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The Effects of Online Interactions on Markets and Society

DISSERTATION

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for the degree of

DOCTOR OF PHILOSOPHY

in Economics

by

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DEDICATION

I dedicate this doctoral dissertation to my parents, Ying Huang and Dihua Jiang, my wife, Dan Luo, and my parents-in-law, Jianwei Xi and Zhongshu Luo.

My parents have been supportive and encouraging of my academic endeavors since as early as I can remember. Their work ethic, inquisitiveness, and thoughtfulness, among many other traits have shaped me into the person that I am today.

My wife, and fellow classmate and economist, has been an integral part of my life in the past five years. She is kind, caring, hard-working, fun, loving, and forgiving, and I am truly lucky to have found her at UCI. Marrying her is more important than any research paper, and being with her helps me rediscover this fact every day.

My parents-in-law, like my parents, have also been supportive and encouraging since I met them in 2010. Even when my research was not going smoothly and the outcome of my dissertation appeared uncertain, they believed that my work would eventually reflect my effort.

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WORKING PAPERS

"Online Dealers versus Brick-and-Mortar Stores: A Welfare Analysis"
Abstract: Online intermediaries play an increasingly important role in numerous markets. The literature on intermediation has mainly considered intermediaries as information gatekeepers, a role limited to advertising sellers' prices. This paper focuses on intermediaries as dealers or resellers, who acquire final goods through wholesale trade with producers. Consumers often believe that intermediaries can benefit them by mitigating information imperfections. But in many cases, intermediary entry actually lowers consumer surplus, and having more than one intermediary in the one-producer setting allows the monopolist producer to extract the entire consumer surplus. In all cases, however, conditions exist under which the presence of an intermediary improves overall welfare, including producer surplus.

"Cultural Polarization through Online Communication and Economic Growth"
Abstract: Over the past decade, people have become increasingly partisan in their political views (Stroud 2011). While a growing literature examines the relationship between media slant and polarizing views, this paper provides an explanation of cultural polarization without endogenous media bias. Whereas word-of-mouth communication combines speaking and listening, online communication through social media has decoupled interaction into the sending and receiving of messages. Consumers are influenced by the news content viewed and the messages received. When the cost of sending messages is higher, extremists have a greater influence on preference formation. Rising wages over time naturally raise the opportunity cost of sending messages, and, when combined with the decoupling of social interaction, this increase implies that we should expect to see increasing cultural polarization.

"Defensive Extremism"
Abstract: Online communication through social media is reshaping the way people interact. While a rich literature in psychology, sociology, political science, and economics has studied many models of socialization among individuals and within groups, this paper offers a model of socialization between groups. Individuals can now easily identify others with similar views through the Internet, but at the same time, the openness of online interactions exposes people to views representing a variety of beliefs and preferences. In this model, agents choose to join a group, and each group seeks to maximize the collective utility of its members by endorsing a message that represents its views. The agents' views are updated following exposure to the messages, and changes lead to disutility. In many cases, each group chooses an extreme message relative to its members' views in order to minimize this disutility. Messages are not meant to influence the other group's members but rather to balance out the in-group's exposure to the out-group's extremism. This "defensive extremism" leads to interesting results that bolster and add to the literature's understanding of socialization and its consequences.

ABSTRACT OF THE DISSERTATION

The Effects of Online Interactions on Markets and Society

By Fan Jiang

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Professor Jan Brueckner, Co-chair

Assistant Professor Jean-Paul Carvalho, Co-chair

This dissertation is comprised of three economic theory papers: two of them explore the effects of online interactions between firms or individuals; two provide novel explanations of how a society can become culturally polarized (one of them is in both categories).

Chapter 1, “Online Dealers versus Brick-and-Mortar Stores: A Welfare Analysis”, studies online intermediaries as dealers or resellers, who acquire final goods through wholesale trade with producers. Consumers often believe that intermediaries can benefit them by mitigating information imperfections. But in many cases, intermediary entry lowers consumer surplus by allowing a monopolist producer to extract the consumer surplus through indirect sales. In all cases, however, conditions exist under which the presence of an intermediary improves overall welfare, including producer surplus.

Chapter 2, “Cultural Polarization through Online Communication and Economic Growth”, provides an explanation of cultural polarization without endogenous media bias. Online communication has decoupled word-of-mouth communication into the sending and receiving of messages. Consumers are influenced by the news content viewed and the messages received. When the cost of sending messages is higher, extremists have a greater influence on preference formation. Rising wages over time naturally raise the opportunity cost of sending messages, and, when combined with the communication decoupling, this increase implies that we should expect to see increasing cultural polarization.

Chapter 3, “Defensive Extremism”, further examines naturally polarizing forces in society. It offers a model of socialization between groups. Individuals can now easily identify others with similar views through the Internet, but at the same time, the openness of online interactions exposes people to views representing a variety of beliefs. In this model, agents choose to join a group, and each group maximizes the collective utility of its members by endorsing a message that represents its views. The agents’ views are updated following exposure to the messages, and changes lead to disutility. In many cases, each group chooses an extreme message relative to its members’ views in order to minimize this disutility. Messages are not meant to influence the other group’s members but rather to balance out the in-group’s exposure to the out-group’s extremism, representing a “defensive extremism”.

Chapter 1

Online Dealers versus Brick-and-Mortar Stores: A Welfare Analysis

1.1. Introduction

Basic economic theory predicts that perfect competition yields the efficient market outcome, but competition breaks down for many reasons in the real world. Consider markets with imperfect information and significant search or transaction costs. Buyers cannot easily compare product attributes and may buy a product different from the one that yields the highest match value or not buy at all. An intermediary presents a channel through which such market shortcomings can be mitigated. When an intermediary takes the role of an online dealer or reseller, it purchases wholesale products from traditional brick-and-mortar sellers to be resold to consumers, eliminating significant transaction costs for some consumers. Other consumers who buy from the online dealer may not have transacted directly with any individual producer in its absence. In some contexts, intermediaries also serve as information gatekeepers that provide buyers with information regarding product attributes to lower search costs or as matching platforms on which buyers and sellers are matched to improve the transaction process. What, then, is the overall welfare effect of intermediation, and does an intermediary's entry actually increase consumer surplus?

With the advent of the Internet, there were claims that online purchasing would bring about a "frictionless market" in which many of imperfections of traditional markets would dissipate in light of the free flow of information. But Brynjolfsson and Smith (2000) find price dispersion among online retailers[1], which they viewed as evidence of continuing frictions. Nonetheless, their paper finds that the Internet has had a positive effect on surpluses from trade. Other than previously mentioned channels of welfare improvement, Brynjolfsson, Hu, and Smith (2003) highlight the importance of additional product variety from online booksellers in improving surpluses when compared to the more restrictive traditional outlets.

[1] However, there was significantly less price dispersion than with conventional retailers.

These papers belong to an empirical literature that highlights ways in which online transactions improve surpluses and quantifies these improvements.

The present paper analyzes the effect of intermediaries on social welfare in a theoretical setting, focusing on a model with a wholesale market. In this setting, locally monopolistic producers own brick-and-mortar stores that act as the only channel for direct transactions with consumers in each locale. When online dealers enter the market, a wholesale market emerges where producers dictate the wholesale price. The online dealers purchase goods at this price to be resold to consumers in all locales, expanding the producers' market coverage but also creating competition for the producers in final sales. While the improved coverage increases the market's total surplus, the multi-layered interaction between producers and intermediaries in the wholesale and final good markets can actually lower consumer surplus in many cases. Compared to the setting with no intermediation, consumer surplus increases only when there is price competition between multiple producers and multiple intermediaries.

This setting applies to the markets for many consumer products, including those for books and consumer electronics. To consider this model of intermediation as representative of these industries, producers could be viewed as being vertically integrated with the brick-and-mortar outlets. In reality, these outlets are usually just traditional resellers, but this simplifying view allows the extraction of interesting results. Imagine that Barnes & Noble is owned by publishers in the market for books, acting as their brick-and-mortar outlet, with Amazon as the online intermediary, or that Best Buy is the brick-and-mortar outlet owned by the makers of electronics, with Amazon again the online intermediary. In reality, however, Barnes & Noble and Best Buy are themselves intermediaries, but of the brick-and-mortar variety. Alternatively, the model matches the real world cases if the brick-and-mortar intermediaries are separate entities but buy from the producers at cost. Under this condition, the market outcome is as if the producers are selling directly to consumers at brick-and-mortar stores. Although the model involves instances where intermediaries instead buy wholesale goods above cost, this discrepancy should not undermine the intuitive results on the welfare effects of intermediation generated by the model.

The market effects of intermediaries as resellers, as examined by the literature, have been summarized in Spulber (1999). His book discusses settings with various types of transaction costs. The one that most closely relates to resellers portrays the intermediary as having a cost advantage over other sellers as a result of economies of scale from centralized trading. Buyers and sellers must be connected to enable trading, but forming connections is costly. There is a fixed cost of setting up a central intermediary to facilitate trade, the hub in a hub-and-spoke network, but such a network minimizes the number of connections required to enable trade between all buyer-seller pairs. Therefore, having an intermediary improves total surplus for sufficiently many buyers and sellers. In the model explored in this paper, by contrast, the cost advantage of transacting with an online dealer is due to the relatively frictionless nature of online transactions (which eliminate travel cost) and not due to economies of scale.

Most of the literature on online intermediaries, however, studies other types of intermediaries, information gatekeepers (or “infomediaries”) and matching platforms. Baye and Morgan (2001) provide a model of a monopolist gatekeeper that serves a series of local markets, each containing a buyer and a seller. The infomediary earns profit through subscription and advertising fees, and paying these fees enables the buyers and sellers to trade with those outside of their local markets. Their paper finds that, given the gatekeeper’s profit maximizing fees, all buyers but not all sellers use its services. The analysis shows that the market with one gatekeeper is not as efficient as a market without information asymmetries, although it is more efficient than one without any intermediation. On the empirical side of the “infomediary” literature, Smith (2002) provides a meta-analysis on the impact of shopbots, websites that gather desired product information for online shoppers. Although shopbots lower consumers’ search costs, his survey of the literature finds that retailers apply various methods of product differentiation and obfuscation to lower the effectiveness of online product searches.

There has also been work on the roles of matching platforms. Belleflamme and Peitz (2010) discuss how intermediaries improve the matching of buyers and sellers. In their book, the matching model consists of buyers with high or low valuation for the good and sellers with high or low cost of producing the good. In this setting, a matching platform can facilitate the allocation of goods and improve total surplus compared to random matching of buyers and sellers. According to Spulber (1999), such intermediaries can also reduce adverse selection by adjusting their contracts with buyers and sellers. Forming contracts and monitoring product quality can be costly, but an intermediary that handles high volumes of trades is more efficient at enforcing high-quality transactions. Hence, matching platforms improve the gains from trade via this route.

This paper extends the existing literature by analyzing markets with intermediaries who make wholesale purchases from producers and resell to consumers, thereby competing with direct sales by producers. Section 2 discusses a setting in which identical producers and identical intermediaries compete in the same final good markets and consumers differ in the travel cost associated with buying from a producer. In this setup, each producer only sells in its local market and thus does not directly compete with other producers. In the wholesale market, where part of a producer's output is sold to the intermediary for resale, producers compete in setting the wholesale price, and intermediaries' demand for the wholesale product derives from the purchasing decisions of consumers. A few subsections discuss cases with varying levels of market power for the producers and intermediaries, analyzing the effects of intermediation on consumer surplus (*CS*) and total surplus (*TS*). Whereas section 2 assumes that all local markets are the same, section 3 presents an extension in which local markets differ in travel costs. The final section summarizes the paper's findings and makes suggestions for future research.

1.2. Simple Model

Imagine a setting where multiple local markets (indexed by $j = 1, \dots, n$) for some product each have one producer, the sole supplier in its local market. Producers are not capacity constrained and have identical cost structures, no fixed cost and constant marginal cost ($c > 0$). There is a measure-1 continuum of consumers who equally value the product at more than the cost of production (valuation $v > c$) in each of these n markets. Consumers located in the vicinity of producer j will only buy in its local market, but they incur a travel cost ($s > 0$) during purchase which varies among consumers located at different distances from the producer. Producers know the distribution of travel costs within their local markets but do not observe the travel costs of individual consumers and thus cannot price discriminate among them. For simplicity, let s be distributed uniformly over $[0, \alpha]$.

Assume that for some consumers, the travel cost is prohibitively high, so that they prefer not to participate in their local market. That is, α is higher than the consumers' valuation of the product minus the profit-maximizing final good price to be chosen by their producer. This assumption highlights the producers' need for intermediaries, who can resell the product without the travel cost and cover the entire consumer base. Direct sale from producers would not reach the entire potential consumer base without an intermediary.

More generally, this model could apply to markets where a producer's price is only observable to consumers in its vicinity. While some of the literature (e.g. Grossman and Shapiro, 1984 and Stahl, 1994) endogenizes firms' advertising choices, the current model in effect assumes an exogenous form of local advertisement which informs only nearby consumers of the local producer's price. However, a producer has the option to broaden its consumer base through wholesale offerings to intermediaries and subsequently through the intermediaries' resale.

Intermediaries (indexed by $k = 1, \dots, m$) operate online and sell to consumers in all local markets free of travel cost. Though there are fixed costs involved in setting up an intermediary, it is assumed without loss of generality that this cost is zero. Thus, an intermediary's only cost comes from wholesale purchases from producers. Even though producers benefit from making products available to a larger proportion of consumers, they are at a disadvantage when competing against intermediaries for a consumer's business. We will see in the following subsections whether consumers and producers receive a net gain through these interactions and whether social welfare improves as a result of intermediation.

1.2.1. The One-Producer, One-Intermediary Case (1F/1I) [2]

The case with one producer and one intermediary is in some sense more complicated than cases with multiple producers, multiple intermediaries, or both, where price competition simplifies the choices of

[2] 'F' is used to denote producer ("firm") rather than 'P' to avoid confusion with final good prices.

wholesale price, final good prices, or all prices. This section assumes the existence of an intermediary and analyzes the market outcome given that the producer sells through the dealer. The next section then considers the market outcome when there is no intermediary and provides conditions under which the producer prefers to engage in wholesale trade.

Imagine a market for the good, where consumers receive price information from the local producer through advertisements in the mail or on television and from the intermediary on the Internet. This market with one producer and one intermediary consists of several stages, as follows. First, the producer sets the wholesale price (W). Similar results emerge by assuming that W comes from Nash Bargaining between the producer and the intermediary in the wholesale market or by assuming that the intermediary bids for a wholesale price that is acceptable to the producer. However, letting the producer set W conditional on its own production cost c is an attractive approach. Next, the sellers set final good prices (P_F and P_I for the producer and intermediary, respectively) in Nash fashion, each taking the other's final price and the wholesale price as fixed. Thus, neither seller leads in the retail pricing decision. The producer can easily track the intermediary's price by searching online, and the intermediary uses its aptitude at data mining to gather information about the producer's pricing behavior. The ability of the two sellers to view the competing prices and the interdependence of the sellers' price-setting behavior warrant the Nash assumption. Finally, consumers make their purchase decisions after observing both final good prices. Figure A.1 provides a visualization of the market.

Using backward induction, analysis of the consumers' purchasing choice is the first step, with a consumer buying from either the producer or the intermediary at the lower of two prices: the producer's final good price inclusive of travel cost $(P_F + s)$ and the intermediary's final good price (P_I). A third possibility is to not purchase the good at all. Assume that consumers' valuation of the good surpasses its cost of production, so that some consumers will always buy the good. The proportions of consumers who buy from the producer (q_F) or the intermediary (q_I) and the s-threshold for the indifferent consumer (s^*) depend on the final good prices. Specifically, a consumer is indifferent between buying from the producer and buying from the intermediary when $v - (P_F + s) = v - P_I$. Thus, the travel cost threshold is

$$(1) \qquad s^* = P_I - P_F,$$

and consumers with $s > (<)\ s^*$ buy from the intermediary (producer). Recalling the uniformity assumption on s over $[0, \alpha]$ and the unit mass of consumers, the quantities (market shares) demanded from the producer and the intermediary are then:

$$(2) \qquad q_F = \int_0^{s^*} \frac{1}{\alpha} ds = \frac{P_I - P_F}{\alpha},\ q_I = \int_{s^*}^{\alpha} \frac{1}{\alpha} ds = 1 - \frac{P_I - P_F}{\alpha}.$$

Given these quantities as functions of the prices, consider the sellers' profit-maximization problems. The intermediary chooses its final good price, taking the producer's final price and the wholesale price as given, to maximize its profit,

$$(3) \qquad \pi_I = (P_I - W)\left(1 - \frac{P_I - P_F}{\alpha}\right).$$

At the same time, the producer chooses its final price, taking its competitor's final price and the wholesale price as given, to maximize

$$(4) \qquad \pi_F = (W - c)\left(1 - \frac{P_I - P_F}{\alpha}\right) + (P_F - c)\frac{P_I - P_F}{\alpha}.$$

The first term represents the producers' profits from wholesale purchases, and the second term is the profit from final sales.

Instead of looking for an interior solution to these profit-maximization problems, notice that there is a corner solution. The producer knows that the intermediary must set $P_I \leq v$ to attract consumers. Therefore, it cannot set the wholesale price above the consumers' valuation: $W \leq v$. The corner solution is characterized by the producer setting wholesale price equal to consumers' valuation,

$$(5) \qquad W^* = v,$$

which forces the intermediary to set the online price to valuation,

$$(6) \qquad P_I^* = v,$$

and, at the same time, the producer sets the local price to valuation as well,

$$(7) \qquad P_F^* = v.$$

The intermediary can do no better than to break even:

$$(8) \qquad \pi_I^* = 0.$$

With this pricing scheme, the producer only sells to the intermediary, and all consumers buy online:

$$(9) \qquad q_F^* = 0,\ q_I^* = 1.$$

The producer earns profit equal to the difference between consumers' valuation and production cost,

$$(10) \qquad \pi_F^* = v - c,$$

which is the highest possible level. Therefore, there are no interior solutions that give the producer a higher profit, and in fact, it can be shown that there are no interior solutions. Since all consumers buy through the intermediary and pay their valuation, they receive no surplus:

$$(11) \qquad CS = 0.$$

1.2.2. The One-Producer, No-Intermediary Case (1F/0I)

The above results characterize the solution when an intermediary is present in the one-producer case. Now, consider the setting without intermediation in order to find conditions that determine whether the producer chooses to sell through the intermediary. As discussed earlier, the producer unable to reach the entire consumer base because some consumers have high travel costs. This realization leads to some restrictions on the transaction cost under which wholesale trade occurs.

When there is one producer and no intermediary, the consumer's optimization objective is simpler, where she only chooses between buying from the producer at price $P_F + s$ and not buying. Consumers with cost $s \leq v - P_F$ will buy from the producer, and the rest are priced out of the market, so that quantity demanded from the producer is given by

$$(12) \qquad q_F = \int_0^{v-P_F} \frac{1}{\alpha}\, ds = \frac{v-P_F}{\alpha}.$$

The producer chooses price P_F to maximize profit

$$(13) \qquad \pi_F = (P_F - c)\frac{v-P_F}{\alpha},$$

and the optimal price is

$$(14) \qquad P_F^* = \frac{v+c}{2}.$$

The resulting solutions for the consumers' quantity demanded and the producers' profit are

$$(15) \qquad q_F^* = \frac{v-c}{2\alpha} \text{ and } \pi_F^* = \frac{(v-c)^2}{4\alpha},$$

respectively.

Without intermediation, consumers with travel cost $s > v - P_F = \frac{1}{2}(v-c)$ will not buy from the producer. Therefore, for some consumers to not buy,

$$(16) \qquad \alpha > \frac{1}{2}(v - c)$$

must hold. This "incomplete coverage" condition is significant because it guarantees that intermediation broadens the consumer base of a local monopolist by eliminating travel cost for indirect buyers. This condition is henceforth adopted as a maintained assumption.

In comparing the producer's profit with intermediation from (10) and the profit without intermediation derived above, focus on the role of the travel cost parameter, α. Intuitively, the producer prefers to use intermediation since it can achieve the highest possible profit, given in (10). Algebraically, the using intermediation is preferred when doing so yields a higher profit:

$$(17) \qquad v - c > \frac{(v-c)^2}{4\alpha}.$$

This condition reduces to a lower bound for the maximum travel cost: $\alpha > \frac{1}{4}(v-c)$. Since this condition is satisfied by the "incomplete coverage" assumption, the producer always prefers to use intermediation rather than operate as a local monopolist.

To compare consumer surplus with and without intermediation, recall that only consumers whose travel cost is lower than $v - P_F^*$ buy in a market without intermediation. Thus, using (14),

$$(18) \qquad CS = \frac{1}{\alpha}\int_0^{v-\frac{v+c}{2}} \left[v - \left(\frac{v+c}{2} + s\right)\right] ds = \frac{1}{8\alpha}(v-c)^2.$$

The $\frac{1}{\alpha}$ factor rescales the surplus value from the travel cost scale, $[0, \alpha]$, to the continuum of consumers, $[0,1]$. Since consumer surplus when there is an intermediary is given by (11), consumers are better off with intermediation when $\frac{1}{8\alpha}(v-c)^2 < 0$. However, this inequality never holds since the difference between consumers' valuation and the marginal cost of production is strictly positive. Therefore, *CS* is lower when intermediation is used. This counterintuitive result is driven by the sole producer's bargaining power over the intermediary. Without intermediation, the producer sets a lower final price to compensate for travel costs incurred by consumers. When there is intermediation, however, the producer is able to extract more of the consumer surplus by forcing the intermediary to set final price to valuation. The consumers who only buy online are equally well-off with or without intermediation, each with no surplus from trade, but the consumers who switch from direct to online purchase are worse off since they pay a higher price. Thus, overall, intermediary-entry lowers consumer surplus.

Finally, intermediation affects total surplus in the market. This measure of welfare is computed as the sum of the producer's profit, the intermediary's profit, and consumer surplus. Total surplus in a market with one producer and one intermediary is $v - c$, while it is $\frac{3}{8\alpha}(v-c)^2$ without the intermediary. Thus, intermediary entry improves total surplus when $v - c > \frac{3}{8\alpha}(v-c)^2$, which reduces to $\alpha > \frac{3}{8}(v - c)$. This condition is satisfied given "incomplete coverage", so that total surplus is higher with intermediation. Intuitively, the one-producer and one-intermediary results characterize an efficient market outcome. A consumer values the good at v, and the producer's cost of production is c. Therefore, total surplus can only be as large as the difference, $v - c$.[3] Summarizing yields

Proposition 1.1. In the 1F/1I case,

(i) the producer always prefers to sell to the intermediary and makes no direct sales to the final market ($q_F^* = 0,\ q_I^* = 1$),

(ii) consumer surplus is lower when the producer uses intermediation, and

(iii) total surplus is higher when the producer uses intermediation.

Tables A.1 through A.3 summarize the results for this case and the cases considered subsequently.

[3] The same argument shows that the market with intermediation is efficient in the 1F/2I and 2F/2I cases.

1.2.3. The One-Producer, Two-Intermediary Case (1F/2I)

Next is the case where two intermediaries compete to buy from a single producer in the wholesale market. Like in the 1F/1I case, the producer holds the bargaining power, and only it will receive a positive profit. As will be shown, entry of the second intermediary does not affect market outcomes. Bertrand competition between the intermediaries forces them to charge final good prices equal to the wholesale price, at which they purchase their resale inventory, operating at zero profit:

$$(19) \qquad P_{Ik}^{*} = W,\ k = 1,2.$$

The consumer's objective is to choose the highest payoff among $v - (P_{Fj} + s)$ under direct purchase, $v - W$ when buying from an intermediary, and zero when not buying. A consumer is indifferent between buying from the producer or an intermediary if her travel cost is exactly the difference between the final good prices, $s^{*} = W - P_F$. Thus, the quantities demanded from the producer and the intermediaries are

$$(20) \qquad q_F = \frac{W - P_F}{\alpha} \text{ and } q_I = 1 - \frac{W - P_F}{\alpha},$$

respectively, where the two intermediaries each sell half of q_I assuming that online buyers are randomly drawn to an intermediary. Notice that q_F is non-negative if and only if the producer sets its final good price no higher than its wholesale price ($P_F \leq W$), which does not intuitively seem like a profitable choice. In fact, the producer will choose to only sell through the intermediaries in equilibrium, as is now demonstrated.

To do so, consider the producer's profit,

$$(21) \qquad \pi_F = (W - c)\left(1 - \frac{W - P_F}{\alpha}\right) + (P_F - c)\frac{W - P_F}{\alpha} = W - c - \frac{(P_F - W)^2}{\alpha},$$

which is maximized at $P_F^{*} = W$. Thus, all sales go through intermediaries:

$$(22) \qquad q_F^{*} = 0,\ q_I^{*} = 1 \text{ or } q_{Ik}^{*} = \frac{1}{2},\ k = 1,2.$$

The producer's profit then simplifies to $\pi_F = W - c$. Since a consumer's payoff of buying from an intermediary is $v - W$, the upper bound and thus the profit-maximizing value of W is simply the consumers' valuation ($W^* = v$), and the producer's profit is

$$(23) \qquad \pi_F^* = v - c.$$

All consumers buy online and pay their valuation, so consumer surplus is zero ($CS = 0$). The consumer surplus result is the same as in the one-intermediary case. Just as before, the sole producer uses intermediation to broaden market coverage and extract surpluses from all consumers. Since total surplus equals π_F, thus equaling $v - c$, having two competing intermediaries increases total surplus relative to that in a market without intermediation. Since the market outcomes are essentially the same as in the 1F/1I case, the total surplus is higher with intermediation for the same reasons as before. Again, these results characterize an efficient market outcome.

In this setting, the producer prefers to interact with the intermediaries if its profit in (23) is higher than without intermediation: $v - c > \frac{(v-c)^2}{4\alpha}$, which translates to $\alpha > \frac{1}{4}(v - c)$. Recalling the "incomplete coverage" assumption, $\alpha > \frac{1}{2}(v - c)$, the previous inequality is satisfied, so that the producer always prefers to sell through the intermediaries. The intuitive reason is that the producer cannot extract all of the consumers' surpluses through direct sale since it cannot capture the travel cost portion of consumer expenditures. Since the producer extracts the entire consumer surplus when selling through two competing intermediaries, it prefers this method of selling the product. Summarizing yields

Proposition 1.2. In the 1F/2I case,

(i) the producer always prefers to sell to the intermediaries and makes no direct sales to the final market ($q_F^* = 0,\ q_I^* = 1$),

(ii) the entire consumer surplus is transferred to the producer ($CS = 0$), so that surplus is lower than without intermediation, and

(iii) total surplus is at the highest possible level, $v - c$.

1.2.4. The Two-Producer, One-Intermediary Case (2F/1I)

Relative to the 1F/1I case, adding a second producer simplifies the mechanism within the wholesale market due to competition between producers. All of the market power transfers to the monopsonist intermediary. As a result of competition between the producers for the intermediary's business, the wholesale price reduces to a level at which producers are indifferent between selling to the intermediary or not, with W falling to cost c. The producers play a game to determine whether to sell through the intermediary. As will be demonstrated, there exist conditions such that the unique Nash equilibrium has both producers using intermediation.

The consumers' problem is the same as before but has an index (j) for the two local markets. Each local market again has a measure-1 continuum of consumers, who maximize utility by choosing among payoffs of $v - (P_{Fj} + s)$ when buying from producer j, $v - P_I$ when buying from the intermediary, or 0 when not buying. A consumer who is indifferent between buying from the local producer or the intermediary has travel cost $s = P_I - P_{Fj}$. Thus, the quantities demanded for producer j and the intermediary are

$$(24) \qquad q_{Fj} = \frac{P_I - P_{Fj}}{\alpha}, \; q_I^j = 1 - \frac{P_I - P_{Fj}}{\alpha},$$

paralleling (12).[4]

The producers' profit-maximization problem is similar to that in the previous case, except there is now no profit from sales to the intermediary since the wholesale price has fallen to cost. Thus,

$$(25) \qquad \pi_{Fj} = (P_{Fj} - c)\frac{P_I - P_{Fj}}{\alpha}.$$

Solving for the optimal choice of producer j's final good price yields its reaction function,

$$(26) \qquad P_{Fj} = \frac{1}{2}(c + P_I).$$

[4] The superscript j in q_I^j denotes the quantity demanded from the intermediary by the consumers of local market j. This notation discerns the expression from the quantity demanded from each of two intermediaries in the 1F/2I and 2F/2I cases, $q_{Ik}, k = 1, 2$.

The intermediary's profit expression is slightly different from before since it now purchases from two producers:

$$(27) \qquad \pi_I = (P_I - c)\left(1 - \frac{P_I - P_{F1}}{\alpha} + 1 - \frac{P_I - P_{F2}}{\alpha}\right).$$

Solving for the optimal choice of the intermediary's final good price yields its reaction function,

$$(28) \qquad P_I = \frac{1}{2}(\alpha + c) + \frac{1}{4}(P_{F1} + P_{F2}).$$

Simultaneously solving for final good prices using these reaction functions, and imposing symmetry on the producers' prices, gives

$$(29) \qquad P_{Fj}^* = c + \frac{1}{3}\alpha,\ P_I^* = c + \frac{2}{3}\alpha.$$

These results show that the intermediary is able to set a higher final price since online purchases do not incur any travel cost.

Substituting (29) into (24) gives the sellers' market shares:

$$(30) \qquad q_I^* = q_I^{1*} + q_I^{2*} = \frac{4}{3},\ q_{Fj}^* = \frac{1}{3},\ j = 1,2.$$

Therefore, the sellers' profits are

$$(31) \qquad \pi_I^* = \frac{8}{9}\alpha,\ \pi_{Fj}^* = \frac{1}{9}\alpha.$$

All consumers who buy from the intermediary receive the same surplus since travel cost is absent. Surplus for the remaining one-third that buys directly from a producer varies depending on travel cost. The combined consumer surplus is calculated as follows:

$$(32) \qquad CS = 2\left\{\frac{2}{3}\left[v - \left(c + \frac{2}{3}\alpha\right)\right] + \frac{1}{\alpha}\int_0^{\frac{1}{3}\alpha}\left[v - \left(c + \frac{1}{3}\alpha + s\right)\right]ds\right\} = 2(v - c) - \frac{11}{9}\alpha.$$

Competition between the producers keeps them from holding bargaining power over the intermediary, as in the one-producer cases. Also, the *CS* in (32) is strictly positive under "incomplete coverage" and thus higher than in the one-producer cases, where expansion of the producer's market power through intermediation transfers all surpluses from trade to the producer. Now, producers earn greater profits when selling a portion of their goods locally since the profit margin from selling to the intermediary has disappeared. The lack of direct competition in the final good market between producers allows both to operate at a positive profit. This profit is lower than in the one-firm case because their interaction with the intermediary creates indirect competition.

1.2.5. The Two-Producer, No-Intermediary Case (2F/0I)

If there is no intermediary, then the producers are monopolists in their respective local markets. Just as in the 1F/1I case, not all consumers are willing to buy from the producers, but each producer receives a greater profit margin from the consumers in its local market. Since each of the two local markets is like the single market in the 1F/1I case, a producer's profit from setting the monopoly price is the same as before:

$$\text{(33)} \qquad \pi_{Fj}^{*} = \frac{(v-c)^2}{4\alpha}.$$

To find conditions under which a producer prefers to have an intermediary in the market, one must consider the game that the two producers play when choosing either to sell through the intermediary ("use I") or not ("don't"). The producers choose the strategy profile (use I, use I) if neither has an incentive to unilaterally deviate to only sell within its local market. Mathematical Appendix A.1 analyzes this game, demonstrating that the unique Nash equilibrium has both producers choosing to utilize intermediation when

$$\text{(34)} \qquad \alpha > \frac{3}{2}(v-c).$$

When α satisfies "incomplete coverage" but not (34), the case where one producer sells to the intermediary while the other does not is a NE. As the maximum travel cost increases, the producer that does not use intermediation loses more of its local consumers to online sales. When α satisfies (34), this producer is better off switching to "use I" as well, even though competition with the other producer in the wholesale market drives down final prices. For the following discussion of the effects of intermediation on *CS* and *TS*, (34) is a maintained as an assumption to avoid considering a non-coordinating NE, which alters the surplus comparison.[5]

When neither producer sells indirectly, the consumer surplus is double the amount in the one-producer case, given by (18), since there are twice as many local markets. Thus,

$$(35) \qquad CS = \frac{1}{4\alpha}(v-c)^2,$$

whereas the consumer surplus in a market with intermediation is given by (32). Consumer surplus is higher under intermediation when $2(v-c) - \frac{11}{9}\alpha > \frac{1}{4\alpha}(v-c)^2$, which simplifies to $\alpha < \frac{3}{2}(v-c)$. However, this condition contradicts (34), so that whenever the only NE has both producers using intermediation, *CS* is lower.

Finally, summing the firms' profits and the consumer surplus allows comparison of market's total surplus with and without intermediation. When producers sell through the intermediary, $TS = 2(v-c) - \frac{1}{9}\alpha$, while $TS = \frac{3}{4\alpha}(v-c)^2$ when there is no intermediation. A comparison of the total surpluses shows that *TS* is higher with intermediation when

$$(36) \qquad \alpha \in \left(\left(9 - \frac{9}{8}\sqrt{\frac{176}{3}}\right)(v-c), \left(9 + \frac{9}{8}\sqrt{\frac{176}{3}}\right)(v-c)\right).$$

Figure A.3 provides a graphical view of the above comparison and the resulting bounds. Given (34), these restrictions reduce to

$$(37) \qquad \alpha \in \left(\frac{3}{2}(v-c), \left(9 + \frac{9}{8}\sqrt{\frac{176}{3}}\right)(v-c)\right).$$

Proposition 1.3. In the 2F/1I case,

(i) the producers sell both to the intermediary and in the final market when

$$\alpha > \frac{3}{2}(v-c),$$

[5] Consumer surplus and firms' profits are very different depending on whether the second producer is using intermediation (see Mathematical Appendix A.1).

(ii) consumer surplus is lower when intermediation is used, and

(iii) total surplus is higher when intermediation is used and

$$\alpha \in \left(\frac{3}{2}(v-c), \left(9+\frac{9}{8}\sqrt{\frac{176}{3}}\right)(v-c)\right) \text{ holds.}$$

To interpret the upper bound of (37), consider separately the firm profit and consumer surplus portions of total surplus. Total firm profits are higher with intermediation when $\frac{10}{9}\alpha > \frac{1}{2\alpha}(v-c)^2$, which reduces to $\alpha > \frac{3}{2\sqrt{5}}(v-c)$, which is weaker than the lower bound in (37). Therefore, firm profits are higher with intermediation whenever total surplus is higher. On the other hand, consumer surplus is lower on the same domain of α. As α increases, a greater proportion of consumers buy online. Since the online price is higher than the direct-purchase price, consumer surplus decreases. When $\alpha > \left(9+\frac{9}{8}\sqrt{\frac{176}{3}}\right)(v-c)$, the *CS*-loss from intermediation outweighs the firms' profit gains. Thus, total surplus decreases.

1.2.6. The Two-Producer, Two-Intermediary Case (2F/2I)

The case with two intermediaries and two producers serving identical local markets is trivial. Bertrand competition forces the producers to price at cost in the wholesale market,

$$(38) \qquad W_j^* = W^* = c,\ j = 1,2,$$

and forces the intermediaries to price at cost in the final goods market

$$(39) \qquad P_{Ik}^* = W^* = c,\ k = 1,2.$$

A producer cannot make any direct sales unless P_{Fj} is set below P_{Ik}^* and thus below cost. Therefore, all sales occur through the intermediaries since consumers save travel costs.

Compared to the 1F/2I case, having the additional producer prevents either producer from taking advantage of the intermediaries' competition in order to extract consumer surplus. Compared to 2F/1I case, the additional intermediary drives the price of online purchase down to cost. Now, competition yields the intuitive result that consumers' receive a relatively large surplus, a result of buying at cost:

$$(40) \qquad CS = 2(v - c).$$

Proposition 1.4. In the 2F/2I case,

(i) the producers only sell through the intermediaries $\left(q^*_{Fj} = 0,\ q^*_{Ik} = 1,\ j,k \in \{1,2\}\right)$,

(ii) consumer surplus, equal to $2(v - c)$, is higher than without intermediation, and

(iii) total surplus is at the highest possible level, $2(v - c)$.

1.3. Heterogeneous Local Markets

To extend the two-producer cases from section II, consider a setting in which the producers' local markets vary in the extent of consumer travel cost, with the upper bounds of travel cost being different ($\alpha_1 \neq \alpha_2$). Assume that each market again has a measure-1 continuum of consumers. This setting describes local markets where one of the brick-and-mortar stores serves a larger region, perhaps a less densely-populated area, than the other.

1.3.1. The Two-Producer, One-Intermediary Case

First consider the case with one intermediary. In the wholesale market, producers again compete in price so that $W^* = c$, with firms setting their final good prices (P_{Fj}, P_I) in Nash fashion to maximize their respective profits.

Just like in the 2F/1I case with homogeneous local markets, the consumer who is indifferent between buying from her local producer or the intermediary has travel cost $s = P_I - P_{Fj}$. However, generalizing (2), the quantities demanded from each producer now differ based on the heterogeneous maximum travel costs:

$$(41) \qquad q_{Fj} = \frac{P_I - P_{Fj}}{\alpha_j}.$$

Therefore, the quantities demanded from the intermediary in each local market also differ:

$$(42) \qquad q_I^j = 1 - \frac{P_I - P_{Fj}}{\alpha_j}.$$

The implication is that direct-purchase accounts for a smaller share of final sales in the market where the maximum travel cost is greater. The intermediary's total market share is the sum of the shares from each final good market:

$$(43) \qquad q_I = q_I^1 + q_I^2 = 2 - \frac{P_I - P_{F1}}{\alpha_1} - \frac{P_I - P_{F2}}{\alpha_2}.$$

Given these expressions for the quantities demanded, consider the sellers' choices of profit-maximizing final good prices. Producer *j* maximizes profit

$$(44) \qquad \pi_{Fj} = (P_{Fj} - c)\frac{P_I - P_{Fj}}{\alpha_j},$$

and the resulting reaction function is

$$(45) \qquad P_{Fj} = \frac{1}{2}(P_I + c).$$

Similarly, the intermediary maximizes profit

$$(46) \qquad \pi_I = (P_I - c)\left(2 - \frac{P_I - P_{F1}}{\alpha_1} - \frac{P_I - P_{F2}}{\alpha_2}\right),$$

and the reaction function is

$$(47) \qquad P_I = A + \frac{\alpha_2}{2(\alpha_1 + \alpha_2)}(P_{F1} + c) + \frac{\alpha_1}{2(\alpha_1 + \alpha_2)}(P_{F2} + c),$$

where $A \equiv \frac{\alpha_1 \alpha_2}{\alpha_1 + \alpha_2}$. Simultaneously solving the reaction functions yields the following final good prices:

$$(48) \qquad P_{Fj}^* = c + \frac{2}{3}A, \; P_I^* = c + \frac{4}{3}A.$$

Notice that the choice of P_{Fj}^* depends on the extent of travel cost, α_j, only through P_I. When $\alpha_1 = \alpha_2$, the solutions in (48) reduce to those in (29). Substituting (48) into (42) and (41) give the market shares:

$$(49) \qquad q_{Fj}^* = \frac{2}{3\alpha_j}A, \; q_I^{j*} = 1 - \frac{2}{3\alpha_j}A,$$

with $\alpha_1 < \alpha_2$ implying $q_I^{1*} < q_I^{2*}$ and $q_{F1}^* > q_{F2}^*$. The intermediary's total market share is then

$$(50) \qquad q_I^* = \frac{4}{3},$$

and its profit is

$$(51) \qquad \pi_I^* = \frac{16}{9} A.$$

As expected, the market shares show that the producer with the higher maximum travel cost must settle for a smaller market share and thus lower profit:

$$(52) \qquad \pi_{Fj}^* = \frac{4}{9\alpha_j} A^2.$$

This pattern also means that a greater portion of the intermediary's total market share comes from the market with the higher maximum travel cost.

Proposition 1.5. The producer in the local market with the lower maximum travel cost (i) sells less through the intermediary, (ii) holds a larger final good market share, and (iii) earns a higher profit. Assuming without loss of generality that $\alpha_1 < \alpha_2$,

(i) $q_I^{1*} < q_I^{2*}$,

(ii) $q_{F1}^* > q_{F2}^*$, and

(iii) $\pi_{F1}^* > \pi_{F2}^*$.

Imagine that local market with the lower maximum travel cost is located in a densely populated city, whereas the other local market is in a suburb with the same population but dispersed across a larger region. The producer located in the city attracts more consumers because a greater proportion of them prefer to pay the producer's lower price plus the travel cost rather than buy online. Therefore, the producer in the city sells more goods directly to the consumers and less through the intermediary. Since the producers set wholesale price to cost, they earn no profits through the intermediary's online sales. All of their profits come from direct purchase, so the producer in the city earns higher profits.

Although previous sections analyze the effects of intermediary entry on consumer surplus and total surplus, the additional travel cost heterogeneity makes analogous comparisons more difficult and less enlightening here. Table A.1 and Table A.2 highlight the market outcomes and give a sense of the similarities between the current case and the 2F/1I case with homogeneous local markets. Consumer surplus is computed in the same manner as before[6], and total surplus is again the sum of the firms' profits and the consumer surplus.

1.3.2. The Two-Producer, Two-Intermediary Case

Even though local markets are now assumed to be different, the 2F/2I outcome with heterogeneous local markets is the same as in section 1.2.6, where local markets were identical. The reason is simply that when all sellers compete to price at cost, consumers only buy from intermediaries. Since there are no final good transactions with producers, travel cost heterogeneity has no effect on market outcomes.

1.4. Conclusion

This paper adds to the literature on markets with intermediation where the intermediary's actions are endogenously considered. Whereas past work focus on the intermediary's role as an information gatekeeper (Baye and Morgan (2001), Smith (2002)) or a matching platform (Spulber (1999), Belleflamme and Peitz (2010)), this paper considers a model in which the intermediary acts as a reseller. Real-world examples that support this view include, but are not limited to, markets for books and consumer electronics. A particularly interesting set of results is that, in all but the two-producer and two-intermediary case, intermediary entry can improve market efficiency but can also lower consumer surplus. Even though consumers often think of intermediaries as entities that can benefit consumers, this

[6] Since local direct-purchase prices are equal in the two markets, the local thresholds for travel cost under which a consumer chooses to buy from the local producer are the same. Therefore, the consumer surplus of direct buyers, the first term in the consumer surplus expression below, is the same in the two markets, and the second term describes the equal surplus for the two-thirds proportion of consumers that buys through the intermediary:

$$(53) \qquad CS = \left(\frac{1}{\alpha_1}+\frac{1}{\alpha_2}\right)\int_0^{\frac{2}{3}A}\left[v-\left(c+\frac{2}{3}A+s\right)\right]ds+\frac{4}{3}\left[v-\left(c+\frac{4}{3}A\right)\right]=2(v-c)-\frac{22}{9}A.$$

Once again, if $\alpha_1 = \alpha_2$, then the above *CS* expression reduces to (32).

paper finds that intermediaries also transfer surplus from consumers to producers as a result of more efficient online pricing. One example is that of the market for computers. Apple is able to generate and maintain a large premium on the price of Macintosh-based computers (Mac's) by using multiple intermediate resale outlets (e.g. Apple Stores, college bookstores, computer hardware stores), as in the 1F/2I case. In comparison, the 2F/2I setting represents the market for Windows-based computers (PC's), where products are mostly identical aside from some small attempts at product differentiation. In the model, competition between intermediaries in the 1F/2I case allows the producer to set relatively high prices and extract the entire consumer surplus. In the 2F/2I case, competition between multiple producers and intermediaries drive prices down to cost. These results may explain the significant price premium of Mac's over PC's.

Chapter 2

Cultural Polarization through Online Communication and Economic Growth

2.1. Introduction

Over the past decade, people have become increasingly partisan in their political views (Stroud 2011). News outlets with a clear liberal or conservative slant (e.g. MSNBC and Fox News, respectively) have gained popularity. Traditionally, motives such as self-validation have been used to explain the phenomenon that people selectively expose themselves to information (Festinger 1957). With the expansion of the role of social media in news, the way in which news affects individuals' beliefs through consumption and social interaction is changing. Might this relatively new mode of news consumption and sharing further contribute to the polarization of consumers' preferences?

The usage of smartphones provides an example of how news consumption and related social interactions have changed. In February of 2012, half of U.S. cellphone purchases were smartphones, following a trend of increasing usage (Nielsen 2012), and smartphone market penetration is expected to grow (eMarketer 2012). These devices grant their owners instant access to the Internet and have increased people's usage of social media both in the U.S. and abroad (Norwegian Media Barometer 2011). Currently, political social media are still predominantly political blogs, but a growing consumer base draws news from widely-distributed online channels such as Facebook and YouTube. On these social media websites, users read and post messages about news pieces as a way of socializing with other news consumers. We commonly observe others using smartphones while waiting for something or someone (e.g. in traffic and in line for service). Such evidence tells us that any non-spoken communications tend to be brief because they occur between activities that require more attention. These observations suggest that there is a cost to posting messages that decouples online interaction, separating the two components of traditional conversation: listening and speaking.

One can interpret the messaging cost as some combination of an explicit cost of effort and an implicit cost of time. These costs are apparent from the examples of smartphone usage in between other activities. Absorption of information through viewing news and messages is quick compared to posting messages, which requires deeper reflection and thought. Think of the act of posting messages as requiring a relatively higher ratio of “slow” to “fast” thinking, in the terminology of Kahneman (2011), and thus as incurring a higher cost of effort. An interpretation of the implicit cost is that of real wages. News consumption and social interaction are leisure activities, and one’s wage is the opportunity cost of leisure time. These costs are significant when one must be able to quickly divert attention to something else: navigating rush hour traffic, ordering coffee, or getting back to work after a quick break.

The cost of posting messages causes the distribution of views expressed by these messages to differ from the distribution of the consumers’ preferences. Specifically, only consumers who strongly agree or disagree with the news they consumed will be motivated enough to post a message because they still receive some payoff from posting net of the associated cost. The key component of the mechanism through which online communication polarizes views is the cost of posting messages. If consumers’ preferences are influenced not just by the news they consume but also by the viewpoints of their fellow consumers, then seeing a skewed distribution of messages in addition to consuming slanted news can polarize a consumer’s views more than that from only news consumption.

In a simple one-period model, consider a market for news with two producers and a continuum of consumers. These consumers are heterogeneous only in terms of their preference for news, reflecting underlying political preferences, and the producers’ are assumed to place their news products on opposing sides of the preference spectrum, equidistant from and symmetric about the median consumer. This simplified view focuses on the change in consumer preference after news consumption and social interaction via messages. Consumers are aware of the existing media slant when making their consumption choice. Comparative statics on the cost of messages shows that a higher cost leads to a post-interaction preference distribution with more weight at the extremes, confirming the suspicion that the messaging cost associated with social media contributes to further polarization of people’s views.

Online communication has decoupled traditional word-of-mouth interaction into the sending and receiving of messages, which have replaced speaking and listening, respectively. Due to a combination of lower payoff and higher cost from posting messages, moderates only “listen” but do not “speak”, biasing the distribution of messages to the extremes and driving the polarization of updated preferences. Given the opportunity-cost interpretation of the message-posting cost, rising wages increase this cost and contribute to the polarization of a society’s views over time, adding to any effects of endogenous media slant discussed in the existing literature. This important extension is explored before concluding.

This paper is partially motivated by individuals’ selective exposure to information, and the idea that people prefer to take in information that confirms their prior beliefs and to avoid information that conflicts with those beliefs. Selective exposure is closely related to confirmation bias, which also includes selective recall of information from memory, ideas popularized by psychologist Leon Festinger (1957).

Partisan selective exposure is a subcategory of this phenomenon, where self-selection in information choice is driven by individuals’ political stances. One might think of this phenomenon as generally driven by the need for validation, but there have been a few specific psychological theories for why selective exposure might occur. The most prominent explanation is cognitive dissonance (Festinger 1957), where the dissonance from facing conflicting ideas can lead to selective exposure. Psychologists also believe that some people are “cognitive misers” and thus prefer to exert as little effort as possible in order to reach a decision (Taylor 1981; Edwards and Smith 1996; Ziemke 1980). Kahneman (2011) also discusses cognitive “ease” and “strain” with regard to the effort involved in the decision-making process. Other theories for the occurrence of selective exposure are motivated by individuals’ need for closure or to avoid closure (Kruglanski 1989, 2004; Kruglanski and Webster 1996), by their ultimate goals for processing information (Kunda 1990), or by their perception of information quality (Fischer, Schulz-Hardt, Frey 2008). While selective exposure is intimately related to this paper and explains the existence of polarization, selective exposure alone does not explain the phenomenon of increasing polarization.

Economists have provided theories for polarization in the preferences for news. Part of the literature has focused on supply-side decisions that drive media bias and influence news consumption, where slants reflect the preferences of media owners (Djankov et al 2003) or journalists (Baron 2004). Mullainathan and Shleifer (2005) consider demand-side drivers and find that reader heterogeneity is a more important determinant of media slant than competition among the firms. Gentzkow and Shapiro (2006) provide a model where media bias emerges due to market factors from both sides. Bayesian consumers are uncertain about quality but believe, after consumption, that quality is higher if the news piece more closely aligns with their initial preferences. News producers use this fact to slant news toward these preferences in order to build reputation among consumers. These models describe the market for newspapers and only consider how market interactions between the firms and their readers produce bias. The main contribution of this paper is to illustrate how polarization can occur through only communication among the consumers of news and how preferences can become increasingly extreme without endogenous firm choice.

2.2. Simple Model

In the simplest case, consider a one-period model in which the news producers' product locations are exogenously set at the extremes of the preference spectrum. This setup offers a focused look at consumption behavior and the transition of preferences after consumption and social interaction. The producers' exogenous locations can be generalized to be any two locations that are symmetric about median without qualitatively changing the results (see discussion at the end of Section 2.3).

The flow of events in this market for news is as follows. At the beginning of the period, there is some initial distribution of consumer preferences. Consumers observe the available news products and make their consumption choices, choosing a single news source, to maximize their payoffs. After viewing the news, consumers choose whether to post a message in response to the consumed piece, and all posts are simultaneously made. Assume that a consumer can only view messages posted by consumers of the same product. For simplicity, assume that consumers view all messages posted by fellow consumers. Alternatively, they may only view some random representative sample of messages. A more realistic assumption might be that not all consumers read these messages, and Section 3 offers discussion about the possible effects of adding that bit of realism to the model. After social interaction through messages, each consumer updates her preferences based on the news she consumed and the messages she read, so that there is a new distribution of preferences at the end of the period.

Two producers offer news products a and b, respectively. Let the preference type, denoted τ, be the defining characteristic of a measure-1 continuum of otherwise homogeneous consumers. In the simplest case, product locations are set to $a = 0,\ b = 1$, and there is no consideration of the producers' profit-maximizing behavior. Each consumer chooses to consume a product (q) to maximize expected payoffs. After viewing the news content, consumers decide whether to post a message (p). Assume that this message-posting decision is not a strategic choice but rather a simple payoff-maximizing choice from an internalized cost-benefit comparison. Further, this decision is binary, ruling out varying messaging intensities among consumers. A further simplifying assumption is that consumers only post messages regarding the news content and not in reply to viewed messages sent by others. In reality, there can be numerous replies between or among consumers, and a setting with those back-and-forth conversations can be explored as an extension. If a consumer feels strongly enough about the views expressed by the news piece, then her payoff from posting a message net of the messaging cost will be positive, and she will decide to post.

A consumer with initial preference $\tau_{i,0}$ who consumes product q_i and makes posting decision p_i receives payoff

(54) $$\pi(q_i, p_i; \tau_{i,0}, q_{-i}, p_{-i}, c)$$
$$= \underbrace{V - (q_i - \tau_{i,0})^2}_{\text{viewing news}} + \underbrace{p_i\left[E - (q_i - \tau_{i,0})^2 - c\right]}_{\text{sending messages}} + \underbrace{M - [m(q_i; q_{-i}, p_{-i}) - \tau_{i,0}]^2}_{\text{viewing messages}}.$$

This payoff function can be interpreted as the sum of three components. The first component represents the direct payoff from news consumption, where V is the constant valuation of viewing news and the payoff decreases quadratically in the discrepancy between the consumer's own initial views and the views expressed by the news. The second component is the payoff from either posting a message or not caring enough to do so. Similar to viewing news, there is a constant valuation of sending the message (E), but there is an extra fixed cost of posting (c). The benefit of posting a message also diminishes as consumer's views differ from the news. The idea is that viewers who strongly agree with what they see are motivated to express their agreement. Whereas all agents consume news, some agents do not post messages since the cost outweighs the benefit, reflected in the payoff expression by the binary posting decision, p_i. The third component is similar to the first but describes the payoff from viewing messages posted in response to the news piece, where M is the constant valuation from seeing other viewers' comments and $m(q_i; q_{-i}, p_{-i})$ is the average preference expressed by all messages for product q_i, which also depends on the consumption and message-posting decisions of all other consumers. *V* and *M* are sufficiently high such that all consumers prefer to view news and the accompanying message posts.

To elaborate on the messaging cost bounds, if there is no net cost associated with posting a message $\left(c = E - \frac{1}{4}\right)$, then all consumers would comment on the news piece that they just consumed, yielding a distribution of messages that exactly equals the distribution of preferences for consumers of the product. Further, there is a cost threshold $(c = E)$ above which no consumers have an incentive to post messages, making the market devoid of consumer interaction. Thus, $c \in \left(E - \frac{1}{4}, E\right)$ is assumed to eliminate uninteresting cases. Figure B.1 provides a visualization of the benefit from sending messages relative to the cost.

For simplicity, the initial distribution of preferences is assumed to be uniform over [0,1] and denoted by $\phi_0(\tau)$, with $\phi_1(\tau)$ representing the distribution of preferences at the end of the period after the preference transitions. These transitions occur according to the rule:

$$\tau_{i,1}\left(q_i; \tau_{i,0}, q_{-i}, p_{-i}\right) = \theta_1 \cdot \tau_{i,0} + \theta_2 \cdot q_i + (1 - \theta_1 - \theta_2) \cdot m(q_i; q_{-i}, p_{-i}), \quad (55)$$

where the weights θ_1, θ_2, and $1 - \theta_1 - \theta_2$ lie in the interval $(0,1)$. That is, a consumer's updated preferences are influenced by her initial preferences, the news she consumed, and the messages she read. The assumptions on the weights guarantee that each term carries strictly positive weight in order to avoid a degenerate case with no communication among consumers.

Even though results from this simplified market setup will not yield any firm-side effects, they will highlight the consumption-side effects of online media usage. The focus here is whether the introduction of a messaging cost leads to more severe polarization of consumer preferences after consumption and then interaction. The first step in answering this question is a definition of equilibrium:

Definition 2.1. A subgame perfect (Nash) equilibrium (SPE) in the model is characterized by a vector of equilibrium strategies consisting of the consumption and message-posting choices, (q^*, p^*).

The proposed SPE involves consumers choosing the news piece that slants closer to their own preferences and posting a message only when the strength of their feelings or ideals outweigh the messaging cost.

Proposition 2.1. Assuming $a = 0$ and $b = 1$, an SPE consists of the following strategies:

$$q_i^*(\tau_{i,0}) = \begin{cases} a \text{ if } \tau_{i,0} \in \left[0, \frac{1}{2}\right] \\ b \text{ if } \tau_{i,0} \in \left(\frac{1}{2}, 1\right] \end{cases},$$

and

$$p_i^*(\tau_{i,0}, c) = \begin{cases} 0 \text{ if } \tau_{i,0} \in \left[\sqrt{E-c}, 1-\sqrt{E-c}\right] \\ 1 \text{ if } \tau_{i,0} \in \left[0, \sqrt{E-c}\right) \text{ or } \tau_{i,0} \in \left(1-\sqrt{E-c}, 1\right] \end{cases}.$$

The news consumption strategy given in Proposition 2.1 is sensible since consumers choose the news outlet that most closely matches their preferences. In addition, they post messages only if they strongly agree with the views expressed by that outlet.

The proof of Proposition 2.1 relies on backward induction. The binary message-posting decision in the second stage is a sum of two indicator functions

$$(56) \qquad p_i = \mathbf{1}\{E - {\tau_{i,0}}^2 - c > 0\} + \mathbf{1}\left\{E - \left(1 - \tau_{i,0}\right)^2 - c > 0\right\}.$$

Thus, the optimal posting decision implies that the payoff from sending messages reduces to

$$\text{(57)} \qquad \max\left\{E - {\tau_{i,0}}^2 - c, E - \left(1 - \tau_{i,0}\right)^2 - c, 0\right\}.$$

The payoff expression then simplifies from

$$\text{(58)} \qquad \pi\left(q_i, p_i\left(\tau_{i,0}, c\right); \tau_{i,0}, q_{-i}\left(\tau_{-i,0}\right), p_{-i}\left(\tau_{-i,0}, c\right), c\right)$$

$$= \underbrace{V - \left(q_i - \tau_{i,0}\right)^2}_{\text{viewing news}} + \underbrace{p_i\left(\tau_{i,0}, c\right)\left[E - \left(q_i - \tau_{i,0}\right)^2 - c\right]}_{\text{sending messages}} + \underbrace{M - \left[m\left(q_i; q_{-i}\left(\tau_{-i,0}\right), p_{-i}\left(\tau_{-i,0}, c\right)\right) - \tau_{i,0}\right]^2}_{\text{viewing messages}},$$

which is (54) with the realization that agent *i*'s message-posting decision depends on her initial preference and that both choices made by all other agents depend on their initial preferences, to

$$\text{(59)} \qquad \tilde{\pi}\left(q_i; \tau_{i,0}, c\right)$$

$$= \underbrace{V - \left(q_i - \tau_{i,0}\right)^2}_{\text{viewing news}} + \underbrace{\max\left\{E - {\tau_{i,0}}^2 - c, E - \left(1 - \tau_{i,0}\right)^2 - c, 0\right\}}_{\text{sending messages}} + \underbrace{M - \alpha\left[\tilde{m}(q_i; c) - \tau_{i,0}\right]^2}_{\text{viewing messages}}.$$

The notation for the average message stance viewed by the agent is redefined to depend on her product choice and the cost of sending a message: $\tilde{m}(q_i; c) = m\left(q_i; q_{-i}\left(\tau_{-i,0}\right), p_{-i}\left(\tau_{-i,0}, c\right)\right)$. Similarly, the payoff function in (59) redefines the agent's payoff as a function of only her product choice, her initial preference, and the cost of sending a message. This notational simplification can be made since her proposed optimal posting decision, $p_i^*\left(\tau_{i,0}, c\right)$, has been incorporated into the "sending messages" payoff component, and all other agents are assumed to follow their proposed optimal strategies, $q_{-i}^*\left(\tau_{-i,0}\right)$ and $p_{-i}^*\left(\tau_{-i,0}, c\right)$.

Given that all consumers follow p_i^*, q_i^* is part of a NE strategy if no consumer *i* has an incentive to deviate from it given that all other consumers follow q_{-i}^*. Given that all non-*i* consumers follow q_{-i}^*, the means of the distributions of posted messages are computed to be

$$\text{(60)} \qquad \tilde{m}(0; c) = \frac{E^2 - c^2}{4\sqrt{E - c}}$$

and

$$\text{(61)} \qquad m(1; c) = 1 - \frac{E^2 - c^2}{4\sqrt{E - c}},$$

which are to be substituted into the corresponding consumer payoffs.

Substituting in (59), a consumer with preference $\tau_{i,0} \in \left[0, \frac{1}{2}\right)$ who chooses $q_i = 0$ has payoff

(62) $$\tilde{\pi}(0; \tau_{i,0}, c)\big|_{\tau_{i,0} \in \left[0, \frac{1}{2}\right)}$$

$$= V - (0 - \tau_{i,0})^2 + \max\left\{E - \tau_{i,0}{}^2 - c, E - (1 - \tau_{i,0})^2 - c, 0\right\} + M - \alpha \left[\frac{E^2 - c^2}{4\sqrt{E - c}} - \tau_{i,0}\right]^2.$$

One who deviates to $q_i = 1$ has payoff

(63) $$\tilde{\pi}(1; \tau_{i,0}, c)\big|_{\tau_{i,0} \in \left[0, \frac{1}{2}\right)}$$

$$= V - (1 - \tau_{i,0})^2 + \max\left\{E - \tau_{i,0}{}^2 - c, E - (1 - \tau_{i,0})^2 - c, 0\right\} + M - \alpha \left[1 - \frac{E^2 - c^2}{4\sqrt{E - c}} - \tau_{i,0}\right]^2.$$

Since the "viewing news" term in (61) is larger than the corresponding term in (62) by inspection, and since the "viewing messages" terms have the same relationship, the payoff expression in (61) is greater than in (62), and deviation is not desirable. Repeating the argument for a consumer with preference $\tau_{i,0} \in \left(\frac{1}{2}, 1\right]$ establishes the proposition.

SPE also exist under certain conditions where all consumers either totally coordinate on consuming *a* = 0 or *b* = 1, but those equilibria are not analytically interesting for the purpose of this paper since such coordination outcomes are not commonly observed. Proposition 1 can be generalized to cover any product locations that are equidistant from $\frac{1}{2}$, but this extension is not explored here.

Notice that a result of the optimal message posting decision is that consumers with relatively moderate beliefs are not compelled to post messages, while those with more extreme preferences are. This result drives the key polarization implications of the model. In a more general setting where product locations are symmetric about $\frac{1}{2}$ but not at the extremes or are asymmetric about $\frac{1}{2}$, the assumption that only consumers who react strongly to the news post messages does not necessarily imply that only moderate types do not post. Further discussion of this insight is left for the concluding section.

In addition to characterizing the market equilibrium, an essential result of this paper describes the polarizing transition of consumer preferences. Propositions 2.2 summarizes this result:

Proposition 2.2. Given a uniform initial distribution of preferences, with $\phi_0(\tau) = U[0,1]$, $c_1 > c_2$ implies that $\phi_1(\tau; c_1)$ is a mean-preserving spread of $\phi_1(\tau; c_2)$ for all $c_1, c_2 \in \left(E - \frac{1}{4}, E\right)$.

Before proceeding with the proof, the updated preference function must be redefined as payoff and average message stance were in (59):

$$(64) \qquad \tilde{\tau}_{i,1}\left(q_i; \tau_{i,0}, c\right) = \theta_1 \cdot \tau_{i,0} + \theta_2 \cdot q_i + (1 - \theta_1 - \theta_2) \cdot \widetilde{m}(q_i; c).$$[7]

For any consumer type $\tau_{i,0} < \frac{1}{2}$ and corresponding consumer type $\tau_{j,0} = 1 - \tau_{i,0} > \frac{1}{2}$, it will be shown that $c_1 > c_2$ implies

$$(65) \qquad \tau_{i,1}\left(0; \tau_{i,0}, c_1\right) < \tau_{i,1}\left(0; \tau_{i,0}, c_2\right),\ \tau_{j,1}\left(1; \tau_{j,0}, c_1\right) > \tau_{j,1}\left(1; \tau_{j,0}, c_2\right),$$

and

$$(66) \qquad \tau_{i,1}\left(0; \tau_{i,0}, c_2\right) - \tau_{i,1}\left(0; \tau_{i,0}, c_1\right) = \tau_{j,1}\left(1; \tau_{j,0}, c_1\right) - \tau_{j,1}\left(1; \tau_{j,0}, c_2\right).$$

That is, for any pair of consumer types symmetric about $\frac{1}{2}$, a higher messaging cost causes the "left-leaning" type $\left(\tau_{i,0}\right)$ to lean further left and the "right-leaning" type $\left(\tau_{j,0}\right)$ to lean further right after news consumption and social interaction. In addition, the amounts by which their preferences shift in reaction to a change in messaging cost must be equal. These conditions establish Proposition 2.2.

To see how the above conditions are met, recall the equation for an individual's updated preferences from (55). The first two terms are constant with respect to messaging cost, so it is only necessary to show that

$$(67) \qquad m(0; c_1) < m(0; c_2),\ m(1; c_1) > m(1; c_2)$$

and that

$$(68) \qquad m(0; c_2) - m(0; c_1) = m(1; c_1) - m(1; c_2).$$

[7] Note that messaging cost, c, is added as a parameter of updated preferences to simplify notation of different preferences depending on messaging cost.

The first requirement is immediately satisfied since $m(0;c)$ decreases in c and $m(1;c)$ increases in c, and the second is easily verified through algebraic manipulation:

$$(69) \qquad m(0;c_2) - m(0;c_1) = \frac{E^2-c_2^2}{4\sqrt{E-c_2}} - \frac{E^2-c_1^2}{4\sqrt{E-c_1}},$$

and

$$(70) \qquad m(1;c_1) - m(1;c_2) = 1 - \frac{E^2-c_1^2}{4\sqrt{E-c_1}} - \left(1 - \frac{E^2-c_2^2}{4\sqrt{E-c_2}}\right) = \frac{E^2-c_2^2}{4\sqrt{E-c_2}} - \frac{E^2-c_1^2}{4\sqrt{E-c_1}}.$$

Thus, $c_1 > c_2$ implies that $\phi_1(\tau;c_1)$ is a mean-preserving spread of $\phi_1(\tau;c_2)$.

Proposition 2.2 highlights that uniformity of the initial distribution of preferences guarantees that the distribution of preferences at the end of the period has the same mean regardless of the messaging cost. This result reflects the sustained symmetry of preferences through consumption and interaction. Even though consumers' preferences are being influenced by the exogenously slanted news and the messages that bias toward the corresponding news pieces, the manner in which preferences are drawn to the extremes is balanced. This realization leads to the rest of Proposition 2.2, which states that although a higher messaging cost does not change the mean of the distribution of preferences, it does make preferences more polarized. A higher cost translates to more skewed distributions of messages for both news products. These distributions have means that are biased toward the views expressed by the corresponding news, and these means act as a stronger polarizing force in determining the consumers' updated preferences at the end of the period. Thus, a higher cost of posting messages as a part of online communication, when interacted with the individuals' selective news consumption motive, causes greater polarization of preferences in a setting where product characteristics are fixed.

The next section describes a multi-period extension where rising opportunity cost of time leads to increasing polarization over time and discusses extensions that are not rigorously explored here.

2.3. Model Extensions

Consider a multiple-period extension of the basic model. Let $\phi_t(\tau)$ denote the distribution of consumer preferences at the end of period t and c_t the cost of posting a message in that period, where $t = 1,2,\ldots$.

Let the initial distribution of preferences (at the beginning of the first period) be denoted $\phi_0(\tau) = U[0,1]$. The consumption and messaging decisions are static in any period, only affecting preferences in that particular period. Therefore, this extension is a repeated game where every round resembles the basic model but where the preference distribution evolves over time. This realization allows us to quickly arrive at the following result.

Proposition 2.3. For any $\phi_{t-1}(\tau; c_{t-1})$ and $t \in \{1,2,\ldots\}$, $c_t > c_{t-1}$ implies that $\phi_t(\tau; c_t)$ is a mean-preserving spread of $\phi_t(\tau; c_{t-1})$.

This result follows straightforwardly from the proof of Proposition 2.2 and by induction.

Proposition 2.3 states that if the cost of posting messages rises over time, then the distribution of preferences in any period is more extreme than it would have been if the messaging cost had stayed constant. Recall that we can interpret the messaging cost as an opportunity cost of time spent on leisure activities. Historically, real wages have risen over time, so the opportunity cost of leisure has risen as well. Although consuming news, viewing other consumers' messages, and posting one's own message are all leisure activities, posting a message incurs a higher cost. Therefore, a rising opportunity cost of leisure translates to a greater premium to posting a message. In conjunction with Proposition 2.3, rising real wages implies that we should also expect consumers' preferences to become increasingly polarized.

The results from Propositions 2.1 through 2.3 are all robust to consumption errors. Suppose that consumers are uncertain about the news slants of each product and can mistakenly choose the product that is located farther from their own preferences. The results hold as long as the probability of erring is not greater than $\frac{1}{2}$, and that consumers with more extreme views are less likely to err. In addition, the probability of erring must be the same for consumers whose views are located equidistantly from $\frac{1}{2}$. This last constraint is required for the analog of Proposition 2.2 to hold, but relaxing this constraint should allow the qualitative polarization results to remain.

Finally, consider some quick intuitive results from extensions that are not fully explored in this paper. First, the key results should be generalizable to a setting where product locations are equidistant from and symmetric about $\frac{1}{2}$. In this situation, consumers with initial preferences that are more extreme than the closer news product will update their preferences to a less extreme viewpoint. Second, the qualitative results should hold when the initial distribution of preferences is generalized to be any distribution that is symmetric about $\frac{1}{2}$. This extension is simple since the logic of the proof from Proposition 2.2 can be applied to any such distribution. Third, consider the case where producers are allowed the flexibility to change their product locations between periods, after consumers' preferences have updated and before consumers make news consumption decisions in the next period. There is an incentive that is present in the Hotelling model for firms to move their products toward the center. Such a move would lower the payoffs from viewing news for the more extreme consumers, but each firm would otherwise have an incentive to move toward the center to gain market share. The polarization results may still hold if there are sufficient switching costs for news consumption, especially if such costs are higher for consumers whose views more closely align with the product they consumed. Fourth, the model assumes that consumers view all messages or at least view a representative sample of the messages posted to the consumed news product. If this message viewing assumption is relaxed, there can still be a polarizing effect in some cases. Suppose that not all consumers read the messages but that those who do are randomly distributed over the distribution of preferences. Then, the only difference is that the rate of polarization is slower since the polarizing influence of viewing messages would have zero weight for many consumers. If we instead assume selective viewing of messages, polarization can still arise. Anecdotal evidence shows that more extreme messages tend to be shorter. Simply put, more sophisticated statements are required to represent centrist than extremist views. Suppose that consumers are more likely to read shorter messages, which are correlated with more extreme messages. Then there is actually a stronger polarizing influence from viewing messages.

2.4. Conclusion

We observe increasing polarization in ideology. Psychologists have proposed theories of selective exposure, which explain the existence of partisanship but not why it grows. In economics, theoretical models have focused on media slant, which can be driven by biases of the news producers or by characteristics of the news consumers. However, these models have generally been applied to newspapers, where consumption of news is detached from social interactions among consumers regarding the news. Moreover, polarization among consumers occurs purely through the channel of endogenous media slant. This paper provides a model in which polarization occurs as a result of communication among news consumers alone. Social media have combined the consumption of news and sharing of views through online messages. It has also decoupled interaction in the tradition sense (e.g. word-of-mouth communication) into the sending and receiving of these messages, allowing the additional cost of sending messages to skew the distribution of messages away from the distribution of consumer preferences. Further, the model contributes an explanation for increasing polarization, which can occur due to naturally rising opportunity cost of time in the form of increasing real wages.

Chapter 3

Defensive Extremism

3.1. Introduction

Online communication through social media has increased people's accessibility to a "deliberative democracy". However, can exposure to opposing views actually lead to extremism? As a society, we care about extremism because it's an essential factor affecting stability and contributing to conflict resolution through the democratic process. There is a growing literature in economics on cultural transmission that examines polarizing forces in settings where parents exert effort to socialize their offspring with views that resemble their own (Bisin, Patacchini, Verdier, and Zenou (2011)). There are also wide bodies of work on post-deliberation group polarization (Festinger (1954); Brown(1965)) and the mere-exposure effect (Zajonc (1968)) in social psychology that highlight an individual's affinity for familiar views as a polarizing motive. This paper proposes a model of endogenous group formation and policy choice that describes how the formation and evolution of individuals' preferences in a group socialization setting breed extremism.

The literature has discussed many examples where groups of people maintain a diverse set of socioeconomic backgrounds rather than assimilate in a melting pot setting. [8] Polarization is commonly observed among political parties or groups, religious groups, and jury members and can occur in any context where socialization leads to the revelation of others' views. Social media have allowed individuals to more easily identify others who share their beliefs and find belonging in a group of such people. While the literature has focused on interactions between members within a group, the openness of online discussion also exposes people to ideas from those with different preferences. It is therefore important to also study a setting in which socialization occurs across groups.

[8] Bisin and Verdier (2000) provide numerous historical and contemporary examples.

Recently, there have been interesting examples of polarization in the social media's discussion of some prominent issues. In the two months following the May 31, 2009 murder of Dr. George Tiller, a doctor at an abortion clinic in Georgia, there were some 30,000 tweets (messages) sent over Twitter, and most of them were replies between individuals expressing differing pro-life or pro-choice views (Yardi and Boyd (2010)). This occurrence illustrates group socialization since all followers of a Twitter topic, in this case the various chains regarding the doctor, are exposed to all related tweets. During the starting months of the Occupy movement in 2011, opposing groups like "We are the 99%" and "We are the 53%" contributed online content in response to each other's protests.[9] In more traditional media, there have also been notable examples of polarization through exposure, such as Piers Morgan's discussions with American radio host Alex Jones and Republican New York State Senator Greg Ball on the topics of gun control and torture, respectively.[10] Morgan would pose a question from a point of view opposing the guests' relatively extremist comments, and the guests do not directly answer Morgan's questions but instead give increasingly extreme responses. There is little transfer of persuasive information from the guests, which makes such situations different from the deliberative contexts discussed in the group polarization literature.

This paper models these social situations in a setting where an individual's preferences and payoffs are affected by their degree of exposure to different views but where socialization of views occurs at the group level. This model illustrates a one-period setting where agents have varying preferences on an issue that can be anything over which people hold disagreement. Agents choose to join one of two groups, both of which are *ex ante* neutral in that they do not have any intrinsic preference. In each group, a social planner then chooses a group message, a stance that the group endorses, to maximize a weighted sum of the payoffs of all group members. This aggregation scheme simulates a socializing setting in

[9] "We are the 99%" and the "We are the 53%" groups correspond to the ownership of wealth and effective tax payments in the U.S. "We are the 99%" began the Occupy movement and started the media blitz of personal stories relating mostly to the imbalanced distribution of wealth, and "We are the 53%" responded with stories of how they struggled their way to self-sufficiency.
[10] Morgan hosts "Piers Morgan Live" on CNN. He invited Jones to discuss gun control after the Sandy Hook shootings and Ball to discuss torture after the capture of Dzhokhar Tsarnaev in relation to the 2013 Boston Marathon bombings.

which individuals are exposed to some subset of others' views, and this subset is summarized by endorsements that are optimal for their respective groups.

Although the agents' payoffs only factor into their own planners' objectives, they are exposed to the messages from both groups. An agent's updated preference depends on her initial preference and a weighted average of the two group messages. One interpretation of such updating of preferences can be that of parents trying to instill values in their offspring, as described in the literature on cultural transmission (Bisin and Verdier (2000, 2001a)). Another is that individuals dislike being "wrong" about the issue but are still influenced by society's views. The planners take these effects of exposure on preferences into account and prefer to present to society a balanced set of group messages. Since a planner must endorse an opposing message in order to counter the other group's message, this concern for balance leads to polarized group messages as a form of defensive extremism.

In addition to balance as a motivation for extremism, there are a few other key results of this model in the static setting. Firstly, there are two types of equilibria: one in which agents are integrated so that the groups are identical in membership and message endorsement and there is no extremism, and one in which agents segregate themselves into groups of relatively like-minded people and group messages are polarized. In any out-of-equilibrium situation of the segregated setting, the concern for balance drives planners to endorse polarized messages that spiral toward the optimal messages in the segregated equilibrium. Secondly, the degree of exposure to the out-group's message and the population size affect the degree of extremism. If a group's members are becoming more exposed to the other group's message, then that group's planner must choose a more extreme message to maintain the balance. As the population size increases, there is less of an incentive for any agent to switch groups since each agent has less of an effect on the optimal group messages when strategically choosing group membership. Thirdly, changes in the relative in-group exposure do not affect agents' updated preferences. As the measure of exposure changes, both planners adjust their messaging choices to balance with each other, minimizing disutility within their groups. These adjustments exactly offset so that the way in which messages affect preferences do not change. Fourthly, the optimal group messages are more extreme than the groups' average preferences. This result reflects how planners use extremism in messaging to minimize changes in their group members' preferences. Lastly, if the degree of in-group exposure is different for the two groups, then the group whose members are relatively more exposed to the other's views chooses a more extreme message. The group with the lesser degree of exposure might be a "fringe" group, which must appear more extreme relative to the other, "mainstream", group to defend its members' views.

Before concluding, this paper also explores a dynamic extension of the static model, discussing changes in optimal messages and agents' preferences over time. In particular, the group averages of agents' preferences do not change over time since the planners are not restricted in the degree of extremism and can thus insure this outcome, which maximizes the collective group utility. The optimal group messages also do not change over time. Since planners care about minimizing the deviation of preferences from the group average, this result follows from the previous that group averages do not change. It then follows that the distributions of the agents' preferences evolve so that preferences converge to the group averages over time, which is both in congruence with and in addition to the tradition models of group polarization.

3.2. Related Literature

Studies on assimilation and polarization span many of the social sciences. By the 1960's, evidence against a "triple melting pot" of religions in the United States and the assimilation of ethnic minorities in New York City had begun to shift the discussion toward explaining observations of sustained or rising polarization. Festinger (1954) and Brown (1965) are seminal studies on group polarization. They propose that individuals are more likely to accept or be convinced by statements that resemble or reassure their own views. Zajonc (1968) finds that people develop a preference for something to which they are repeatedly exposed, and the research on affinity from familiarity has since expanded to encompass memory and cognitive ease (Kahneman (2011)). In studies of group polarization, deliberation occurs within a group, and key results are that group members move toward a more extreme point in the direction indicated by their pre-deliberation tendencies and that group members' views become more homogeneous (Sunstein (2009)[11]). The model presented here describes socialization between groups and produces a result where exposure to dissimilar views leads to polarization between the groups being socialized and more exposure yields stronger extremist tendencies. This theory of defensive extremism does not contradict the theories of group polarization but rather generalizes it to contexts where there is between-group exposure, which has become commonplace given the advent of social media.

In the economic literature, models of cultural transmission from parent to offspring explain the lack of assimilation through an altruistic but imperfect socialization mechanism (Bisin and Verdier (2000, 2001a); Bisin, Patacchini, Verdier, and Zenou (2011)). Parents can pass down their traits to their offspring through direct socialization but they choose the costly socialization effort to maximize an expected payoff from their own perspective rather than their offspring's.[12] They find that there exists a dynamically stable equilibrium where agents with different traits do not assimilate and parents socialize their offspring more than is efficient. Brueckner and Smirnov (2007) present a related model in which socialization of traits occurs through adjacent contacts in a network. Their model yields convergence of traits over time, but the convergence is slowed when individuals endogenously choose their intensity of socialization and prefer to interact with similar agents. This paper contributes a model of polarization when socialization occurs at the group level, and it provides a novel explanation for extremism that is fueled by a concern for balance.

Other related papers include Glaeser, Ponzetti, and Shapiro (2005) and Brueckner and Glazer (2007). The first discusses polarizing motives from the politicians' point of view. In their model, two political parties choose policies to maximize vote share on one issue in a majoritarian system. They assume that party affiliates receive targeted information such that those affiliated with a party are more likely to learn about the party platform. This assumption drives voter extremism where previous models generate convergence to the median voter's policy preference. My model differs in that it considers a setting without politicians, using group social planners as a way to illustrate interaction and polarization between groups of agents who can represent voters with different political affiliations. Further, my model

[11] Sunstein highlights many of the more recent experimental studies on group polarization.
[12] Bisin and Verdier (2001a, 2001b) provide justification for this "imperfect empathy".

applies to a more general setting beyond one of voting for a political seat. Brueckner and Glazer (2007) provide an explanation for extremism in a setting where two types of agents choose between two candidates based on public good provision. The result is similar in that each candidate proposes to provide a more extreme than the optimal level of provision desired by the type of agent she is trying to attract.

3.3. Simple Model

Consider a finite population of agents (*N* with size *n*) whose initial preferences (τ_i) are uniformly distributed over the interval, $\left[-\frac{1}{2},\frac{1}{2}\right]$. Specifically, the most left-leaning agent has a preference at $-\frac{1}{2}$, the most right-leaning agent has a preference at $\frac{1}{2}$, and the most centrist agents have a preference at 0 if *n* is odd or $-\frac{1}{2(n-1)}$ and $\frac{1}{2(n-1)}$ if *n* is even. There are also two groups (*a* and *b*), acting as utilitarian social planners to maximize the welfare of their own members. The groups are *ex ante* neutral in that they do not have any intrinsic preference. Each agent *i* chooses group membership, $g_i \in \{a, b\}$. Each group then sends a message representing the position that it endorses, which is observed by the entire population. Each agent's final preference on the issue depends on her initial preference (τ_i) but is also affected by a weighted average of the two group messages:

$$\text{(71)} \qquad \tau_i' = \theta \cdot \tau_i + (1-\theta)\left[\beta \cdot x_{g_i} + (1-\beta)x_{g_{\text{other}}}\right],$$

where x_{g_i} is the overall message for her own group and $x_{g_{\text{other}}}$ for the other group. The parameters, β and θ, represent weights on the various components of the updated preference. β is the agent's degree of exposure to the in-group message, while $1-\beta$ is her exposure to the out-group message. θ is the weight on initial preferences when the agent forms her updated preferences, and $1-\theta$ is the weight on the weighted average of both messages to which she is exposed.

Firstly, assume that $\beta \in \left(\frac{1}{2}, 1\right)$ so that an agent's in-group message has a stronger influence than the out-group's message, but positive weight is placed on both messages. Secondly, $\theta \in (0,1)$ so that the updated preference is influenced by both the initial preference and the publicized messages with positive weight. While an agent prefers that her ideals do not deviate from her initial stance, she is nonetheless influenced to some degree by the messages. There might be *ex post* utility from updating her preference to a perceived truth, but there is still an *ex ante* disutility from having to alter her preference. One can also interpret this assumption as a parent preferring to have her child's stance align closely to her own. Lastly, *n* is greater than 3, so that any agent's unilateral deviation in group choice does not decrease a group's membership to zero, thus dissolving the group that loses the agent's membership.

Individual i's payoff is given by $u_i(g_i; \tau_i) = G - (\tau_i' - \tau_i)^2$, where *G* is the constant payoff from being part of a group. A social planner chooses its group's message to maximize a utilitarian payoff, an equally weighted sum of all agents' payoffs within that group. For example, group k's planner faces the following problem:

$$\text{(72)} \qquad \max_{x_k} \sum_{j \in N_k} \left(G - \left\{ \theta \cdot \tau_j + (1-\theta)[\beta \cdot x_k + (1-\beta) x_{-k}] - \tau_j \right\}^2 \right),$$

where N_k is the sub-population (with size n_k) of agents who chose to join group *k*, for $k = a, b$. The group message choice, x_k, is unbounded, so that group planners can endorse ideals that are more extreme than even the most extreme individual preferences.

To solve for the optimal group messages, each planner's problem is solved individually to find its reaction function. Consider the group *a* planner's problem ((72) with $k = a$). Taking the derivative of the objective function with respect to the choice variable, x_a, yields the best response function

$$\text{(73)} \qquad x_a = \frac{1}{\beta} \cdot \frac{1}{n_a} \sum_{j \in N_a} \tau_j - \frac{1-\beta}{\beta} \cdot x_b.$$

By symmetry, the group *b* planner's best response function is

$$\text{(74)} \qquad x_b = \frac{1}{\beta} \cdot \frac{1}{n_b} \sum_{j \in N_b} \tau_j - \frac{1-\beta}{\beta} \cdot x_a.$$

An equilibrium concept is now defined for this game, and discussion of the existing equilibria follows.

3.3.1. Equilibria

Definition 3.1. A subgame perfect equilibrium (SPE) in this model is characterized by a vector of strategies consisting of group membership and group message choices, $\left(g_i^*(\tau_i), (x_a^*, x_b^*)\right)$.

There are two types of SPE in this game: an 'integrated' equilibrium in which agents sort into groups with the same average preference and planners set identical group messages, and a 'segregated' equilibrium in which agents sort into groups that are segregated by members' type and planners endorse polarized group messages. Propositions 3.1 and 3.2 present these two types of SPE. There exists a continuum of group formations that can be part of an integrated equilibrium, in which the average preferences of agents in both groups are equal to the centrist stance. Specifically, for any threshold $T \in \left(0, \frac{1}{2}\right)$, agents whose preferences lie within this threshold from zero join group *a*, while all other agents join group *b*.

Proposition 3.1. (Integrated Equilibrium) There is a continuum of integrated equilibria, where the average preference is zero in each group. For any $T \in \left(0, \frac{1}{2}\right)$, strategies for group membership, $\hat{g}_i(\tau_i) = \begin{cases} a \text{ if } \tau_i \in [-T, T] \\ b \text{ if } \tau_i \in \left[-\frac{1}{2}, -T\right) \cup \left(T, \frac{1}{2}\right] \end{cases}$, and group messages, $\hat{x}_a = 0$ and $\hat{x}_b = 0$, constitute an SPE for *n* sufficiently large.

When agents form groups where the average preferences are the same, the group planners, who maximize the collective group payoffs, choose the same messages, matching the average preference. There are infinitely-many ways to form such groups. Consider a group *a* member (agent *i*) with preference $\tau_i \in [-T, T]$. If she deviates to group *b*, then the planners' best responses change to

$$(75) \qquad x_a = \frac{1}{\beta} \cdot \frac{1}{n_a - 1}\left(\sum_{j \in N_a} \tau_j - \tau_i\right) - \frac{1-\beta}{\beta} \cdot x_b, \;\; x_b = \frac{1}{\beta} \cdot \frac{1}{n_b + 1}\left(\sum_{j \in N_b} \tau_j + \tau_i\right) - \frac{1-\beta}{\beta} \cdot x_a.$$

Since the groups have the same average preferences at zero, $\sum_{j\in N_a}\tau_j=\sum_{j\in N_b}\tau_j=0$. Thus, the functions in (75) simplify to

$$(76)\qquad x_a=-\frac{1}{\beta}\cdot\frac{1}{n_a-1}\cdot\tau_i-\frac{1-\beta}{\beta}\cdot x_b$$

and

$$(77)\qquad x_b=\frac{1}{\beta}\cdot\frac{1}{n_b+1}\cdot\tau_i-\frac{1-\beta}{\beta}\cdot x_a.$$

Simultaneously solving (76) and (77) yields the following optimal messages given the deviation:

$$(78)\qquad \tilde{x}_a=-\frac{\beta}{2\beta-1}\left(\frac{1}{n_a-1}+\frac{1-\beta}{\beta}\cdot\frac{1}{n_b+1}\right)\tau_i,\ \tilde{x}_b=\frac{\beta}{2\beta-1}\left(\frac{1}{n_b+1}+\frac{1-\beta}{\beta}\cdot\frac{1}{n_a-1}\right)\tau_i.$$

Comparing the payoffs from following or deviating from the equilibrium group membership strategy then determines when an agent has a profitable unilateral deviation.

Note that agent *i*'s payoff can be rewritten as

$$(79)\qquad G-\left\{(1-\theta)\left[\beta\cdot x_{g_i}+(1-\beta)x_{g_{\text{other}}}-\tau_i\right]\right\}^2,$$

and the only part affected by the deviation is the weighted average of the two group messages, located inside the square brackets. If agent *i* follows the equilibrium strategy, then the expression is

$$(80)\qquad \beta\cdot\hat{x}_a+(1-\beta)\hat{x}_b=0.$$

If agent *i* deviates to group *b*, then

$$(81)\qquad \beta\cdot\tilde{x}_b+(1-\beta)\tilde{x}_a=\frac{1}{n_b+1}\cdot\tau_i.$$

Thus, agent *i* has an incentive to deviate if

$$(82)\qquad [\beta\cdot\hat{x}_a+(1-\beta)\hat{x}_b-\tau_i]^2>[\beta\cdot\tilde{x}_b+(1-\beta)\tilde{x}_a-\tau_i]^2.$$

The left-hand side of the inequality reduces to τ_i^2, while the right-hand side reduces to $\left(-\frac{n_b}{n_b+1}\right)^2\tau_i^2$. For finite *n*, the inequality holds for all τ_i so that all agents have an incentive to deviate to join the other group. However, when *n* is sufficiently large, the disutility of exposure when deviating to group *b* converges to the disutility when in group *a*. By symmetry, the same comparison can be made for an arbitrary group *b* agent. No agent would switch group membership since no single agent carries enough weight to sway the group messages. Thus, $(\hat{g}_i(\tau_i), (\hat{x}_a, \hat{x}_b))$ is an SPE for *n* sufficiently large and for any $T \in \left(0, \frac{1}{2}\right)$.

The integrated equilibrium describes a case where the two groups have the same average preferences regardless of group size. This result is a knife-edge outcome that holds only if a single agent's group choice does not affect the groups' averages. Though fragile, this equilibrium highlights an interesting point. Upon exposure to the identical, centrist messages, all agents' preferences are drawn toward more moderate stances. Over time, integration leads to the homogenization of agents' preferences to the middle of the spectrum. This result lies in contrast to that of Bisin, Patacchini, Verdier, and Zenou (2011), where the homogenizing effect of social mixing can be offset and dominated by the segmenting effect of greater socializing effort by parents due to the social mixing. In their dynamic model, there is a unique steady-state equilibrium in which agents are segregated. Like in their paper, this model also has an segregated equilibrium, which is described in Proposition 3.2.

Proposition 3.2. (Segregated Equilibrium) There exists a unique segregated SPE consisting of: strategies for group membership, $g_i^*(\tau_i) = \begin{cases} a, \text{ if } \tau_i \in \left[-\frac{1}{2}, 0\right] \\ b, \text{ if } \tau_i \in \left(0, \frac{1}{2}\right] \end{cases}$, and group messages, $x_a^* = -\frac{n}{4(2\beta-1)(n-1)}$ and $x_b^* = \frac{n}{4(2\beta-1)(n-1)}$ for even n, or $x_a^* = -\frac{\beta}{2\beta-1}\cdot\frac{1}{4} - \frac{1-\beta}{2\beta-1}\cdot\frac{n+1}{4(n-1)}$ and $x_b^* = \frac{\beta}{2\beta-1}\cdot\frac{n+1}{4(n-1)} + \frac{1-\beta}{2\beta-1}\cdot\frac{1}{4}$ for odd n, for $\beta \in \left(\frac{1}{2}, 1\right)$, $n > 3$.[13]

The approach here is similar to that taken in the proof of Proposition 3.1, to check that no agent has an incentive to deviate from the proposed equilibrium. However, to demonstrate that the equilibrium holds even for finite *n*, this discussion must separately check cases for even and odd *n* since the two groups are not exactly symmetric for the latter case. Recall that for even *n*, the most centrist agents have

[13] As $n \to \infty$, the optimal group messages converge to $x_a^* = -\frac{1}{4(2\beta-1)}$ and $x_b^* = \frac{1}{4(2\beta-1)}$.

preferences at $-\frac{1}{2(n-1)}$ and $\frac{1}{2(n-1)}$, while for odd *n*, the most centrist agent has a preference at 0. Thus, for even *n*, groups are segregated symmetrically about 0, while for odd *n*, group *a* is assumed to have one more member (the centrist) than group *b*. First, for the case with an even number of agents, consider a group *a* agent with an initial preference of $\tau_i \in \left[-\frac{1}{2}, 0\right]$. If she deviates to group *b*, then the weighted sums in the planners' best responses will change:

$$(83) \qquad x_a = \frac{1}{\beta} \cdot \frac{1}{\frac{n}{2}-1}\left(\sum_{j \in N_a} \tau_j - \tau_i\right) - \frac{1-\beta}{\beta} \cdot x_b, \;\; x_b = \frac{1}{\beta} \cdot \frac{1}{\frac{n}{2}+1}\left(\sum_{j \in N_b} \tau_j + \tau_i\right) - \frac{1-\beta}{\beta} \cdot x_a.$$

Substituting $\sum_{j \in N_a} \tau_j = -\frac{1}{4} - \frac{1}{4(n-1)}$ and $\sum_{j \in N_b} \tau_j = \frac{1}{4} + \frac{1}{4(n-1)}$ into (83) and simultaneously solving these equations yield the following optimal messages given the deviation:

$$(84) \qquad \tilde{x}_a = \left[\frac{\beta n}{n-2} + \frac{(1-\beta)n}{n+2}\right] x_a^* - \frac{1}{2\beta-1}\left[\frac{2\beta}{n-2} + \frac{2(1-\beta)}{n+2}\right] \tau_i,$$

$$(85) \qquad \tilde{x}_b = \left[\frac{\beta n}{n+2} + \frac{(1-\beta)n}{n-2}\right] x_b^* + \frac{1}{2\beta-1}\left[\frac{2\beta}{n+2} + \frac{2(1-\beta)}{n-2}\right] \tau_i.$$

If agent *i* follows the equilibrium strategy, then the weighted average of the two group messages is evaluated to be

$$(86) \qquad \beta \cdot x_a^* + (1-\beta) x_b^* = -\frac{n}{4(n-1)}.$$

If agent *i* deviates to group *b*, then

$$(87) \qquad \beta \cdot \tilde{x}_b + (1-\beta)\tilde{x}_a = \frac{2n^2}{4(n-1)(n+2)^2} \cdot \tau_i.$$

Again, there is an incentive to deviate under condition (82), which holds when $\tau_i \in \left(-\frac{n}{4(n^2-1)}, 0\right]$ under the constraints $n > 3$ and $\tau_i \in \left[-\frac{1}{2}, 0\right]$. The most centrist group *a* member has a preference equal to $-\frac{1}{2(n-1)}$. However, for any $n > 3$, $-\frac{1}{2(n-1)} \leq -\frac{n}{4(n^2-1)}$. That is, the most centrist group *a* member does not have an incentive to deviate to group *b*, and thus none of the group *a* members do. By symmetry, no agent has an incentive to deviate from group *b* to group *a*.

For the case with an odd number of agents, again consider a group *a* agent with an initial preference of $\tau_i \in \left[-\frac{1}{2}, 0\right]$. Note that group *a* has $\frac{n+1}{2}$ agents, while group *b* has $\frac{n-1}{2}$ agents. Substituting

$\sum_{j \in N_a} \tau_j = -\frac{1}{4}$ and $\sum_{j \in N_b} \tau_j = \frac{1}{4} + \frac{1}{2(n-1)}$ into (83) and simultaneously solving these equations yield the following optimal messages given the deviation:

$$(88) \qquad \tilde{x}_a = -\frac{\beta}{2\beta-1}\left(\frac{2}{n-1} + \frac{1-\beta}{\beta} \cdot \frac{2}{n+1}\right)\tau_i - \frac{\beta}{2\beta-1}\left[\frac{n+1}{4(n-1)} + \frac{1-\beta}{\beta} \cdot \frac{1}{4}\right],$$

$$(89) \qquad \tilde{x}_b = \frac{\beta}{2\beta-1}\left(\frac{2}{n+1} + \frac{1-\beta}{\beta} \cdot \frac{2}{n-1}\right)\tau_i + \frac{\beta}{2\beta-1}\left[\frac{1}{4} + \frac{1-\beta}{\beta} \cdot \frac{n+1}{4(n-1)}\right].$$

If agent *i* follows the equilibrium strategy, then the weighted average of the two group messages is evaluated to be

$$(90) \qquad \beta \cdot x_a^* + (1-\beta)x_b^* = -\frac{1}{4}.$$

If agent *i* deviates to group *b*, then

$$(91) \qquad \beta \cdot \tilde{x}_b + (1-\beta)\tilde{x}_a = \frac{1}{4} + \frac{2}{n+1} \cdot \tau_i.$$

There is an incentive to deviate under the condition (the analog of (82)):

$$[\beta \cdot x_a^* + (1-\beta)x_b^* - \tau_i]^2 > [\beta \cdot \tilde{x}_b + (1-\beta)\tilde{x}_a - \tau_i]^2,$$

which fails to hold for all $\tau_i > 0$. Thus, no group *a* member has an incentive to deviate to group *b*. When considering whether any group *b* members would deviate, note that there is always less incentive for an agent to switch out of a relatively smaller group. When an agent switches from her in-group to her out-group, planners adjust both optimal group messages. If the out-group is larger, then the agent's preference carries relatively less weight in the out-group planner's adjustment, pushing the weighted average of group messages farther from her beliefs after switching. Since group *b* is smaller than group *a* in this case, no group *b* members would deviate either. Therefore, for $n > 3$, the strategy profile, $\left(g_i^*(\tau_i), (x_a^*, x_b^*)\right)$, is an SPE.

Unlike the integrated equilibria, there are only two cases of segregated equilibria, as described in Proposition 3.2. No group formation that is more asymmetric than in the Proposition 3.2 case for odd *n* can be part of a segregated equilibrium. In that case, the most centrist agent ($\tau_i = 0$; belonging to the slightly larger group) is indifferent between staying in her in-group or deviating to her out-group. The most borderline agent in the larger group of any formation that is more asymmetric would strictly prefer to deviate since there is always a greater incentive to deviate from a relatively larger group to a relatively smaller one.

Also unlike the integrated equilibria, the segregated equilibria are stable and hold even for finite populations of agents. The significance and interpretation of this type of equilibrium can be seen in the planners' reaction functions in (75). Notice that the group messages are strategic complements in the sense that a planner responds to a more extreme message from the other by endorsing a more extreme message as well: as x_b becomes more polarized $\left(\text{closer to } \frac{1}{2}\right)$, x_a becomes more polarized $\left(\text{closer to } -\frac{1}{2}\right)$, and *vice versa*. Each planner wants to endorse a message so that the overall weighted average of the messages presents a balanced viewpoint to its own group's members. The planners' motive is not to influence the other group's preferences but to maximize their own group's payoffs by offsetting any extremism exposed to their own groups. Therefore, the resulting phenomenon may be called "defensive extremism".

3.3.2. Out-of-Equilibrium Dynamics

What separates the integrated and segregated equilibria is stability. The defensive motivation for extremism makes the integrated equilibrium a knife-edge result: as soon as one group's message is even slightly skewed to either side of the spectrum, the other group responds with an even more extreme message on the other side. Thus, the equilibrium collapses. This same force makes segregated equilibria stable, as illustrated by the best response functions in Figure C.1. Suppose that agents have joined the two groups by choosing membership according to the segregated equilibrium. If the group *a* planner chooses a message that is more left-leaning than the centrist position (less than zero) but not as extreme-left as the equilibrium message, then group *b* responds by choosing a message that is right-leaning and closer to its equilibrium message. That is, group *b*'s response is more extreme than group *a*'s message. However, group *a* then chooses to update its message to a more extreme-left position in order to balance the stance taken by group *b*, and the messages become more extreme in response to each other until they reach the segregated equilibrium. An analogous illustration applies to how messages are updated through best response dynamics if one group initially chooses a stance that is more extreme than the equilibrium position.

3.3.3. Comparative Statics

Focusing on the segregated equilibria, comparative statics exercises with respect to relative exposure and population size offer some insight on the relationship between these factors and the planners' equilibrium strategies. Proposition 3.3 highlights these results.

Proposition 3.3.

i. As the relative out-group exposure $(1-\beta)$ increases, the optimal group messages (x_a^*, x_b^*) become more extreme.
ii. As the population size (*n*) increases, the optimal group messages become less extreme.

The level of exposure to the out-group's message affects the in-group's best response. Recall the group *a* planner's reaction function in (73): $x_a = \frac{1}{\beta} \cdot \frac{1}{n_a} \sum_{j \in N_a} \tau_j - \frac{1-\beta}{\beta} \cdot x_b$. β is the relative exposure of a group *a* member to the in-group message. When β is close to 1, an agent is influenced almost completely by the ideals of her own group. As β approaches $\frac{1}{2}$, the agent's updated preference is drawn more strongly toward the out-group's message, which has a negative effect on the aggregated payoffs of all group *a* members. Since $\frac{1-\beta}{\beta}$ is decreasing in β, group *a* is more exposed to and more influenced by group *b*'s message as β decreases. The group *a* planner then endorses a more extreme message (a more negative x_a) to maintain the balance between the two group messages. Similarly, a decrease in β would have the same polarizing effect on x_b, pushing it in the positive direction. The comparative statics of β can also be derived directly from the solution of the segregated equilibrium: $x_a^* = -\frac{n}{4(2\beta-1)(n-1)}$ and

$x_b^* = \frac{n}{4(2\beta-1)(n-1)}$ for even n, or $x_a^* = -\frac{\beta}{2\beta-1} \cdot \frac{1}{4} - \frac{1-\beta}{2\beta-1} \cdot \frac{n+1}{4(n-1)}$ and $x_b^* = \frac{\beta}{2\beta-1} \cdot \frac{n+1}{4(n-1)} + \frac{1-\beta}{2\beta-1} \cdot \frac{1}{4}$ for odd n. Another way to think about this result is that in-group exposure is like media bias. In the symmetric setting, both groups have media outlets that favor their agendas. When media bias is stronger, β is larger, and the optimal group messages are not as extreme. However, if media bias is weaker, the messages must be more extreme in order to minimize the disutility to group members. Here, the groups' extremism acts as a substitute for media bias as a way to lower disutility.

The degree of polarization between the two optimal group messages also depends on the population size n. Consider the segregated equilibrium for even n:

$$(82) \qquad (x_a^*, x_b^*) = \left(-\frac{n}{4(2\beta-1)(n-1)}, \frac{n}{4(2\beta-1)(n-1)}\right).$$

As n increases, the optimal messages change at the following rates:

$$\frac{\partial x_a^*}{\partial n} = \frac{1}{4(2\beta-1)(n-1)^2} \text{ and } \frac{\partial x_b^*}{\partial n} = -\frac{1}{4(2\beta-1)(n-1)^2}.$$

Notice that $\frac{\partial x_a^*}{\partial n} > 0$ and $\frac{\partial x_b^*}{\partial n} < 0$. That is, x_a^* and x_b^* draw closer to zero as n increases, so that these messages become less extreme. In larger populations, a deviation in group membership by any single agent has a smaller effect on how planners adjust their group messages. In the segregated group formations, the more centrist agents receive higher payoffs from deviating than other agents. To a certain degree, announcing more extreme messages lowers the deviation payoffs for these agents. However, when individual agents become insignificant, planners care less about maintaining these centrists' membership and more about maximizing all members' collective utility. Therefore, optimal group messages become less extreme.

3.3.4. Other Results of the Simple Model

In addition to affecting the optimal messages in the segregated equilibrium, changes in relative in-group exposure may also affect agents' preferences after exposure to these messages. For example, when relative exposure decreases and out-group exposure increases, planners respond by setting more extreme messages. However, both planners make this change, and their adjustments exactly cancel out, so that the weighted average of the messages in both groups does not change. Proposition 4 summarizes this finding.

Proposition 3.4. Changes in the relative in-group exposure (β) do not affect the agents' updated preferences.

For simplicity, the following discussion assumes that *n* is large, but analogous results follow for finite *n*. Given that the group message choice is unbounded, optimal group messages in the segregated equilibrium (x_a^*, x_b^*) are chosen so that

$$\beta \cdot x_a^*(\beta) + (1-\beta)x_b^*(\beta) = -\frac{1}{4},$$

and

$$\beta \cdot x_b^*(\beta) + (1-\beta)x_a^*(\beta) = \frac{1}{4}.$$

That is, the relative exposure-weighted averages of group messages are exactly the average preferences of the two groups. For example, a group *a* member's updated preference is determined by her initial preference and the influence from exposure to messages $\left(-\frac{1}{4}\right)$. When β changes, group planners simply update the group messaging decision so that the weighted averages of the group messages remain at $-\frac{1}{4}$ and $\frac{1}{4}$. Since group messages are not bounded, there is always some sufficiently extreme pair of messages that balance each other in such a way. Therefore, changes in the degree of relative exposure (β) have no effect on the agents' updated preferences.

Propositions 3.3 and 3.4 state the effects of changes in relative exposure on optimal group messages and agents' actual preferences, respectively. Proposition 3.5 discusses the relationship between optimal group messages and agents' preferences.

Proposition 3.5. The optimal group messages (x_a^*, x_b^*) are more extreme than the average preferences of their respective groups.

From (82), it can be shown that for sufficiently large n, $x_a^* < -\frac{1}{4}$ and $x_b^* > \frac{1}{4}$, for any $\beta \in \left(\frac{1}{2}, 1\right)$. That is, the optimal group messages are more extreme than the average preference in their respective groups. The discussion of Proposition 3.4 demonstrates that the average group preferences remain at $-\frac{1}{4}$ and $\frac{1}{4}$ after exposure. Thus, the averages of the agents' preferences are less extreme than the optimal group messages. Further discussion of this result follows in section 3.5.

3.4. "Mainstream" versus "Fringe" Groups

Section 3.3 restricts the analysis to homogeneous groups with no *ex ante* preference identity. Given that each group has the same relative in-group exposure, Proposition 3.2 presents segregated equilibria in which the groups choose symmetric optimal messages, and less in-group exposure leads to more extremism. Suppose instead that one of the groups receives greater exposure. For example, one group might have a more "mainstream" stance on the issue, and its message gains greater exposure relative to the other, "fringe", group due to media bias. Proposition 3.6 presents the optimal messaging result in this case of asymmetric group exposure.

Proposition 3.6. Given that $\beta_F < \beta_M$, the optimal group F message is more extreme than the optimal group M message in a segregated equilibrium.

This result requires only a slight modification of the analysis used for Proposition 3.2. Without loss of generality, denote groups a and b as M and F, corresponding to "mainstream" and "fringe" groups, so that the group sizes remain equal. Let the relative in-group exposure of group M be higher than group F: $\beta_M > \beta_F$. The best response functions from (73) and (74) become

$$(83) \qquad x_M = \frac{1}{\beta_M} \cdot \frac{1}{n_M} \sum_{j \in N_M} \tau_j - \frac{1-\beta_M}{\beta_M} \cdot x_F$$

and

$$(84) \qquad x_F = \frac{1}{\beta_F} \cdot \frac{1}{n_F} \sum_{j \in N_F} \tau_j - \frac{1-\beta_F}{\beta_F} \cdot x_M.$$

Let $\bar{\tau}_M$ and $\bar{\tau}_F$ denote the average preferences in the two groups. Simultaneously solving (83) and (84) yields

$$x_M^* = \frac{\beta_F}{\beta_M+\beta_F-1} \cdot \bar{\tau}_M - \frac{1-\beta_M}{\beta_M+\beta_F-1} \cdot \bar{\tau}_F, \text{ and } x_F^* = \frac{\beta_M}{\beta_M+\beta_F-1} \cdot \bar{\tau}_F - \frac{1-\beta_F}{\beta_M+\beta_F-1} \cdot \bar{\tau}_M.$$

Since $\beta_M > \beta_F$,

$$\frac{\beta_F}{\beta_M+\beta_F-1} < \frac{\beta_M}{\beta_M+\beta_F-1}, \text{ and } -\frac{1-\beta_M}{\beta_M+\beta_F-1} > -\frac{1-\beta_F}{\beta_M+\beta_F-1}.$$

That is, the optimal "mainstream" message (x_M^*) is closer to the average "fringe" preference $(\bar{\tau}_F)$ than the optimal "fringe" message (x_F^*) is to the average "mainstream" preference $(\bar{\tau}_M)$. For segregated groups, this result implies that the fringe group will endorse a more extreme message than under symmetric exposure, in order to maintain that sense of balance which drives defensive extremism. This result has a similar flavor to those of the cultural transmission literature, where parents with the minority trait expend more effort in socializing their offspring with that trait.

3.5. Dynamic Model

While sections 3.3 and 3.4 discuss the results of the static model, it is also important to consider how group messages and agents' preferences may change over time. In extension from the static model, let $t = 1,2,\ldots$ denote the time period. The dynamic representation of a group *k* agent's updated preferences is then

$$(85) \qquad \tau_{i,t+1} = \theta \cdot \tau_{i,t} + (1-\theta)\left[\beta \cdot x_{k,t} + (1-\beta) x_{-k,t}\right],$$

where $x_{k,t}$ and $x_{-k,t}$ are the in-group and out-group messages in period *t*, respectively. For convenience, let $\bar{\tau}_{a,t}$ and $\bar{\tau}_{b,t}$ denote the period-*t* average preferences in groups *a* and *b*, respectively. The extensions of the best response functions from (73) and (74) are then

(86) $$x_{a,t} = \frac{1}{\beta} \cdot \bar{\tau}_{a,t} - \frac{1-\beta}{\beta} \cdot x_{b,t},$$

and

(87) $$x_{b,t} = \frac{1}{\beta} \cdot \bar{\tau}_{b,t} - \frac{1-\beta}{\beta} \cdot x_{a,t}.$$

The results in the dynamic setting follow fairly immediately from the analysis in the previous sections, and Proposition 3.7 presents the key findings.

Proposition 3.7. Consider the segregated equilibrium.

i. The group averages of agents' preferences do not change over time: $\bar{\tau}_{a,t} = \bar{\tau}_{a,1}$, and $\bar{\tau}_{b,t} = \bar{\tau}_{b,1}$, for all *t*.

ii. The optimal group messages do not change over time: $x^*_{a,t} = x^*_{a,1}$, and $x^*_{b,t} = x^*_{b,1}$, for all *t*.

iii. Each group's limiting distribution of preferences converges to a single spike at the group's average preference: for $\tau_{i,0} \leq 0$, $\lim_{t\to\infty} \tau_{i,t} = -\frac{1}{4}$, and for $\tau_{i,0} > 0$, $\lim_{t\to\infty} \tau_{i,t} = \frac{1}{4}$.

The first two results follow by induction. For the base case ($t = 1$), recall that the group averages are $\bar{\tau}_{a,1} = -\frac{1}{4}$ and $\bar{\tau}_{b,1} = \frac{1}{4}$ for large *n*. Simultaneously solving (86) and (87) yields the optimal period-1 messages,

(88) $$x^*_{a,1} = -\frac{1}{4(2\beta-1)} \text{ and } x^*_{b,1} = \frac{1}{4(2\beta-1)}.$$

For group a, substituting (88) into (85) and averaging over all agents yields

$$\bar{\tau}_{a,2} \equiv \frac{1}{n_a}\sum_{j\in N_a} \tau_{j,2} = \frac{1}{n_a}\sum_{j\in N_a}\{\theta \cdot \tau_{j,1} + (1-\theta)[\beta \cdot x^*_{a,1} + (1-\beta)x^*_{b,1}]\} = -\frac{1}{4}.$$

By symmetry, $\bar{\tau}_{b,2} = \frac{1}{4}$, so result (i) holds for $t = 1$. For the inductive step ($t = s$), given that $\bar{\tau}_{a,s} = -\frac{1}{4}$ and $\bar{\tau}_{b,s} = \frac{1}{4}$, the optimal period-*s* group messages are the same as the optimal period-1 messages, $x^*_{a,s} = -\frac{1}{4(2\beta-1)}$ and $x^*_{b,s} = \frac{1}{4(2\beta-1)}$, and the group averages are the same as well, $\bar{\tau}_{a,s+1} = -\frac{1}{4}$ and

$\bar{\tau}_{b,s+1} = \frac{1}{4}$. Thus, by induction, the average preferences and optimal group messages do not change over time:

$$\bar{\tau}_{a,t} = -\frac{1}{4} \equiv \bar{\tau}_a,\ \bar{\tau}_{b,t} = \frac{1}{4} \equiv \bar{\tau}_b,\ x^*_{a,t} = -\frac{1}{4(2\beta-1)},\ \text{and}\ x^*_{b,t} = \frac{1}{4(2\beta-1)},$$

for all t.

The result that each group's limiting distribution of preferences converges to a single spike at the group's average preference (Proposition 3.7 (iii)) follows quickly from equation (85) and the previous results in Proposition 3.7. For an arbitrary agent ($i \in N_k,\ k = a, b$), her updated preference is closer to the group mean than is her initial preference, for any period t. Thus, over time, every agent's period-t preference converges to her group's average preference, and the limiting distribution of agents' preferences are simply spikes at $-\frac{1}{4}$ and $\frac{1}{4}$.

Together with Proposition 3.5, Proposition 3.7 relates this paper's model of socialization across groups and the literature on post-deliberation group polarization, which focuses on socialization within groups. Like the models of group polarization, there is also convergence of in-group members' preferences in this model. However, another characteristic of group polarization is that within each group, socialization leads to further extremism. In this paper, there is only extremism in the group planners' messages, while agents' preferences do not collectively become more extreme. This difference is due to the exposure of all members to the out-group messages, which does not exist in models of group polarization. Therefore, this paper supports the findings of previous work but also presents novel and relevant findings from the addition of socialization across groups.

3.6. Conclusion

Unlike "melting pot" theories of assimilation, more recent studies demonstrate that extremism can arise from socialization within groups or among individuals in general. This paper studies a form of socialization across groups to model the expanding mode of online interactions through social media. Although there exists a type of "integrated" equilibrium in which agents' preferences become more homogeneous, this equilibrium describes a knife-edge outcome in which even a small deviation in either group message leads to further extremism. The other, more stable, type of equilibrium describes groups that are segregated by their members' preferences, and groups support views that are more extreme than their members' average preferences. The segregated equilibrium also describes a defensive motivation for groups to endorse polarized messages: to minimize their members' disutility from shifting to new preferences. Extremism is also a way for a group to balance increased external influence. Specifically, the group with the lower in-group exposure chooses a more extreme message in equilibrium. While group messages may be polarized, the members' preferences are more moderate. Over time, average preferences within each group do not change, and preferences converge to the group averages due to the nature of this defensive extremism.

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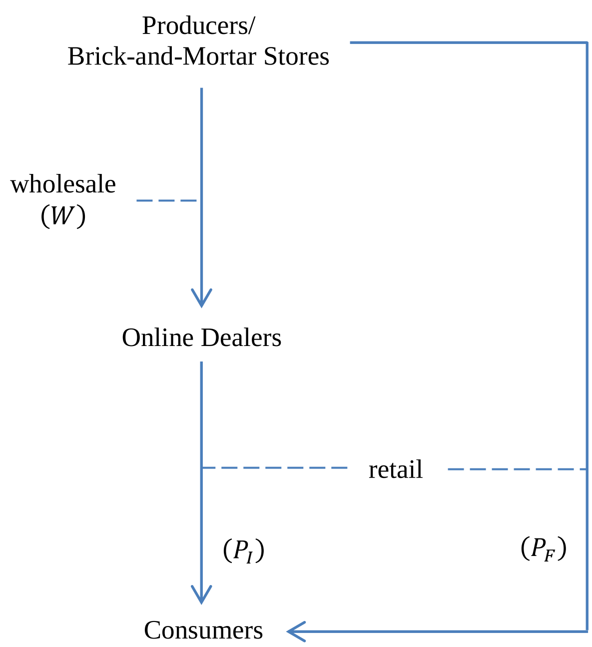
APPENDICES

Appendix A

Figure A.1. A diagram of the market



When buying directly, consumers effectively pay the producer's retail price plus travel cost, $P_F + s$.

Figure A.2. The segmentation of consumers by means of purchase in the 1F/1I and 2F/1I cases

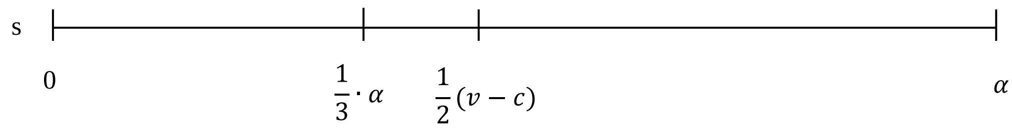
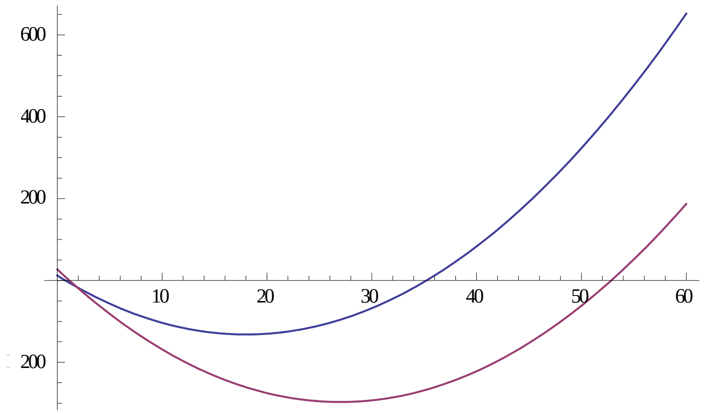


Figure A.3. The 2F/1I case: graph of $f(\alpha; v-c) = \frac{4}{9}\alpha^2 - 8(v-c)\alpha + 3(v-c)^2$ (roots denote equality of total surplus with and without intermediation, graphs for $v - c = 2, 3$)



In the domain of α where $f(\alpha; v-c)$ lies above zero and α simultaneously exceeds $\frac{1}{2}(v-c)$, total surplus is higher with intermediation.

Table A.1. Summary of Equilibrium Outcomes by Market Setting

Market: Numbers of Producers / Intermediaries	Wholesale Price	Producer's Final Good Price	Intermediary's Final Good Price	Producer j's Market Share	Total Intermediary Market Share
(homogeneous local markets)					
1F/1I	v	v	v	0	1
1F/2I	v	v	v	0	1
2F/1I	c	$c + \frac{1}{3} \cdot \alpha$	$c + \frac{2}{3} \cdot \alpha$	$\frac{1}{3}$	$\frac{4}{3}$
2F/2I	c	c	c	0	2
(heterogeneous local markets)					
2F/1I	c	$c + \frac{2}{3} \cdot A$	$c + \frac{4}{3} \cdot A$	$\frac{2}{3\alpha_j} \cdot A$	$\frac{4}{3}$
2F/2I	c	c	c	0	2

Table A.2. Summary of Total Surplus by Market Setting

Market: Numbers of Producers / Intermediaries	Total Producer Profits	Total Intermediary Profits	Consumer Surplus over all markets	Total Surplus
(homogeneous local markets)				
1F/1I	$v-c$	0	0	$v-c$
1F/0I	$\frac{1}{4\alpha}(v-c)^2$	0	$\frac{1}{8\alpha}(v-c)^2$	$\frac{3}{8\alpha}(v-c)^2$
1F/2I	$v-c$	0	0	$v-c$
2F/1I	$\frac{2}{9}\alpha$	$\frac{8}{9}\alpha$	$2(v-c)-\frac{11}{9}\alpha$	$2(v-c)-\frac{1}{9}\alpha$
2F/0I	$\frac{1}{2\alpha}(v-c)^2$	0	$\frac{1}{4\alpha}(v-c)^2$	$\frac{3}{4\alpha}(v-c)^2$
2F/2I	0	0	$2(v-c)$	$2(v-c)$
(heterogeneous local markets)				
2F/1I	$\frac{4}{9}A$	$\frac{16}{9}A$	$2(v-c)-\frac{22}{9}A$	$2(v-c)-\frac{2}{9}A$
2F/2I	(same as 2F/2I case with homogeneous markets)			

Table A.3. Summary of Welfare Comparison by Market Setting

Market: Numbers of Producers / Intermediaries	Can Intermediation Induce Welfare Improvement?	Conditions Required for Welfare Improvement [a]
(homogeneous local markets)		
1F/1I	Yes	Total surplus is always higher with intermediation.
1F/2I	Yes	Total surplus is always higher with intermediation.
2F/1I	Yes	$\alpha \in \left(\frac{3}{2}(v-c), \left(9+\frac{9}{8}\sqrt{\frac{176}{3}}\right)(v-c)\right)$
2F/2I	Yes	Total surplus is always higher with intermediation.

[a] in addition to $v > c > 0$ and $\alpha > \frac{1}{2}(v-c)$

Mathematical Appendix A.1.

In the 2F/1I case, producers play a game in order to determine whether to sell through the intermediary. Each producer can either sell through the intermediary ("use I") or not ("don't"), so there are four possible strategy profiles. Figure A.1 gives the normal form of this game.

When both producers sell through the intermediary, producer *j* has a profit of $\pi^*_{Fj} = \frac{1}{9}\alpha$. When both do not, remaining local monopolists, producer *j* has a profit of $\bar{\pi}_{Fj} = \frac{(v-c)^2}{4\alpha}$. Consider the payoffs from deviation for producer 1. When neither producer uses intermediation, it can be shown that deviating to "use I" yields $\hat{\pi}_{F1} = 2(v-c) - \frac{(v-c)^2}{2\alpha}$. When both producers use intermediation, deviating to "don't" yields $\tilde{\pi}_{F1} = \frac{1}{9}\alpha$.

In addition to deviations from one of the two coordinating strategy profiles, it is important to consider the possible incentive for producer 2 to also use intermediation once producer 1 is doing so. In this case, producer 2's profit is $\pi_{F2} = \frac{1}{4\alpha}(v-c)^2$. If producer 2 switches to "use I", then the market outcome is that from the 2F/1I case, where $\pi_{F2} = \frac{1}{9}\alpha$.

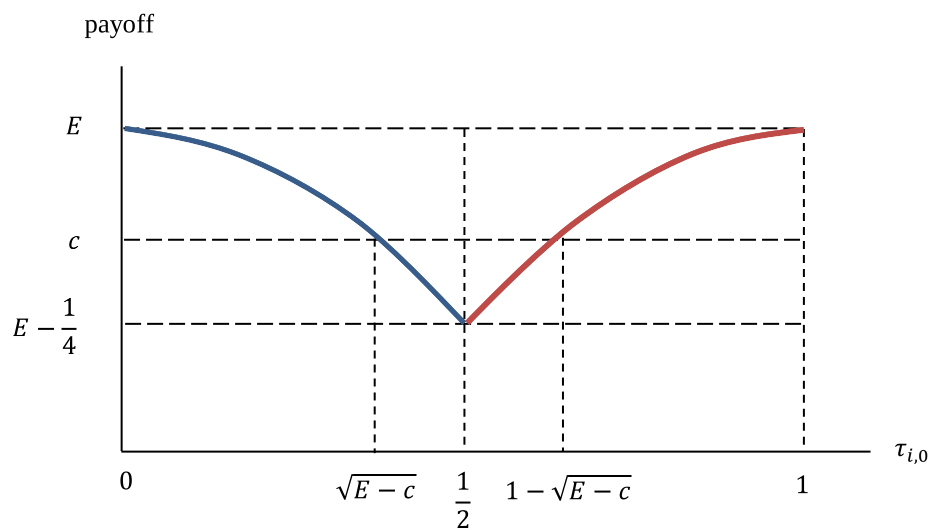
First, notice that (use I, use I) is a NE since there is no incentive for either producer to deviate to "don't": $\tilde{\pi}_{Fj} = \pi^*_{Fj}$. In addition, (don't, don't) is a NE when $\hat{\pi}_{F1} \leq \bar{\pi}_{Fj}$ or $2(v-c) - \frac{(v-c)^2}{2\alpha} \leq \frac{(v-c)^2}{4\alpha}$. This inequality reduces to $\alpha \leq \frac{3}{8}(v-c)$, which never holds given the "incomplete coverage" assumption. Thus, (don't, don't) is not a NE. Further, (use I, don't) (and similarly (don't, use I)) is a NE when $\frac{1}{4\alpha}(v-c)^2 \geq \frac{1}{9}\alpha$, which reduces to $\alpha \leq \frac{3}{2}(v-c)$. Hence, (use I, use I) is the unique NE when $\alpha > \frac{3}{2}(v-c)$.

Figure A.4. Normal form of game played by the 2 producers in the 2F/1I case, displaying only producer 1's profit

		Producer 2: Use I	Producer 2: Don't
Producer 1	Use I	$\pi^*_{F1} = \frac{1}{9}\alpha$	$\hat{\pi}_{F1} = 2(v-c) - \frac{(v-c)^2}{2\alpha}$
	Don't	$\tilde{\pi}_{F1} = \frac{1}{9}\alpha$	$\bar{\pi}_{F1} = \frac{(v-c)^2}{4\alpha}$

Appendix B

Figure B.1. The benefit and cost of sending messages



Appendix C

Figure C.1. Out-of-Equilibrium Dynamics