the above statement about the comparison of consumption translate into a comparison in welfare. □

Proof of Proposition 5. Consider a candidate equilibrium with $p_u^* = 0$, $r_u^* = 0$, and $r_n^* = 1$. If demand of used equals supply, then a change in used demand by Δ requires that some consumers switch their demand from used to new given the fixed supply of used, hence $r_u^* > 0$. Thus this can be an equilibrium only if there is a strict excess supply of used goods. In this case, an increase in used demand can be absorbed without a price shift, so that it doesn't affect the consumption of any other consumer, showing that $r_u^* = 0$ and $r_n^* = 1$ are consistent. This shows that we have an equilibrium if and only if we have oversupply of used goods. A consumer chooses the new goods if $P + k < \frac{l}{(1-f)} \iff k < \frac{l}{1-f} - P$ and used if the inequality is strict in the other direction, with consumption given by Fact 1: $u'^{-1}(P+k)$ for new and $(1-f)^{-1}u'^{-1}(l/(1-f))$ for used consumption. Since the second group can cover a share $1-f$ of their demand for used via their own consumption of used in the past period, we need that the consumption of new goods strictly exceeds f times the total amount of used goods consumed, i.e., there is an oversupply of used goods if and only if $\int_{\underline{k}}^{l/(1-f)-P} u'^{-1}(P+k)g(k)dk > \frac{f}{1-f} \cdot \Big(1 - G\left(l/(1-f) - P\right)\Big) u'^{-1}\Big(l/(1-f)\Big)$. Notice that all consumers that buy new buy the same amount of new goods as without a secondary market and consumers buying used buy 0 new goods and hence strictly less new goods than without a secondary market. The total consumption of new goods and hence production is strictly lower and therefore welfare is strictly higher. □

Proof of Proposition 6. Proposition 2 part III. shows that there are no strict equilibria. Consider now equilibira where one consumer type is indifferent. Since $p_u^* \geq 0$, selfish consumers always strictly prefer new goods, so that socially responsible consumers must be indifferent for a possible non-strict equilibrium. Then following a shift in demand, the new market-balancing price p_u required for consistency (page 17) must equal p_u^*: if it would change, indifference would be broken, which would change demand non-continuously. Since we require that the impacts arise as a differential, this would not be consistent. Therefore $p_u = p_u^*$ following the shift. Therefore demand cannot change and socially responsible consumers would consume all the remaining used goods and consume the remainder as new. Hence an increase in used consumption would cause responsibly consumers to increase their new consumption by $(1-f)$ units. Therefore, the only consistent impacts r_n^* and r_u^* are such that $r_u^* = (1-f)r_n^*$, so that the per-consumption-unit impact would be the same for used and new products. But then, because $l > (1-f)P$, socially responsible consumers would strictly prefer new goods, a contradiction. Therefore, there can't be any equilibrium with indifferent consumers and hence no equilibrium at all. □

B A Small Consumer's Impact on Production

In this section, we restate the main insight in Section II.A of Kaufmann et al. (2024) in a different way. This motivates our definition of a consumer's impact in Section 2.

For simplicity, we use Kaufmann et al.'s static framework; adapting the analysis to our dynamic setting is notationally heavy, but does not change the logic. To understand a small consumer's impact, we use a "replicator economy:" we introduce identical copies of the other participants, and let the number of copies approach infinity. Suppose, then, that our single individual enters a market with I other consumers and I suppliers. The other consumers all have the same demand curve $D(p)$, and the suppliers all have the same supply curve $S(p)$. Both curves are continuously differentiable, with $D'(p) < 0$ and $S'(p) > 0$ everywhere. There is a price $p^* > 0$ for which $S(p^*) = D(p^*)$.

The market mechanism is the following. First, the individual submits her demand $c \in \mathbb{R}$. Then, the price $p_I(c) > 0$ is chosen to clear the market, i.e., to satisfy $c + ID(p_I(c)) = IS(p_I(c))$; suppose that $p_I(c)$ exists and is unique for all I and c of interest. Finally, the equilibrium quantity $q(c) = IS(p_I(c))$ is produced and consumed.

A vanishingly small consumer's impact on the price is then obviously zero: for any c, $\lim_{I\to\infty} p(c) = p^*$. For her impact on production, note that $c + ID(p_I(c)) = IS(p_I(c))$ is equivalent to $c/I + D(p_I(c)) = S(p_I(c))$, so that $p_I(c) = p_1(c/I)$. Hence, the individual's impact is

$$IS(p_I(c)) - IS(p_I(0)) = \frac{S(p_1(c/I)) - S(p_1(0))}{1/I} = c \cdot \frac{S(p_1(c/I)) - S(p_1(0))}{c/I}$$

Taking the limit yields that a vanishingly small consumer's impact is

$$c \cdot \lim_{I\to\infty} \frac{S(p_1(c/I)) - S(p_1(0))}{c/I} = c \cdot r^*,$$

where r^* is the marginal effect of shifting demand in an economy with representative demand curve $D(\cdot)$ and supply curve $S(\cdot)$ (i.e., the derivative of production with respect to Δ at $\Delta = 0$ when the demand curve is $\Delta + D(p)$ and the supply curve is $S(p)$). Our definition of r_n^* and r_u^* adapts this observation to our more complicated setting.