Macroeconomics and Monetization: Product Innovation, Rent Extraction, and Consumer Welfare in an Agent-Based Macroeconomic Model

Chris Georges

Hamilton College

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Abstract

Capitalist firms allocate resources toward both genuine product innovation and monetization of their products. The latter includes a broad set of strategies for extracting revenue from consumers that need not track improvements in the true usefulness of goods and services. This paper develops an agent-based macroeconomic model in which firms invest in both true product quality and *artificial* quality, while boundedly rational consumers search over a Lancasterian product space to optimize *effective* quality – the sum of true and artificial quality. We illustrate how monetization can reduce consumer welfare by diverting innovation and distorting consumer demand as well as a regime in which monetization can increase consumer welfare.

1 Introduction

Capitalist firms balance investment in the development of new and improved products and investment in the *monetization* of their products – that is, in the capacity to extract revenue from consumers for a given product. Monetization is often discussed in the context of digital platforms, but the phenomenon is considerably more general.

Monetization need not be socially costly. Some of it is necessary or efficiency enhancing under capitalism. For example, investments in the excludability of products can be necessary to make profit driven market exchange possible. However, other forms can be, at best, redistributive and, at worst, actively wasteful or predatory. These can include efforts to build sustained rent extraction through intermediation, monopolization, mergers and acquisitions, and political influence; strategies of taking short-run losses in order to exploit network externalities and switching costs to lock in a user base for later extraction; investments in capturing and holding consumer attention, including the deliberate cultivation of addictive product qualities; and the exploitation of asymmetric information, bounded rationality, and cognitive biases – what Akerlof and Shiller (2015) term "phishing for phools."

Concrete examples are widespread. Firms take losses or make large up-front investments to establish future extraction regimes – a pattern visible for example in platform businesses such as

ride-share, food-delivery services, and AI hosts, various private-equity investments, and electronic marketplaces. Firms invest in excludability through both technology (digital rights management, payment technology, bioengineering) and public policy (lobbying, patenting, copyright) across software, news, film, music, agriculture, and health care. Firms and interest groups convert public goods into private ones, or otherwise enclose commons resources, by lobbying against public provision – see for example tax-preparation software and weather applications. Regulatory capture reduces competition and secures monopoly rents in industries from credit cards to incarceration to transportation. And firms across many sectors invest directly in capturing consumer attention and manufacturing addictive engagement, from social-media algorithms and gaming to gambling, payday lending, and opioid marketing. To the degree that these practices lead ultimately to high prices and fees, the erosion of quality, encroachments on privacy, or poor consumer choices, this process falls under Cory Doctorow's (2025) rubric of "enshittification."[1]

In practice, we generally see a combination of genuine product improvement with a mix of productive and unproductive (or destructive) monetization efforts across firms, industries, and domains. This paper explores, in a formal agent-based macroeconomic setting, how these investments can evolve, and what this mix implies for economic dynamism and consumer welfare.

2 Related Literature

This paper connects three literatures. The first concerns monetization, rent seeking, and misallocation, including Veblen (1904), Baumol (1990), Murphy, Shleifer, and Vishny (1991), Warusawitharana and Zucchi (2022), Heijdra and Heijnen (2025), Naude (2024), Farboodi and Veldkamp (2026), Geloso (2025), Gallay and Geloso (2023), Bowles (2025), and Bowles and Carlin (2021). The second concerns product innovation, income, and inequality, including Jaravel (2019, 2024), Georges (2019), Comin, Lashkari, and Mestieri (2021), Hubmer (2023), and Imas and Madarasz (2024). The third is the agent-based computational economics (ACE) literature on product innovation, consumer choice, income dynamics, and growth, including Chen and Chie (2005), Chie and Chen (2014), Ciarli et al. (2010, 2016), Marengo and Valente (2010), Georges (2011, 2018), Fagiolo and Roventini (2017), Dawid et al. (2018), Colombo, Dawid, and Harting (2024), and Delli Gatti et-al. (2024).

3 Approach

We build directly on the agent-based macroeconomic model of Georges (2011, 2018, 2019), in which growth and business cycles are driven by ongoing, decentralized product innovation and adaptation by firms operating in a Lancasterian product space. There are two classes of consumer/worker – production workers and salaried overhead employees – who consume different bundles of goods

[1] Others (e.g., Parramore (2026), Lazonick and Shin (2020)) have argued that "financialization" has become a powerful catalyst for some of these forms of value extraction in recent years.

subject to nested CES consumer preferences. Firms and consumers exhibit bounded rationality in their adaptation, and the economy is in perpetual disequilibrium.

Our extension here focuses on growth and introduces investment in monetization capacity, which has both direct effects (diverting resources away from true product quality) and indirect effects (altering the information environment in which consumers search and firms innovate) on consumer welfare and economic dynamism.

4 The Model

4.1 Environment

The economy contains $n_{1,t} + n_{2,t} = n$ firms at any point in time t, each producing a single, unique product. Type-1 firms produce for production workers and type-2 firms produce for salaried overhead workers. There are m product characteristics valued by all consumers. All firms employ both variable (production) and overhead labor to meet forecasted demand. There are two representative consumers – one for each worker type – who spend all of their income (wages or salaries, respectively) and search over their own market segment for improved bundles of goods. Prices are set as a fixed markup over marginal cost.

Product innovation depends stochastically on firms' R&D decisions, which are modeled as the outcomes of discrete-choice (DC) social-learning rules. Product innovation improves *true* product quality. Monetization innovation (described further below), by contrast, creates *artificial*, or perceived, product quality; it does not make the product genuinely better, but it does lead to increased consumer demand.

Consumers search over the product space to update their consumption baskets – that is, their spending shares across goods – based on *effective quality*, which is the sum of true and artificial quality. In other words, consumers use prospective effective utility to compare and choose among consumption bundles, while their *actual* welfare depends only on true quality. Insolvent firms exit the market and are replaced by new entrants, who also have some opportunity to migrate across the two market segments based on recent profitability.

We note that monetization innovation could be modeled in a variety of alternate ways, such as operating on firms' ability to alter markups or to directly shift consumer demand shares. The approach taken here – treating monetization as generating an artificial quality wedge – is nonetheless quite general either directly or as a metaphor for the the various processes outlined above, and it has the advantages both of simplicity and of cleanly separating true utility from effective (perceived) utility.

4.2 Consumer Preferences

For each consumer type, let $q \in \mathbb{R}^n$ denote the vector of products consumed and $z \in \mathbb{R}^m$ the corresponding perceived vector of characteristics consumed, related by a home-production mapping

$z = g(q)$. Specifically, each characteristic j is aggregated across goods i via a CES aggregator,

$$z_j = \left[\sum_{i=1}^{n} (q_i \cdot z_{i,j})^{\rho_1} \right]^{1/\rho_1},$$

and utility is given by a CES aggregator over these aggregated characteristics,

$$u(z) = \left[\sum_{j=1}^{m} z_j^{\rho_2} \right]^{1/\rho_2}.$$

This nested CES structure imposes a taste for variety over both characteristics and goods.

4.3 Product and Monetization Innovation, Timing

Product innovation increments the elements of a firm's characteristic vector z_i by positive or negative integers, with the probability of an innovation event depending on the firm's recent R&D investment (via a distributed lag) and exhibiting preferential attachment toward characteristics with sufficient existing hedonic quality. Firms decide whether to switch R&D investment on or off via social learning, comparing their profits against a reference pair of firms (either high- versus low-R&D firms, or firms in the own versus the other market). For a firm in the low-profit group, the probability of switching R&D status follows a discrete-choice (logit) rule,

$$\Phi = \frac{e^{\gamma \pi_1}}{e^{\gamma \pi_1} + e^{\gamma \pi_2}}, \qquad \gamma > 0,$$

where π_1 and π_2 are the recent profits of the two reference firms.

Monetization innovation operates through a simple mechanism layered on top of this process: true qualities convert to artificial qualities, above a threshold, at a slow stochastic rate, and artificial qualities in turn depreciate at a second slow stochastic rate. Thus, monetization both relies on and degrades actual product quality. The net effect on demand, and thus the market viability of the individual product, on the other hand is ambiguous.

Within each period, events unfold as follows. First, firms choose their current R&D investment level (on or off). Second, firms experience product innovation with probability related to recent R&D investment. Third, firms experience monetization innovation, converting a portion of true (hedonic) quality into artificial quality, subject to depreciation of existing artificial quality. Fourth, firms forecast sales, hire production labor, and produce to meet forecasted demand. Fifth, firms pay wages to production workers and salaries to overhead workers. Sixth, representative consumers search – based on effective utility – and update their consumption baskets. Seventh, consumers spend all of their labor income on their chosen baskets. Finally, firms with insufficient working capital exit and are replaced, with new entrants potentially migrating across market segments.

4.4 Firm Pricing, Production, and Trade

Firms produce using both overhead and production labor and set prices as a fixed markup η over marginal cost. Production-labor productivity is fixed at the firm level at A_i, and the wage rate is w. Overhead-labor requirements for each firm have a fixed component h, and, when the firm engages in R&D, an R&D component r, and the salary rate is s. Firms produce to meet expected demand, forecast using a simple extrapolation of past nominal demand. Trade occurs on the short side of each market; products and residual income are perishable, so there is no saving or inventory accumulation. A firm/product is replaced once its working capital reaches zero, with entrants imitating an existing firm and having some opportunity to switch market segments.

4.5 A Representative-Agent Benchmark

If firms were homogeneous (other than their market label) and all were to engage in R&D, the model would admit a representative-agent benchmark in which equilibrium production and sales of the consumption good are

$$Y^* = Y_1^* + Y_2^* = \left(\frac{1}{\eta - 1}\right) \cdot \frac{A}{W} \cdot (h + r) \cdot s \cdot (n_1 + n_2),$$

which is independent of characteristic magnitudes and of preferences over characteristics, with $\partial Y/\partial A > 0$, $\partial Y/\partial W < 0$, $\partial Y/\partial[s(h + r)] > 0$, and $\partial Y/\partial \eta < 0$, all purely demand-driven. This benchmark is a locally stable steady state, and in it the utility of production and overhead workers each grow in the long run through the net effects of product and monetization innovation in their own market and depend positively on variety in their own market (i.e., on n_1/n_2).

5 Simulation Results

5.1 Baseline: Monetization versus No Monetization

In the baseline calibration without monetization, utility for both production-worker (PL - green below) and overhead-worker (OH - yellow below) consumers grows roughly in parallel over time. In the following representative run, utility rises from near zero to just over 10 utils over 10,000 periods Figure **??**(a)). Introducing monetization – with a relatively large artificial-quality conversion rate on hedonic quality elements (above a threshold of 5) of 0.05, and a depreciation rate on artificial quality of 0.001 – substantially slows utility development for both consumer types (blue for PL, red for OH), which in the representative run reach only around 6 to 6.5 utils over the same horizon (Figure **??**(b)).

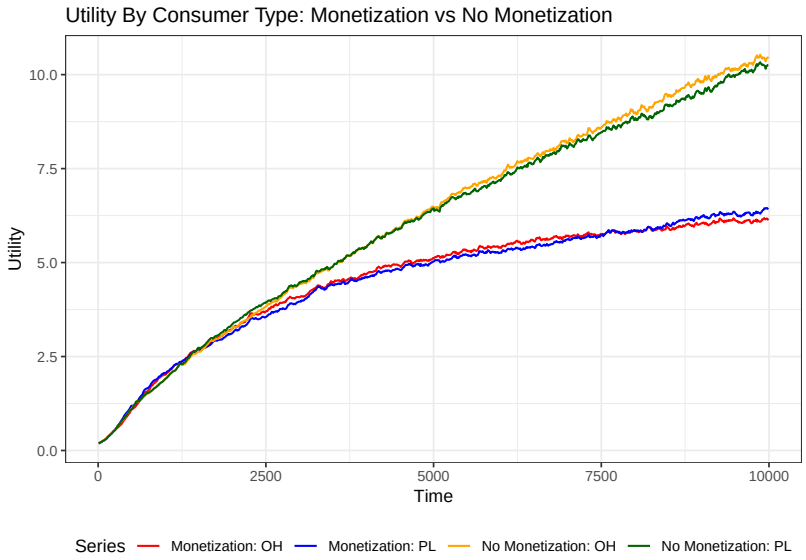


Figure 1: Utility by consumer type (OH, PL) over 10,000 periods, baseline calibration, with and without monetization innovation.

Extending the baseline example to 50,000 periods and including a low monetization case (with both artificial quality conversion and depreciation rates set at 0.0002) confirms that this welfare gap is persistent rather than transitory, as illustrated in Figure 2.

Similarly, turning monetization on partway through a long run (e.g., after period 20,000, or during periods 20,000–35,000) produces an immediate and persistent slowdown in utility growth relative to the no-monetization case (Figure 3).

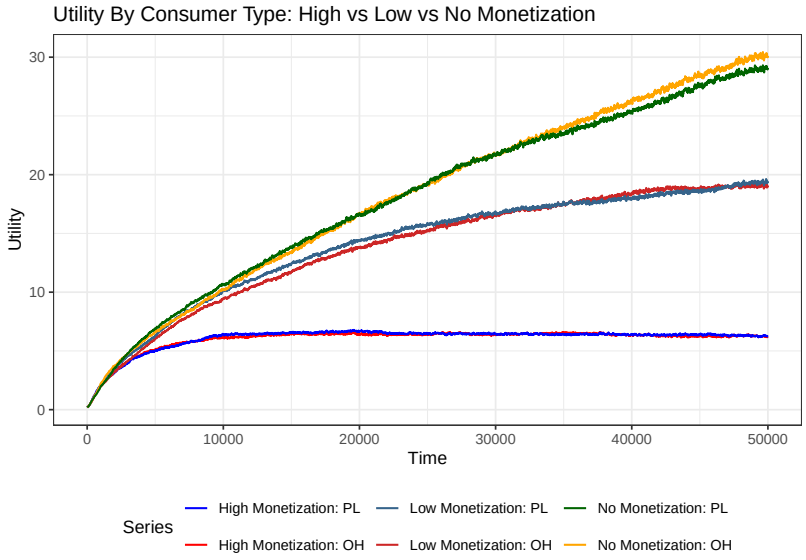
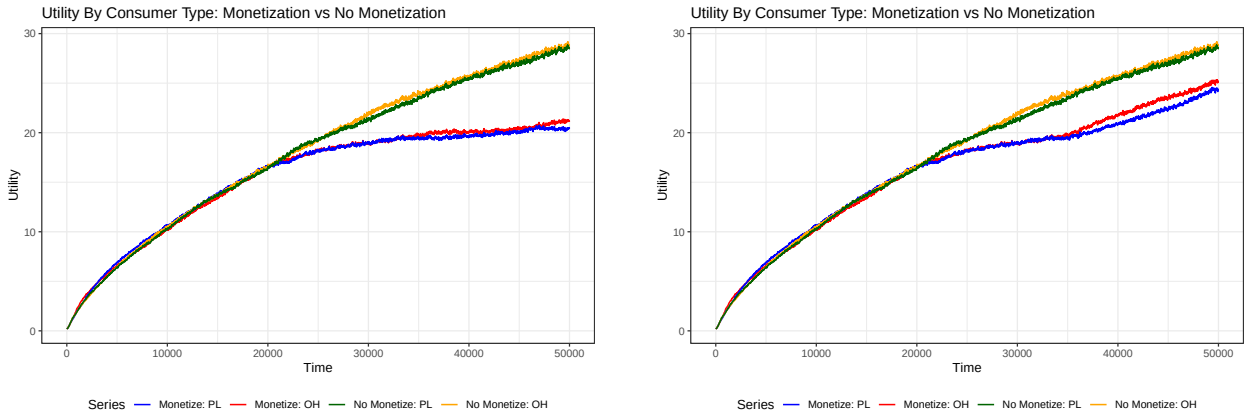


Figure 2: Utility by consumer type over 50,000 periods: high, low, and no monetization.



(a) Monetization introduced after round 20K

(b) Monetization active only in rounds 20K–35K

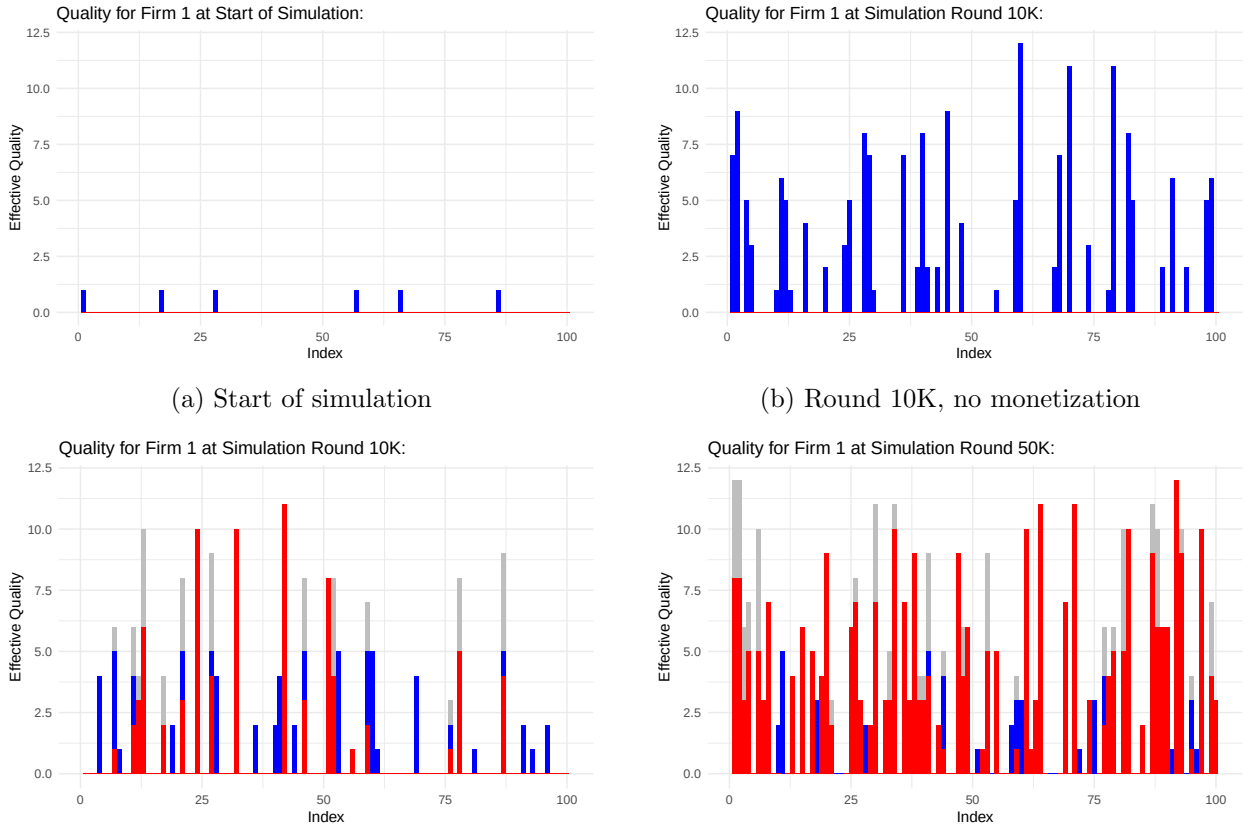
Figure 3: Utility by consumer type, low monetization introduced at different points in a 50,000-period run, versus no-monetization counterfactual.

5.2 Mechanisms

Two distinct mechanisms drive the welfare gap in these baseline cases. The first is a *innovation diversion* mechanism. Hedonic-quality increments that would otherwise accrue to true product quality are instead converted into artificial quality, which does not enter true utility. This can be interpreted as either a diversion of innovative effort away from more productive applications (from the point of view of the consumer) or a true quality *offset* in which the product is actually made worse (or more costly) in order to monetize it. In either case, the reduction of true quality can additionally reduce the subsequent accumulation of true quality by weakening the experience based preferential attachment mechanism that promotes the accumulation of specialized quality.

The second is a *misallocation* mechanism. Because consumer search is driven by effective (true plus artificial) quality rather than true quality alone, consumers are induced to shift spending toward goods whose apparent quality exceeds their actual quality, at the expense of goods that would deliver higher true utility.

It may be instructive to visualize the evolution of quality for an individual firm. The following charts track a single firm in a representative 10,000 period run. The first chart shows the the no-monetization baseline, in which the firm accumulates only true hedonic quality (Figure 4(a)) and round 10,000 (Figure 4(b)). With monetization activated, by contrast, the same firm's *effective* quality (true plus artificial - shown in grey) at round 10,000 is lower on average than in the no-monetization benchmark and is now divided between true (blue) and artificial (red) quality (Figure 4(c)). When artificial-quality depreciation is switched off entirely, this pattern becomes still more pronounced by round 50,000 (Figure 4(d)): artificial quality comes to dominate effective quality, with true quality remaining persistently low.



(a) Start of simulation

(b) Round 10K, no monetization

(c) Round 10K, with monetization

(d) Round 50K, monetization without depreciation

Figure 4: Hedonic quality elements (100 characteristics) for a representative firm (Firm 1). Panels (c)–(d) decompose effective quality (grey) into true quality (blue) and artificial quality (red).

The misallocation mechanism is more directly visible if we impose an exogenous, one-time monetization shock rather than the model's endogenous, gradual process. The following figure adds artificial quality to half of type-1 (production-worker) consumers' goods in a single round, with a 20 percent chance of a positive shock of between 0 and 20 units to each hedonic element of each affected good (Figure 5). We see the utility of production workers (PL) dropping sharply after the shock relative to that of overhead workers (OH), as they rebalance their consumption baskets based on their new effective utility perceptions, even though nothing about the true quality of any good has changed. Relative to a baseline in which R&D and true innovation behavior are frozen after the shock but no artificial quality is inserted, the relative utility ratio of overhead to production workers rises by roughly 25 percent following the shock in this example – a pure misallocation effect, isolated from any change in the underlying rate of true innovation.

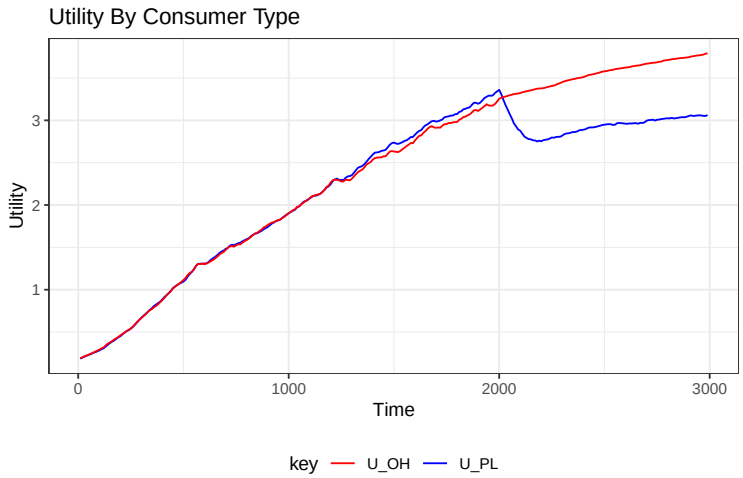


Figure 5: Utility by consumer type following an exogenous artificial-quality shock to half of type-1 (PL) consumers' perceptions at round 2,000.

5.3 A Third Mechanism and Alternate Outcome

In the model, each firm faces a tension between the negative short term costs of engaging in R&D and the longer term benefits from the effect of innovation on market share. Current R&D unambiguously reduces current profit, but recent R&D may increase it. In the baseline above, the balance leads to moderate *R*&D take-up and subsequent product innovation by firms over time, which results in sustained but sub-exponential growth in consumer welfare. Monetization tends to deteriorate that welfare further.

However, higher innovation rates (contingent on R&D) and lower per unit costs of R&D investment improve the tradeoff for firms, boosting the average near-term profitability of engaging in R&D investment. This can lead to the emergence of a high innovation regime with exponential or even super-exponential utility growth. Further, monetization may, somewhat paradoxically, reduce the short term profitability gap between engaging or not in R&D investment, thereby accelerating the adoption of such a high innovation, high growth regime. It is then possible, though atypical, for the net effect of monetization to raise rather than lower utility growth, even dramatically, over some time horizon.

Thus, to the two negative mechanism discussed above, we must also add an overall innovation rate effect that operates through the interaction between aggregate profitability dynamics and the discrete choice R&D rule followed by firms. This mechanism can (in some cases) act to both shrink the average profit gap and increasing the variability of profits, which can increase the likelihood of R&D adoption and accelerate growth.[2]

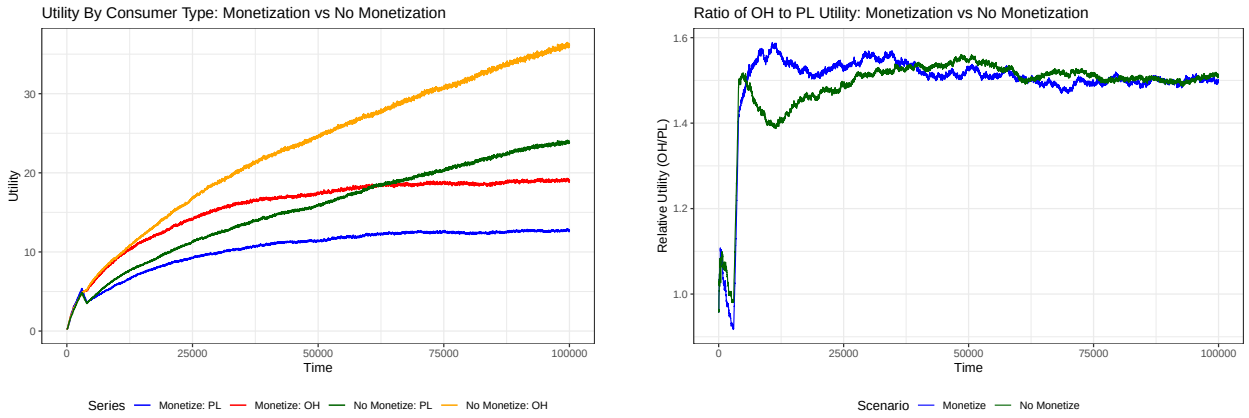
[2]Again, this is a possible but not typical outcome. It should also be noted that monetization is not the only feature that can have this somewhat paradoxical affect on innovation in this model.

5.4 Monetization, Markups, and Macroeconomic Gentrification

Georges (2019) showed that in the model without monetization consumption inequality is governed by firm markups. Higher markups cause the utility of production workers (U1) to fall (or stagnate) relative to overhead-worker utility (U2). This occurs through three channels: income, variety, and innovation. We termed the resulting divergence *macroeconomic gentrification*: as the markup rises, income, variety, and innovation all shift toward the overhead-worker market segment.

This effect does not appear to be substantively altered by the presence of monetization innovation in both markets. In the illustration below, a gradual increase in the markup μ (here from 2 to 2.4, phased in over periods 3,000–4,000) causes the utility of production workers (U1) to stagnate relative to overhead-worker utility (U2), widening consumption inequality between the two groups

The effect on consumption inequality is persistent, and while the presence of monetization lowers utility for both types of worker (red for OH, blue for PL in Figure 6(a)), the long run effect on inequality does not appear to be sensitive to the presence or absence of monetization, as illustrated in Figure 6(b).



(a) Utility by consumer type

(b) Ratio of overhead to production utility

Figure 6: Markup experiment with and without monetization: utility by consumer type (a) and the OH/PL utility ratio (b).

6 Discussion

These results reported in this paper suggest that monetization – modeled here as the conversion of true product quality into artificial quality – may systematically reduce or enhance consumer welfare and slow or accelerate the growth of true product quality relative to a world without monetization. The mechanism operates through three broad channels: the diversion of innovative effort away from true quality improvement, the misallocation of consumer spending induced by search based on effective rather than true quality, and general disequilibrium effects on the relative profitability of R&D. Monetization can have the net effect of making consumer experiences worse, by degrading and offsetting the benefits of true product innovation. However, it is also possible for there to be a

regime in which innovation takes off earlier under monetization and that the effect on true product quality of the high innovation swamps the negative effects of monetization for the consumer.

An extension would be to allow the underlying innovation rate (given R&D) to vary in order to allow or construct switching histories in which eras of rapid innovation can lead first to rapid growth in consumer welfare followed by increasing erosion of the benefits through pervasive monetization.

7 Conclusion

This paper introduces monetization innovation – the accumulation of artificial product quality – into an agent-based macroeconomic model of product innovation and growth. Monetization reduces consumer welfare by diverting or offsetting productive innovation and by causing a misallocation of consumer spending. However, monetization can also indirectly influence the rate of innovation, and it is possible in some cases for the net effect on consumer welfare to be positive.

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