Markup Cyclicality: Extreme Value Theory within a Macroeconomic Framework

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Abstract

We build a business cycle model in which the markup of price over marginal costs can respond either procyclically or countercyclically to a sectoral-level shock. In order to do so, we rely on the microeconomic foundations by Gabaix et al. (2016) who showed that markups can either increase or decrease in the number of market competitors, depending on the shape of the probability distribution of consumers' taste shocks, especially their tail properties. In our dynamic setting with firm entry, the markup can then either increase or decrease in response to a positive productivity shock which unambiguously increases market competition. Therefore, we are able to explain the differentiated cyclical behavior of markups observed across sectors in the US economy even for recessions in which the shock is symmetric across sectors.

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1 Introduction

A very well-documented macroeconomic fact is the long-term decline in the labor share observed over the recent decades in the United States and in other countries. Among the many rationales of this phenomenon is the rise of 'superstar firms' or, more generally, the increase in market concentration (Autor et al., 2017; Hall, 2018; Autor et al., 2020; Loecker et al., 2020). Indeed, the market power resulting from concentration increases the markup of price over marginal costs, thereby reducing the relative share of value added going to labor compensation. This does not only support the long-term trends of labor shares and estimated markups, but also the heterogeneity in markup *levels* across sectors, since sectors with higher concentration tend to exhibit higher markup levels, and respectively lower labor shares, as compared to other sectors in the same economy.[1] Yet, this literature has so far little explored the implications for the *cyclical* properties of markups, i.e its correlation with output over business cycles. The reason is straightforward. As such, the degree of market concentration matters for the magnitude but not for the sign of the response of the markup to exogenous macroeconomic shocks.

In Figure 1, we report the labor shares of selected three-digit industries. It is striking that industries are very heterogeneous, in terms of levels but also in terms of cyclicality of their labor share. On the one hand, some economic shocks like the Covid19 crisis clearly had a differentiated impact across sectors, with some being more affected by lockdown measures than others. For instance, the labor share in air transportation has dramatically increased, mostly because of a collapse in their profits and markup in 2020 On the other hand, during the Great Recession, which is mostly a symmetric shock across sectors leaving finance aside, labor shares responded very differently. Indeed, sectors such as oil or primary metals responded with a countercyclical labor share, and therefore presumably a procyclical markup,

[1] See Basu (2019) for a recent review of the different methods to estimate markups, among which one refers to the markup as the inverse of the labor share. This is the terminology we adopt in this paper as labor is the only production input in our model.

while other sectors such as food and beverage responded in the opposite way. This suggests that industry-level characteristics matter for the response of markups to symmetric macroeconomic shock.

Beyond anectodal evidence, the literature on markup cyclicality is very mixed, both theoretically and empirically. First, the method used to estimate the markup is found to be critical for the sign of the correlation between markup and output, with measures of the markup based on the inverse of the labor share being moderately procyclical, versus moderately countercyclical otherwise (Nekarda and Ramey (2020)). Second, the level of aggregation matters, and signs are different whether firm-, sector-, or aggregate-level markups and outputs are considered (Burstein et al. (2020)). Third, the nature of the shock matters, although there is no consensus about which shocks generate procyclical versus countercyclical markups. Most often, markups seem procyclical for productivity shocks and countercyclical for monetary policy shocks. For instance, Hong (2017) develops both an oligopolistic competition and a New Keynesian frameworks, and finds results in line with previous New Keynesian models from (Bils (1987), Rotemberg and Woodford (1999), and Galí et al. (2007)). Yet, this is not always and other papers find the opposite, such as Nekarda and Ramey (2020) who obtain a procyclical markup response conditional on a demand shock. Afrouzi and Caloi (2023) show that markups are procyclical conditional on TFP shocks only when output has a hump-shaped output response, both theoretically and empirically.

In this paper, we build a dynamic general equilibrium model with firm entry, where the markup can respond either procyclically or countercyclically, in response to a symmetric sector-level shock. This way, we aim at replicating the possibility that a common shock (such as a Great Recession) can end up in very different market responses, depending on the characteristics of the sector, in particular the presence of superstar firms, or 'hype' products. In order to do so, we rely on the 'Extreme Value theory' and its recent application to the microeconomic literature, in

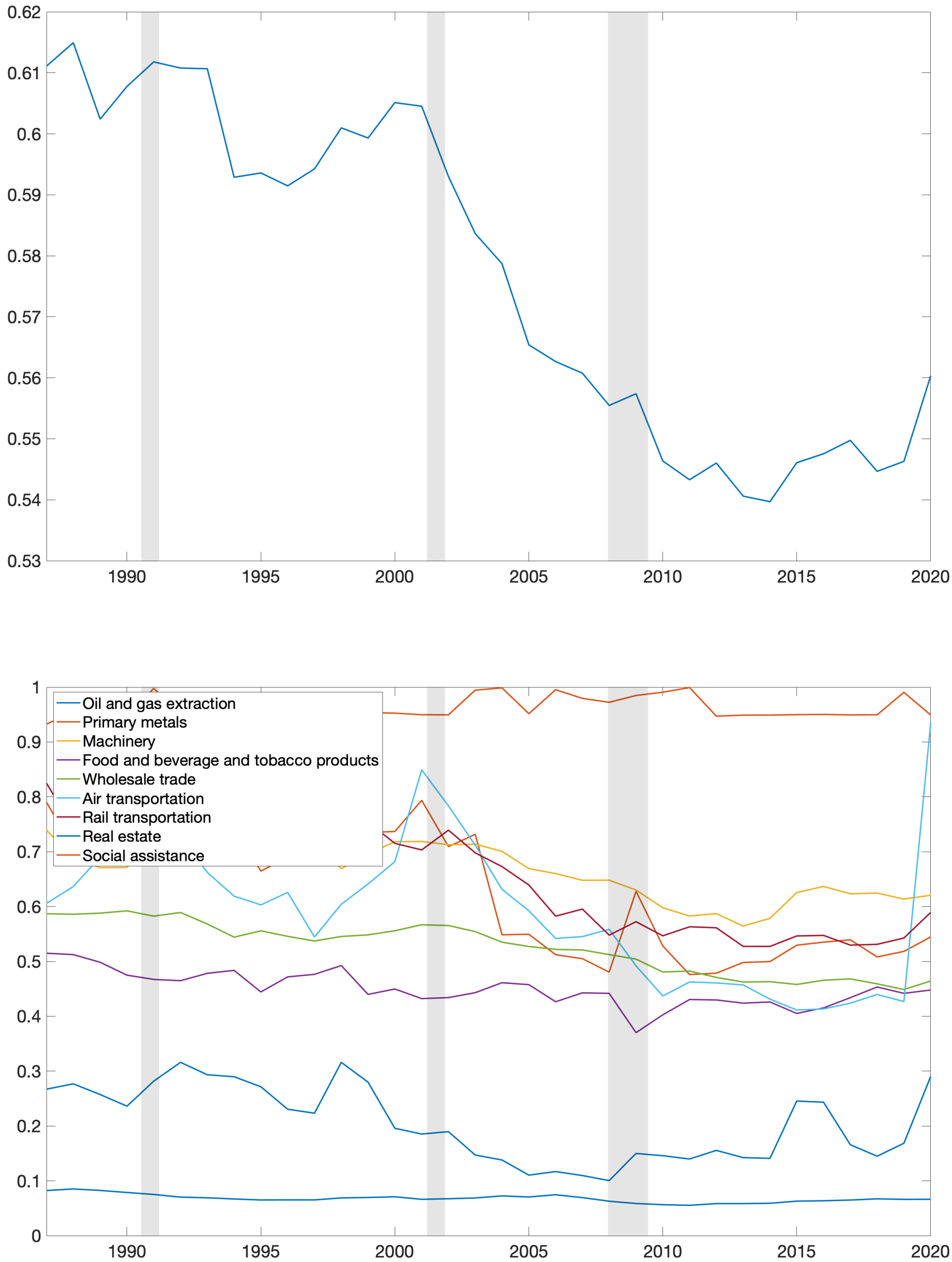

Figure 1: The labor share, defined as labor compensation over value added, in selected 3-digit industries, in the United States. Source: BEA-KLEMS

particular by Gabaix et al. (2016) who showed that markups may increase or decrease with the number of competitors on the market, depending on the distribution of consumer's taste shocks over potentially 'hype' goods. While their model is static and the number of market competitors exogenous, we build on this approach to develop a dynamic business cycle model, where both markups and firm dynamics are endogenous. According to the distribution of consumers' taste, a productivity shock can then replicate the ambiguous cyclical properties of markups over time.

The intuition goes as follows. At a microeconomic level, consumers' valuation for goods is idiosyncratic and drawn from some distribution. The tail properties of this distribution then determine the properties of markup. Indeed, with a thin-tail distribution, the firm who randomly gets the highest valuation expects to have close competitors. In that case, its price strategy is to decrease its markup as the number of firms in the market increases. On the contrary, with a thick-tail distribution, producers with the highest valuation are able to differentiate themselves from their competitors, such that they can choose a high price relative to their marginal costs. Hence, the markup does not necessarily decrease in the number of competitors, as shown already in Sattinger (1984) and Perloff and Salop (1985)'s so-called 'random utility models'. In our dynamic setup where firm entry is endogenous and time-varying, higher expected profits attract more competitors when a positive shock hits, yet these microfoundations remain, such that the markup response can be differentiated – countercyclical or procyclical – depending on the tail properties of consumer valuation.

Although the extreme value theory is not often used in macroeconomic models, a part of our results is aligned with the recent literature on markup cyclicality on several aspects. For instance, Burstein et al. (2020) find that sectoral output and markups comove positively in response to shocks to large firms in the sector, whereas they comove negatively in response to shocks to small firms. Similarly, we find that sectors where superstar firms are very far off their competitor in terms of product valuation generate a positive co-movement between sectoral markup and output, while less extreme tailed sectors generate a negative co-movement. In the same vein, (Amountzias, 2021) empirically find that more profitable firms charge procyclical markup ratios, thus validating predatory pricing strategies in more concentrated sectors. However, our approach shows that the cyclical properties of markups across sectors are not conditional on the type of shocks since common shocks can lead to differentiated market behaviors.

The remainder of this paper is as follows. Section 2 develops a macroeconomic dynamic model with extreme value theory and endogenous entry. Section 3 simulates the responses to a productivity shock under various distributions of the taste shocks and replicate different cyclical patterns for the markup among other variables. Section 4 concludes.

2 Model

2.1 Households

Households derive utility from consumption and labor as

$$U_0 = \sum_{t=0}^{\infty} \beta^t \frac{\left(C_t - \chi \frac{L_t^{1+\eta}}{1+\eta}\right)^{1-\sigma}}{1-\sigma} \tag{1}$$

where C denotes consumption, L labor supply, η the inverse of Frisch elasticity, and σ risk aversion.[2] We assume that consumption is a bundle of a competitive good, denoted Z, and a monopolistic competition good, denoted Q, as

$$C_t = Z_t^{1-\theta} \left(\sum_{i}^{N_t} e^{X_{i,t}} Q_{i,t} \right)^{\theta} \tag{2}$$

[2] GHH preferences ensure that the labor response to a productivity shock is procyclical.

where $0 < \theta < 1$ is a parameter, where $i = 1, \ldots, N_t$ denotes the monopolistic competitor among a total number N_t which endogenously varies over time (see Section 2.2.4), and where $X_{i,t}$ is an i.i.d. shock which affects the consumer's relative valuation of good i.

More specifically, we assume that households do not consume all Q_i varieties of monopolistic goods in each period, but only those which become "hype" in a certain period, i.e those which get the highest valuation $e^{X_{i,t}}$ relative to their price $P^Q_{i,t}$,[3] as

$$\frac{e^{X_{i,t}}}{P^Q_{i,t}} \geq \max\left(\frac{e^{X_{j,t}}}{P^Q_{j,t}}\right), \text{ for } i, j = 1, \ldots, N_t. \tag{3}$$

In other words, consumers are not after variety here, but rather after the "hype" product. In this paper, we do not seek to explain why and how some products become hype in the eyes of consumers but how the presence of this feature affects the economy when an aggregate shock occurs. The critical element here will be the distribution of the valuation shock $X_{i,t}$, hereafter also labelled as a "taste shock". Indeed, this distribution will be sufficient to make the aggregate response of the markup either procyclical or countercyclical, everything else equal. In turn, other macroeconomic quantities, prices, and asset pricing responses will also be affected.

The household's budget constraint is

$$\sum_i^{N_t} P^Q_{i,t} Q_{i,t} + P^Z_t Z_t + V_t(N_t + N^e_t)s_{t+1} = W_t L_t + \left(V_t N_t + \sum_i^{N_t} D_{i,t}\right) s_t \tag{4}$$

where P^Z denotes the price of the competitive good Z, W the nominal wage rate, and where s are shares of the monopolistic sector, composed of N incumbent and N^e entrant firms, with price V, paying off dividends $D_{i,t}$ per period. This investment in shares of a monopolistic sector with firm entry is close to Bilbiie et al. (2012), yet differentiation across goods here comes from the hype motive versus a preference for

[3] The price $P^Q_{i,t}$ is freely chosen by monopolistic producers in each period, before the draw of the taste shock. Consumers take it as given.

variety in their case.

Overall, households choose their labor supply (L_t), consumptions of competitive (Z_t) and monopolistic ($Q_{i,t}$) goods, and investment (s_{t+1}) in the equity fund, in order to maximize (1) subject to (2), (3) and (4). After substituting out the Lagrange multiplier on the budget constraint (see Appendix for calculation details), we obtain three optimality conditions as

$$\chi \frac{L_t^\eta}{W_t} = (1-\theta)\frac{C_t}{P_t^Z Z_t} \tag{5}$$

which is the usual consumption-labor trade-off,

$$P_t^Z Z_t = \frac{1-\theta}{\theta}\frac{P_{i,t}^Q}{e^{X_{i,t}}}\left(\sum_i^{N_t} e^{X_{i,t}} Q_{i,t}\right) \tag{6}$$

which is the optimal consumption mix of competitive and monopolistic goods, and

$$\frac{C_t\left(C_t - \chi\frac{L_t^{1+\eta}}{1+\eta}\right)^{-\sigma}}{P_t^Z Z_t} V_t N_{t+1} = \beta E_t\left[\frac{C_{t+1}\left(C_{t+1} - \chi\frac{L_{t+1}^{1+\eta}}{1+\eta}\right)^{-\sigma}}{P_{t+1}^Z Z_{t+1}}\left(V_{t+1}N_{t+1} + \sum_i^{N_{t+1}} D_{i,t+1}\right)\right] \tag{7}$$

which is a Euler equation on equity shares.

Finally, for the sake of simplicity, we will further assume that the taste shock X_i is continuous, such that only one monopolistic firm becomes hype per period. Hence, we can simplify the optimality conditions as follows. First, (6) simply becomes

$$P_t^Z Z_t = \frac{1-\theta}{\theta} P_{i,t}^Q Q_{i,t} \tag{8}$$

Second, let P_t be the aggregate price index such that the household's total good expenditure at of time t is

$$P_t C_t \equiv P_{i,t}^Q Q_{i,t} + P_t^Z Z_t, \tag{9}$$

and the demand for each good can be expressed as a function of relative price as

$$Q_{i,t} = \begin{cases} \theta \left(\frac{P^Q_{i,t}}{P_t} \right)^{-1} C_t, & \text{if } j = i \\ 0, \text{ otherwise,} \end{cases} \tag{10}$$

for the monopolistic competition good, and

$$Z_t = (1-\theta) \left(\frac{P^Z_t}{P_t} \right)^{-1} C_t$$

for the competitive good, with $P_t = \frac{(P^Q_{i,t})^{\theta}(P^Z_t)^{1-\theta}}{(e^{X_{i,t}})^{\theta}\theta^{\theta}(1-\theta)^{(1-\theta)}}$.[4] The latter allows us to simplify the other household's optimality conditions, (5) and (7), as

$$\chi L_t^{\eta} = \frac{W_t}{P_t} \tag{11}$$

and

$$\frac{V_t N_{t+1}}{P_t} = E_t \left(\beta^{\star}_{t,t+1} \frac{V_{t+1} N_{t+1} + D_{i,t+1}}{P_{t+1}} \right) \tag{12}$$

with

$$\beta^{\star}_{t,t+1} = \beta \frac{\left(C_{t+1} - \chi \frac{L_{t+1}^{1+\eta}}{1+\eta} \right)^{-\sigma}}{\left(C_t - \chi \frac{L_t^{1+\eta}}{1+\eta} \right)^{-\sigma}} \tag{13}$$

the stochastic discount factor.

2.2 Monopolistic firms

The timing of events is as follows. In the beginning of period t, monopolistic producers choose their price level. Then, the shock $X_{i,t}$ is drawn. The firm which becomes "hype" knows the demand for its product, hires labor and produces accordingly. Recall that under the assumption of a continuous taste shock, only one firm becomes hypes and therefore produces. The other monopolistic firms do not produce

[4]See Appendix A.1.4 for calculation details. The monopolistic good producer will use the demand function as a constraint in a standard manner, further below.

anything within the current period but passively stay on the market and expect to become hype in future periods. New entrants also arrive into the monopolistic market even if they do not produce yet, with the prospect of future positive profits.

2.2.1 Cost minimization

Conditional on becoming hype, a monopolitistic firm produces with technology

$$Q_{i,t} = A_t^Q L_{i,t}^Q \tag{14}$$

where A_t^Q is sectoral technology, following an AR1 shock process,

$$A_t^Q = (1 - \rho_{AQ})\bar{A}^Q + \rho_{AQ} A_{t-1}^Q + \epsilon_{AQ}, \tag{15}$$

with $0 < \rho_{AQ} < 1$ a persistence parameter and ϵ_{AQ} a normally distributed disturbance, and where $L_{i,t}^Q$ is labor input of firm i.[5]

The labor demand is chosen so as to minimize the wage bill $W_t L_{i,t}^Q$ subject to the production function (14). The first-order condition is

$$\frac{W_t}{A_t^Q} = \psi_{i,t} = \psi_t \tag{16}$$

where ψ is the Lagrange multiplier associated with the production function, which turns out to be identical for all firms.

2.2.2 Price setting

A monopolistic firm also chooses its current period price $P_{i,t}^Q$, before the shock $X_{i,t}$ is drawn. Upon the realization of the shock, the firm may become hype if it satisfies (3), in which case it produces the quantity demanded by consumers (10), hires labor

[5] Labor is competitive even though only one hype firm is hiring and producing at a time because the same labor supply is also used by the competitive Z industry. We precisely do not assume differentiated labor markets in order to avoid a monopsony labor effect, but this could be an interesting extension of the model.

accordingly (14), and gets a profit flow $P^Q_{i,t}Q_{i,t} - W_t L^Q_{i,t}$. If the firm does not become hype, it makes zero profit and wait for the next period draw. Hence, the price $P^Q_{i,t}$ is chosen so as to maximize the expected profit

$$E\Pi(Q_{i,t}) = (P^Q_{i,t}Q_{i,t} - W_t L^Q_{i,t})\ H(P^Q_{i,t}, P^Q_t; N_t) \tag{17}$$

subject to the demand function (10) and the production function (14), where $H(P^Q_{i,t}, P^Q_t; N_t) = Pr\left[\frac{e^{X_{i,t}}}{P^Q_{i,t}} = \max\left(\frac{e^{X_{j,t}}}{P^Q_{j,t}}\right)\right]$ is the probability of becoming hype.

This problem is solved in a standard monopolistic fashion, first inserting the production function (14) so as to eliminate labor $L^Q_{i,t}$ from the previous equation as

$$E\Pi(Q_{i,t}) = P^Q_{i,t}Q_{i,t}\left(1 - \frac{W_t}{P^Q_{i,t}}\frac{1}{A^Q_t}\right)\ H(P^Q_{i,t}, P^Q_t; N_t),$$

then substituting in the demand function for the hype good (10) as

$$E\Pi(Q_{i,t}) = \frac{\theta}{(1-\theta)}\frac{P^Z_t Z_t Q_{i,t}}{\left(\sum_i^{N_t} e^{X_{i,t}}Q_{i,t}\right)}\left(1 - \frac{W_t}{P^Q_{i,t}A^Q_t}\right)\ H(P^Q_{i,t}, P^Q_t; N_t)$$

which we finally maximize with respect to $P^Q_{i,t}$ so as to obtain the first-order condition as

$$P^Q_{i,t} = -\frac{H(P^Q_{i,t}, P^Q_t; N_t)/P^Q_{i,t}}{\partial H(P^Q_{i,t}, P^Q_t; N_t))/\partial P^Q_{i,t}}\frac{W_t P^Q_{i,t}/A^Q_t}{P^Q_{i,t} - W_t/A^Q_t} \tag{18}$$

Note that there is no nominal rigidity preventing a firm to choose this optimal price at each point in time. The only real friction here is that it has to be chosen before the taste shock is realized.

2.2.3 Endogenous markup

Rearranging the price expression (18) with the marginal cost (16), we get

$$-\frac{H(P^Q_{i,t}, P^Q_t; N_t)/P^Q_{i,t}}{\partial H(P^Q_{i,t}, P^Q_t; N_t)/\partial P^Q_{i,t}} = \frac{P^Q_{i,t} - \psi_t}{\psi_t} \equiv \mu_t \tag{19}$$

where μ_t is the net markup of price over marginal cost. Hence, the key determinant of the markup here is the price-elasticity of the probability of becoming hype $H(.)$.

The probability of becoming hype is

$$H(P_{i,t}^Q, P_t^Q; N_t) = Pr\left[\frac{e^{X_{i,t}}}{P_{i,t}^Q} = \max\left(\frac{e^{X_{j,t}}}{P_{j,t}^Q}\right)\right] = \frac{1}{N_t} \tag{20}$$

with derivative

$$\frac{\partial H(P_{i,t}^Q, P_t^Q; N_t)}{\partial P_{i,t}^Q} = -\frac{1}{P_{i,t}^Q}(N_t - 1)\int f^2(x)F^{N_t-2}(x)dx \tag{21}$$

where f is the probability density function and F is the cumulative distribution function of the random taste shock x. See Proof in Appendix.

Subsituting (20) and (21), we can reexpress (19) as

$$\mu_t = \frac{1}{N_t(N_t-1)\int f^2(x)F^{N_t-2}(x)dx} \tag{22}$$

This makes it clear that the markup has two determinants in our economy. First, it depends on the number N_t of firms, with a negative impact on the markup. This is very intuitive, the higher the number of competitors, the lower the markup. Second, the taste shock x affects the markup, either positively or negatively, depending on its distribution F. Also, the number of competitors N_t interacts with F in a non-trivial way such that the total effect of N_t on markup is actually ambiguous. To give a feel for the role of the distribution here, let us consider some particular cases for which there exists an analytical solution for the markup (22) under a finite number N_t of firms. Hence, let us consider the Uniform, Gumbel, and Frechet distributions, with corresponding markups (22) reported in Table 1.

The last column in Table 1 reports the partial derivative of the markup expression with respect to the number of firms. The sign is unambiguously negative in the first two cases, i.e the Uniform and the Gumbel distributions, and positive under

Table 1: Taste shock distributions, markups, and effect of the number of firms

	Density function (f)	Tail	Markup (μ_t)	Derivative $\partial\mu_t/\partial N_t$
Uniform	$1, \quad x \in [-1, 0]$	-1	$1/N_t$	$-1/N_t^2 < 0$
Gumbel	$e^{-x} \exp(-e^{-x})$	0	$\frac{N_t}{N_t-1}$	$-1/(N_t-1)^2 < 0$
Fréchet	$\alpha x^{-\alpha-1} \exp(-x^{-\alpha}), \alpha > 1, x \geq 0$	$1/\alpha$	$\frac{1}{\alpha\Gamma\left(2+\frac{1}{\alpha}\right)} \frac{N_t^{1+1/\alpha}}{N_t-1}$	$\frac{1}{\alpha\Gamma\left(2+\frac{1}{\alpha}\right)} \frac{N_t^{1/\alpha}\left[\frac{1}{\alpha}(N_t-1)-1\right]}{(N_t-1)^2}$ > 0 if $N_t > 1+\alpha$

Note: This Table expresses markups for various noise distributions of taste x as a function of the number of firms N. Distributions are listed in order of increasing tail fatness. $\alpha > 1$ is the Frechet distribution parameter.

a fairly general parameter choice for the Frechet distribution. The macroeconomic implication is important. Consider for instance a positive shock to the sectoral productivity level, A^Q. This shock will increase the number of entrants, and therefore the number of firms, on the market. Yet, the markup may either be countercyclical or procyclical, depending on the distribution of the taste shock x. The intuition lays in the fatness of the distribution. Indeed, when the tail is small, as in Uniform or Gumbel cases, firms which draw the highest value of the taste shock are not far from their competitors, and therefore cannot price very much over marginal cost if they seek to remain hype, as defined in (3). Since they choose their price before knowing their draw, it is in their best interest to lower their markup following a sectoral productivity shock that increases the number of competitors. In contrast, firms get far away from their competitors under a Fréchet distribution, and therefore increase their markup in response to the same shock. Since the market is of "winner-takes-it-all" type, they get nil profits if they do not get the hype draw but can make much higher profits with a higher markup if they become hype. This narrative is further illustrated with impulse response functions in Section 3.

Using the markup definition, the marginal cost (16) can be rewritten as

$$P_{i,t}^Q = (1 + \mu_t) \frac{W_t}{A_t^Q} \tag{23}$$

which expresses the price of the hype good as the markup over its the marginal cost.

2.2.4 Firm dynamics

The total number of firms in the economy evolves over time as

$$N_{t+1} = (1-\delta)(N_t + N_t^e) \tag{24}$$

with $\delta \in (0,1)$ an exogenous exit rate, which occurs at the end of period t and affects both incumbent and new entrants equally.

Entrants at time t produce only in $t+1$, i.e there is a one-period time-to-build lag, as in Bilbiie et al. (2012). Upon entry, new firms are subject to a sunk cost equal to κ labor units paid at wage W_t.[6] In the next period, the entrant becomes an incumbent firm, with the same expected sum of profit flows, such that

$$V_t = E_t \sum_{\tau=t+1}^{\infty} \beta^{\star}_{t,t+\tau}(P^Q_{i,\tau} Q_{i,\tau} - W_\tau L^Q_{i,\tau}) \frac{1}{N_\tau}$$

where $\beta^{\star}_{t,t+1}$ is households' stochastic discount factor. Free entry implies that

$$V_t = \kappa\, W_t. \tag{25}$$

2.3 Competitive firms

A representative firm produces the competitive Z_t good, taking price P_t^Z as given. Labor L_t^Z is the only input, chosen to maximize its profit flow $P_t^Z Z_t - W_t L_t^Z$ subject to the production function

$$Z_t = A_t^Z (L_t^Z)^{\phi_Z} \tag{26}$$

where A_t^Z is an exogenous productivity level, subject to AR(1) shock process, and where $\phi_Z \leq 1$ is a returns-to-scale parameter. The first order condition is

$$P_t^Z = \frac{W_t}{A_t^Z \phi_Z (L_t^Z)^{\phi_Z - 1}} \tag{27}$$

[6] This assumption allows the sunk cost to vary over time.

2.4 Market Clearing and Aggregation

On the labor market, household's supply must equate the demand from all firms, i.e Z good producers, Q good producers, and entrant, i.e

$$L_t = L_t^Z + L_{i,t}^Q + F\,N_t^e \tag{28}$$

Besides, dividends are equal to monopolistic firms' profits as

$$\sum_i^{N_t} D_{i,t} = \sum_i^{N_t} (P_{i,t}^Q Q_{i,t} - W_t L_{i,t}^Q) \tag{29}$$

where the sum operator can be dropped out in case of a continuous distribution of the taste shock, whereby only one firm becomes hype and thus generates positive profits per period.

Finally, equity shares are normalized to 1 at the aggregate level, $s_t = s_{t+1} = 1$, such that the household's budget constraint (4) can be rewritten as

$$\sum_i^{N_t} P_{i,t}^Q e^{X_{i,t}} Q_{i,t} + P_t^Z\,Z_t + V_t N_t^e = W_t L_t + \sum_i^{N_t} D_{i,t} \tag{30}$$

which holds as the aggregate resource constraint, and expresses that the nominal consumption expenditure plus the entry costs are equal to nominal output. Here again, the sum operators can be dropped out in case of a continuous distribution of the taste shock.

3 Effect of a symmetric productivity shock

3.1 External evidence [IN PROGRESS]

3.2 Estimation [IN PROGRESS]

3.3 Theoretical Impulse Response Functions

Let us consider a positive productivity shock in the hype good sector (increase in A^Q) and observe responses of the model, in particular according to the distribution (Uniform, Gumbel, and Frechet) of the idiosyncratic taste shock.

3.4 Parameterization [PRELIMINARY]

The calibration is illustrative so far, but will be replaced by an estimation. It Is also identical across distribution cases, implying different steady-state values across cases.

Table 2: Parameter values

Description	Parameter	Value
Discount factor	β	0.95
Risk aversion	σ	2
Inverse of Frisch elasticity	η	1.5
Labor supply parameter	χ	1
Share of hype goods	θ	0.5
Exit probability	δ	0.025
Entry cost	F	0.5
Frechét parameter	α	2
Demand shock in steady state	X_i	0
Z production parameter	ϕ^Z	0.5
Q technology shock in steady state	A_Q	1
Q technology shock persistence	ρ_Q	0.96
Q technology shock std	σ_Q	0.01
Z technology shock in steady state	A_Z	1
Z technology shock persistence	ρ_Z	0.96
Z technology shock std	σ_Z	0.01

3.4.1 Response to a productivity shock: Case 1, Uniform

Figure 2 shows the impulse response functions to a shock in the monopolistic competition sector A^Q when the taste shock follows a Uniform distribution. For bounded distributions, such as the uniform distribution, the distance between the highest and the second highest valuation is expected to be small, and it gets smaller as the number of competitors increases. Thus, firms set the markup countercyclically.

3.4.2 Response to a productivity shock: Case 2, Gumbel

Figure 3 shows the impulse response functions to a shock in the monopolistic competition sector A^Q when the taste shock follows a Gumbel distribution. Gumbel is an example of a distribution with intermediate tail thickness. Intuitively, the products remain imperfectly substitutable even when the number of firms grows large, as the expected gap between the highest and the second highest noise shock are bounded away from zero. With this distribution, the asymptotic markup elasticity is zero and, for a finite but large number of firms, competition puts only a weak pressure on prices, leading to countercyclical markup but with a lower magnitude than in the previous Uniform case. Meanwhile, note that the positive productivity shock still attracts more firms to enter the competition.

3.4.3 Response to a productivity shock: Case 3, Frechet

Figure 4 shows the impulse response functions to a shock in the monopolistic competition sector A^Q when the taste shock follows a Frechet distribution. Fréchet distribution has a fat tail, thus making the probability of an extreme value higher. Asymptotically, the expected gap between the highest and the second highest draw is increasing in the number of competing firms. In this context, markups increase in competition. In response to the positive productivity shocks, firms still set lower prices and firm entry still goes up, but the markup is now procyclical as firms take advantage of their tailed valuation.

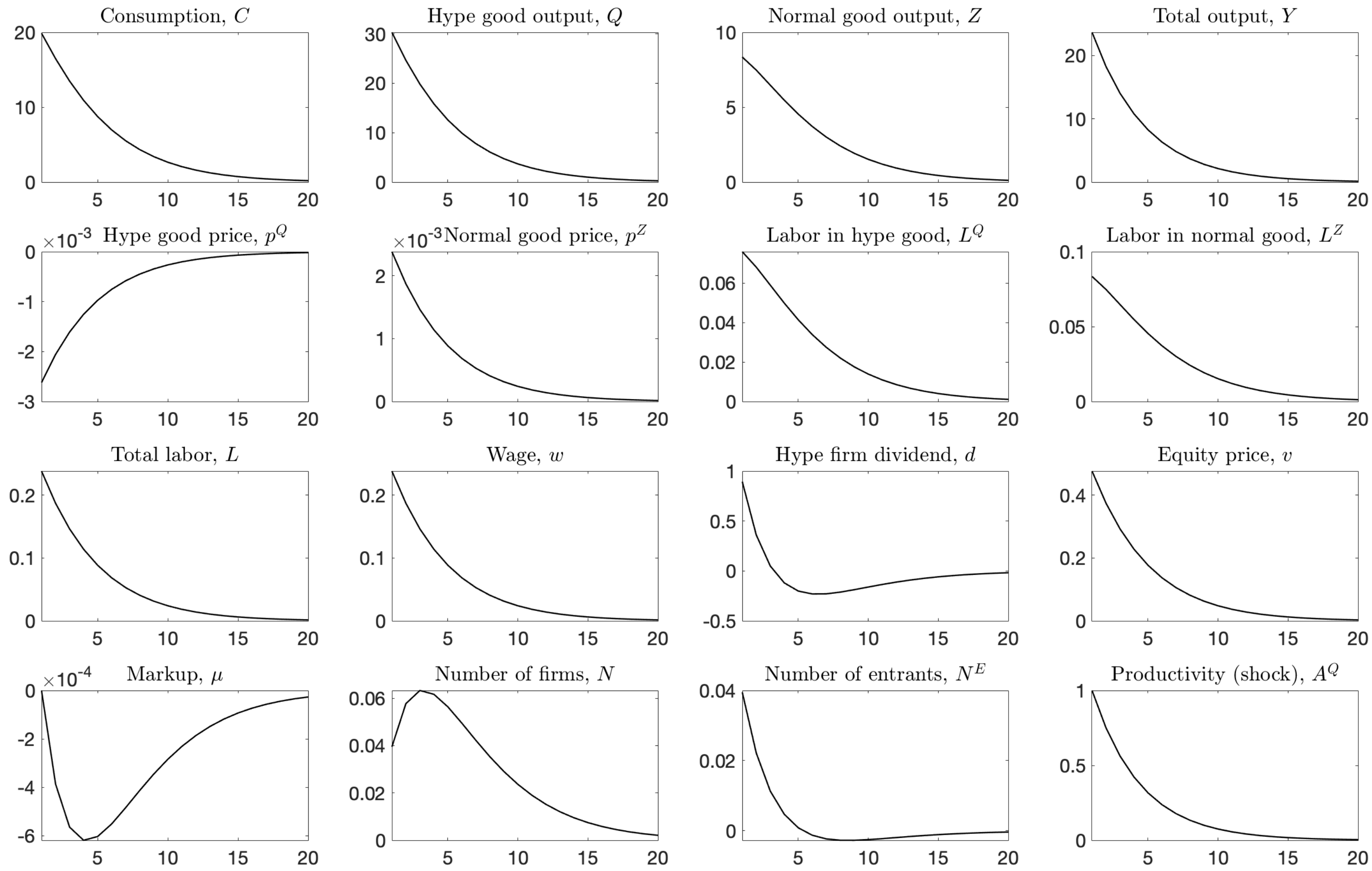

Figure 2: Effect of a one standard deviation increase in A^Q. Uniform case.

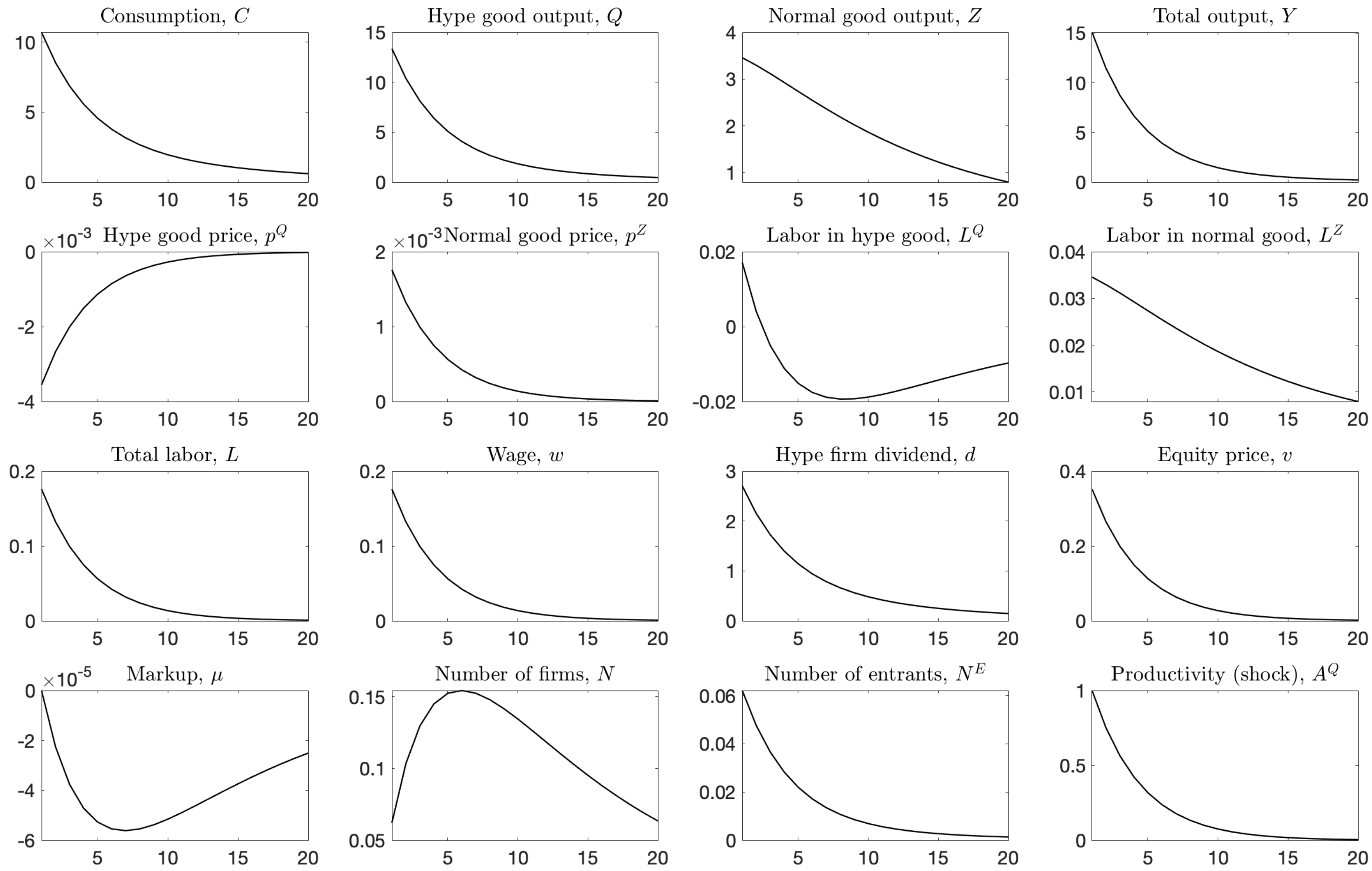

Figure 3: Effect of a one standard deviation increase in A^Q. Gumbel case.

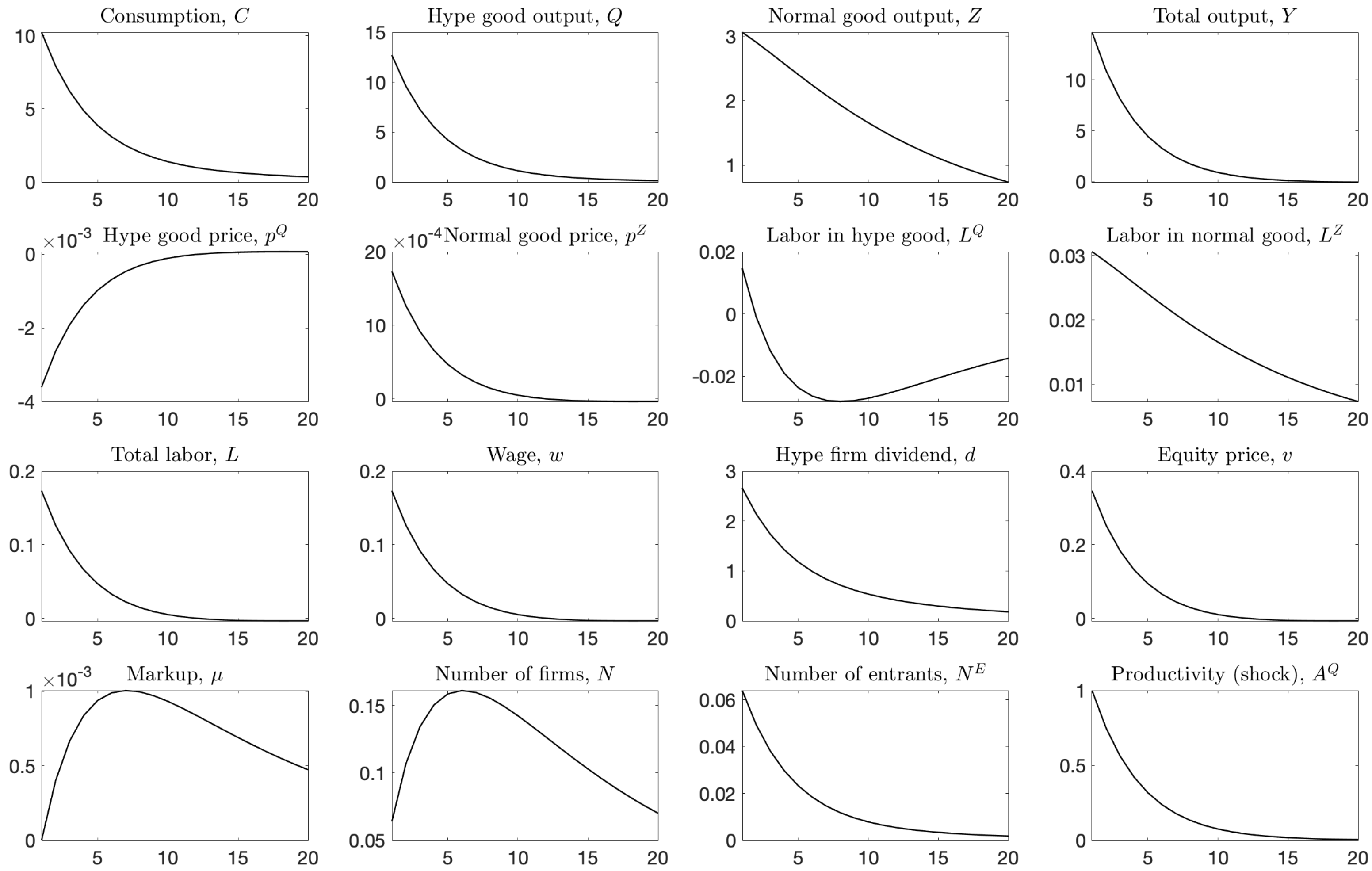

Figure 4: Effect of a one standard deviation increase in A^Q. Frechet case.

4 Conclusion [TBD]

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A Mathematical Appendix

A.1 Household problem

A.1.1 Initial problem and solution

Households maximize

$$U_0 = \sum_{t=0}^{\infty} \beta^t \frac{\left(C_t - \chi \frac{L_t^{1+\eta}}{1+\eta}\right)^{1-\sigma}}{1-\sigma} \tag{31}$$

subject to

$$C_t = Z_t^{1-\theta} \left(\sum_i^{N_t} e^{X_{i,t}} Q_{i,t} \right)^{\theta}, \tag{32}$$

$$\frac{e^{X_{i,t}}}{P_{i,t}^Q} \geq \max \left(\frac{e^{X_{j,t}}}{P_{j,t}^Q} \right), \text{ for } j = 1, \ldots, N_t, \tag{33}$$

and

$$\sum_i^{N_t} P_{i,t}^Q Q_{i,t} + P_t^Z Z_t + V_t \frac{N_{t+1}}{1-\delta} s_{t+1} = W_t L_t + \left(V_t N_t + \sum_i^{N_t} D_{i,t} \right) s_t \tag{34}$$

The first-order conditions, with respect to (L_t), (Z_t), $(Q_{i,t})$, and (s_{t+1}), respectively are

$$(L_t :) \quad \chi L_t^{\eta} \left(C_t - \chi \frac{L_t^{1+\eta}}{1+\eta} \right)^{-\sigma} = \lambda_t W_t, \tag{35}$$

$$(Z_t :) \quad (1-\theta) Z_t^{-\theta} \left(\sum_i^{N_t} e^{X_{i,t}} Q_{i,t} \right)^{\theta} \left(C_t - \chi \frac{L_t^{1+\eta}}{1+\eta} \right)^{-\sigma} = \lambda_t P_t^Z, \tag{36}$$

$$(Q_{i,t} :) \quad \begin{cases} \theta Z_t^{1-\theta} e^{X_{i,t}} \left(\sum_i^{N_t} e^{X_{i,t}} Q_{i,t} \right)^{\theta-1} \left(C_t - \chi \frac{L_t^{1+\eta}}{1+\eta} \right)^{-\sigma} = \lambda_t P_{i,t}^Q, & \text{if } j = i \\ 0, \ \text{otherwise.} \end{cases} \tag{37}$$

$$(s_{t+1} :) \quad \lambda_t V_t \frac{N_{t+1}}{1-\delta} = \beta E_t \left[\lambda_{t+1} \left(V_{t+1} N_{t+1} + \sum_i^{N_{t+1}} D_{i,t+1} \right) \right] \tag{38}$$

where λ_t is the Lagrange multiplier on the budget constraint. Substituting it out and rearranging, we first get from (35) and (36) the usual consumption-labor trade-off as

$$\chi \frac{L_t^{\eta}}{W_t} = (1-\theta)\frac{C_t}{P_t^Z Z_t} \tag{39}$$

Then, from (36) and (37), we obtain the optimal consumption mix of competitive and hype goods as

$$\frac{P_{i,t}^Q}{P_t^Z} = \frac{\theta}{1-\theta}\frac{e^{X_{i,t}} Z_t}{\sum_i^{N_t} e^{X_{i,t}} Q_{i,t}} \tag{40}$$

Finally, from from (36) and (38), we get the Euler equation as

$$\frac{C_t\left(C_t - \chi\frac{L_t^{1+\eta}}{1+\eta}\right)^{-\sigma}}{P_t^Z Z_t} V_t \frac{N_{t+1}}{1-\delta} = \beta E_t\left[\frac{C_{t+1}\left(C_{t+1} - \chi\frac{L_{t+1}^{1+\eta}}{1+\eta}\right)^{-\sigma}}{P_{t+1}^Z Z_{t+1}}\left(V_{t+1}N_{t+1} + \sum_i^{N_{t+1}} D_{i,t+1}\right)\right] \tag{41}$$

A.1.2 Continuous random variable X

Assuming that the distribution of the taste shock X_i is continuous, only one firm becomes hype per period. Then, (39) remains unchanged, while (40) simplifies as

$$\frac{P_{i,t}^Q}{P_t^Z} = \frac{\theta}{1-\theta}\frac{Z_t}{Q_{i,t}}, \tag{42}$$

and (41) simplifies as

$$\frac{C_t\left(C_t - \chi\frac{L_t^{1+\eta}}{1+\eta}\right)^{-\sigma}}{P_t^Z Z_t} V_t \frac{N_{t+1}}{1-\delta} = \beta E_t\left[\frac{C_{t+1}\left(C_{t+1} - \chi\frac{L_{t+1}^{1+\eta}}{1+\eta}\right)^{-\sigma}}{P_{t+1}^Z Z_{t+1}}\left(V_{t+1}N_{t+1} + D_{i,t+1}\right)\right] \tag{43}$$

A.1.3 General price index P

First, we can define the general price index P such that the household's nominal consumption expenditure is

$$P_t C_t \equiv \sum_{i}^{N_t} P_{i,t}^Q Q_{i,t} + P_t^Z Z_t \tag{44}$$

In the case where X is a continuous random variable such that only one monopolistic sector good is consumed per period, this simplifies as

$$P_t C_t = P_{i,t}^Q Q_{i,t} + P_t^Z Z_t \tag{45}$$

Second, let us rewrite the consumption bundle (32) for a continuous X as

$$C_t = Z_t^{1-\theta} \left(e^{X_{i,t}} Q_{i,t} \right)^{\theta} \tag{46}$$

$$\Leftrightarrow \quad Z_t = \frac{C_t^{\frac{1}{1-\theta}}}{\left(e^{X_{i,t}} Q_{i,t} \right)^{\frac{\theta}{1-\theta}}}$$

which we can insert into the optimality condition (42) to get

$$Q_{i,t} = \left(e^{X_{i,t}} \right)^{-\theta} \left(\frac{P_{i,t}^Q}{P_t^Z} \frac{1-\theta}{\theta} \right)^{-(1-\theta)} C_t \tag{47}$$

Then, similarly for the other good, we write (32) for a continuous X as

$$Q_{i,t} = \frac{C_t^{\frac{1}{\theta}}}{Z_t^{\frac{1-\theta}{\theta}}} \frac{1}{e^{X_{i,t}}}$$

which we can insert into (42) to get

$$Z_t = \left(e^{X_{i,t}} \right)^{-\theta} \left(\frac{P_{i,t}^Q}{P_t^Z} \frac{1-\theta}{\theta} \right)^{\theta} C_t \tag{48}$$

Finally, inserting (47) and (48) into (45) gives

$$P_tC_t = P_{i,t}^Q(e^{X_{i,t}})^{-\theta}\left(\frac{P_{i,t}^Q}{P_t^Z}\frac{1-\theta}{\theta}\right)^{-(1-\theta)}C_t + P_t^Z(e^{X_{i,t}})^{-\theta}\left(\frac{P_{i,t}^Q}{P_t^Z}\frac{1-\theta}{\theta}\right)^{\theta}C_t$$

$$\Leftrightarrow \quad P_t = (e^{X_{i,t}})^{-\theta}(P_{i,t}^Q)^{\theta}(P_t^Z)^{1-\theta}\left[\frac{\theta^{1-\theta}}{(1-\theta)^{(1-\theta)}} + \frac{(1-\theta)^{\theta}}{\theta^{\theta}}\right]$$

$$\Leftrightarrow \quad P_t = \frac{(P_{i,t}^Q)^{\theta}(P_t^Z)^{1-\theta}}{(e^{X_{i,t}})^{\theta}\theta^{\theta}(1-\theta)^{(1-\theta)}} \tag{49}$$

which is the general price index as a function of relative good prices.

A.1.4 Simplification of household's optimality conditions

With (45), we can use (42) so as to express the standard demands for goods Q and Z as functions which are decreasing in their relative price, as

$$Z_t = (1-\theta)\left(\frac{P_t^Z}{P_t}\right)^{-1}C_t \tag{50}$$

and

$$e^{X_{i,t}}Q_{i,t} = \begin{cases} \theta\left(\frac{P_{i,t}^Q}{P_t}\right)^{-1}C_t, & \text{if } j = i \\ 0, \text{ otherwise.} \end{cases} \tag{51}$$

Besides, (50) can in turn be used to simplify (39) as

$$\chi\frac{L_t^{\eta}}{W_t} = \frac{1}{P_t} \tag{52}$$

and (43) as

$$\frac{\left(C_t - \chi\frac{L_t^{1+\eta}}{1+\eta}\right)^{-\sigma}}{P_t}V_t\frac{N_{t+1}}{1-\delta} = \beta E_t\left[\frac{\left(C_{t+1} - \chi\frac{L_{t+1}^{1+\eta}}{1+\eta}\right)^{-\sigma}}{P_{t+1}}(V_{t+1}N_{t+1} + D_{i,t+1})\right] \tag{53}$$

A.1.5 In real terms

The household's optimality conditions are (42), (52), and (53) in nominal terms. Let us define $p^Q_{i,t} \equiv P^Q_{i,t}/P_t$, $p^Z_t \equiv P^Z_t/P_t$, $w_t \equiv W_t/P_t$, $v_t \equiv V_t/P_t$, and $d_{i,t} \equiv D_{i,t}/P_t$, such that they can be reexpressed in real terms as

$$\frac{p^Q_{i,t}}{p^Z_t} = \frac{\theta}{1-\theta}\frac{Z_t}{Q_{i,t}}, \tag{54}$$

$$\chi L^\eta_t = w_t, \quad \text{and} \tag{55}$$

$$\left(C_t - \chi\frac{L^{1+\eta}_t}{1+\eta}\right)^{-\sigma} v_t\frac{N_{t+1}}{1-\delta} = \beta E_t\left[\left(C_{t+1} - \chi\frac{L^{1+\eta}_{t+1}}{1+\eta}\right)^{-\sigma}(v_{t+1}N_{t+1} + d_{i,t+1})\right]. \tag{56}$$

A.1.6 Stochastic discount factor

Without the Q and Z goods, households would maximize

$$U_0 = \sum_{t=0}^{\infty}\beta^t\frac{\left(C_t - \chi\frac{L^{1+\eta}_t}{1+\eta}\right)^{1-\sigma}}{1-\sigma} \tag{57}$$

subject to

$$P_tC_t + V_t\frac{N_{t+1}}{1-\delta}s_{t+1} = W_tL_t + \left(V_tN_t + \sum_i^{N_t} D_{i,t}\right)s_t \tag{58}$$

The first-order conditions are

$$\left(C_t - \chi\frac{L^{1+\eta}_t}{1+\eta}\right)^{-\sigma} = \lambda_tP_t \tag{59}$$

and

$$\lambda_tV_t\frac{N_{t+1}}{1-\delta} = \beta E_t\left[\lambda_{t+1}\left(V_{t+1}N_{t+1} + \sum_i^{N_{t+1}} D_{i,t+1}\right)\right] \tag{60}$$

$$\Leftrightarrow \quad V_t N_{t+1} = \beta(1-\delta) E_t \left[\frac{\left(C_{t+1} - \chi \frac{L_{t+1}^{1+\eta}}{1+\eta}\right)^{-\sigma}}{\left(C_t - \chi \frac{L_t^{1+\eta}}{1+\eta}\right)^{-\sigma}} \frac{P_t}{P_{t+1}} \left(V_{t+1} N_{t+1} + \sum_i^{N_{t+1}} D_{i,t+1} \right) \right] \tag{61}$$

With a stochastic discount factor expressed as

$$\beta^{\star}_{t,t+1} = \beta(1-\delta) \frac{\left(C_{t+1} - \chi \frac{L_{t+1}^{1+\eta}}{1+\eta}\right)^{-\sigma}}{\left(C_t - \chi \frac{L_t^{1+\eta}}{1+\eta}\right)^{-\sigma}} \tag{62}$$

the Euler equation thus simplifies as

$$v_t N_{t+1} = E_t \left[\beta^{\star}_{t,t+1} \left(v_{t+1} N_{t+1} + d_{i,t+1} \right) \right] \tag{63}$$

A.2 Monopolistic firms and endogenous markups

The probability of firm i to become hype is

$$\begin{aligned}
H(P^Q_{i,t}, P^Q_t; N_t) &= \Pr\left[\frac{e^{X_{i,t}}}{P^Q_{i,t}} \geq \max_{j=1,\ldots,N_t} \left(\frac{e^{X_{j,t}}}{P^Q_{j,t}} \right) \right] \\
&= \Pr\left[X_{i,t} - \ln P^Q_{i,t} \geq \max_{j=1,\ldots,N_t} \left(X_{j,t} - \ln P^Q_{j,t} \right) \right] \\
&= E_{X_i} \left\{ \Pr\left[x \geq \max_{j=1,\ldots,N_t} \left(X_{j,t} - \ln P^Q_{j,t} + \ln P^Q_{i,t} \right) \mid X_i = x \right] \right\} \\
&= E_{X_i} \left\{ \prod_{j \neq i} F(x - \ln P^Q_{i,t} + \ln P^Q_{j,t}) \right\} \\
&= \int f(x) \prod_{j \neq i} F(x - \ln P^Q_{i,t} + \ln P^Q_{j,t}) dx \\
&= \int f(x) F^{N_t - 1}(x) dx \\
&= \frac{1}{N_t}
\end{aligned}$$

The derivative of this probability with respect to firm i's price is

$$\frac{\partial H(P_{i,t}^Q, P_t^Q; N_t)}{\partial P_{i,t}^Q} = \frac{\partial \int f(x) F^{N_t - 1}(x - \ln P_{i,t}^Q + \ln P_t^Q) dx}{\partial P_{i,t}^Q}$$

$$= -\frac{1}{P_t^Q}(N_t - 1) \int f^2(x) F^{N_t - 2}(x) dx$$

Hence the markup is

$$\mu_t = -\frac{H(P_{i,t}^Q, P_t^Q; N_t)/P_{i,t}^Q}{\partial H(P_{i,t}^Q, P_t^Q; N_t)/\partial P_{i,t}^Q}$$

$$= \frac{1}{N_t(N_t - 1) \int f^2(x) F^{N_t - 2}(x) dx}$$

The demand function for the monopolistic good found as expression (10) (with proof details in Appendix A.1.4) can be expressed before the realization of the draw X_i as a function of the probability to become hype, i.e

$$Q_{i,t} = \theta \frac{P_t C_t}{P_{i,t}^Q} H(P_{i,t}^Q, P_t^Q; N_t)$$

$$Q_{i,t} = \theta \frac{P_t C_t}{P_{i,t}^Q} \Pr\left[\frac{e^{X_{i,t}}}{P_{i,t}^Q} \geq \max_{j=1,\ldots,N_t} \left(\frac{e^{X_{j,t}}}{P_{j,t}^Q}\right)\right]$$

$$Q_{i,t} = \theta \frac{P_t C_t}{P_{i,t}^Q} \Pr\left[X_{i,t} - \ln P_{i,t}^Q \geq \max_{j=1,\ldots,N_t} \left(X_{j,t} - \ln P_{j,t}^Q\right)\right]$$

$$Q_{i,t} = \theta \frac{P_t C_t}{P_{i,t}^Q} E_{X_i} \left\{\Pr\left[x \geq \max_{j=1,\ldots,N_t} \left(X_{j,t} - \ln P_{j,t}^Q + \ln P_{i,t}^Q\right) \mid X_i = x\right]\right\}$$

$$Q_{i,t} = \theta \frac{P_t C_t}{P_{i,t}^Q} E_{X_i} \left\{\prod_{j \neq i} F(x - \ln P_{i,t}^Q + \ln P_{j,t}^Q)\right\}$$

$$Q_{i,t} = \theta \frac{P_t C_t}{P_{i,t}^Q} \int f(x) \prod_{j \neq i} F(x - \ln P_{i,t}^Q + \ln P_{j,t}^Q) dx$$

$$Q_{i,t} = \theta \frac{P_t C_t}{P_{i,t}^Q} \int f(x) F^{N_t - 1}(x) dx$$

$$Q_{i,t} = \theta \frac{P_t C_t}{P_{i,t}^Q} \frac{1}{N_t}$$